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Data driven X — Turning Data into Value

Band III

Paul Drews, Burkhardt Funk, Peter Niemeyer und Lin Xie (Hrsg.)

6. - 9. März 2018, Leuphana Universität Lüneburg

LEUPHANA
UNIVERSITÄT LÜNEBURG

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Energieinformatik, Erneuerbare Energien und Neue Mobilität

Teilkonferenzleitung

Michael Breitner
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A Literature Review on Energy Information System Software Development: Research Gaps and Questions in Industrial Manufacturing

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Abstract. In recent years, energy information systems (EIS) have become a growing area of research interest in industrial applications. In this article, we assume that the majority of scientific papers on EIS for industrial manufacturing are neglecting the software development aspect. Therefore, this article performs a systematic literature review on energy information systems for energy-aware industrial manufacturers. One of the main findings is that there are few scientific achievements for this research area. To support this, current research gaps of and questions for energy information systems are proposed.

Keywords: energy information system, energy consumption, energy efficiency production, literature review, industrial manufacturing.

1 Introduction

The improvement of energy efficiency is a key challenge in the industrial sector, especially in industrial manufacturing [1]. This can be observed, for example, in industries such as the steel, paper, chemical, or cement industry [2–4]. In the context of sustainable and cleaner production, a substantial amount of industrial manufacturers are confronted with the second key challenge of emission management. Therefore, the analysis and reduction of emissions (e.g. carbon dioxide or NOx), and the improvement of the energetic footprint of the products in the industrial manufacturing process are addressed by researchers [5–7].

From an energy perspective, there are even more challenges. There are always political, social, environmental [8–10], and technological drivers [11] that are influencing energy behavior. The consideration of all aspects at the same time enables the process of decision-making and changing the energy behavior in an industrial process [12]. The outlined key challenges can be addressed by energy information system (EIS).

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We are following the definition of EIS as "organizational-technical systems for systematically obtaining, processing, and making available environmental information available in companies" [13]. However, the term environmental information describes a large concept. In the context of this paper, the term energy data is more precise. Therefore, we are using the term energy data in this article to describe every relevant and measurable energy type in the context of an industrial plant.

Instead of developing an EIS individually for every industrial manufacturer, reusable information systems with well-defined architectures and software paradigms might be able to gain crucial benefits. In this paper, we assume that this aspect of systematic software development for EIS is neglected in the scientific literature. Therefore, we perform a systematic literature review on EIS for industrial manufacturers to identify the current scientific gaps and questions.

This paper is divided into four parts. After this section, the next part moves on to describe the research methodology for the systematic literature review. In the third part, the results are presented and discussed. Finally, the paper concludes with a summary of the findings.

2 Methodology

In this paper, a systematic literature review was performed. The results will be used as a foundation for future research projects. The article was following the methodology for literature reviews from Kitchenham [14] and the guidelines from Webster and Watson [15]. We aimed to give an answer to the following research question:

- What are the current research gaps and questions for EIS software development research in the context of energy-aware industrial manufacturing?

In the beginning, a keyword search in EBSCO BSC, EBSCO ASC, SpringerLink (SL), AIS Library (AIS Conferences and WI), and ScienceDirect was performed. In addition, a manual search for the MKWI was conducted (from 2003 until start of research in February 2016). The keywords were (including German equivalents): environmental management information system, energy and carbon management system, environmental decision support system, energy data information system, energy information system, energy management information system, energy data management, energy process data, energy efficiency production, energy supply chain management, and energy procurement.

This resulted in 3680 articles from peer-reviewed academic journals that were filtered in two exclusion phases. In the first exclusion phase, duplicates were eliminated and the titles and abstracts were read. 291 articles remained (study selection and study quality assessment).

In the second exclusion phase, all of the 291 articles were read and checked for suitability (the subject of the article had to cover industrial manufacturing and EIS). This resulted in 131 articles. To ensure that all relevant literature is included, a backward search was performed (repetition of study selection and study quality assessment). This led to 158 articles from more than 60 different academic journals and proceedings.

For the data extraction process, the articles were coded by their methodological direction. The methodological codes are: model development (mathematical), model development (non-mathematical), method construction, survey, case study, experiments, literature review. Combinations of codes were allowed. The methodological code for non-mathematical model development is used for actual modeling and not tool development.

3 Results and Discussion

This research examined the remaining 158 articles by performing a statistical meta-analysis over the literature first (see Fig. 1). The meta-analysis shows that only 38 articles were published from 2003 to 2009; furthermore, it can be seen that only one article was found in 2005. However, there was a significant increase of articles published in 2010 (16 articles), followed by a small decrease in the next two years (12 and 13 articles). Since 2013, the articles published are increasing, indicating a growing importance of EIS research in an industrial context (79 articles from 2013 until February 2016).

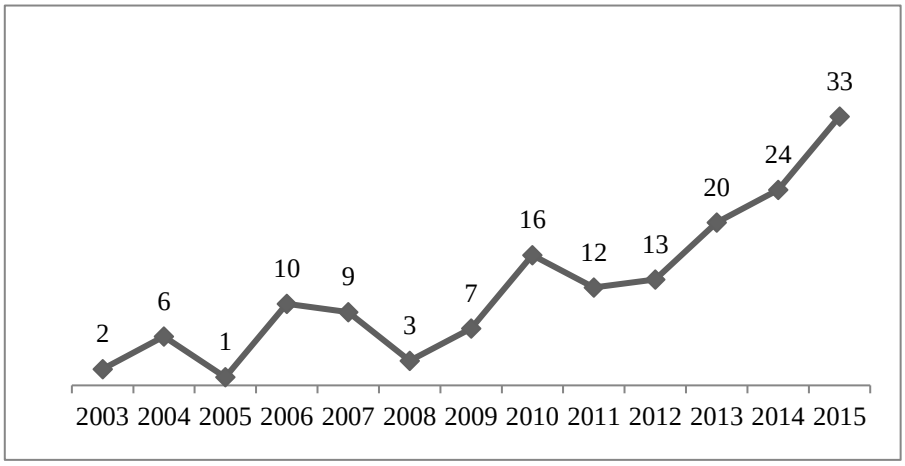

Figure 1. Articles published per year (numbers are shown for full years from 2003 to 2015)

On the one hand, this might be due to the commitment of the European Union to reduce emission of greenhouse gas by 20%, increase energy efficiency by 20%, and increase the use of renewable energies by 20% [16]. On the other hand, climatic catastrophes, such as the explosion of Deepwater Horizon in 2010, were leading to more ecological awareness in politics. Governmental grants as well as agreements in the UN Climate Conference helped to improve energy efficiency and to support research [17, 18]. In other words, the political and environmental factors might be influential for an increasing amount of research since 2010.

In the next step, we analyzed the paper by their methodological direction. In an article, multiple methods can be applied. For this reason, the number of methodological directions can be greater than the total number of 158 articles. Approximately 67% of all articles are trying to develop a model and 54.43% of all articles concentrated on using single case studies to evaluate their results. 74.53 % of these modeling papers are focusing on a mathematical model, hereby showing that those are the methods most commonly used. Five percent of the articles used surveys and 1.9% performed experiments in their paper. In 34.81% of the articles, a literature review is performed as the foundation for the specific research.

The construction of methods (2.53%) and non-mathematical modeling (17%) can be classified as design science. This shows that the actual software development and modelling of EIS does not have the highest priority in the research area. This can be explained by the high usage of single case studies in the articles; this suggests that EIS are development individually.

3.1 Research Gaps

We identified two articles that had a similar scope to our research. El-Gayar and Fritz [19] and Watson et al. [20] identified several important research gaps and questions that focus on the software development aspect of EIS. Watson et al. are presenting the research gap of increasing energy efficiency by integrating supply and demand data, the usage of information systems to change social norms, and the report of information to governments [20]. El-Gayar and Fritz are showing several research gaps including the need for identifying specific informational needs, the influence of environmental and business processes on EIS, and the nature of environmental information and the capturing of such data [19]. However, during our literature review, we were able to identify more research gaps and questions. These new gaps and questions will be presented next.

The main usage of single case studies is resulting in individually developed EIS that are not reusable. It can be seen from the meta-analysis that these EIS are used to apply methods for one specific instance of one problem. The main usage of case studies suggests that reusability and software development process of EIS is not one of the current main concerns and neglected. In addition, it can be seen from the literature that only a limited amount of methods and insights from information system research is used. A stronger collaboration of both research areas would be beneficial for researchers and practitioners.

As can be seen from the literature, there are modeling approaches for the analysis of energy and machine (process) data [21]. However, there is a substantial amount of unused potential in combining these two types of data. An industrial manufacturer might be able to increase his energy efficiency by adjusting his machines as well as to change flexible parts of production processes and shifts to save energy costs and improve the usage of his own energy production. Research in demand-response programs are addressing this topic partly, primarily focusing on the mathematical and price-side of the market, therefore neglecting the energy information system that is needed for these calculations as well as possible partnerships between different market participants [22, 23].

For example, through cooperation between consumers and retailers, energy consumption forecasts might be improved, therefore enabling optimized energy procurement and adding value for both sides [24]. These approaches can be further investigated by scientists to develop a holistic approach. This can be achieved by defining a reusable information model for energy and machine (process) data in industrial manufacturing.

In addition, the incorporation of constantly changing requirements should be supported by the developed and existing reference models. These can be used to develop a reusable architecture or architecture description. In the last years, the modeling community is using several approaches for standardizing information systems through reference architectures or architecture descriptions that can be applied for EIS [25, 26].

3.2 Research Questions

If the scientific gaps are addressed by the scientific community, EIS software development might benefit from scientific achievements. This could lead to further optimization of industrial manufacturers. To be able to address this problem, we formulated the following two future research questions (**RQ**) in addition to El-Gayar and Fritz [19] and Watson et al. [20]:

- **RQ01:** What are the design principles of a reusable information model focusing on the combination energy and machine data?
- **RQ02:** How can the development of a reusable architecture for EIS in industrial manufacturing be supported?

4 Conclusion

The aim of this study was to identify new research gaps and questions regarding the software development aspect of energy information systems. This research area is still young and therefore dominated by the use of case studies instead of empirical data. The results suggest that there is an overlooked potential in this field of study. However, the importance of EIS is growing and future scientists are encouraged to perform research to expand on the identified scientific achievements.

In addition to the already identified research gaps and questions by El-Gayar and Fritz [19] as well as Watson et al. [20], we were able to identify several new research gaps that lead to two new research questions regarding the combination of energy and machine data as well as a potential reusable architecture for EIS development. Therefore, the search for answers to these research questions is the next logical step.

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Assessment of Market Power in Local Electricity Markets with regards to Competition and Tacit Collusion

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Abstract. Increasing intermittent electricity generation from renewable sources challenges network operators to find ways of integrating non-controllable generation. Microgrids and local markets are a means to better coordinate local renewable electricity generation. Given that smaller markets are being served by fewer entities, sufficient competition is at risk. In this paper, we investigate the number of energy suppliers needed to ensure competitive prices and study the effect of tacit collusion in the form of signaling by individual suppliers. We construct an agent-based model using reinforcement learning. Our results indicate that controllable generation, especially peak capacity, must be provided by several suppliers to ensure a welfare optimal pricing. Signaling only affects prices in specific scenarios.

Keywords: *Market power, multi-agent systems, distributed learning algorithms, electricity market design*

1 Introduction

The penetration of renewable generation in the electricity market constantly increases, not only in Germany but also in other markets of the world. The intermittent nature of renewable energy sources makes it more difficult to coordinate electricity markets securely and efficiently. One means to overcome this challenge is the establishment of microgrids [1]. In such microgrids coordination will occur locally first. Thus, demand side flexibility, storage capacity and renewable infeed can be coordinated more easily. One or several microgrids can form a local market [2]. On local markets, different products such as power or flexibility can be traded. However, smaller electricity markets bare the risk of allowing producers to build a monopoly or oligopoly, where they can control the prices [3]. Several authors have already investigated smaller market sizes with respect to market power of agents, however, with divergent results [3–6]. Yet, there is no definitive answer to the question how many market participants are required to ensure a sufficient level of competition. More so, the possibility of oligopolistic coordination has not been considered. In this paper, we investigate the effect of a specific signaling strategy [7] in electricity auctions on non-competitive price markups, as a form of tacit collusion. The objective of this paper is to provide clear recommendations regarding the necessary competition on local electricity markets and

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to provide insights on the effects of oligopolistic coordination. We use an agent-based model to simulate the outcome of a day-ahead merit order electricity auction and investigate the achieved markups by market participants over several scenarios. The chosen scenarios are based on empiric data from the German electricity market. Therefore, this paper answers the following questions:

1. What is the effect of market concentration on oligopolistic markups?
2. What is the number of required competitors in a local electricity market to ensure competition?
3. Can competitors use signaling to increase their oligopolistic markups?

2 Related Work

High entry barriers and the traditional regulation of electricity markets have caused many electricity markets around the world to be oligopolies [8]. Therefore, the investigation of market power has long been in the focus of electricity market research [9, 10]. Market power itself is characterized as the ability to defer market prices from a competitive equilibrium to increase profits [11]. A competitive equilibrium in power markets is characterized by marginal cost bids [5]. This means that the price will be determined by the marginal cost of the last MWh that is needed to meet the demand. The abuse of market power usually manifests itself in the form of withheld capacity either physically or financially by bidding prices above the marginal cost [12]. According to [9] there are three determinants of market power: Demand elasticity, generation concentration and the volume of long term contracts. We investigate the concentration of generation, as demand elasticity can hardly be influenced and the volume of long-term contracts strongly depends on short-term price volatility. In [4] the authors come to the conclusion that market power will rise locally, when only few competitors are able to match the remaining demand. [13] also identify local market power as a significant problem for electricity markets and [3] argue that market power will increase with smaller market zones. Therefore, we focus on the effect of competition on market power in small electricity markets.

Microgrids are investigated as a means to control loads locally and increase resiliency of the electricity system [14]. [1] describe microgrids as an approach to integrate distributed energy resources, which especially encompasses renewable generation. There is a wide area of research on the economic coordination of microgrids [15, 16]. Most proposed auction mechanisms rely on merit order pricing with marginal cost since it is less prone to strategic behavior as pay-as-bid mechanisms [15, 17, 18]. Therefore, we will use this auction design to evaluate the effects of market power.

Several authors have used agent-based models with reinforcement learning to investigate electricity markets. [19] review agent-based models with learning market participants applied to electricity markets. They conclude that the most common approach is to assume fixed demand and let the supply side learn the profit maximizing strategies. We follow this approach in the model at hand. In [20], the authors apply a

learning algorithm to a market with individual step-wise supply functions and proof its convergence. We build on this research and use the same algorithm. In [21] the authors follow a similar approach as in the model at hand. They employ an evolutionary algorithm to measure market power under different ratios of supply and demand agents. However, the authors assume a very elastic demand and even observe buyer market power, which makes the simulation more of a general study of market power on a conventional market, than on an electricity market. Furthermore, the authors are unable to find evidence that a higher market concentration leads to the increased exercise of market power, which contradicts basic economic theory.

Signaling games are an area of basic game theory. A sender with a specific type chooses an action, which the receiver processes as a message and then chooses his action accordingly. The payoffs depend on the sender's type, which is unknown to the receiver [18]. Signaling as a means of tacit collusion has been investigated for telecommunication markets [22]. However, it has rarely been applied in electricity market research. [23] evaluate the performance of two different auction mechanisms using a signaling game. In their paper, the bids of competitors are perceived as signals, that can be used to learn their marginal cost and with that information, the personal bidding strategy is adjusted. We will follow a similar approach, where competitors receive signals of other bidders to negotiate mutually beneficial higher markups.

In conclusion, great efforts have been undertaken to analyze market power in electricity markets. However, there is no clear indication regarding the extent of necessary competition to prevent oligopolistic profits. This question becomes more pronounced, as local markets become an option of (re-)structuring electricity markets.

3 Model

The proposed model considers a single price electricity market over a specified period. The supply curve represents the merit order, i.e., the supply bids in ascending order. Demand is assumed to be fixed [19] meaning that the last power generator needed to satisfy demand, sets the price. The supply side consists of a set of agents $I = \{i_1, \dots, i_n\}$, which have a specific generation capacity c_i. We further differentiate controllable conventional generation agents $S = \{s_1, \dots, s_m\}$ and non-controllable renewable generation agents $R = \{r_1, \dots, r_l\}$, such that $S \cup R = I$. The controllable generation agents are further divided into the generation classes of base $B = \{b_1, \dots, b_k\}$ and peak $P = \{p_1, \dots, p_h\}$ supply agents. Their marginal costs are such that $mc_B < mc_P$. The renewable generation agents are divided into the generation classes wind $W = \{w_1, \dots, w_g\}$ and photovoltaics (PV) $V = \{v_1, \dots, v_e\}$ supply agents. The marginal cost of the renewable generation agents are assumed to be $mc_W = mc_V = 0$.

3.1 Bidding

Before each auction, every agent determines her price bid $q_{i,t}$ with $t \in \{1, \dots, T\}$ being the *t'th* time step. We assume that agents only act strategically, when they assume that

their generation class is price setting and otherwise bid their marginal cost mc_i. If a more expensive class sets the price, agents are expected to make a profit anyway and would risk to fall out of the merit order if they acted strategically. In case cheaper generation classes can cover the demand, they expect not to be dispatched. To determine their expectation of belonging to the price setting class, all agents are aware of the capacities of cheaper generation classes. However, no one can determine the generation from renewables or the demand with complete certainty. Therefore, every agent forecasts these two values as $f_{i,t}^{d}$ and $f_{i,t}^{\rho}$. To do so they draw a random number from a normal distribution $f^{d} \sim N(\mu, \sigma) = N\left(d_t, \frac{0.1 d_t}{3}\right)$ and $f^{\rho} \sim N(\mu, \sigma) = N\left(\rho_t, \frac{0.1 \rho_t}{3}\right)$. This implies that agents are expected to forecast generation and demand correctly on average. The standard deviations σ of the normal distributions are chosen to ensure that the error margin stays within 10 % of the original value with a very high confidence. Renewable agents are expecting to be price setting if their forecasted demand does not surpass their forecasted generation of renewables. Base agents expect to be price setting if demand surpasses renewables but not the sum of renewables and their own capacity. Peak agents expect to be price setting otherwise. We now describe the procedure of bid price determination in the case that an agent expects to be price setting.

We use the Probe and Adjust learning algorithm [21]. The decision for this learning method is based on that fact that it can capture collusive behavior and has been proven to converge for standard electricity markets [16]. To apply this algorithm every agent $i \in I$ first calculates her base value a_i. In the first round this base value is set to the marginal cost of the agent such that $a_i = mc_i$. The agents then vary their bid from the base value with the learning parameter δ_t such that $bid_{i,t} \sim U(a_i - \delta_t, a_i + \delta_t)$ and $q_{i,t} = \max(mc_i, bid_{i,t})$ to ensure that no agent makes the economically unreasonable decision to bid below her marginal cost. The initial learning parameter δ shrinks over time to ten percent of its original value $\delta_t = \delta\left(1 - 0.9\frac{t}{T}\right)$ to avoid strong deviation from optimality after convergence, where 10% is randomly chosen [24]. The complete bid of a conventional generator consists of her capacity and price bid $(c_i, q_{i,t})$ and for a renewable generator it consists of her generation at *t* and her price bid $(g_{i,t}, q_{i,t})$. A renewable generator only bids her actual generation $g_{i,t}$.

3.2 Signaling

If an agent is signaling, he tries to send a message to his competitors by bidding especially high. This bid is supposed to show the receiver agents that higher revenues are possible if they follow the example of the sender agent. Therefore, the sender agent *s* always adds the current learning parameter to his original bid price $q_{i,t}^{s} = q_{i,t} + \delta_t$. However, he learns as if he had bid $q_{i,t}$ to prevent distorted results after convergence. We deviate slightly from the traditional signaling theory in [7] with this approach, as the sender does not have different types and the payouts of the receivers do not depend on this type. However, they receive a message of the sender in the form of a specific

bid and use this input to maximize their personal output. More specifically, with signaling it becomes more probable that randomly occurring high bids will lead to higher profits, as they are met by the simultaneous high signaling bids, which will shift the entire merit order to the right.

3.3 Merit Order

After each agent has determined her bid, the agents enter the competition. The bids are sorted in ascending order determining the merit order supply curve $\left(\left(h_{(1)}, q_{(1),t}\right), \dots, \left(h_{(n)}, q_{(n),t}\right)\right)$, where $h_{(i)} = \{c_{(i)}, g_{(i),t}\}$ is the capacity of a conventional generator or the generation of a renewable generator and $q_{(1),t} \leq q_{(2),t} \leq \cdots \leq q_{(n),t}$ are the ask prices of the supply agents. The price p_t is then determined as $p_t = q_{(J),t}$, such that the sum of all procured generation exceeds demand d_t with the last added bid: $\sum_{j=1}^{J-1} h_{(j)} < d_t$ and $\sum_{j=1}^{J} h_{(j)} \geq d_t$. Every agent registers her profits $y_{(i)}$ by

$$y_{(i)} = \begin{cases} h_{(i)}(p_t - mc_{(i)}), i \in \{1, \dots, J-1\} \\ (d_t - \sum_{j=1}^{J-1} h_{(j)})(p_t - mc_{(J)}), i = J. \\ 0, otherwise \end{cases} \quad (1)$$

Where generator *J* is the *price setting agent that* only partially sells her generation.

3.4 Learning

After each round in which an agent expected to be setting the price, she records her total profit and her bid. Every time this list counts ten entries the agent updates her base value a_i. This is done by first sorting the list in descending order and then using the average of the first three strategies as the new base value, meaning $a_i = \frac{q_{i,(1)} + q_{i,(2)} + q_{i,(3)}}{3}$ such that $y_{i,(1)} \geq y_{i,(2)} \geq y_{i,(3)} \geq \cdots \geq y_{i,(10)}$.

3.5 Market power

Market power is measured by the daily price markup m on the competitive price at marginal cost p_i^{mc}, following the definition of market power by [9]. Assuming that a day consists of *K* trading periods it is calculated as follows:

$$m = \sum_{t=1}^{K} (p_t - p_t^{mc}) \quad (2)$$

4 Evaluation

In the following we evaluate the presented market model using empirical data from the German electricity market. We use the given definitions to evaluate market power and determine the influencing factors.

4.1 Simulation Setup

Demand is represented by a small city with 10,000 households. We use representative demand profiles [25] for summer, winter, and spring & fall days. Base capacity includes nuclear power plants, lignite and half of the hard coal capacity. This sums up to 51.9 % of the total controllable generation capacity. Peak capacity is comprised of gas power plants and the other half of the coal power plants, which means 48.1 %. The total controllable generation capacity is then scaled with regards to the maximal demand. This factor was 1.14 in Germany in 2015 according to ENTSO-E load data.[1] The renewable capacity and generation are determined according to real data from 2015. Installed capacity of wind power plants amounted to 57.6 % of the maximal demand and the installed capacity of PV to 50.7 %. The actual generation per 15 minutes is calculated as the average generation relative to the total installed capacity during winter, summer, and fall & spring days of 2015. This way we generate representative wind and PV days for all seasons.

We calculate every scenario for winter, summer, and spring & fall. The relative share of signaling agents in every generation class is altered between 0 %, 20 %, 30 % and 50 % where the absolute number of signaling agents is always rounded down. We then alter the number of agents in each generation class between 1 and 10. This creates 120,000 scenarios. An auction is performed for every 15 minute slot, meaning that there are 96 auctions every day. Each scenario runs through 30 days to adjust the bidding strategy before day 31 is evaluated. Following [26], the marginal cost for base generators is set to $mc_B = 0.02 \frac{€}{kWh}$ and for peak generators to $mc_P = 0.06 \frac{€}{kWh}$. The learning parameter δ is initialized with $\delta = 0.01$. To evaluate the market concentration we use the Herfindahl-Hirschman Index (HHI) which is a common measure in electricity markets [9]. We cannot use capacity values for renewable generators in the calculation of market shares since they are not controllable. Therefore, we calculate the HHI for every time slot given the specific renewable generation in that time slot and then take the mean over all time slots as an indicator for a specific run.

4.2 Results

First we analyze which amount of variation in the daily markup can be explained by the investigated factors. We perform a linear factor regression using the HHI, the number of agents in each generation class, the season and the share of signaling agents as explanatory variables. The R^2 of the regression is 0.87, implying a high dependence

[1] https://www.entsoe.eu/data/data-portal/consumption/Pages/default.aspx

between the markup and the given variables. Almost all factor values and the HHI valuation are significantly different from zero, implied by low p-values. Fig. 1 shows boxplots of the daily markup in relation to the total number of competitors for all simulation runs. The minimum number of competitors is 4 (if there is one supply agent in every generation class) and the maximum number is 40 (if there are 10 supply agents in every generation class). It is clearly visible that higher concentration (i.e., less competitors) lead to increasing markups. The median markup decreases with an increasing number of competitors. In general, more competitors seem to stabilize the results, as the quantiles are closer to the median with increasing competition.

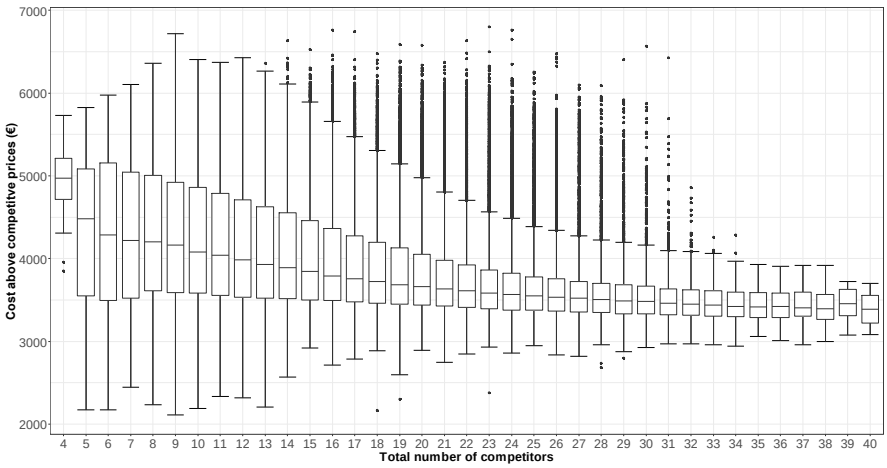

Figure 1. Total markup given the number of total competitors

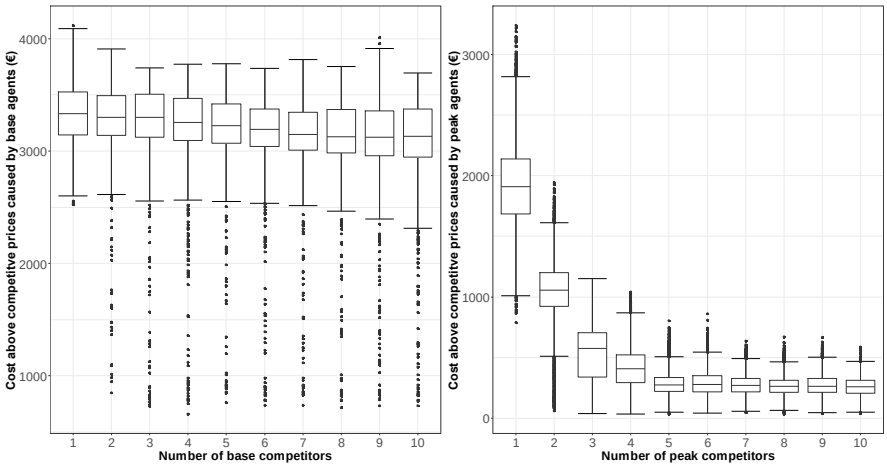

Figure 2. Markup caused by peak and base agents given competition in respective classes

To further interpret the results, we now divide the total markup into markups caused by base competitors who deviate from the competitive strategy and peak competitors deviating from their competitive strategy (Fig. 2). As we can see, increasing competition leads to decreasing markups for each generation class. However, the base markup is more stable and only decreases slowly with more competition. The difference in generation class markup between one and ten competitors is about 5 % for base agents and 87 % for peak agents. On the other hand, the peak markup decreases quickly and is reduced to a minimum with five or more competitors. The reason is that base capacity is often used to a large extend. When base capacity is setting the price the average utilization of base capacity 60.2 %. That means agents learn to further increase their bids until they surpass the peak marginal cost and are outbid by peak generators. At the same time there is little competition within the group of base agents as their capacity is often needed to a large extend.

This is different for peak producers. They have no upper price bound from a different generation class which is why markups rise dramatically with little competition. At the same time, their capacity is rarely needed to a large extend. If they are price setting, the average utilization of peak capacity is 23.2 %. This makes competition fiercer and therefore, reduces prices if agents do not collude. It is also remarkable that the total markup caused by base agents is generally higher than the markup caused by peak agents. This is caused by two factors. Firstly, base power plants set the price more often than peak power plants, as peak power plants are not needed due to renewable generation. Overall, base agents set the price in 80.9 % of the cases. This also increases the total markup. Secondly, as base agent bids are less sensitive to competition and base agents have more opportunities to learn, their average bid is further away from their real marginal cost. The average base value in the last time slot $\overline{a_T}$ of base agents is $0.080\ \frac{€}{kWh}$ and therefore $0.060\ \frac{€}{kWh}$ away from base marginal cost, while it is $0.094\ \frac{€}{kWh}$ for peak agents, meaning a difference of only $0.034\ \frac{€}{kWh}$ from peak marginal cost. This result implies that it is important to ensure a mixed set of suppliers for local markets with mixed marginal cost. Thereby, upper price bounds for the bids of all agents would be imposed and it would be more difficult to game the step-wise supply function. Furthermore, competition for peak capacity needs to be ensured. The simulation results suggest that the market share of any peak producer should be limited to 20 %.

4.3 Tacit collusion

We now analyze the consequences of signaling. A first general analysis shows little impact of signaling (Fig. 3). The total markup difference between the lowest and the highest value of signaling is about 1.6 %. This has two reasons: (a) When competition in the form of agents is low, there are few signaling agents, given the rule to round down the absolute number of signaling agents. For example, if there are three agents in a specific generation class and the signaling factor is 0.3 there are zero signaling agents. These scenarios still contribute to the 0.3 signaling scenario average. And (b) when there are many agents (e.g., ten), the increased amount of signaling agents does not make a difference as competition reduces its effect. For example, in the case of ten

competitors and five signaling agents for peak power, there would still be five peak agents competing, which we found to be sufficient to ensure competition. Furthermore, as base markups rise to their maximum even without signaling, the additional signaling agents only help to arrive at the same result faster.

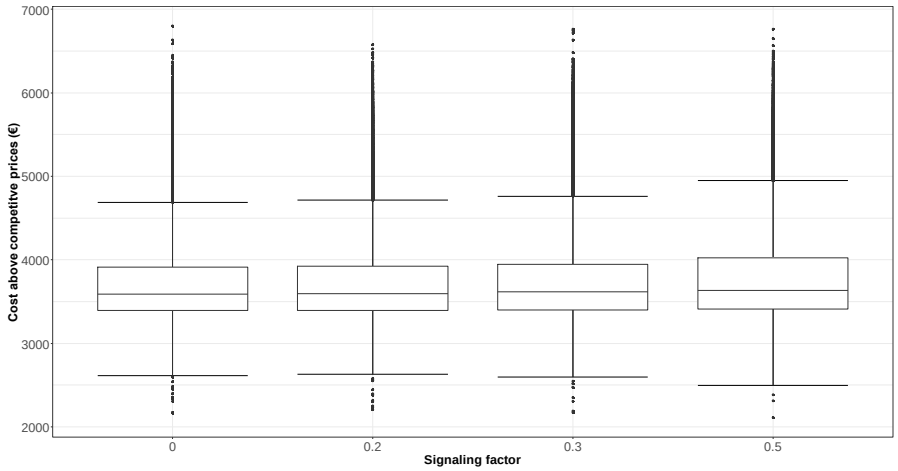

Figure 3. Markup by signaling factor over all simulation scenarios

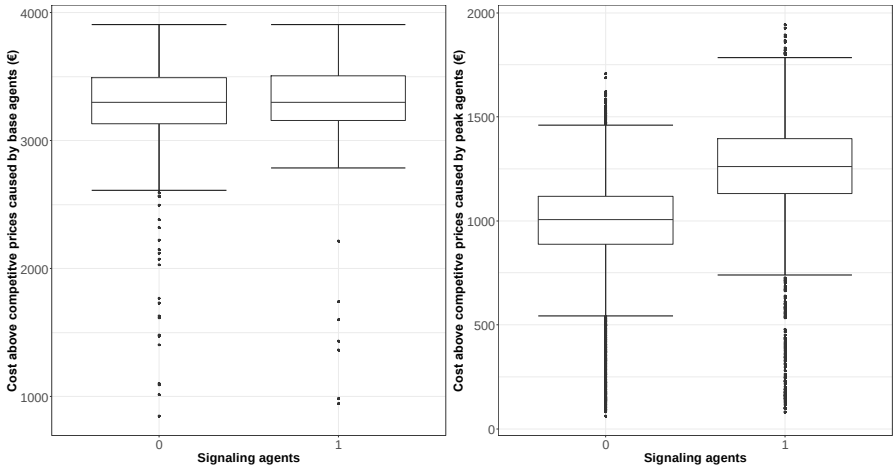

Figure 4. Markup in scenarios with two competitors with (1) and without (0) signaling

To dig deeper into the impact of signaling on price markups, we further analyze the special case of two base or peak agents (Fig. 4). We find that in this special case, where we would expect signaling to have the strongest effects, there is still no considerable difference in the markup caused by base agents. However, we can observe an effect for peak agents. The markup caused by peak agents rises by 26 % on average, if there are

two peak agents with one of them signaling. The effect persists for peak capacity but weakens with more competition. For three peak agents with one signaling agent the markup is 15 % and for four peak agents it is 9 % with one signaling agent and 18 % with two signaling agents. In general, it seems that tacit collusion can be mitigated by competition for peak agents, while it cannot further increase markups for base agents in the given scenarios. Another explanation is that the way the receivers interpret the signals is insufficient. In a real world setting, bidding agents would analyze the overall bidding curves and find signals more easily. However, in [22] the author concludes that few competitors might already be enough to ensure competition.

The number of renewable competitors has no effect in the presented simulation, as they are never price setting. Therefore, their behavior does not influence the final results. However, this might change as renewable capacity increases, especially in local markets. In case local demand can be completely satisfied by renewable generation, we would expect similar behavior as for base agents.

5 Avenues for extensions

In the simulation we assumed equal market shares between agents of one generation class. An interesting extension would be to investigate if different market share distributions would lead to differing results. Furthermore, demand in this paper only consists of residential customers. Including industrial customers and assessing their impact on market power would extend the presented simulation. Additionally, in the local market setup the assumption of a price taker might no longer be valid with larger customers on smaller markets. To fully grasp the potential of tacit collusion, the intelligence of agents could be enhanced allowing them to interpret signals in more detail, e.g., by simulating the analysis of supply curves and implementing a reaction to anomalies in these curves. Finally, an extension could be to allow generators to act strategically even if they are not in the price setting class.

6 Conclusion

With this research we contribute to the ongoing refinement of market mechanisms for local electricity markets. It is fundamental to consider the effects on market power and keep in mind, that sufficient competition has to be ensured as new market mechanisms and auction designs for local electricity markets are developed. The objective of this work is to investigate competition on local electricity markets to (a) avoid effects of market power and to (b) analyze the impact of tacit collusion on the possibility of exercising market power. We develop an agent-based simulation model that captures the dynamics of a merit-order electricity market, using a reinforcement learning algorithm that has been tested for similar applications. We allow signaling in the form of increased price bids to be exercised in certain scenarios, to research the effects of tacit collusion. We implement the model using empirical data and run the simulation over a wide range of scenarios.

Our results show that more competition generally reduces the effects of market power. This is in line with economic theory. Especially peak production needs a high level of competition, with market shares of not more than 20% for each competitor in this sector, meaning that with equally distributed market shares at least five competitors are necessary. Furthermore, to avoid the exercise of market power by base agents, a variety of generators with different marginal cost is needed, to ensure that high markups up to the next cost step are avoided. This means that for base supply it is not the number of competitors, but rather the form of the supply curve that prevents market power. This could become critical in scenarios with a large share of generation from renewable energy sources with low marginal cost, backed up by expensive peak power plants. Competition among renewable generators is neglectable, as long as they do not become price setting. The overall effect of tacit collusion seems to be small. Tacit collusion in the form of signaling has no impact on base agent markups. However, signaling increases peak agent markups if competition is small.

The presented research can help practitioners with the correct implementation and regulation of local markets. The assumed local generation structure can be adapted to any local generation structure depending on the analyzed market and the model can be used to assess the possible risk of market power.

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Decentralizing Energy Systems Through Local Energy Markets: The LAMP-Project

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Abstract. The increasing amount and volatile generation from renewable energy sources causes challenges for its integration into the German energy system. Furthermore, the rise of smart prosumers and energy aware consumers results in new energy users and small-scale producers that are currently excluded from the energy market. We conduct the decentralization of the energy system into local energy markets on which consumers and prosumers can trade locally generated energy within their community. We present the ongoing implementation of a local energy market project in Germany, the LAMP-project. To give an impression of the project's results, we simulate the LAMP market in a multi-agent simulation and evaluate the projected market prices and level of self-consumption. Local energy markets as new concepts of energy systems call for innovative information technologies to support the decentralization of the formerly centralized energy system. Therefore, we use the innovative blockchain technology to sustain the implemented LAMP market.

Keywords: decentralization, local energy market, renewable energy, blockchain.

1 Introduction

A main objective of the German government's *Energiewende* is to increase the share of renewable energy sources (RES) in the electricity generation to 60% by 2050 [1]. At the same time, criticism of the current centralized electricity system in terms of its costs, environmental impact, transmission losses and security vulnerabilities has been constantly growing [2]. A change from the formerly linear energy value chain to a complex and multidirectional system seems inevitable [3]. Due to the distributed nature of RES, a decentralization of the German energy system into localized energy balances seems natural. Adding the roles of active prosumers (consumers, who also produce energy) and energy aware consumers leads to the idea of local energy markets. A local energy market (LEM) is a market platform, that offers local producers, prosumers and consumers the opportunity to trade energy locally at prices of their own valuation [4].

To validate current LEM research, we implement a prototypical LEM between up to 20 household residents in Landau, Germany (Landau Microgrid Project (LAMP))[1]. We

[1] http://www.energie-suedwest.de/unternehmen/projekte/lamp/

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measure the market development and participation as well as the participants' acceptance of the project. Firstly, we conduct a literature overview of current LEM research as an introduction into the topic. As the project is currently ongoing, we then focus on an agent-based simulation of the project's setup to show insights into the predicted market results.

2 State-of-the-Art: Local Energy Markets

LEM aim at maximizing the utilization of distributed RES in a specific region [5] by offering a local marketplace for prosumers and consumers. LEM are often community-oriented and put emphasis on empowering their community, decreasing electricity costs and reducing electricity production by conventional sources through encouraging local RES [6]. The idea of using LEM to integrate RES into existing energy systems has been around for several years [7]. [8] argue that LEM can be used for integrating large amounts of fluctuating RES into the energy system and will incentivize RES more efficiently on a prosumer level than the current centralized energy market. [9] give a short overview of energy auction mechanisms in local energy markets ranging from double-sided auction models to continuous double auctions, that give insights into LEM efficiency. [10] also focus on a stock exchange model. However, they put emphasis on the decentralized nature of LEM and give public access to the entire order book.

The compatibility of LEM designs with current regulation is a critical topic that is not sufficiently addressed yet. [11] draw attention to the importance of European regulation by discussing how LEM can be implemented in different ways. New regulation needs to be able to cover several market types as long as no superior LEM framework emerges. Furthermore, the transaction object of LEM is not yet clearly defined. While several authors focus on energy demand and generation for trading on LEM, e.g. [12], others focus on balancing and reserve energy trading, e.g. [13].

A large drawback of LEM is their limited number of potential market participants and tradable volume, which may result in limited market liquidity [13]. Thus, LEM need to be well adaptable to low liquidity markets or participation needs to be ensured.

Recently, LEM are often associated with being the ideal scenario for combining the innovative blockchain technology and the energy sector [14]. Blockchains consist of a secure chain of data blocks. The content of a block is unchangeable once it is confirmed. The chain is ordered chronologically and distributed to all participating nodes. The addition of new data is protected by a decentralized consensus mechanism and cryptographic security measures. Thus, blockchains are a distributed software architecture that may enable agents to interact amongst each other without the need of a central intermediary [15]. The distributed software architecture as well as the absence of need for a central intermediary and the secure transaction platform are the main reasons why blockchain-based energy trading is currently being actively discussed.

Implementations of LEM have developed very recently. German companies (e.g. Lumenaza GmbH[2] and sonnen GmbH[3]) develop concepts to buy and sell locally

[2] https://www.lumenaza.de/

[3] https://www.sonnen-batterie.com/de/home

produced electricity on a residential level. These projects give residential customers the chance to become more active in their energy procurement. However, the introduction of blockchain technology promises a real-time market place without supervision by a central intermediary. Such markets are not yet implemented in real world scenarios. The worldwide first project implementing a (near) real-time, blockchain-based LEM with active traders is the Brooklyn Microgrid [14]. However, the project is not yet market-ready and its academic evaluation is just beginning.

There exists a considerable gap in academic literature discussing blockchain-based LEM, and industry actually implementing projects of blockchain-based LEM. We address this research gap and conduct a comprehensive approach towards the implementation of a blockchain-based LEM by leading and shaping LAMP from an academic point of view. We conduct a rigorous project management and research approach in terms of replicability and control over the project's and participants' degrees of freedom. Thus, we are first to implement a pilot project of a blockchain-based LEM and to evaluate the pilot according to strict academic guidelines.

3 The Landau Microgrid Project (LAMP)

The LEM in LAMP is being implemented between up to 20 residential households on an area grid in Southern Germany. The residential consumers and prosumers (photovoltaic (PV) systems operated by the local utility) access the LEM within their community via a specialized smartphone application (app). They can set maximum prices for buying local electricity as well as minimum prices for selling their PV production within the community. The local energy retailer provides the payment system, while an energy service company provides the market place and blockchain infrastructure. Every market participant can propose one order (bid or ask) for local electricity every 15 minutes. These orders are matched by a central market mechanism at one market price per time slot. Orders are generated automatically based on the price preferences the market participants provide via the app.

Thus, LAMP provides its participants with the chance to buy locally produced electricity at prices of their own valuation. Thereby, they can support their community through keeping the profits within the vicinity. Furthermore, reinvestments in RES are encouraged as projected market prices (see Figure 1) are expected to settle above the current feed-in tariff for PV energy in Germany. The objectives of LAMP are:

1. Design and implementation of a prototype blockchain-based LEM abiding by German regulation
2. Evaluation of market and agent behavior, motivation, acceptance and participation of German residential energy customers to participate in a LEM
3. Evaluation of reached autarky, simulated vs. real local electricity prices and comparison to the existing green electricity tariffs

3.1 Simulation of LAMP

During the project-planning phase, several LAMP simulations were conducted. We extend the market model from [4] that already focuses on small-scale LEM and specify

it to the exact planned LAMP setup to project LAMP's market behavior. Thus, we simulate 20 residential German households based on randomized H0 consumption profiles as well as five 5 kWp PV systems based on measured data from German PV panels over one year. Hence, 15 consumers and 5 prosumers are simulated that trade electricity every 15 minutes for the next time slot. The simulation results yield a necessary understanding of the project before implementation and a direct transmission of [4]'s theoretical market model to a practical implementation.
Based on a time discrete double auction mechanism [4] the 20 households trade for the locally produced PV electricity. Based on a price descending (ascending) order for bid (ask) orders, the lowest priced bid order still served by the aggregated local generation sets the market price for local electricity in the current time slot. In LAMP, we only auction local PV electricity in addition to the still existing German electricity tariffs. This means, that electricity supply, balancing energy and grid stability are always ensured by the existing connection of the area grid to the public grid. Thus, the LAMP marketplace is an addition to the current energy market and an experimental project in which we determine the market behavior of the typical German electricity customer without changing the level of service security to which he is accustomed.

Assuming the typical energy customer has little knowledge about strategic bidding in energy markets and is risk-averse [16], it is natural to assume that he will bid prices between the current feed-in tariff for PV electricity (0,1231 €/kWh) and his current variable electricity price (0,2549 €/kWh) in the LAMP region. Provided a basic understanding of markets, we assume the LAMP participants (or agents) to be able to learn from their past trades and adjust their bidding strategies accordingly. Thus, we implement a basic, continuous learning algorithm for electricity agents [17] which adapts the probability to choose a certain price for local electricity on the LAMP market according to [4]. We assume a perfect forecast for generation in the next time slot.

In the LAMP simulation, we arrive at a mean self-consumption of local PV electricity in LAMP of 42% of the aggregated generation over one year. The agents directly consume 26% and trade 16% of the locally produced PV energy. Consequently, the market place increases the self-consumption by 16%. Figure 1 shows the typical course of the PV price on a winter and summer day. It differentiates between the local market price and the overall electricity price, which includes the weighted local prices as well as the weighted energy prices at standard electricity tariffs.

Obviously, the local electricity price during a typical winter day only decreases during midday, when the solar irradiation and the corresponding PV production is high. During summer, due to long hours of solar irradiation, local prices begin to drop as early as sunrise and stay low until evening.

It is interesting to note that local price levels always drop to approximately 0.16 €/kWh once PV production is high. This is due to the very similar production of the 5 PV systems in the simulation (in a local scenario irradiation can be expected to be similar). Thus, all prosumers sell excess energy simultaneously during the day when consumer demand is low compared to local supply. Hence, local prices decrease in the competitive environment. Accordingly, less PV production increases price levels. Figure 1 also shows that the overall electricity price approximately follows the local price. Thus, once local electricity is produced, it amounts for a high percentage of the

local demand. Hence, the market participants' overall electricity price is only slightly higher than the local price during generation hours. However, as PV only produces during daylight hours and mostly in summer, the mean yearly overall price for all electricity procured converges at approximately 0.24 €/kWh which is 94% of the original electricity tariff. Yet, the mean yearly price for only local electricity is 0.20 €/kWh. This shows the potential for significantly lower local prices. However, it cannot be exploited due to the temporal discrepancy between demand and PV production. Energy storage or another source of local generation could reduce this issue.

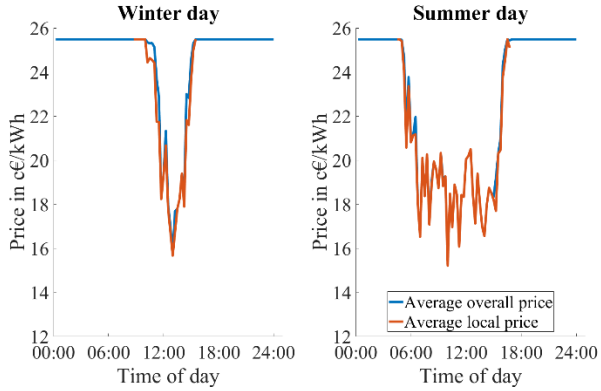

Figure 1. Local PV electricity price (red) and average overall electricity price (blue) during a typical winter and summer day.

3.2 Discussion of LAMP Setup and Evaluation

The conducted simulation can partly project the expected market behavior of LAMP. Yet, especially the agent behavior, which we assumed to be rational, is difficult to project and highly influences the implementation results. Thus, we need to be careful to directly transfer the simulation evaluation to the implementation. Consequently, we only draw broad conclusions. Specially, we do not deem the simulated electricity prices to be reliable enough for an in-depth conclusion and expect differing prices in the implementation as the agent behavior is largely untested yet.

One conclusion we can draw from the simulation is that to reach a high autarky of the community, a second source of energy generation and/or energy storages should be added to the project. A thorough evaluation should document changed bidding behavior and community self-consumption through these additions. The simulation runs of LAMP show that self-consumption can be increased by approximately 16% through solely PV generation. The combined 42% of autarky do not represent the aspired high level of autarky for which the project was designed. Thus, we decided to further include controllable local generation. Due to usual implementation challenges (regulation, budget) we decided on a combined heat and power (CHP) plant with a maximum of 80 kWh to be incorporated in LAMP. Thus, the project setup will be as follows.

- 20 residential market participants
- 25 kWh residential PV production

- 80 kWh CHP
- Blockchain-based market trading platform in 15 minute time slots

In addition to the market and participation evaluation of LAMP, we will also provide a pilot implementation and feasibility study of a private blockchain protocol sustaining a LEM. A technological evaluation study of the suitability and adequacy of using a private blockchain as information and communication system of a LEM will be conducted during the project. We will focus on data consistency, transaction rates and resource consumption of the blockchain as well as susceptibility of errors.

From an LEM perspective, we use LAMP to evaluate real market and agent behavior, and validate and adapt our simulation. Simultaneously, we focus on participation and acceptance of LEM as well as activity on the market.

4 Conclusion

We present the project setup of the ongoing implementation of a LEM in Landau, Germany in the LAMP project. LAMP will sustain a local electricity market place for up to 20 residential households and is based on a private blockchain protocol. We present a research agenda for energy market analysis, social participation and acceptance of LEM evaluation, and technological consideration of blockchain characteristics. Through simulations of the LAMP energy market we show that solely local PV production is insufficient for a high level of autarky. Thus, a CHP plant is added to the project. This is expected to result in a higher level of autarky and should lower the overall electricity prices in LAMP as the CHP energy will be priced below current electricity tariffs. The LAMP project runs from September of 2017 to December 2018. It is one of the very first pilot and research projects of an implementation of a blockchain-based LEM and abides by German regulation.

5 Acknowledgements

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Towards Smart Meter Service Engineering: A Research Approach for Market Segmentation

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Abstract. The paper at hand answers the question, how a traditional industry transforms from a non-digital business into a digital business. The European energy industry is changing enormously. The regulatory enforced installation of smart meters (SM), allows power supply companies (PSCs) to develop additional digital services. With regard to the smart meter rollout plan, especially small and mid-sized enterprises (SMEs), come into the focus. Therefore, it is important for PSCs to understand, how this heterogeneous market of SMEs is characterized to initiate a service engineering process for digital value-added services (VAS). So far there is no approach for this. Thus, we developed a research approach for this purpose, which is introduced to the interested scientific community for the first time. We believe that using this approach, we will be able to segment the SME market according to the defined categories.

Keywords: renewable energies, smart meter, value-added services, market segmentation.

1 The Market for Smart Metering Technology

The European energy industry is undergoing a far-reaching transition, driven by the liberalization of the energy market, the growing number of wind, water and solar supply as well as increasing socially importance of sustainable actions. The change of paradigm in the energy industry to decentralized feed-in causes major challenges in terms of information processing and business models [1]. The involvement of information technology is a vital component in the ongoing evolution of the energy industry. As a consequence, the research areas energy production, transport and supply have become topics in Information Systems Research within the past years [2, 3]. Especially energy providers have to adapt and develop new IT-driven business models, because the installation of SM generates digital data. This leads to new concepts and innovations in the energy sector, also in terms of customer retention. As a result, customers can be offered additional services. Especially the development of VAS provides several potentials, which complement the core features of PSCs (e.g. [4]). VAS are applications, which use smart metering technology (SMT) collected data in solutions like consumer feedback systems, analytic and prediction applications and to regulate electrical loads (e.g. [5]).

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The Federal Ministry for Economic Affairs and Energy issued a change of the law in terms of installation of smart electricity meters in 2015 [6]. According to the new regulation, the installation of SMT depends on the energy consumption of consumers. Exclusively consumers with an annual consumption in the range of 6,000 to 100,000 kWh of electricity are affected. This implies that B2B markets are primarily covered in the rollout of SMT and B2C markets are mostly excluded.

Recent experiences from cooperative research projects involving PSCs, reveal that there is a lack of knowledge regarding the different customers of PSCs and their needs. As a result of this finding, the conceptual design stage within the process of service engineering is considerably more difficult. Concurrently, the development of custom services implies close cooperation with customers to fulfill their expectations [7]. The uncertainty towards the development of VAS and the requirements of the market are high. According to the heterogeneity of the existing market, the potentials, needs and energy-related problems are also heterogeneous, in terms of different SMEs. Therefore, the segmentation of the existing market is a required method to identify equal market participants and their needs regarding VAS (Fig. 1 part II). The market segmentation is prerequisite to start the service engineering process and the design and development of custom services (Fig. 1 part III). To identify different market segments, a segmentation framework is required (Fig. 1 part I, focus of research). This leads to the research question (RQ):

RQ1: What are the needs of SMEs regarding potential digital VAS?

RQ2: How can different market segments be identified?

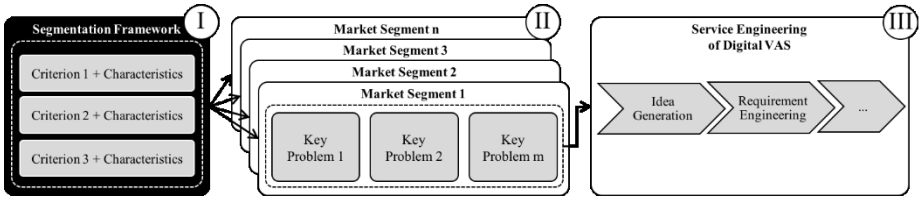

Figure 1. Context of the Research Focus

To answer the research question, the paper is structured as follows: In chapter 2 we first address the related literature. Then we describe the technical and methodological realization in chapter 3. The final section provides an outlook on future research.

2 Related Work

As the technical possibilities represented by SM are limited, they can be enhanced by linking it with product-related services. In the literature, the linkages between physical things and related services are described as product-service systems (PSS) [8]. The development of new services is known as service engineering and describes a systematic, sequential development and design of services using appropriate models, methods and tools [9]. Due to Carbonell et al. the involvement of the customer is central to ensure acceptance and the application when developing new services [10]. The methodical development of new services starts, as seen in figure 1 part III, with the

process steps “idea generation” and “requirement engineering” [11]. To address the customer needs it is necessary to know which VAS are required by different SMEs. Therefore, the approach of service engineering is suitable for the development of VAS for SM. Customers are not only included as testers in the phases of implementation and market launch. Rather, the requirements analysis already examines the external requirements of potential customers on the market and evaluates these with internal factors such as the feasibility with the SM. Due to Luczak et al., the customer acts as co-producer during the service engineering process [12]. Bullinger and Schreiner criticise the fact that market analyses are insufficiently carried out in service engineering and that potential for success is seldom recognized [13]. Therefore, market analysis is an important part of the evaluation of the success probability of new services.

The aim of market segmentation is to divide the overall market into clusters of companies and their different needs. The resulting homogeneous submarkets can be analyzed, selected and addressed by differentiated marketing or individual services. There are both single-stage and multi-level procedures in the field of market segmentation [14]. Due to the complexity of buying decisions on B2B markets, single-stage procedures are not suitable in most cases. As a result, multidimensional segmentation approaches are generally used in practice. This circumvents the problem by using several segmentation criteria simultaneously [15].

3 Research Method

In order to integrate customer requirements into the idea generation process, both quantitative and qualitative methods are suitable [16]. Quantitative methods in terms of service engineering are only suitable, if the sample is familiar with the examined device and associated features. A sample survey of companies led to the conclusion that respondents have little or no knowledge of the potential and possibilities offered by smart meters. Therefore, we want to collect qualitative data to identify the needs of different enterprises. Furthermore, we want to ask companies about current challenges and issues in order to identify suitable services for this purpose. This approach is called "proactive market orientation" and describes "the discovery, understanding and fulfilment of latent customer needs" [17]. The survey can also collect initial information on customer requirements. This knowledge is useful for requirements analysis, market introduction and new development of services [18]. During our research and discussions with PSCs, we found out that the market for energy consumption is heterogeneous and PSCs collect only few and elementary customer data for billing purposes. Therefore, we decided to enhance our survey with questions in order to identify worthwhile market segments for PSCs. On the one hand, the identified SMEs are supposed to have equal challenges and issues and on the other hand, they supposed to be equal in terms of their company phase. We subsequently combined equal needs of different SMEs and matched them with identified segmentation criteria to define homogenous market segments. Our research approach is shown in figure 2.

First, we started with the definition of variables for market segmentation, following a multidimensional segmentation approach. The derivation of the segmentation criteria and its characteristics were carried out through a detailed analysis of SMT and the

results of the data collection process. Secondly, we developed an interview guide to collect the data. We need to identify different market segments as well as current issues and challenges of companies. Furthermore, we already did some data collection to proof, if our approach leads to the expected results. During our sample survey, we found out that the initially segmentation variables did not lead to the expected results, in terms of a clear differentiation of companies. Therefore, we did iterative adjustments to adapt the variables and the corresponding interview guide until the results were satisfying. The iterative adjustments led to a theory and databased result of seven segmentation criteria for end-user markets (B2B) with 28 possible characteristics (table 1).

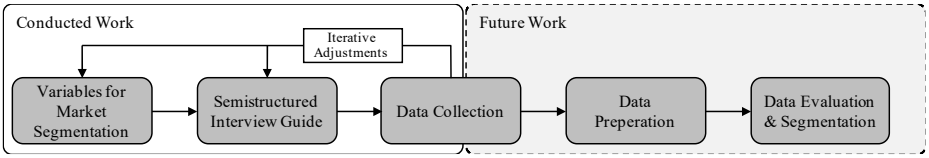

Figure 2. Research Approach

3.1 Variables for Market Segmentation

In the literature, there are several approaches for market segmentation and empirical tested segmentation criteria. Nevertheless, we defined additional criteria following the requirements of segmentation criteria to appropriately categorize the energy market.

In the B2B environment, several quality requirements are established to obtain a more detailed view of companies [14]. In case of the usage of new segmentation criteria, several requirements are essential to ensure the usefulness regarding the market segmentation: *buying behavior relevance, measurability, accessibility, capacity to act, economic efficiency, temporal stability and reference to service* (e.g. [19]).

In consideration of the design principles a catalogue of seven criteria were defined in five expert workshops with a PSC, a strategic energy consulting company and representatives of science referring to the recommendations of Skinner et al. [20]. Following the Delphi method strategy in IS research, we first characterized the subject under discussion. Each expert contributed additional information from his point of view. Subsequently we discussed and validated the findings to reach a similar understanding. Significant disagreements were explored to identify the underlying reasons and to reach a broad agreement. The described process led to a criteria catalogue, which was pretested in four qualitative data acquisitions using a semi-structured interview guide. The results were discussed in another expert workshop to validate, adjust or reject each criterion. We continued this approach until the findings were satisfying [20]. This procedure is also aligned to the recommendations of Luo and Wildemuth [21]. Table 1 shows the identified segmentation criteria as the result of the applied Delphi approach. The variables are focused on strategic and economic aspects and can be categorized as follows [22]:

The **organizational segmentation criteria** include the *company phase* and the *competitive position*. The company phase determines the growth potential of each

company and has an impact on the company objectives (e.g. establishing in the market vs. process optimization) [23]. The competitive position is an indicator for cost pressure of a company.

The **organizational member criteria** pick up the possibilities of the SMT derived from the scientific literature and analyze the attitude of the companies referring to the usage criteria. Conclusions can be drawn to the specific attitude towards buying decisions from analyzing the general attitude in the areas of *energy awareness, technology affinity, process flexibility* and *innovativeness*. Due to this it is pertinent to the design of digital VAS.

The segmentation criterion for the **organizational behavior** includes the *financial viability*. The financial viability provides information about the capital spending of companies and due to this about their pricing behavior.

Table 1. Variables for Market Segmentation Including Characteristics

Company Phase	Start-up		Growth Phase		Maturity Phase
Competitive Position	Weak	Stable	Reasonable	Strong	Dominant
Energy Awareness	Beginner	Advanced	Competent	Experienced	Expert
Technology Affinity	Negative Attitude	Positive Attitude	Competency	Enthusiasm	
Process Flexibility	Slightly		Moderate	Strong	
Innovativeness	Innovators	Early Adopters	Early Majority	Late Majority	Laggards
Financial Viability	Low		Moderate	High	

After the determination of the segmentation criteria to identify homogeneous market segments in the B2B market for digital VAS, we derived characteristics from the scientific literature to classify and analyze SMEs within the criteria [15, 19, 23, 24].

3.2 Semi-structured Interview Guide & Data Collection

Based on the identified criteria and characteristics, an interview guide was developed to collect data from companies and to proof the applicability of our research approach. Furthermore, energy-specific questions about current issues and challenges of companies are also included in the survey in order to connect them with the clusters, as shown in the interview guide. Ideas for VAS can be derived through qualitative methods e.g. expert interviews and evaluation of complaints or difficulties within enterprises [17]. According to the recommendations of Pare, the interview guide is characterized as semi-structured [25]. This provides the interviewer several possibilities and ensures the comparability of the data sets. Therefore, it is possible to add or to drop questions within the interview [21]. For reasons of space, the interview guide is not part of the paper at hand[1]. As mentioned before, we already did some data collection and interviewed 12 companies in a pre-test to proof the applicability of our research approach and to adjust the variables for market segmentation as well as the corresponding interview guide. While doing so, we worked together with a PSC, who has supported us with customer data. This helped us to preselect the participants of the

[1] The interview guide can be requested from: https://tinyurl.com/mkwi-interview-guide

sample survey and to choose companies from different industries. Furthermore, we have also limited the survey to Germany. However, expansion to Europe is possible.

4 Conclusion and Outlook

It is important for PSCs to understand, how the heterogeneous market of SMEs is characterized to initiate a service engineering process for digital VAS. One assumption regarding the energy market was, that despite the same industries in terms of energy use and energy consumption, companies differ from each other. We have already been able to prove this in our pre-test. For example, companies in the same industry and with different company phases had a different energy awareness and different issues regarding their energy consumption. This assumption has to be investigated in greater detail by conducting a larger market analysis. Furthermore, the sample survey led to the conclusion that respondents have little or no knowledge of the potential and possibilities offered by SM. As a result, they were not able to identify possibilities in their company, autonomously from the technology and how they could use the potential of the SM through services. Furthermore, the identified issues and challenges provide the basis for services that need to be developed. These VAS have to be individually adapted to the clusters identified as worthwhile. The individual needs and requirements of companies are therefore at the forefront of the development of services. This is the only way to ensure acceptance by companies. This is also the main objective of market segmentation, which aims to achieve "a high degree of identity between the market performance offered and the needs of the target group" [22]. Thus, we developed a segmentation framework for this purpose and proofed it with qualitative interviews. In the future, we are going to collect more data to evaluate our research approach and to collect the required data for market segmentation. Furthermore, we want to apply a cluster analysis to identify homogeneous market segments. Afterwards, the resulting submarkets can be analyzed, selected and addressed by differentiated marketing or individual services.

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Akzeptanz autonomer Verkehrsmittel: Eine Analyse relativer Mehrwerte selbstfahrender Autos im Vergleich zu heutigen Verkehrsmitteln

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Abstract.
Durch die Digitalisierung befindet sich die Mobilitätsbranche im starken Umbruch. So wird man bei der Verkehrsmittelwahl zukünftig wohl auch auf selbstfahrende Autos zurückgreifen können. Die Studie erweitert die Verkehrs- und Nutzerakzeptanzforschung, indem unter Berücksichtigung relativer Teilmehrwerte tiefergehend analysiert wird, wie sich die neuen Verkehrsmodi autonomer Privat-PKW, autonomes Carsharing und autonomes Taxi aus heutiger Sicht in den bestehenden Verkehrsmix einsortieren. Hierzu wurde auf Basis der Nutzerpräferenztheorie eine Onlineumfrage (n=172) zu den relativen Mehrwerten der neuen autonomen Verkehrsmodi durchgeführt. Es zeigt sich, dass Nutzer im Vergleich zum PKW bei den autonomen Modi Verbesserungen im Fahrkomfort und in der Zeitnutzung sehen, in vielen anderen Bereichen – insbesondere bei Fahrspaß und Kontrolle – hingegen keine Vorteile oder sogar relative Nachteile sehen. Gegenüber dem ÖPNV bieten die autonomen Modi in fast allen Eigenschaften Mehrwerte. Diese Betrachtung auf Teilnutzenebene liefert eine genauere Erklärung für Nutzerakzeptanz des automatisierten Fahrens.

Keywords: Selbstfahrende Autos, Verkehrsmittelwahl, Nutzerakzeptanz, Relativer Mehrwert

1 Einleitung

Selbstfahrende Fahrzeuge (SAE-Level 5, [1]) stellen einen Technologiesprung dar, der Lösungen für aktuelle Verkehrsprobleme bieten und den Umgang mit Mobilität dramatisch verändern kann [2, 3]. Vollautonome Fahrzeuge werden seit einigen Jahren in mehreren Pilotprojekten getestet [4]. Die führenden Automobilhersteller und IT-Konzerne im Bereich des autonomen Fahrens gehen davon aus, dass innerhalb der nächsten fünf bis zehn Jahre die Vollautomation Serienreife erlangen könnte. Experten erwarten von fahrerlosen Autos eine Reduzierung von Unfällen und Verkehrsproblemen sowie einen effizienteren Verkehrsfluss [5–7]. Durch die Selbstfahrtechnik werden auch neue, innovative Geschäftsmodelle wie Vehicle-on-Demand-Dienste

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entstehen [5, 8]. Mobilitätsservices wie selbstfahrende Taxis bzw. selbstfahrendes Carsharing profitieren von der Selbstfahrtechnik in besonderem Maße: Fahrerlose Taxis können wegen geringerer Personalkosten wesentlich günstiger operieren [5] und das vollautonome Carsharing verspricht Verbesserungen in der Verfügbarkeit, da das Auto zum Nutzer kommt, statt umgekehrt [6]. In diesem Zusammenhang sehen einige Forscher eine starke Konvergenz von Taxi und Carsharing [8]. Verschiedene Autoren erwarten durch die Stärkung nutzungsbasierter Mobilitätsservices eine signifikante Reduzierung des Privat-PKWs [5, 8]. Um ein besseres Verständnis für die Nutzerakzeptanz zu erlangen und um zukünftige Veränderungen im Mobilitätsverhalten aufgrund von neuen autonomen Verkehrsmitteln besser prognostizieren zu können, haben wir eine Studie durchgeführt, die autonome Verkehrsmittel im Vergleich zu existierenden Modi und anhand deren jeweiligen Eigenschaften untersucht.

2 Stand der Forschung

2.1 Verkehrsmittelwahl

Das menschliche Bedürfnis nach Mobilität wird durch die räumliche Verteilung von Arbeitsplätzen, Einkaufszentren, Schulen/Universitäten, Freizeitmöglichkeiten, Ämtern etc. bestimmt [9]. Zur Befriedigung dieses Bedürfnisses stehen dem Nutzer dabei verschiedene Verkehrsmittel zur Verfügung. Aus den verschiedenen Alternativen wählt der Nutzer diejenige, die gegenüber den anderen einen relativen, oft nur subjektiv wahrgenommenen, Vorteil aufweist und so seinen persönlichen Nutzen maximiert [10]. Dabei spielen neben nutzerbezogenen und externen Einflussgrößen vor allem die produktbezogenen Einflussgrößen eine Rolle. Denn nach Lancaster [11] stiftet nicht das Produkt als Ganzes, sondern dessen spezielle Eigenschaften dem Konsumenten einen Nutzen, die sogenannten Teilnutzen. So konnten in der Vergangenheit neben demographischen, sozio-ökonomischen, psychographischen, geographischen und situativen Faktoren eine Reihe produktspezifischer Eigenschaften identifiziert werden, die die Verkehrsmittelwahl beeinflussen [10, 12, 13]. Studien kommen hinsichtlich einer Rangfolge der Faktoren zu unterschiedlichen Ergebnissen, zeigen aber, dass insbesondere Reisezeit, Reisekosten und Zuverlässigkeit eine entscheidende Rolle spielen [6, 14, 15]. Weitere Studien wie die von Steg [16] haben die Ausprägungen der Eigenschaften bei PKW und ÖPNV als meistgenutzte Verkehrsmittel aus Nutzersicht analysiert. Die Bewertungen spiegeln das Nutzungsverhalten der Nutzer wieder (oder vice versa), indem sie deutlich zeigen, dass das Auto in fast jeder Hinsicht besser bewertet wird als der öffentliche Verkehr – bei Bequemlichkeit, Unabhängigkeit, Flexibilität, Fahrkomfort, Schnelligkeit und Zuverlässigkeit. Andere haben zusätzlich die Verkehrsmittel in Relation zueinander bewertet, um die relativen Vorteile der Verkehrsmittel in ihren einzelnen Eigenschaften herauszuarbeiten [13].

2.2 Nutzerakzeptanz selbstfahrender Autos

Die transformativen Vorteile der Selbstfahrtechnik können erst realisiert werden, wenn selbstfahrende Autos von einem Großteil der Nutzer angenommen werden [2]. Forscher haben sich dem Thema Nutzerakzeptanz in jüngster Zeit intensiv gewidmet. Ihre Studien zeigen, dass ein Großteil der Menschen positiv gegenüber dem autonomen Fahren eingestellt ist und sich vorstellen kann, selbstfahrende Autos zu kaufen und/oder zu nutzen [17–19]. So hat die Mehrheit der Befragten eine positive Meinung über die Technologie und optimistische Erwartungen an deren Nutzen [19]. Nutzer sehen Mehrwerte in einer verbesserten Verkehrssicherheit, einem effizienteren Verkehrsfluss [2, 20, 21], in der Bequemlichkeit, keine Parkplätze finden zu müssen und Annehmlichkeiten wie einer besseren Zeitnutzung während der Fahrt [2, 8]. Am ehesten können sich Nutzer das autonome Fahren für das Fahren auf der Autobahn, bei Staus und für das automatische Parken vorstellen [17]. Im gleichen Zuge berichten die Studien über die Sorgen der Befragten: Sie befürchten Software-Hackings und -Missbrauch und zeigen sich besorgt über Rechtsfragen, Sicherheit und Verlässlichkeit der Technik [7, 19]. Viele Befragte halten den Menschen für den besseren Fahrer [20] und fürchten sich, die Kontrolle an die Technik abzugeben [2]. Gegen die Nutzung sprechen aus Nutzersicht die hohen Anschaffungs- und Betriebskosten [2, 20], die sie bei autonomen Fahrzeugen erwarten und der Verlust des Fahrspaßes, der mit dem Entfall der Fahraufgabe einherginge [4, 20, 21].

Da neue Verkehrsmodi wie autonome Privat-PKW, autonome Taxis oder autonomes Carsharing zukünftig die Optionen bei der Verkehrsmittelwahl erweitern könnten, stellt sich die Frage, welches Verkehrsmittel Nutzer bevorzugen und wie sich dadurch das Mobilitätsverhalten insgesamt verändern wird. Zwar gibt es viele Akzeptanzstudien zum autonomen Fahren, diese Studien betrachten den autonomen PKW jedoch i. d. R. isoliert. Unserer Kenntnis nach beziehen Verkehrsmittelwahlanalysen bisher weder die neuen Modi mit ein, noch werden sie im Vergleich zu den bestehenden Verkehrsmitteln bewertet. In einer vorherigen Studie haben wir deshalb Nutzer im Rahmen eines kompletten Paarvergleichs zwischen den aktuellen Verkehrsmodi PKW, ÖPNV, Carsharing und den neuen Modi autonomes PKW und autonomes Carsharing wählen lassen [22]. Die Ergebnisse zeigen, dass aus Nutzersicht die autonomen Verkehrsmodi im Vergleich zum ÖPNV deutlich besser abschneiden während sie gegenüber dem klassischen PKW fast identisch bzw. schlechter abschneiden. Offen blieb die Frage, was die genauen Gründe für die Wahl der Teilnehmer war – in welchen Faktoren sie also relative Vor- oder Nachteile der jeweiligen Verkehrsmodi sehen. Deshalb sollen in dieser nachfolgenden Studie die Teilnutzenwerte analysiert werden, um genauere Aufschlüsse darüber zu bekommen, wie sich die Nutzerakzeptanz zusammensetzt. Die zentralen Forschungsfragen lauten:

1) *Wie setzt sich die Entscheidung für oder gegen ein Verkehrsmittel in Bezug auf den relativen Gesamtnutzen zusammen?*
2) *Welche relativen Teilmehrwerte bieten autonome Verkehrsmittel?*

3 Methodologie

Zur Beantwortung der Forschungsfragen wurde eine zweistufige Erhebung durchgeführt. Im ersten Schritt wurden in einer qualitativen Vorstudie die in der Literatur identifizierten Kriterien in Bezug auf ihre Relevanz für die neuen Verkehrsmodi verifiziert bzw. adaptiert. Hierzu wurden zehn qualitative Interviews durchgeführt, bei denen die Interviewten den traditionellen, wie auch den neuen Verkehrsmodi Eigenschaften zuordnen und deren Relevanz erläutern sollten. Anhand dieser Vorstudie wurde im zweiten Schritt ein quantitativer Fragebogen erstellt.

Der Fragebogen begann mit einer Gegenüberstellung des traditionellen PKWs mit dem autonomen Privat-PKW, dem autonomen Carsharing und dem autonomen Taxi. Anhand der Eigenschaften Fahrtzeit, Wartezeit, Verfügbarkeit, Flexibilität, Fahrspaß, Fahrkomfort, Handhabung, Kontrolle über das Fahrzeug, Sicherheit, Transport von Gegenständen, Zuverlässigkeit, Kosten und Zeitnutzung sollten die Teilnehmer Vor- bzw. Nachteile der neuen Modi in Relation zum klassischen PKW festmachen. Analog wurde der ÖPNV mit den autonomen Verkehrsmitteln verglichen. Anschließend sollten die Befragten angeben, welche Verkehrsmittel sie in Zukunft regelmäßig nutzen bzw. besitzen würden. Zur Auswahl standen die traditionellen und die automatisierten Fortbewegungsmittel. Abschließend wurden demografische Angaben und Informationen zum aktuellen Mobilitätsverhalten abgefragt.

Insgesamt nahmen 172 Personen an der Befragung teil, 49% davon waren weiblich. Die Altersspanne reichte von 17 bis 79 Jahren (Durchschnitt 35,6). 64,7% leben (eher) städtisch, die anderen 35,3% (eher) ländlich. Fast alle Personen (95%) besitzen einen Führerschein und 80% ein eigenes Fahrzeug. Von den Befragten waren 119 Berufstätige (71%), 44 Schüler oder Studenten (26%) und fünf Rentner (3%). Knapp 63% der Befragten nutzen das Auto als Hauptverkehrsmittel und 20% den ÖPNV.

4 Ergebnisse und Diskussion

4.1 Nutzungsintention in Hinblick auf zukünftige Verkehrsmittel

Bei der Frage, welchen Verkehrsmodus sich die Befragten vorstellen könnten in Zukunft regelmäßig zu nutzen oder zu besitzen, zeigt sich, dass der private PKW weiterhin eine zentrale Position einnimmt. Fast 90% der Befragten möchten auch in Zukunft den privaten PKW (sehr) wahrscheinlich regelmäßig nutzen, gefolgt vom ÖPNV mit etwa 65%. Erst nach diesen beiden traditionellen Modi folgt der autonome Privat-PKW (37,5%) vor dem klassischen Taxi (27,4%), dem autonomen Taxi (22%), dem autonomen Carsharing (16,7%) und dem klassischen Carsharing (14,3%). Die größte Ablehnung erfährt ebenfalls das Carsharing – die Befragten können sich weder vorstellen die klassische (65,5%) noch die autonome Variante (63,1%) zukünftig zu nutzen.

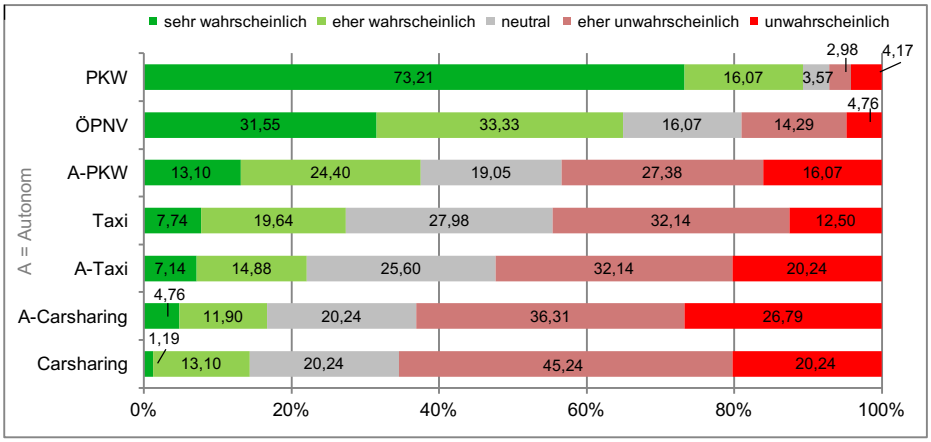

Abbildung 1. Intention ein Verkehrsmittel in Zukunft regelmäßig zu nutzen/besitzen

Obwohl durch die Automatisierung des PKWs objektiv viele Mehrwerte gegenüber dem klassischen PKW – mehr noch gegenüber dem ÖPNV – zu erwarten sind [2, 8, 21, 22], bevorzugen die Teilnehmer die klassischen Verkehrsmodi PKW und ÖPNV. Auch beim Taxi vertrauen die Befragten auf die bereits bekannte klassische Version; bei diesen vollautonomen Verkehrsmitteln überwiegen Skepsis vor Innovationen und Sicherheit durch Zurückgreifen auf Bekanntes die vermeintlichen Mehrwerte einer Automatisierung. Einzig beim Carsharing können sich die Befragten eher die Nutzung der autonomen Variante als die der klassischen Variante vorstellen. Dieses Ergebnis deckt sich mit dem der früheren Studie [22]. Bei diesem Verkehrsmittel überwiegen also die Vorteile, die mit der Automatisierung einhergehen (insbesondere abgeholt und gefahren zu werden, anstatt das Fahrzeug aufsuchen zu müssen) die Nachteile (Ungewissheit, Komplexität neuer Technologie, Aneignung). Die Veränderung des Verkehrsmittels Carsharing durch eine Automatisierung wird von den Befragten also als größer und als positiver wahrgenommen als beim PKW. Die Bewertung weist zudem darauf hin, dass sich die Verkehrsmodi Taxi und Carsharing durch die Selbstfahrtechnik einander annähern, wie dies z.B. auch von [5, 6] prognostiziert wird.

4.2 Relative Teilnutzenwerte im Vergleich zum privaten PKW

Abbildung 2 zeigt die subjektive Bewertung der einzelnen Teilnutzenwerte durch die Teilnehmer der Befragung. Die automatisierten Modi weisen aus Sicht der Befragten lediglich bei den Eigenschaften Fahrkomfort und Zeitnutzung während der Fahrt Vorteile im Vergleich zum traditionellen PKW auf. In allen anderen Eigenschaften sehen die Teilnehmer hingegen leichte, bei den Kriterien Fahrspaß und Kontrolle starke Vorteile für den traditionellen PKW. Mit einem (ungewichteten) Durchschnitt von -0,28/-0,52/-0,49 liegt im direkten Vergleich der relative gesamte Mehrwert jeweils beim traditionellen PKW, sodass zu erwarten wäre, dass Nutzer sich entsprechend zwischen den Varianten für den klassischen PKW entscheiden würden.

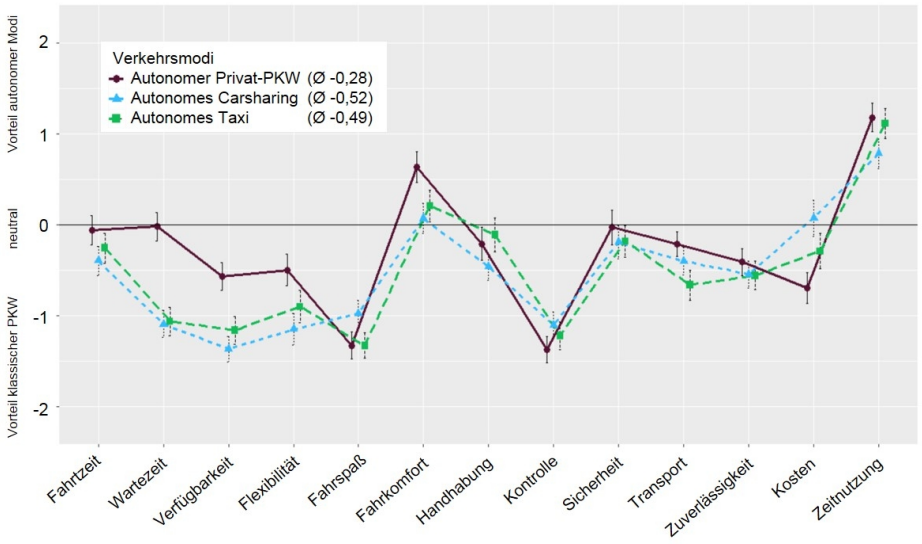

Abbildung 2. Vergleichende Bewertung autonomer Verkehrsmodi vs. traditioneller PKW (n=172, Konfidenzintervallbalken = 95%)

Im Folgenden wollen wir auf einzelne, stark hervorstechende Merkmale näher eingehen und Überlegungen anstellen, weshalb die Teilnehmer zu dieser Einschätzung gekommen sind.

Autonome Fahrzeuge bieten einen höheren Fahrkomfort und eine bessere Zeitnutzung während der Fahrt als der traditionelle PKW. Beide Teilnutzen sind tatsächlich auch eng miteinander verknüpft. **Fahrkomfort** ist ein multidimensionales Konstrukt, unter dem fast jeder Nutzer etwas anderes versteht [10]. Dazu zählen die Gemütlichkeit, die Behaglichkeit, aber auch die Psychohygiene. Diese Eigenschaften werden vor allem dann negativ bewertet, wenn man ein Verkehrsmittel mit vielen anderen (fremden) Personen teilen muss (insb. ÖPNV) [12]. Die autonomen Verkehrsmodi bieten die große Privatsphäre und Annehmlichkeiten eines eigenen PKWs, zusätzlich aber auch die Vorteile des öffentlichen Verkehrs (sich fahren lassen).

Die **Zeitnutzung** während der Fahrt ist beim traditionellen PKW auf eher passive Tätigkeiten wie z.B. Radio/Musik/Hörspiele hören oder Telefonieren beschränkt. Durch den Wegfall der Fahraufgabe erlaubt die Selbstfahrtechnik die Zeit im Auto besser zu nutzen [23]. Damit wird einer der Vorteile des ÖPNV nivelliert, weil der Autofahrer zum Passagier wird [24]. Deshalb entspricht der attestierte Mehrwert in der Zeitnutzung beim autonomen PKW gegenüber dem traditionellen PKW den Erwartungen. Überraschend ist jedoch, dass die Teilnutzen der Zeitnutzung für Carsharing und Taxi nicht so hoch sind, wie beim autonomen PKW. Eine Erklärung könnte sein, dass der Privat-PKW besser individualisierbar erscheint, so dass die Zeit dort effektiver genutzt werden kann als z. B. in einem fremden Taxi.

Hinsichtlich Fahrspaß und Kontrolle bietet hingegen der traditionelle PKW deutliche relative Mehrwerte gegenüber den autonomen Verkehrsmodi. Dieses Ergebnis bestätigt Studien wie [4, 20, 21], die zeigen, dass einige Befragte befürchten, dass

durch die Automatisierung des PKWs der Fahrspaß abnehmen wird. **Fahrspaß** entsteht für Nutzer durch die Befriedigung eines persönlichen Verlangens nach Nervenkitzel durch risikobehaftete Fahrweisen beim aktiven Steuern eines Fahrzeuges[1]. Somit bietet der PKW aufgrund der Notwendigkeit der aktiven Steuerung Nutzern in der Tat ein höheres Potential für viel Fahrspaß als Modi, die der Nutzer nicht aktiv steuert. Die Befragung bestätigt diese Einschätzung: Die Teilnehmer sehen für den Fahrspaß einen klaren Mehrwert beim klassischen Auto gegenüber allen fahrerlosen Modi. Das aktive Steuern geht eng einher mit der **Kontrolle** über das Fahrzeug, die darüber hinaus die gesamte physische als auch organisatorische Gewalt über ein Verkehrsmittel umfasst und für Nutzer eine große Bedeutung hat [2, 20].

Wartezeit, Zuverlässigkeit, Verfügbarkeit und Flexibilität sind bei allen autonomen Modi nachteilig gegenüber dem klassischen PKW, stärker jedoch bei den autonomen Services. Die **Wartezeit** wird beim autonomen Carsharing/Taxi signifikant schlechter gegenüber den PKW-Varianten bewertet. Dies überrascht nicht, da ab dem Zeitpunkt, zu dem ein Nutzer fahrbereit ist und er eine Bestellung für ein autonomes Taxi/Carsharing abgibt, bis zum tatsächlichen Fahrtbeginn eine Wartezeit entstehen kann, wenn das Fahrzeug zum Standort des Passagiers gelangen muss.

Die neutrale Bewertung der Wartezeit beim autonomen Privat-PKW war zu erwarten. Erklärungsbedürftig ist jedoch, warum die Bewertung der Flexibilität/Unabhängigkeit und der Verfügbarkeit bei der autonomen Variante des PKWs signifikant schlechter ausfällt als bei der traditionellen. Hier scheinen die Kriterien auch von der Zuverlässigkeit abzuhängen. Die schlechte Bewertung der **Zuverlässigkeit** kann wahrscheinlich auf die Neuheit der Technologie zurückgeführt werden, mit der Nutzer noch unerfahren sind und in die sie noch kein Vertrauen haben. So äußerten Teilnehmer früherer Studien Bedenken, dass die Technik versagen könnte [7, 19]. Dies würde erklären, warum man glaubt, dass autonome PKWs nicht im gleichen Maße in jeder Situation verfügbar und flexibel nutzbar sind.

Modellsimulationen gehen zwar davon aus, dass durch die datengetriebene Steuerung, die automatische Relokation und das automatische Abholen die **Verfügbarkeit** insbesondere gegenüber dem heutigen Carsharing stark erhöht wird, sodass der Nutzer im Schnitt weniger als eine Minute warten muss [5]. Dem gewöhnlichen Nutzer fehlen jedoch solche Kenntnisse und so fehlt ihm scheinbar das Vertrauen, dass eine rasche Verfügbarkeit garantiert werden kann (z. B. wenn Fahrzeuge besetzt oder nicht in nächster Nähe sind), so dass die Bewertung geringer ausfällt als beim eigenen PKW. Insbesondere erzeugt das private Auto vor der Haustür ein Gefühl von **Flexibilität** und Unabhängigkeit, was scheinbar durch einen Mobilitätsdienstleister nicht in gleicher Weise erfüllt werden kann – selbst durch die Vollautomatisierung nicht. Der Privat-PKW bietet seinem Besitzer vor allem durch die freie und eigenverantwortete Zeit- und Routenplanung ein hohes Ausmaß an Flexibilität. Die Vollautomatisierung macht den PKW aber eigentlich noch flexibler, da so z.B. autonome PKWs Nutzer direkt vor der Haustür abholen und am Zielort absetzen können, um anschließend

[1] Eigene Definition auf Basis der Gemeinsamkeiten verschiedener Quellen, die das Thema Fahrspaß adressieren z.B. [4, 25].

eigenständig zu parken. Die Befragung zeigt aber, dass der klassische PKW besser bewertet wird. Eine Erklärung ist, dass Flexibilität/Unabhängigkeit nicht nur eine flexible Zeit- und Routenplanung, sondern aus Nutzersicht auch die physische Kontrolle über das Fahrzeug und Freiheit über Fahrstil und spontane Entscheidungen (plötzlicher Fahrtstopp oder Richtungswechsel) umfasst. Hier spielt möglicherweise die Befürchtung eine Rolle, dass die autonome Technik Nutzer in ihren eigenen (ad-hoc) Entscheidungen einschränkt. Damit wirkt sich der wahrgenommene Verlust der Kontrolle (s.o.) auch negativ auf Unabhängigkeit und Flexibilität aus.

Bei den **Kosten** sehen die Befragten auch einen Nachteil – insbesondere beim privaten autonomen PKW. Bei letztem würden im Gegensatz zu den nutzungsbasierten Modi nicht nur nutzungsabhängige variable Kosten, sondern nach wie vor fixe Kosten des Besitzes anfallen. Außerdem erwarten Nutzer höhere Anschaffungskosten aufgrund der Selbstfahrtechnik sowie höhere Betriebskosten durch die zusätzliche Technologie, die neue Störungen hervorbringen und Wartung erfordern kann [2, 20].

Durch die Vollautomatisierung ergeben sich vor allem beim Carsharing Verbesserungen, wenn der Nutzer das Gepäck nicht zur Abholstation tragen muss. Obwohl man also annehmen könnte, dass bei gleichartigen vollautonomen Fahrzeugen, die den Nutzer immer an der Haustür abholen, der **Transport** von Gegenständen gleichermaßen gut möglich sei, sehen die Befragten weiter einen leichten Vorteil beim klassischen PKW. Hier lässt sich nur vermuten, dass Nutzer in einem eigenen Fahrzeug Dinge lieber transportieren oder insbesondere die Services schlechter bewerten, da sie ihr aktuelles Bild von Taxi und Carsharing auf die automatisierten Modi übertragen.

Bei den Kriterien **Fahrzeit**, Handhabung/Komplexität und Sicherheit ergeben sich keine signifikanten Unterschiede zwischen den Modi. Objektiv betrachtet erscheint dies beim Kriterium **Handhabung** erklärungsbedürftig, da das heutige Autofahren mit zu den komplexesten und gefährlichsten Kulturtechniken unserer Zeit gehört. Das autonome Fahren befreit den Nutzer von dieser komplexen Aufgabe, so dass z. B. Kinder, ältere Menschen und Behinderte einen autonomen PKW eigenständig nutzen können. Da aber fast 95% der Befragten einen Führerschein besitzen, scheint diese Komplexität nicht mehr ausschlaggebend zu sein, sobald das Fahrzeugsteuern zur Routine geworden ist. Vielmehr befürchten Nutzer neue Nutzungstechniken erlernen zu müssen. Obwohl Studien vollautomatisierten Fahrzeugen eine höhere **Sicherheit** prognostizieren als dem klassischen PKW [2, 20, 21], sind Nutzer bisher skeptisch, haben wenig Vertrauen und halten sich oft noch für den besseren Fahrer als eine Maschine [20]. Durch diese beiden konträren Argumente kommt es in der Summe zu einer neutralen Bewertung – dafür spricht auch die durchweg hohe Streuung im Antwortverhalten der Befragten (Standardabweichung 1,14 bis 1,28).

Insgesamt zeigt sich, dass die autonomen Verkehrsmodi im Vergleich zum klassischen PKW in fast allen Eigenschaften (subjektiv wahrgenommene) relative Nachteile haben. Lediglich der Fahrkomfort sowie die Zeitnutzung während der Fahrt werden bei den autonom fahrenden Verkehrsmitteln deutlich positiver bewertet als beim privaten Auto.

4.3 Relative Teilnutzenwerte im Vergleich zum privaten ÖPNV

Beim Vergleich der Profillinien (Abbildung 2 und 3) fällt auf, dass der relative Mehrwert der vollautonomen Modi gegenüber dem traditionellen PKW viel geringer ist als gegenüber dem ÖPNV. Während die Teilnutzen der neuen autonomen Verkehrsmodi in vielen Bereichen als schlechter oder gleichwertig gegenüber dem Privat-PKW gesehen werden, ist es beim ÖPNV genau umgekehrt. Dies bestätigt Ergebnisse unserer Vorstudie, die zeigte, dass Nutzer autonome Verkehrsmodi dem ÖPNV vorziehen würden, nicht jedoch dem heutigen Privat-PKW [22].

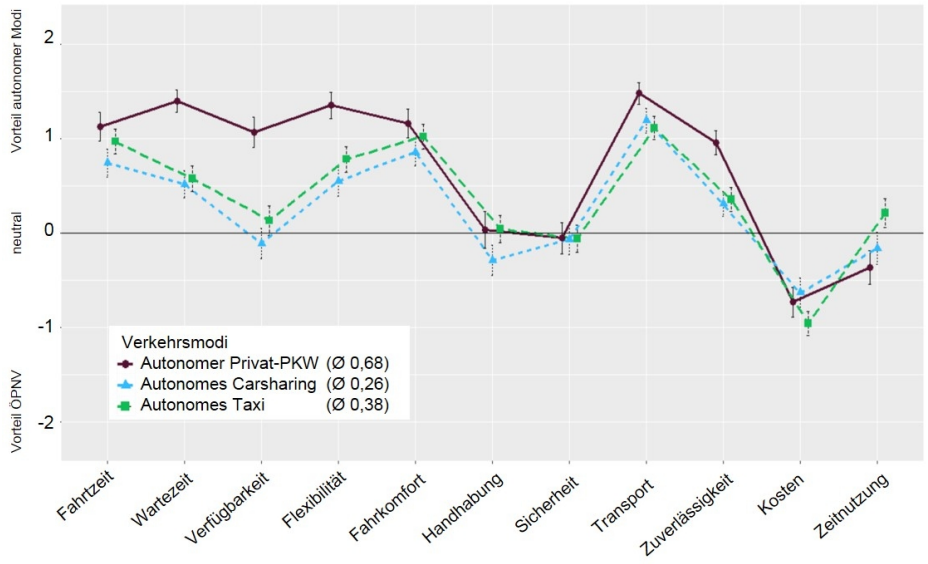

Abbildung 3. Vergleichende Bewertung autonomer Verkehrsmodi vs. ÖPNV (n=172, Konfidenzintervallbalken = 95%)

Alle drei autonomen Verkehrsmodi bieten gegenüber dem ÖPNV einen deutlichen relativen Gesamtmehrwert (+0,68/+0,26/+0,38). Interessant ist, dass nicht nur der autonome Privat-PKW fast überall besser abschneidet, sondern auch die autonomen Mobilitätsdienste Taxi und Carsharing mit Ausnahme der Kosten, bzw. der Handhabung (nur bei Carsharing) und der Zeitnutzung (beim PKW). In allen anderen Bereichen attestieren die Befragten den autonomen Modi durchweg Vorteile. Hierbei schneidet der private autonome PKW aufgrund des jederzeitigen Zugriffs (vgl. 4.2) bei den Kriterien Wartezeit, Zuverlässigkeit, Verfügbarkeit und Flexibilität wie zu erwarten erneut besser ab als die autonomen Mobilitätsdienste. Ein hoher relativer Vorteil einer Innovation oder eines Alternativproduktes erhöht die Übernahmewahrscheinlichkeit [26]. Deshalb würde man auch erwarten, dass die Nutzungsintention bei diesen Modi höher ausfällt als beim ÖPNV. **Abbildung 1** zeigt jedoch, dass dies nicht der Fall ist. Eine Erklärung besteht darin, dass für die ÖPNV-Nutzer die Kosten einen zentralen Aspekt darstellen. Des Weiteren verweist dieser Widerspruch darauf,

dass nicht alle relevanten Faktoren in der Umfrage erfasst worden sind, wie z.B. der Faktor Umweltfreundlichkeit oder andere nicht-produktbezogene Eigenschaften wie nutzerbezogene (Gewohnheit und Mobilitätssozialisation [10]) und externe Einflussgrößen [26]. Insbesondere die Bedeutung von Erfahrungen und Routinen verweist darauf, dass sich der wahrgenommene Vorteil nur langsam in der Praxis durchsetzen wird – prinzipiell mit den autonomen Mobilitätsdienstleistungen aber eine latente, ernstzunehmende Konkurrenz zum ÖPNV entsteht.

4.4 Konvergenz von Taxi und Carsharing

Obwohl die Bewertung der einzelnen Eigenschaften des autonomen Taxis und des autonomen Carsharings auf eine Konvergenz der beiden Modi hinweist, zeigen einzelne Teilnutzendifferenzen, dass Nutzer durchaus noch Unterschiede zwischen beiden Modellen sehen. Es gibt eine leichte Präferenz für das autonome Taxi. Dafür sprechen zwei Gründe. Erstens tendieren Nutzer dazu, eine gut bekannte Alternative zu bevorzugen. Das Geschäftsmodell Carsharing ist im Vergleich zum Taxi weniger bekannt. Zweitens präferieren Nutzer unverbindliche Angebote. In dieser Hinsicht unterscheiden sich die beiden Konzepte dahingehend, dass man für die Nutzung von Carsharing eine regelmäßige und längerfristige Verpflichtung eingeht (Mitgliedschaft), während man beim Taxi nur die tatsächliche Nutzung zahlt. Diese Erkenntnis sollten Praktiker bei der Gestaltung autonomer Mobilitätsdienste beachten.

5 Limitationen und Forschungsbedarf

Limitierend muss bei der Bewertung der Ergebnisse beachtet werden, dass die Stichprobe nicht repräsentativ ist und Ergebnisse somit nicht auf die Gesamtbevölkerung übertragbar sind. Auch kann kein Anspruch auf Vollständigkeit hinsichtlich der ausgewählten Produkteigenschaften gestellt werden. Weitere Faktoren wie Gewohnheiten, Symbolkraft etc. könnten auch die Verkehrsmittelwahl bei autonomen Fahrzeugen und Services beeinflussen. Bei der Bewertung von relativen Teil- und Gesamtnutzen wurde außerdem die subjektive Relevanz (Gewichtung) der einzelnen Kriterien nicht miteinbezogen. Dennoch verhilft die Studie zu einem verbesserten Verständnis der Nutzerakzeptanz von autonomem Fahren durch die Berücksichtigung alternativer Verkehrsmodi und eigenschaftsabhängiger relativer Teilnutzen.

Zukünftige Forschung sollte bei dieser komparativen und teilnutzenbasierten Betrachtung ansetzen und um weitere Verkehrsmittelvarianten wie autonome Busse und Ridesharing erweitern, Korrelationen der Faktoren prüfen, die Faktoren ggf. anpassen und zusätzlich um die subjektiven Gewichtungen von Nutzern ergänzen. Nur so lassen sich zuverlässige Rückschlüsse auf die Nutzerakzeptanz ziehen und Veränderungen im Mobilitätsmix prognostizieren. Weiterhin sollten zukünftige Studien sich der Frage widmen, inwiefern sich spezifische Unterschiede hinsichtlich der Akzeptanz bei verschiedenen Personengruppen ergeben (insbesondere differenziert nach Alter, Hauptverkehrsmittel und Innovationsbereitschaft).

6 Fazit

Nutzerstudien zeigen, dass die à priori-Akzeptanz für autonomes Fahren relativ hoch ist [17–19]. Diese betrachten das autonome Fahren jedoch zumeist isoliert, sodass Rückschlüsse auf zukünftige Veränderungen des Mobilitätsverhaltens nur schwierig abzuleiten sind. Erste Studien haben deshalb Nutzerpräferenzen für die neuen Verkehrsmodi im Vergleich zu den bestehenden Verkehrsmodi analysiert und gezeigt, dass Nutzer den Privat-PKW, unabhängig davon ob traditionell oder vollautomatisiert, nach wie vor präferieren, im direkten Vergleich das Carsharing jedoch viel stärker von der Vollautomation profitiert als der PKW [22]. Die vorliegende Befragung von 172 Nutzern ergab, dass die Nutzungsintention für den traditionellen PKW nach wie vor am höchsten ist, vor ÖPNV, autonomem Privat-PKW, klassischem Taxi, autonomem Taxi, autonomem Carsharing und klassischem Carsharing. Nutzer sehen in der Automatisierung von PKW, Taxi und Carsharing Vorteile beim Fahrkomfort und der Zeitnutzung, befürchten in vielen anderen Bereichen jedoch keine Mehrwerte oder sogar signifikante Nachteile gegenüber dem klassischen PKW. Beim ÖPNV verhält es sich umgekehrt: Alle drei autonomen Verkehrsmodi bieten gegenüber dem ÖPNV deutliche relative Gesamtmehrwerte. Lediglich bei Kosten und Handhabung behält der ÖPNV aus Nutzersicht einen Wettbewerbsvorteil.

Insgesamt legen die Ergebnisse nahe, dass sich autonomes Fahren kurz- bis mittelfristig vor allem beim Individualverkehr durchsetzen wird, während sich nutzungsbasierte (Sharing-)Modelle erst langfristig etablieren können. Erst durch Erfahrungen und neue Routinen wird sich der relative Vorteil der autonomen Mobilitätservices durchsetzen, die dann jedoch eine ernstzunehmende Konkurrenz für den ÖPNV werden könnten.

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Human-centric Information Systems Design und Development

Teilkonferenzleitung

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Which concepts do inexperienced modelers use to model work? – An exploratory study

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Abstract. Modeling languages are generally designed to meet the requirements imposed on them by the domain to be represented and the intended application area of the resulting models. Their comprehensibility and appropriateness for domain experts, who are not necessarily experienced modelers, usually is not considered during language design. While some aspects such as notational properties of languages and their understandability have been subject to extensive research in this area, the semantic appropriateness of language constructs has hardly been a subject of research so far. This paper presents a set of exploratory studies that examine the use of different conceptual modeling languages by inexperienced modelers. The results indicate that the set of available modeling language concepts seems to influence the focus of articulation for inexperienced modelers. Mismatches between modeling language concepts and modelers' conceptualizations of the modeling domain appear to be compensated by ad-hoc re-definitions of language element semantics. Based on these findings we identify implications that need to be considered when designing modeling languages suitable for articulation by inexperienced modelers.

Keywords: Novice Modelers, Modeling Language Semantics, Stakeholder Articulation

1 Introduction

The last years have seen numerous research efforts on involving domain experts in modeling activities on an enterprise level (e.g., [1-3]). Traditionally, domain experts are considered a source of information for process analysts, who are responsible for creating models appropriate for the respective aim of modeling [4]. Active involvement in the modeling process is largely constrained to validation activities, during which the appropriateness of the information represented in the models is checked, e.g., via model walkthroughs [5] or simulations [6]. Research consequently has focused on examining understandability of models [7, 8], which is a prerequisite to enable domain experts to assess whether the information represented in models is correct. Domain experts do not necessarily have modeling skills or experiences. Their involvement in model creation thus has not been addressed to such a large extent. Most existing research either tries to avoid involving domain experts directly in conceptual modeling activities [9] or

assumes that they acquire the necessary modeling skills over time [10]. Requirements on modeling languages that can be used by domain experts inexperienced in modeling have hardly been examined.

Modeling by domain experts is referred to by Krogstie et. al [11] as *manual articulation*, during which domain experts externalize their knowledge about the domain into a model. The modeling language here plays a crucial role and needs to be "comprehensible" and "appropriate […] with respect to the domain and participants' knowledge" [11, p. 95]. Whether or not a modeling language meets these requirements consequently cannot be assessed objectively, but is depended on the individual domain experts' conceptualization of how they describe the aspects of the real world that should be represented in the model [12]. *Comprehensibility* is enabled when the semantics of modeling language are described so that participants involved in modeling understand how the language concepts should be used to describe their perceptions of the modeling topic. *Appropriateness* is only achieved if language concepts are comprehensible for a modeling participant, and their semantics match those the participant expects to be available. Mismatches between modeling language semantics and the concepts used by participants to refer to the modeling topic require acts of translation [13]. Such required translations distract from the subject of modeling and interrupt the articulation process, potentially leading to reduced model quality.

To avoid such interruptions, modeling languages designed to be used by inexperienced modelers should allow them to express their expected semantics. How this requirement can be accounted for, however, has hardly been examined empirically in existing research. Zarwin et al. [12, p. 4] state, that "users invent their own notations, decide to break the rules, introduce new conventions, converge to new modes of modeling, and all this on the fly." The present paper sets out to examine how people with no or limited modeling experiences are influenced by modeling language semantics with respect to which concepts they choose to incorporate in their models. The aim is to identify issues that need to be considered when designing modeling languages that should be used by inexperienced modelers to articulate their knowledge in models.

The remainder of this article is organized as follows: in section 2, we briefly review related work in modeling by inexperienced modelers. Section 3 introduces our research setup and describes the deployed methodology. Section 4 summarizes the results of the study we have conducted in the present research. Section 5 discusses the results in the light of the aims of this article and gives an initial account on issues to be considered during language design or selection.

2 Related Work

The use of modeling languages by inexperienced modelers has been a subject of research in several studies over the last years. Recker et al. [14] have examined how inexperienced modelers design business processes. They have identified five different process design archetypes, which differ in their degree of formalization (abstract vs. concrete) and their form of presentation (text vs. graphics vs. mixed). For their study,

they have analyzed models concerning their syntactic, semantic and empirical quality based on existing theoretical frameworks. They found that different aims of modeling are approached via different design archetypes and that graphical representation, in general, seems to be preferable over textual descriptions in most cases. While the aims of the present study are similar to those described by Recker et al. [14], our approach differs in that we explicitly examine how semantic constraints imposed by different modeling languages influence inexperienced modelers when describing their perception of work. Our focus is on the needs of modelers rather than on the semantic quality of models measured against a theoretically backed baseline. This requires a different methodological approach to model analysis that allows extracting the latent semantics represented in a model.

Starting from a similar problem diagnosis as described in section 1, Monsalve et al. [15] set out to specify a method that allows accommodating different stakeholder perspectives in business process modeling. The method achieves this by performing an ex-ante ontological analysis to identify those aspects of a business process a particular group of stakeholders needs to represent their perceptions appropriately. While pursuing a similar aim as this paper, the approach taken is fundamentally different: Their analysis is based on a set of theoretically derived approaches and industry standards and does not directly involve the affected group of stakeholders. The study presented by Patig & Casanova-Brito [16] uses an empirical approach to collect requirements on process modeling languages. They adopt a perspective of industry needs and collect their data from company representatives mainly active in IT and BPM. Such people can be assumed to be more experienced modelers, the study thus present requirements derived from a different target group than addressed here.

The visual notations of modeling languages and their appropriateness for inexperienced modelers have been examined in several works. Genon et al. [17] discuss the notation of BPMN in the light of the Physics of Notation theory [18]. Figl [7] presents a meta-study of aspects impacting the comprehensibility of business process models. Türetken [8] et al. discuss the impact of cognitive style on the understanding of business process models. They all share a focus on people using process models rather than actively designing them. Their findings also indicate that modeling language design and individual characteristics of modelers (or model users) are factors that influence how appropriate models perceived to be for a particular usage scenario. Such influences are also diagnosed by Zur Muehlen & Recker [19], who have examined BPMN models created and deployed in industry settings. They found that modelers usually do not use the whole set of language concepts, but rather focus on subsets depending on modelers' preferences and the aim of modeling.

3 Methodology

Our research question is to examine the effects of prescribed modeling language semantics on the actual meaning of elements used in the articulation results (i.e., models) created by inexperienced modelers. Based on the findings from related work, our hypothesis is that the degree a chosen modeling language constrains what can be

expressed semantically (independent variable) has an impact on the concepts inexperienced modelers use describe their knowledge about the domain (dependent variable). We do not assess the content of the created models themselves, but only examine the semantics of the used language elements.

The data necessary to evaluate this question was generated in real-world modeling workshops to generate models that are based on modeler's actual knowledge about the model subject. The modeling tasks consequently differed in their aims and context. While generating an artificial experimental setup with better controllable conditions and a consistent modeling scenario would be preferable to raise internal validity, modelers in such a case could not rely on real-world knowledge on what to represent in their models. Forcing modelers to explicitly think about what to represent in the models might already be constrained by the semantics of the language to be used for modeling. This would potentially introduce a selection bias in terms of what to represent in the model already before the act of modeling itself and thus threaten external validity. We are aware of the limitations of our chosen approach with respect to the potential impact of the different modeling scenarios, but still have chosen to work with real world cases to avoid this confounding factor. We mitigated the scenario selection problem by selecting workshops that consistently were concerned with representing work processes, thus providing a common scope in the universe of discourse [4].

We operationalize the independent variable by varying the modeling languages used in the examined modeling workshops. The modeling languages were selected to represent different degrees of semantic constraints imposed during modeling (for details, see description of the series below). Overall, we conducted three series of workshops, each using a particular modeling language. All three languages were suited for representing work processes (either being explicitly designed for this purpose or leaving the freedom to use according semantics). The participants in the workshops did not have any prior modeling experiences.

The dependent variable is operationalized by analyzing the concepts modelers use when creating their models. We expect the frequency of concept occurrence in the models to be influenced by the used modeling language and its semantic constraints. We hypothesize that languages with less semantic constraints lead to models that more exactly match what the modelers consider relevant to be represented in a model. Our hypothesis would be backed if we could observe the use of different concept types across the workshop series.

In *series 1*, modelers had diverse professional backgrounds. They were asked to describe re-occurring work processes they experience in their daily professional or private lives. They were given no pre-specified semantics to adhere to during modeling but were asked to use equally colored modeling elements for concepts of the same kind. For each used color, they were asked ex-post to describe the concept the color referred to. No further constraints on how to represent work processes or which concepts to use were given. Overall, 26 modelers each created a model, which overall contained 416 elements (min = 6, max = 104, mean = 16.0, std.-dev. = 19.4).

In *series 2*, the modelers were healthcare professionals and industrial production workers participating in vocational training activities. They were asked to describe

work processes that they perceived to be problematic in their daily work. They were provided with three different types of modeling elements that were inspired by modern process modeling languages such as BPMN and vaguely defined as representing "What" (i.e., what needs to be done), "Who" (i.e., who is doing the "What") and "Exchange" (i.e., what is required from others or can be provided to others when doing the "What"). Details on the deployed modeling approach can be found in [20]. The exact semantics of the modeling elements were deliberately left vague and provided room for choosing one's preferred level of granularity and meaning of the elements (e.g., describing "Exchange" on the level of messages, documents, materials, etc., or describing "Who" by referring to actual people or abstract organizational roles). Overall, 82 modelers each created a model, which overall contained 1221 elements (min = 3, max = 56, mean = 14.8, std.-dev. = 12.3).

In *series 3*, the modelers were students of a bachelor's curriculum in business information systems in their first year. Neither of them had any background in process modeling. They were asked to use BPMN (Business Process Modeling and Notation) [21] to describe an event agency's process for organizing a customer event. The students did not have prior own knowledge about the process but were provided with information on this process as transcribed interviews, which were deliberately not formulated in a way that would make the mapping to modeling elements straightforward. After familiarizing themselves with the scenario, they were given a 1-hour theory-driven introduction to BPMN and its semantics before starting their task. For modeling, they were provided with a reference chart. Overall, 30 modelers each created a model, which overall contained 3296 elements (min = 32, max = 177, mean = 109.9, std.-dev. = 37.3).

The collected models were analyzed using a variant of thematic content analysis [22] to identify the concepts used for modeling (dependent variable). Thematic analysis is a method for identifying and analyzing patterns (themes) within data. As we were interested in the emerging semantics of the used modeling element types, we used an *inductive* coding approach to identify *latent* themes. Inductive coding here refers to the fact that the set of themes is not derived a priori from a guiding theory, but emerges "bottom-up" directly from the data based on the research question. Thematic analysis on latent level goes beyond the explicit semantics of the data (i.e., the semantics of the model elements as specified in the used modeling language), and examines the "underlying ideas, assumptions, and conceptualizations" [22]. Latent analysis is necessary in our case, as our study requires to examine the actual semantics of elements used in the articulation results.

Interpretation of the models is a subjective process that is prone to coder's bias, in particular when trying to identify latent themes. This was accounted for by having two independent coders assess all models. In the case of divergent codings, the author evaluated the respective element and decided which of the codings was to be used.

Using an initial sample of 10% the of models from all three series (selected from those models sized close to the median of each series), we deductively created a set of initial codes that allowed to classify the model elements used by the inexperienced modelers semantically. Following the procedure proposed by Braun & Clarke [22], the codes were not named a priori, but defined using a qualitative description and examples

of the elements that belong to the theme designated by the respective code. When elements were encountered that could not be interpreted using the set of available codes, it was extended accordingly. In case the coders were not able to conclusively assign an element to a theme, the affected theme descriptions were refined.

Based on this set of codes, the full data set from all three series were coded independently by each of the two coders. Consistent coding was assessed using Cohen‘s Kappa as a metric, as suggested by Trickett & Trafton [23]. Overall, Cohen‘s Kappa was 0.943, which indicates a set of clearly defined and delimited themes and a good understanding of these themes by the coders. The set of codes thus was not modified any further. In a final step, the codes were named to designate the different themes and be able to refer to them in the following description of the results. In the following section, we summarize the results of our analysis and give an initial account of patterns that emerge from the available data.

4 Results

The results of the thematic analysis of the data collected in the three series of modeling workshops are presented in this section. We first describe the results of the inductive development of a set of codes used for describing the latent themes of the elements contained in the collected models. We then progress with an overview of the coding results, showing the distribution of identified themes for each of the examined series.

4.1 Concepts used for modeling

As described in the methodology section, we have derived the set of codes to designate latent themes used for modeling elements from a sample of 10% of the available models. These codes were validated in a double-coding process using the whole body of data. The set of codes was not altered in the validation process. After the coding process, the identified themes were revisited, named and described. Also, they were grouped into thematic clusters, which refer to the aspects of organizational work represented by elements assigned to the contained themes. The descriptions of the themes in Table 1 are grouped in these clusters:

Themes referring to WHAT-aspects describe those aspects of the work that can be executed by somebody and directly or indirectly contribute to achieving the aim of the work represented in the model (indirect contributions, e.g., would be coordinative activities [24]). **Themes referring to WHO-aspects** describe aspects of who is responsible for, or involved in, (parts of) the described work. **Themes referring to WITH WHAT-aspects** refer to those aspects that are required for, produced by, or exchanged in the course of carrying out (parts of) the described work. This also includes tools required for carrying out (parts of) the described work. **Themes referring to WHEN-aspects** refer to those aspects that describe under which conditions (parts of) the work can be executed. Such aspects are not constrained to temporal or causal aspects, but also include other types of constraints or conditions. The only aspect that could not be assigned to any of the clusters above are generic comments, which

consequently were introduced as a separate theme. Table 1 shows the identified themes and the descriptions used during coding.

Table 1. Themes identified during latent coding

WHAT	
Activity	Elements describing aspects of the work that can be executed by any instance of the themes for WHO and directly or indirectly contribute to achieving the aim of the work.
Communication	Elements describing aspects of the work that are executed by at least two instances of the themes listed under WHO collaboratively and designate an exchange of information among them
WHO	
Individual Actor	Elements representing a specific person (i.e., somebody who can be distinctively identified and named ad personam).
Role	Elements representing abstract organizational positions or responsibilities, that can be taken by an individual actor.
Organization / Unit	Elements describing whole organisations or organizational units that do not give any explicit information on how many actors or roles are contained in them, but usually would contain more than one actor or role.
WITH WHAT	
Resource	Elements describing anything that is need to perform an instance of the themes listed under WHAT and is independent of the concrete work instance (i.e., its content or nature remains unaltered between work instances). This, e.g., includes tools, machinery, but also procedural guidelines.
Physical Object	Elements describing physical objects that are needed to perform an instance of the themes listed under WHAT and are consumed or altered in the process thereof. This, e.g., includes raw materials.
Document	Elements describing documents that are needed to perform an instance of the themes listed under WHAT and contain data specific for the particular work instance. This, e.g., includes filled paper forms.
Information	Elements describing information that is needed to perform an instance of the themes listed under WHAT. The way of delivery of this information is not specified (i.e., the information could be conveyed verbally as well as via paper).
Skill	Elements describing skills that are required from an actor / role / organization(al unit) to perform an instance of the themes listed under WHAT.
Communication Channel	Elements describing ways to exchange information between instances of the themes listed under WHO. This, e.g., includes email, phone calls, but also informal coffee talk.
WHEN	
Temporal Constraint	Elements describing temporal constraints for executing instances of the themes listed under WHAT. This, e.g., includes absolute and relative time constraints, such as events or causal relationships between WHAT-elements.
Spatial Constraint	Elements describing spatial constraints for executing instances of the themes listed under WHAT. This, e.g., includes locations or proximity to mobile instances of WHO.
Availability Constraint	Elements describing constraints for executing instances of the themes listed under WHAT that are dependent on the availability of particular WITH WHAT elements. This, e.g., includes elements representing waiting for incoming information, or the availability of a particular resource.
Alternative Activity flow	Elements representing choices on which of several potential instances of WHAT should be executed. This, e.g., includes exclusive or event-based gateways.
Parallel Activity flow	Elements representing that several potential instances of the themes listed under WHAT call be executed in parallel. This, e.g., includes parallel or inclusive gateways.
OTHER	
Comments	Elements containing unspecific comments, i.e., comments that cannot be classified under one of the themes described above.
Not coded	Elements that could not be coded for reasons independent of this coding scheme. This, e.g., includes elements with unreadable designators.

The set of themes gives an overall impression of which categories the inexperienced modelers used to describe the work in their models. It is important to note that the

presence of certain themes and, in particular the absence thereof has potentially been influenced not only by the used modeling languages but also by the modeling tasks. Only the models of series 3 are based on an explicitly described scenario, which still was formulated in a way that did not impose any "obvious" modeling elements to be used. It can thus be assumed that the presence of certain themes is mainly dependent on the modelers' way of describing their work in a conceptual model and the deployed modeling language. Overall, the themes are in line with what Fjuk el al. [25] in the context of CSCW refer to as the "salient dimensions of work — who, what, when, how" ("how" referring to aspects we have clustered under "with what").

4.2 Coding Results

The set of codes described above was used to analyze the model elements collected in all three series of workshops. Table 2 shows the detailed numerical distribution of the observed codes. The data reveals several striking differences between models generated in the different series. We discuss them in the following paragraphs per series.

Table 2. Distribution of themes per series

	Theme	Series 1	Series 2	Series 3
WHO	individual actor	0,48%	2,21%	0,76%
	role	9,62%	11,96%	4,28%
	organization unit	4,81%	6,47%	3,43%
WHAT	activity	12,26%	25,63%	21,00%
	communication	4,33%	9,42%	15,02%
WITH WHAT	resource	4,09%	0,08%	0,18%
	physical object	10,58%	0,00%	0,24%
	document	4,33%	1,31%	3,49%
	information	28,13%	23,67%	6,98%
	skill	10,34%	0,08%	0,00%
	communication channel	0,00%	1,15%	1,40%
WHEN	spatial constraint	0,48%	0,00%	0,09%
	availability constraint	0,00%	0,00%	0,00%
	temporal constraint	2,40%	9,50%	24,15%
	alternative activity flow	0,00%	0,00%	12,01%
	parallel activity flow	0,00%	0,00%	3,64%
OTHER	comment	0,00%	0,00%	1,24%
	not coded	8,17%	8,52%	2,09%

In *series 1*, where modelers could define their own semantic concepts when describing their work, 57.5 % of the elements represent aspects of the WITH WHAT cluster. This is a remarkable amount when compared to the other series, where the share of this cluster is around 25% in series 2 and only around 11% in series 3. Series 1 furthermore is the only series that contains elements categorized in the theme "skills" to a relevant amount (it is also present in series 2 with 1 element, which accounts for 0.08% of the elements). When specifying their own concepts, inexperienced modelers thus seem to strongly focus on the WITH WHAT aspect, where the largest shares of elements belong to the themes "information" (28.1%), "physical object" (10.6%), and "skill" (10.3%). In contrast, the themes belonging to the WHEN aspect were hardly used in series 1 and only account for 2.9% of the elements. This is remarkable, as this

cluster contains all elements describing temporal and causal relationships. Consequently, the absence of elements in this cluster means that modelers have hardly adopted a flow-oriented perspective when describing their work processes.

While the modeling language deployed in *series 2* is only vaguely specified and would allow representing elements stemming from nearly all identified themes, it still poses some constraints on what can be represented in models. The language, e.g., does not provide constructs to represent communication channels or communication activities. Still, both themes have been used in the collected models to a limited extent (communication channels: 1.2%, communication: 9.4%). The prescribed semantics of the modeling language obviously has been re-defined by the modelers implicitly during modeling for nearly 10% of the used model elements to fit better the modelers' perceptions of how the represented work is organized. This redefinition has mainly happened for elements concerned with communication among people during the work process and might indicate too limited expressiveness of the used modeling language.

The models in *series 3* show a high number of elements belonging to the *WHEN*-cluster (39.9% overall). This is remarkable when compared to the other series, where the share of this cluster is around 23.8% in series 3, 9.5% in series 2 and only 2.9% in series 1. Looking at this cluster in more detail, 24.2% of the overall elements belong to the "temporal constraint" theme, which contains elements representing causal and temporal relationships. A total of 15.6% of the elements belongs to the themes concerned with representing alternatives and parallelization in the flow of activities. While this is not surprising – given the representational scope of BPMN – it still poses a major difference from the other series, where such themes were not present at all. This phenomenon might be attributable to the scenario description provided in series 3 as a basis for modeling, which contained indications that the process might exist in different variants. When not nudged towards such aspects, however, inexperienced modelers seem to focus on single cases and thus largely refrain from including alternatives or potentially parallel execution of activities. The low number of elements in the WITH WHAT-cluster reflects the semantic focus of BPMN. Some concepts that allow representing information handling or exchange are present in the models and account for the share of elements assigned to themes in this cluster.

5 Discussion

In this section, we first review the results presented above in the light of the research question formulated in section 3. We then address the preliminary implications for selecting or designing modeling languages for use by inexperienced modelers. Overall, the results of the analysis provide indications that the semantic constraints of modeling languages influence how inexperienced modelers select the aspect to be included in their models when describing their work processes. If semantics are left for the modelers to be specified (as in series 1), they seem not necessarily to organize their models along temporal or causal relationships, but also use other constraints to organize their models (such as assigning activities to a place or the availability of resources).

The analysis of the coding results has shown that some models from series 2 and 3 contain latent themes beyond the explicit semantics provided by the deployed modeling languages. This seems to indicate that inexperienced modelers re-define modeling element semantics on the fly to represent aspects of work they consider relevant, but are not covered by the modeling language. We hypothesize that these acts of redefinition hardly are deliberate decisions, but mostly are re-interpretations of modelers' understandings of the semantics of an existing language concept (i.e., "intuitively" using it). We do not follow up on this hypothesis here for reasons of space.

The results of our study on the latent themes used in modeling (cf. section 4.1) overall show that inexperienced modelers in general use concepts to describe their perception of work that do not fundamentally differ from the semantics offered by most conceptual modeling language designed for representing work processes [26, 27]. Some of the concepts observed for constraining the execution of activities (like spatial constraints), however, are hardly considered in common modeling languages (ibid.). This diagnosis is confirmed in ontological analyses [28] of process modeling languages, which found a lack of constructs being able to represent lawful states in process modeling languages – a category that is predominantly applicable to the "constraint"-themes identified during coding. More importantly, no single modeling language covers all aspects identified in coding [28]. A specific deployed language thus constraints which aspects of work can be represented at all, and might prompt modelers to think mainly about those aspects that are explicitly considered in the language.

The prompting effect of the deployed modeling language, i.e. causing modelers to focus on certain aspects of their work, could be indicatively confirmed in our coding results. The distribution of latent themes in the models was highly dependent on the used language. Deploying a language with specific process-oriented semantics such as BPMN appears to prompt modelers to emphasize how work is organized temporally and causally. Leaving open the semantic categories appeared to lead cause a tendency to focus on required resources, skills and work results, which was not observed in any other series. This difference indicates that the appropriateness [11] of a modeling language deployed in workshops involving manual articulation indeed is a relevant issue during modeling. It needs to be explicitly considered when selecting a language aiming at capturing knowledge of inexperienced modelers to avoid the need for translating mental concepts to the semantics of an external model representation [13].

These findings lead to several implications with respect designing or selecting modeling languages to be used by inexperienced modelers: First, the coding process has shown that intersubjective understandability is rarely a problem. The latent semantics of modeling elements was identified with only few inconsistent codings. Consequently, the use of standardized modeling languages seems to be necessary only if the IT-supported processing of models is required (e.g., for workflow execution [29]). Second, it might be useful to provide a set of pre-specified modeling elements to prompt thinking about particular aspects of work. Using a subset of elements provided by an existing modeling language as a foundation might provide a gateway towards IT-supported processing (e.g., as suggested for BPMN [21]).

6 Conclusion

In this paper, we have presented a study to examine the practical use of different modeling languages by inexperienced modelers. We have aimed to identify, whether the semantics of a prescribed language has an impact on the aspects modelers choose to represent in their models of work. We could confirm that modelers focus on different aspects depending on the constraints imposed by the modeling languages. The data suggest that orientation on the flow of activities is not necessarily an intuitively chosen way of representing work by inexperienced modelers. Rather, they have focused on required resources and work results in our study. Based on these results, we suggest to further examine the use of flexibly deployable modeling languages to achieve appropriateness for people without conceptual modeling experiences.

The present study has several limitations. First, data generated from real-world workshops is only of limited validity when aiming at comparing the modeling results produced under different languages constraints. Such settings usually lead to confounding variables that can hardly be observed and accounted for systematically during data analysis. Now that indicative results provide starting points for an informed formulation of more specific hypotheses, studies conducted under more strictly controlled settings, such as (quasi-)experiments, could allow addressing this issue. Second, the absence of conceptual modeling experience has only been considered in our study as a binary value and surveyed through participants' self-declarations. This might be an oversimplification, as our data seems to indicate, that there might be latent influences of participants' earlier acquired skills, such as spreadsheet design (related to data modeling [30]) or software development (related to process modeling [29]).

We currently conduct a follow-up study to the present work, in which we examine prior knowledge of inexperienced modelers and its relation to deployed modeling strategies and used semantics more thoroughly. This will allow a more detailed and grounded discussion of this issue in future work.

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Reading Business Process Models the more Expert Way

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Abstract. Business process models represent complex visual graphics, which often require training and expertise to be read and interpreted appropriately. As experts in this domain have a perceptual advantage based on a higher visual span and access to complex schemas in long-term memory, they faster reach task-relevant information and avoid task-redundant focusing on task-irrelevant information. In business process modeling, visual cues are used to guide readers to relevant information. However, visual cues are often not based on what we know about how experts read visual graphics. Therefore, we review eye-tracking and think-aloud studies for visual graphics and business process models to describe expert strategies when reading business process models. Based on these strategies, we derive implications that will support novices to obtain a more expert view when reading business process models. Our suggestions include different segmentation needs and how experts' reading strategies can be integrated into visual cueing strategies.

Keywords: Business Process Modeling, Expertise, Eye-Tracking, Think-aloud.

1 Introduction

Business professionals use diverse representational forms to describe their processes ranging from textual [1] and semi-structured textual description [2] to more graphical representations using modeling grammars such as the Business Process Modeling and Notation (BPMN) or the Event-driven Process Chain (EPC). Out of these representational forms, business process model readers prefer the more graphical representation based on modeling grammars [3]. This seems surprising, as for visual programming, [4,5] found that we faster understand text than graphical representations. Yet, graphical representations are more appealing. They are richer than text, make structure visible, provide a higher level of abstraction, and are more fun [6].

However, understanding graphical business process models (hereafter referred to as business process models) requires expertise. Understanding these models depends on intensity of prior work with these models (method expertise) and with the domain treated in the model (domain expertise). In most cases, model readers are not method experts and in some cases not even domain experts. For example, business process models are often used for business process documentation [7], which new employees use as introduction to the domain. As method and domain novices, these employees have problems understanding these introductions.

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Why expertise is required for understanding graphical representations is discussed by Petre in [6]. She argues that it is not obvious for model readers where to start looking at in graphical representations. Readers rather choose between different strategies to access the representation. These strategies influence, which meaning is read out of it. If they choose a different strategy, they might face a different meaning. Petre further argues that expertise influences on the strategies readers use to read a graphical representation. Indeed, experts use more effective strategies than novices and tend to stick to their strategy [8]. After experts take a practice trial to identify an appropriate strategy for a certain task, they stick to this strategy for similar tasks. In contrast, novices often vary their strategy and sometimes even change it during the task [8]. Novices further suffer from misreading, a lack of knowledge to identify relevant information, and a feeling to not be reading thoroughly enough. As a result, they have to reread the graphical representation over and over again [6].

Visual cueing is discussed to direct the novices' gaze to those parts that their authors deemed relevant for understanding [9,10]. That way, colour is used to highlight gateways (e. g. [9,11]) or to highlight subflows of business process models (e. g. [10,12]). Yet, visual cuing is not based on what we know about how experts read graphical representations in general and business process model in particular. Hence, it can be questioned whether they are effective to give novices a more expert reading strategy. In search for an answer, we first summarize experts' reading strategies in graphical representations and in business process models. Our focus is on procedural business process models. Based on these strategies we discuss implications for model readers and further assess whether current visual cuing strategies allow to give novices a more expert view when reading business process models. To summarise the experts' reading strategies in graphical representations, we focus on eye-tracking evidence for two reasons: First, eye movement behaviour has been studied for various domains of expertise, such as chess, medicine, art and aviation [13,14]. Second, expertise rather relies on procedural knowledge (knowing how) than on declarative knowledge (knowing what). Since it is rather difficult to access procedural knowledge, eye-tracking provides a method that allows to make this information more explicit [13]. For business process modeling, we further include think-aloud studies as we aim to describe prior research more complete. We do not include prior empirical findings that do neither include eye-tracking nor think-aloud as we focus on the reading process and this process cannot easily be assessed without eye-tracking or think-aloud While the next section summarizes eye-tracking evidence of visual expertise, section 3 reviews eye-tracking and think-aloud evidence for expertise in reading business process models. In section 4, we derive implications for business process modeling and finish with a conclusion in section 5.

2 Eye-tracking evidence of visual expertise

Eye-tracking has often been used in the domains of chess and medicine to describe expertise [13]. As research of these two domains contributed almost without any cross citations, Reingold and Sheridan have integrated their results within a review in [13].

In [14] eye-tracking results from further domains are integrated in a meta-analysis. We use this study to back up results from chess and medicine. Reingold and Sheridan summarize that the global processing advantage, which is often attributed to expertise in medicine [13], is in line with what researchers call perceptual advantage in chess [15]. In medicine, the global processing advantage is explained with the global-focal search model [16] and the two-stage detection model [17]. According to the global-focal search model, experts gain an overall impression when comparing content of graphical representations with internal schemas, leading their gaze to most important areas for problem solving. The two-stage detection model describes that experts initially filter regions that are required for further evaluations. Hence, in both models the authors assume that experts in medicine first scan the global patterns when reading graphical representations. For the chess domain, eye-tracking revealed that experts are even unable to avoid processing the global pattern no matter if it is supportive or detrimental to task performance [18,19]. Gegenfurtner et al. provide evidence for further domains for the holistic model of image perception, which proposes experts to start with an initial global analysis [14]. Hence, across several domains, experts use their perceptual advantage for processing the global pattern first. Yet, why do experts in contrast to novices have a perceptual advantage?

With growing expertise, associations are developed between groups of information that form complex schemas in long-term memory (LTM) [20]. While experts have developed complex schemas, novices often require several schemas to cover the same information. Beyond having complex schemas, expertise is characterized with having many schemas available. An initial estimation of the number of the experts' schemas amounts up to 50.000 [20] and was recently corrected to 300.000,00 [21]. Schemas are further distinguished in chunks and templates. While chunks only cover fix information, templates are more flexible as they also include variable information. Stark et al. have discussed possible chunks and templates for business process modeling [12]. For example, BPMN intermediates and experts might have a template for gateway and use the variables +, o or empty to specify the type of gateway into exclusive, inclusive or parallel. In contrast, novices only have chunks available and might need three different chunks to cover the same information (see fig. 1c-d).

When reading business process models, readers tend to fixate a certain part of the model (fig. 1a), which is then reflected as an iconic representation in working memory (WM) [22]. Based on this representation, WM creates pointers to the schemas stored in LTM [22]. In 1956, Miller estimated the number of pointers to be around 7+/- 2 [23], and Cowan, recently, limited this number to around 4 [24]. Taking 7 as a basis, Stark et al. exemplarily showed that experts would only need 3 pointers to reason about what is fixated while novices would require more than 7 pointers [12] (fig. 1b). Assuming that it is true that experts have access to more complex schemas than novices, Reingold and Sheridan conclude that experts' and novices' fixations must differ in length and location [13]. Based on the amount of information that readers perceive from a fixation, their fixation point varies [13]. While novices rather fixate single objects, experts locate their fixations to maximize the information gain, for instance in between objects. In fact, there is evidence that chess experts rather fixate along the edges of squares [25] or on empty squares [26] while novices tend to

fixate figures. For further domains, Gegenfurtner et al. provide evidence for the theory of long-term working memory [14]. In line with schema theory, this theory assumes that expertise allows to extend the capacity of WM as more complex retrieval structures are available [27]. This is why, Gegenfurtner et al. predicted that experts have shorter fixation durations and showed in their experiments that experts had slightly shorter fixation durations than novices [14].

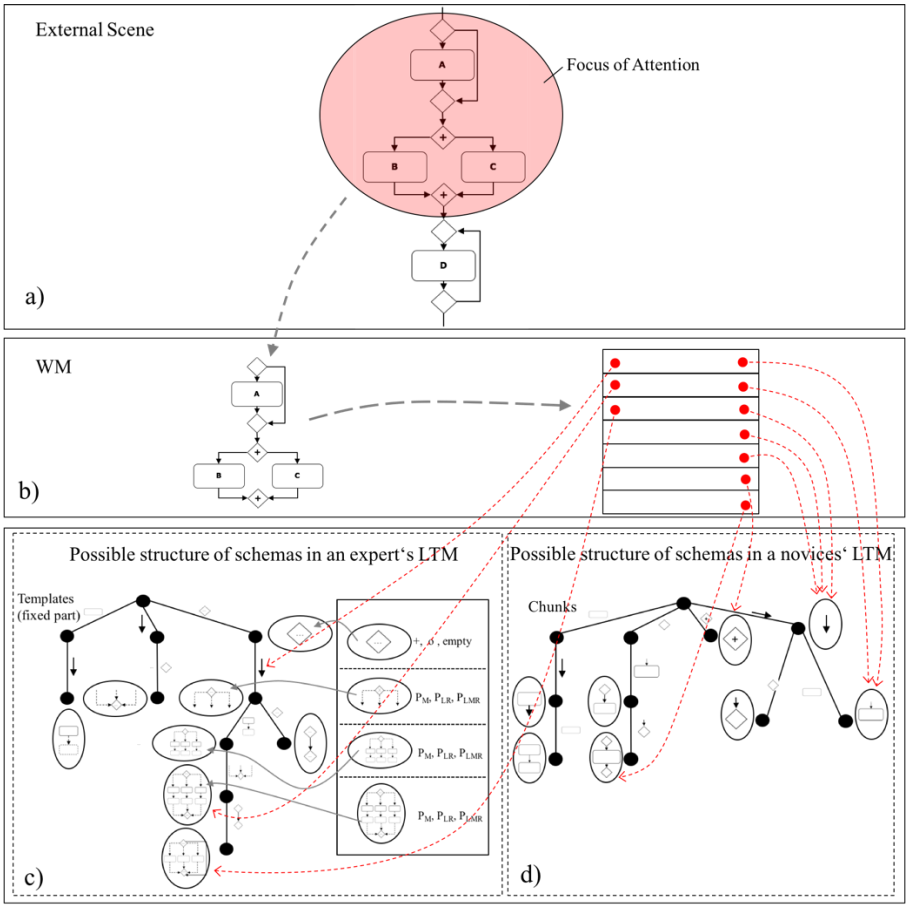

Figure 1. Integrating schemas into the reasoning process on the basis of [12]

Experts do not only extend limitations of WM. They also perceive more domain-related information from a fixation as they have a large visual span. In contrast to novices, experts also use parafoveal and peripheral vision to detect information [13]. For chess, evidence for the expert's larger visual span is reported in [15]. In line with this research, Carmody et al. showed that under brief exposure conditions, which preclude further eye-movements, expert radiologists detected nodules that were 15 degrees away while less experienced persons only detected nodules that were 10

degrees away [28]. Also in other domains, experts detect information without bringing it into the fovea [14]. As a consequence, experts perceive (including foveal, parafoveal and peripheral vision) and process (accessing complex schemas in LTM) more information within a single fixation. These advantage allow experts to first scan the global pattern in complex representations.

Experts' behaviour to first scan the global pattern has been used to explain why experts are able to rather fixate task-relevant objects and to arrive faster at these objects than novices. For the chess domain, Charness et al. showed that when experts fixate figures these figures are to a greater proportion task relevant than those of intermediates [29]. Also for radiology, there is evidence that experts spend a greater proportion of time fixated on abnormalities [30,31] and arrive at the abnormalities faster [32,33]. Gegenfurtner et al. showed for further domains that experts have more fixations on task-relevant areas than novices [14]. When scanning the global patterns, experts benefit from free viewing conditions [34]. Yet, when segmenting their global perspective, a decrease in accuracy was found [35]. To sum up, experts are able to process the global patterns first, which helps them to faster arrive at task-relevant information. Yet, how experts process the global patterns differs among the domains. Skills that make an expert in one domain might not be transferred to others [36], which is why expertise needs to be considered for the domain.

3 Eye-tracking evidence of visual expertise

Reading business process models has been analysed for error detection and understanding with think-aloud and eye-tracking (see table 1). For error detection, subjects were asked to identify possible errors. While error detection tasks were rather similar, understanding tasks varied. For example, Petrusel et al. used a sequential procedure by asking specific questions about the model and continued with further questions after the subject provided an answer [9,37]. In contrast, Haisjackl et al. used open questions, where subjects had to describe how they read the model [38,39].

Table 1. Previous eye-tracking and think-aloud studies on reading business process models

Lit.	*Tasks*	*Participants*	*Focus*	*Method*
[38]	Under-standing	9 intermediate experts	Reading strategies in declarative process models	Think-aloud
[39]	Under-standing	18 intermediate experts	Follow-up study of [38]	Think-aloud
[40]	Error detection	12 intermediate experts	Error detection in models that differ in complexity	Think-aloud
[41]	Error detection	12 experts	Reasoning in multiple diagrams	Think-aloud
[42]	Under-standing	26 experts	Relevance of Relevant Region	Eye-tracking
[9]	Under-	75 experts and int.	Colouring elements of the	Eye-

	standing	experts	Relevant Region	tracking
[37]	Under-standing	75 experts and int. experts	Visual Cognition Efficiency and Intensity	Eye-tracking
[43]	Under-standing	29 novices and experts	Infl. of layout quality on novices' and experts' reading strategy	Eye-tracking

For error detection, reading strategies have been assessed in multiple diagrams [41] and in single diagrams [40]. Hungerford et al. used think-aloud to assess reading strategies in multiple diagrams including Data Flow Diagrams (DFDs), ERDs and a Statement of Problems [41]. They found subjects switched attention between the design documents. While doing this, some subjects used a fast-switching behaviour with a focus for short periods on one and quick switches to other models while other subjects first focussed the DFD and then switched to the ERD replicating this behaviour up to three times [41]. As the fast-switching behaviour was most effective, the authors suggest that search effectiveness can be increased if personal is employed that fast switches between diagrams [41].

Haisjackl et al. focussed on reading strategies in single diagrams with different complexity [40]. They identified three reading strategies: Getting an overview (which is in line with first scanning the global pattern), directly starting to read the model, and creating a mental list of possible errors. For the less complex model, about 58% of the subjects first got an overview, 17% first created a mental list of possible errors and 25% started reading directly. For more complex models, a part of the subjects that directly started to read the model switched to first getting an overview. Subjects that used the other two strategies, sticked to their strategy. Haisjackl et al. further describe the strategy of first getting an overview as reading pool and lane descriptions, reading through the whole model, or analysing the structure of the model [40].

For understanding tasks, Petrusel et al. define a relevant region as an area that model readers require to analyse for solving their task [42]. Investigating this region in an eye-tracking experiment, they found that experts make more fixations on elements of the relevant regions than on other elements, spent a higher percentage of time fixated on relevant regions than on other regions, and give more correct answers when showing higher shares of fixations on relevant regions. Continuing this research by colouring elements of the relevant region that are crucial to solve a specific task, Petrusel et al. found that colouring helps to decrease the total duration of fixation, to reduce time and to improve efficiency [9]. We remark that Petrusel et al. change the natural reading strategy by highlighting the relevant region as task-specific elements pop-out in the model. Yet, with their research they succeed in introducing the relevant region, which is important when discussing how processing the global pattern might faster lead to fixating task-relevant information for our domain. The relevant region might further be used to empirically assess if processing the global patterns helps to faster reach task-relevant information in business process modeling.

Like highlighting elements of the relevant region, also the quality of layout induces changes of the reading strategies as shown by Störrle et al. in [43]. The authors asked novice and expert subjects to answer specific understanding questions for different kinds of UML diagrams varying good and bad layout. They identified three patterns

including [43]: (i) Branch following from anchor (BFFA), which means that an anchor is established (top left corner, largest element, or centre) and subjects started reading from there according to the graph structure, (ii) Left/Right Top/Bottom (LRTB), which means that subjects started at the top-left corner and proceed downwards or to the right irrespective of the arrow direction, and (iii) Random Walk (RW), which means that no discernable pattern was detected. The authors found that for diagrams with a good layout, experts and novices followed BFFA or LRTB, while for diagrams with a bad layout, novices tended to use RW while experts continued using BFFA/LRTB. To their surprise these results were obtained irrespectively of the diagram type. The authors suggest that increasing the number of elements and the number of layout flaws have a similar effect on cognitive processing. Yet, the number of flaws might be reduced, while the number of elements need to be the same to cover the information that has to be conveyed.

For understanding tasks, Haisjackl et al. further use think-aloud to assess the reasoning process in declare models [38,39]. In contrast to procedural process models, declare models specify the interplay of process actions and are typically not sequential [39]. Although we focus on procedural business process models, we decided to integrate this research as Haisjackl et al. found insights for procedural business process models. In particular, they found that subjects followed an iterative and sequential way of reading the models although sequential information was not given [38]. They further describe the reading-routine: Readers first skim over the model to find an entry point. Having found one, they define, in which order the activities are executed. This routine is then repeated for parts of the model that are not connected. Their results might be interpreted that subjects with expertise in business process modeling and intermediate expertise in declarative process modeling might rather have access to LTM-schemas that reflect sequential process modeling patterns. Their behaviour to follow a sequential way of reading declarative process modeling patterns, might be explained as a search to match their LTM-patterns, which can rather be characterized as sequential than declarative. This is also in line with the authors' interpretation that subjects tend to prefer this kind of information [39]. Having summarized how experts read business process models, we further discuss implication on segmentation and for visual cuing.

4 Implications for Business Process Modeling

As discussed in [43], the quality of layout can change the reading strategy. Störrle et al. have suggested that in particular, novices might suffer from a bad layout and switch to a less appropriate reading strategy while experts are more resistant to a bad layout and rather stick to their reading strategy. Apart from layout, also hierarchy might change the reading strategy as the natural flow of the process model needs to be interrupted when integrating sub-processes into the parent-process. As discussed for layout, how hierarchy impacts might depend on the degree of expertise. In section 2 we have discussed that when segmenting the expert's view, a decrease of accuracy is reported [35]. In line with this results, Hungerford et al. show that problem solving in

multiple diagrams occurs most efficiently with the fast-switching strategy [41]. Using this strategy, experts produce unsegmented viewing conditions in a segmented environment and can hence, fully exploit their perceptual advantage. Accordingly, experts might benefit from flat models as they can perceive a lot of information from a fixation without having to switch fast between diagrams and might also benefit from hierarchy in case they can perceive sub- and parent-processes together and thus, use a fast-switching behaviour. Hungerford et al. conclude that search effectiveness can be increased if personal is employed that uses the fast-switching strategy or if personal is trained to use it [41]. We think this seems a valid conclusion for experts but not for novices. Novices do neither have a large visual span nor access to complex domain-related LTM-schemas, which is why their WM is still limited and precludes the processing of complex global patterns and a consequent focus on task-relevant information. Hence, novices might not profit from fast-switching as they cannot perceptually encode the total amount information. As novices might not use fast-switching to perceive and process sub- and parent-process information efficiently, we suggest that they would rather not profit from hierarchy. This suggestion is in line with results from [44], who found that novices rather benefit from flat than hierarchical business process models.

Visual cuing is discussed to increase the novices' understanding. Several visual cuing strategies have been developed (e. g. [9-12],[37]) to highlight those elements that their authors deemed important for understanding. We assess if these strategies focus on those elements that experts fixate on when scanning the global patterns, to further discuss if these strategies might be used to allow novices a more expert reading strategy. To our knowledge visual cuing strategies are so far only discussed for understanding tasks, which is why we also focus on understanding. As described for specific understanding tasks, experts at some point of the reading process seem to detect the relevant region [9,42]. Yet, how do experts detect this region? Haisjackl et al. describe that subjects skim over the model for an entry point and then follow the sequential order [38,39]. Skimming over the model is further specified in [40] with creating a mental list, getting an overview, and directly starting to read the model. While creating a mental list is specific for error detection, getting an overview and directly starting to read the model can also be applied to understanding tasks. Out of these two strategies, Haisjackl et al. argue that, in particular, getting an overview is connected to expertise and specify this strategy into reading pool and lane descriptions, reading through the whole model, or analysing the structure of the model. While the strategy of reading through the whole model does not tell what particular elements experts focus on when processing the global pattern, pools and lanes as well as structure of the model are more concrete. Using this specification, we argue that pools and lanes as well as the structure of the model might be important when scanning the global pattern to further identify the relevant region.

Highlighting these elements is in line with results from Stark et al. in [10, 45], who conducted a content analysis, to find elements that readers need to identify for solving understanding tasks. According to [45], model readers first scan the whole model for some elements before they continue locally, which is why the authors distinguished in global and local search for ERD-understanding tasks. Accordingly,

ERD-readers scan the whole model for particular elements such as entity-types (global search) and continue scanning further elements around previously identified entity-types (local search). For business process modeling, Stark et al. identified tasks and pools / lanes as important for global searches. They further discussed that the process flow is rather used for local searches as for most tasks, model readers first search for two or more tasks and than continue to analyse the process flow in relation with these tasks. Nonetheless, the process flow is present throughout the whole model and some questions might require the model reader to include parts of the process flow before and after two tasks (for example in case of iterations) or to only analyse the process flow, which is why we suggest the process flow to be important also on a global level. As this is in line with Haisjackl et al., who also specified getting in overview with reading the structure of the model in [40], we suggest that also the process flow should be highlighted when using visual cues. Summarizing this discussion, we argue that process flow as well as pools and lanes might be most important to process the global patterns. Highlighting process flow and pools- and lanes, we might direct the novices' attention to the global patterns. In the following we assess whether current visual cuing strategies integrate these elements.

Visual cuing strategies have so far been used for different elements. The process flow has been highlighted by highlighting gateways [9,11,37,46] and subflows [10-12]. For highlighting gateways we can further distinguish visual cuing into task-specific and task-generic. Petrusel et al. show that task-specific highlighting can lead to increased comrehension performance [9,37] (see fig. 2). In contrast, Reijers et al. in [11] and Kummer et al. in [46] have discussed design decisions that are not task-specific. Reijers et al. coloured matching gateways and found support for novices' comprehension accuracy [11]. Kummer et al. derived different visual cuing strategies for the germanic and confucian cultural context [46] assuming that for a confucian background more intensive colours can be used than for a germanic background. In contrast, to highlight the process flow via its gateways, Stark et al. highlighted the process flow by visually distinguishing subflows [10,12]. The authors derive a visual cuing strategy that highlights gateways and boundaries of subflows (e. g. parallel or alternative subflow) and found support for the novices' comprehension efficiency in [12]. Their visual cuing strategy of [12] was further developed in [10] for the dimension of colour harmony. Table 2 summarizes the elements that are focussed on in current visual cuing strategies and contrasts these elements with those identified as important to scan the global patterns. We suggest that the design decision in [10] covers elements that are discussed as important to allow novices to first fixate those elements that experts focus on when processing the global pattern. Yet, to our knowledge effects on understanding based on highlighting gateways and subflows have not yet been contrasted, which is why also highlighting gateways (e. g. [11]) with further highlighting pools and lands might be successful to direct the novices gaze to those part that experts fixate on when first scanning the global pattern.

We further remark that prior eye-tracking and think-aloud findings of reading business process models relate to models that were usually presented from left to right. Figl and Strembeck have assessed the influence of flow direction in a pilot experiment in [47] and found no significance evidence for models for a superiority of

the left-to-right flow direction and cautiously suggest that model readers might adapt also to uncommon reading directions. On this basis, we might suggest that discussed implications might also be useful for models using other reading directions.

Table 2. Covering elements for scanning the global pattern for recent visual cuing strategies

Lit.	*Scope of highlighting*	*Process Flow*	*Pools, Lanes*
[11]	Task-generic matching gateways	X	
[9],[37]	Task-specific relevant elements within the relevant region	X	
[12]	Task-generic process flows	X	
[10]	Task-generic process flow, lanes and tasks.	X	X
[46]	Task-generic highlighting for different cultural backgrounds	X	

5 Conclusion

Our analysis yielded that experts across several domains first process the global patterns, thereby focusing on task-relevant while largely neglecting task-irrelevant information. Experts can use this behaviour as they have developed a perceptual advantage, which bases on their vast visual span and their access to complex domain-related LTM-schemas. We have further specified how experts process the global patterns in business process models by reviewing think-aloud and eye-tracking experiments. Based on the literature we summarise that in business process modeling, experts process the global pattern by focussing on the process flow as well as pools and lanes. We have further discussed that experts, in contrast to novices, might rather profit from segmentation, when presenting hierarchy so that parent- and sub-processes can be perceived together. We have further assessed wether visual cuing strategies can be used to guide the novices' gaze to those elements that experts scan when processing the global patterns. We suggest that the strategies to highlight subflows and pools and lanes as discussed in [12] or the strategy to highlight gateways as discussed in [11] with highlighting pools and lanes might be suited to guide the novices' gaze to those elements that experts fixate on when scanning the global patterns. For future research we suggest to further integrate expertise into segmentation research as experts might have different segmenation needs that novices. We further suggest that current visual cueing strategies need to be investigated with eye-tracking to further show if first fixations of novices approach the early fixations of experts, when using visual cues.

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Sharenting: Making Decisions about Other's Privacy on Social Networking Sites

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Abstract. Sharenting refers to the trend of oversharing photos of children on Social Networking Sites (SNS) by parents. At the same time, this trend is increasingly controversial as parents have to balance their right to share and children's privacy interest. Against this background we investigate parents' underlying decision process and the applied strategies to mitigate children's privacy risks when disclosing pictures of them on SNS. Based on a qualitative online survey among 220 mothers, we shed light on the antecedents of parental sharing, resulting in a comprehensive overview to guide future research and advise SNS providers. Results show that, among others, mothers reveal personal information about their children to participate in social interactions and to show their pride. On the flipside, they care about their children's privacy and the risk of their children being embarrassed or hurt. Beyond that, they apply several cost-mitigating strategies like face-covering and blurring of identifiable information.

Keywords: Social Networking Sites, Privacy, Sharenting, Photo Sharing, Privacy Risks for Others.

1 Introduction

Sharenting is ubiquitous in our digital society. It refers to the phenomenon that parents share pictures of their kids on Social Networking Sites (SNS). As taking photos increases when people have children, it is not a surprise that those get shared on SNS. A study of Nominet among 2,000 parents from the UK has shown that on average 200 pictures of a child are shared yearly [22]. In 2016, parents shared 300 photos of their kids online, with a share of 54% on Facebook [21]. In doing so, parents aim to stay connected [17], get confirmation of their parenthood [2], [32] and receive social support [20].

Despite these benefits for parents, the number of children complaining about their pictures being shared by their parents rises tremendously. Recently, a 13-year old boy sued his parents, because they had shared humiliating photos of him as a baby [3]. Beyond that, one out of ten children asks their parents to delete his/her pictures, whereas 13% felt embarrassed about something which has been shared by their parents based on a study of the Family Online Safety Institute [11]. It appears that while children (whose parents published photos of them on SNS) are getting older, they raise concerns of what and how much their parents disclose about them online. Subsequently, an

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overarching contradiction between parents profiting from information disclosure and children feeling invaded in their privacy emerges. Even though this contradiction received great attention in media and public, it has been neglected in Information Systems (IS) research.

As parents are the gatekeeper of personal information of their children, they are the ones to decide whether and how many pictures they contribute to SNS. Existing research in the field of psychology provides some valuable insights on specific determinants of parental sharing (a term used to describe the information disclosure of children by their parents throughout the paper) [16], [22], [32]. However, little is known about parent's underlying decision process and their strategies to diminish the risks for their children. Therefore, we lack a comprehensive overview of antecedents that influence the disclosure of child' pictures on SNS from a parent perspective. Against the background of this gap and the increased complaints of children, this study follows a qualitative research approach to answer the following questions:

RQ1: *What are the factors parents consider when disclosing personal information about their children on Social Networking Sites?*

RQ2: *What strategies do parents apply when disclosing personal information about their children on Social Networking Sites?*

To answer these questions, we relied on a qualitative approach (with an open-ended questionnaire) that allows an inductive perspective. More specifically, we conducted an online survey among 220 mothers. Thereby, we contribute to theory in three ways: (1) we offer a comprehensive overview of all influential factors for parental sharing, (2) we show that parents weigh up their own benefits and the costs for the child, and (3) we identify strategies parents apply to mitigate perceived risks of parental sharing. Beyond theoretical contributions, our study advises SNS providers on how to support parents to carefully share pictures of their children whereas mothers are informed that they sacrifice their children's privacy in return for their intrapersonal needs and gains.

Our paper commences with related work in the field of parental sharing while outlining its criticality in the digital age. Afterwards, we present our qualitative study along with a detailed description of the applied methodology. We then outline our results and discuss implications for research as well as SNS providers. Our paper closes with its limitations, future research suggestions and gives concluding remarks.

2 Theoretical Background

"Facebook and other online social platforms offer a new and promising platform for mothers to enact and receive validation of good mothering, …" [12, p. 1310]. Thereby, SNS provide a convenient environment to share pictures with families and friends living abroad and to a wide range of friends in parallel [12], [17]. Especially, new mothers are shown to share pictures of their baby on SNS until it turns two years old [10]. Typically, mothers are sharing cute and funny pictures, but refrain from sharing naked or other self-blaming content [14]. Several factors have been found to drive oversharing of new mothers. Psychologists observed that mothers are sharing either to validate their own motherhood or to give advice to others [28]. While they were

focusing on the drivers, other researchers investigated individual differences and the influence of oversharing on mother's well-being in general [9], [19]. Compared to sharing pictures of oneself, publishing pictures of kids sets itself off as it is a decision about another person's privacy. Petronino (2010) points out that privacy management in families is characterized by co-ownership of information and the corresponding interplay between different needs and concerns. This co-ownership can lead to potential harm to others by obtaining benefits against the risks of others [23].

From a legal standpoint, everybody has the right to be forgotten and thus parents are obliged to ask their children for permission before sharing a picture of them online. Babies and young children (0-14 years old) cannot make decisions because they do not have the necessary information to balance the advantages and disadvantages (do not know their pictures might never disappear completely from the internet, etc.). From the age of 14, the child must be asked and his/her decision must be considered by their parents [also see 27].[1]

This tension between parents' right to share and children's interest in privacy deserves attention which has been overlooked in current IS research so far. Moreover, although previous results provide knowledge for associated benefits, privacy concerns and their mental outcome, their results lack to provide a comprehensive list of influential factors which affect parent's disclosure decisions on SNS. Aiming to fill this gap and shed light on the tension between mother's right and children's need, we conducted a qualitative study which will be explained in detail in the next section. Typically, qualitative methods are used in IS research to develop new theoretical insights and uncover psychological mechanisms behind individual's decision-making [36].

3 Qualitative Study

In the following section we will describe our research design thoroughly. The data was collected and analyzed following the qualitative research approach by Mayring (2000) and established content analysis methods [18], [33]. As is usual with exploratory procedures, the research process does not apply to pre-formulated theoretical concepts in the form of hypotheses. This is in line with the suggestion by Parker et al. (2011) who pointed out that qualitative content analysis is especially suitable for the social media context and its fast moving nature [25]. A detailed overview of this process is depicted in Figure 1.

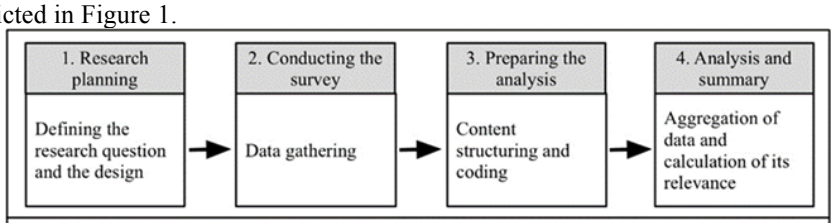

Figure 1. Qualitative research process

[1]This is regulated in the German BGB and more particularly in the UrhG.

As described in Figure 1, our qualitative research comprised four major steps; step three and four have been performed iteratively. In detail, the procedure has been applied as follows: Firstly, we defined the research questions, target group under investigation and the research design. We were seeking to understand influential factors of parental sharing on SNS. In order to investigate our research questions and to ensure that the research case is of theoretical relevance, an adequate sampling logic has to be defined [26]. We decided to focus on mothers as our target population since they are especially likely to share child photos on SNS [1], [31]. Moreover, they are frequent users of baby forums and related Facebook groups and therefore easily reachable and appeared to be willing to share their thoughts and experiences in an online survey. We decided to conduct a structured online survey with open-ended questions. It allowed us to gather unfiltered and unlimited answers. After ensuring the participants that all answers are anonymously treated and aggregated, they were directed to the main part of our survey.

As our topic under investigation were the drivers and inhibitors of disclosing child photos as perceived by mothers, the following questions were included: "Which potential draw backs do you see when sharing photos of your child on SNS?", "What are the reasons for sharing photos of your child on SNS?". To capture specific strategies mothers apply when sharing photos, we also asked: "What are the aspects you pay attention to when sharing photos of your child?". To be able to control for further characteristics of the respondents, we also included questions regarding demographics, number of children and their corresponding age. In addition, we measured SNS usage frequency [6], use of privacy settings (private versus public profile) and the type of SNS used, while relying on established literature from the SNS research domain.

The second step constitutes the data gathering. The survey was distributed via online forums and Facebook groups dealing with baby-related discussions. In total, 221 participants living in Germany and Austria took part in our survey. Of those, one participant had to be removed because she was not a mother, so finally 220 answers build the basis for further analysis. Table 1 illustrates our final sample characteristics in detail.

Table 1. Sample characteristics

Variables	*Characteristic*
Mean Age	31.1
Mean number of children	1.05
Mean age of children	2

While step 1 and 2 deal with the preparation and the conduction of the analysis unit, in step 3 we prepared the analysis of our final dataset. Step 3 is also referred to content analysis as a systematic coding and categorization of initially unstructured text [6], [27]. We used a technique of first-level coding [19] and assigned codes to all statements. Thereby, abstract statements were made to paraphrase the gathered materials and ultimately lead us to subsumed categories. The first-level coding yielded 33 subcategories. In a subsequent phase, we clustered and summarized subcategories,

conducting a sort of pattern coding [19]. By doing so it emerged that all statements fall into three main categories, namely benefits, costs and cost-mitigating factors.

In so called feedback loops, the coding was screened several times and revised accordingly [16]. To ensure reliability of our data analysis, two researchers coded the materials independently and discussed their assignments afterwards. As the two coders eventually identified different subcategories, they were renamed, adjusted or even merged. Exceptional statements with no possible assignment have been compiled in a category called 'Others'. These were unclear statements like "*A beautiful moment that is important to you"* with regard to other benefits and unique statements like *"need to talk"* which was mentioned only once among our participants. The complete process was repeated iteratively throughout the data analysis step in order to reflect new assumptions and ideas [16]. To be plausible and consistent, we spell out explicit definitions and rules for each subcategory. The underlying subcategories were taken from former self-disclosure literature whenever possible. The orientation to existing drivers and inhibitors of content sharing on SNS enables the relation to past research while identifying differences. Finally, 17 determinants of photo sharing of parents emerged and theoretical saturation was reached [35]. Descriptions of the applied categorization are presented in Table 2, 3 and 4.

During the last step we analyzed our coded data [16]. Against this background, we calculated the relevance of each subcategory assuming that it is reflected by the number of statements. As a result, we retrieved tables with benefits, costs, cost-mitigating strategies, its deeper explanation and the accumulated relevance of each determinant. These tables serve as units for further analysis in the next section.

4 Results

After categorizing and quantifying the narrative materials of our qualitative study, the results have to be analyzed and interpreted against the background of common knowledge and theory. Thereby, the aim of this section is to respond to the research questions [26].

Most participants used Facebook (86%) or Instagram (13%) frequently and their profiles are predominantly set private (91%). The posting behavior showed that 60% of mothers in our sample have never shared a picture of their children and 26% share photos of their children less than once a month. This demonstrates that mothers in our sample mostly feel that the costs of sharing their kids' photos outweigh the benefits. 26% of the participants believe that they have no right to decide whether to share their children's photo. These comments where coded as 'Right of the Child' and are not part of any subcategory, because these mothers don't consider the benefits and costs to make any decision. This is reflected by statements like *"My child, if it is old enough, should decide for himself what gets shared online"* or *"It's the right of my child to decide about its ownership. Only my child can decide if and when photos should go online. Parents should not post photos to protect their child's personal rights"* complying with legal requirements in Germany delineated in section 2.

The results section is organized around the three identified determinates of photo sharing about ones' own children: perceived benefits, perceived costs for the children as well as cost-mitigating factors. Since most participants stated more than one determinant, the total number of counted benefits and costs is higher than the sample size. In order to be comprehensive and to narratively describe our results we present certain quotes from our dataset along with each subcategory [31].

4.1 Benefits

As depicted in Table 2, our study reveals that five benefits that drive mothers to share photos of their children on SNS: social participation, pride, confirmation, envy of others and perceived convenience. Beyond that, 36 percent of the participants do not perceive any benefits with regard to 'sharenting' on SNS.

Table 2. Identified benefits along with their description and relevance

Determinant	*Description*	*Relevance (%)*
Social participation	Inform others, keep others up-to-date and document the child's development	18
Pride	To show their pride of their own child	11
Confirmation	The need to be liked, approved and accepted by others	5
Envy of others	To make others	3
Perceived convenience	Sharing information on SNS is easy and effective	3
None	Considering no factor	36
Other	Unclear or unique statements	4

First of all, social participation leads mothers to disclose photos of their children on SNS. Thereby, they are able to keep their families and friends up-to-date about their lives even though they don't see each other frequently in person. This corresponds to the statements *"I would like family and friends to participate in my life"*. The driver of being able to inform others is also discussed in extant literature on self-disclosure on SNS. This is often referred to as relational benefits [10], [20]. In contrast to prior studies about posting behavior in SNS many mothers mentioned the emotional driver pride. That is not surprising, because pride is the predominant affect when feeling accomplished and successful [34]. A typical statement for the determinant pride was *"I am proud of my child and therefore I would like to show it to the whole world"*. Some mothers even admit that the envy of others is also a driver, exemplified by *"It feels good to show my child to others and maybe some even get a little bit envious"*. Corresponding to posting in general, confirmation is also a determinant in case of sharing children's photos. Statements like *"Who aims to get as many likes as possible, has good chances with baby and children photos"* imply that photos with one's child are used to get 'Likes' in return, but it is not clear if mothers want to get confirmation especially in the context of their mother role. Some describe SNSs as an effective

communication tool to share information quickly to a broader range of audience: *"In the case of an extensive network of friends and family, it is of course advantageous if one can show his children without immense effort.",* which is subsumed in the category perceived convenience.

4.2 Costs for the Child

Derived from our study, two perceived costs of parental sharing are identified: privacy risks and face risks for the children as outlined in Table 3. The relevance of 41% shows that mothers mostly care about privacy risks for their children. A typical comment for privacy risks for the children was *"The photo is quickly distributed and might fall into wrong hands"*. Contrary to privacy risks, mothers also care about the face risk of their children. *"There is a fundamental risk that the child will be ashamed of the picture later"* was a typical statement. The comments are constituted of two axes: the concern that the child might feel ashamed about the picture and the concern that others might see the picture as blameworthy and thus the child will feel embarrassed.

Table 3. Identified costs along with their description and relevance

Determinant	*Description*	*Relevance (%)*
Privacy risks for the child	The risk of privacy invasion for the child. Mothers are afraid to lose the control over private information about their child.	41
Face risks for the child	The fear of the child being embarrassed, being the victim of cyber-bullying or simply being negatively evaluated.	6
None	Considering no factor	4
Other	Unique statements	<1

Although two cost factors are predominant, one mother mentioned that she is concerned about *"the envy of others"* which impedes her from sharing. This unique comment was categorized as other costs. Additionally, it is important to note that only 4% of the participants do not consider any cost factor associated with the sharing of their children pictures.

4.3 Cost-mitigating Factors

To respond to RQ2, we also analyzed the strategies mothers apply to reduce their perceived risks when sharing children photos. While mothers seek to obtain certain benefits, they would like to limit or even avoid the perceived costs for their children. Thereby, we identified the following strategies: identifiability, hiding of information, appropriateness, avoidance of oversharing and the age of the child as potential strategies. This is expressed in Table 4.

Table 4. Identified cost-mitigating strategies along with their description and relevance

Determinant	*Description*	*Relevance (%)*
Identifiability	To actively cover the child's face with emoticons or to take a picture without showing a face	40
Appropriateness	Harmless content of the picture	37
Avoidance of oversharing	Sharing only special and no daily moments to reduce the number of posts	5
Hiding of information	To hide information like name, location and age	2
Age of child	Pictures get shared as long as the child is within a certain age range	1

The most frequently mentioned strategy was identifiability. Mothers protect the children's personal information by covering the face in different ways: *"I share my children's photos only if the child is not recognizable. For example, from the back or anonymized by putting stickers on its face"*. Mothers also pay attention whether the content of the picture is appropriate. Mainly, they focus on the clothing. Thereby, they mitigate the face risk for the child; *"Should be beautiful, not naked, nothing that evokes feelings of shame for the child in the future"*. To hide information is another strategy of mothers to mitigate especially privacy risks for the children. A typical statement was *"Not recognizable where it was shot: not at her school or kindergarten. Nameless"*.

Mothers also intent to share only special moments like milestones of the development of their children. This strategy was called avoidance of oversharing: *"I'm not trying to post pictures permanently"*, *"I only share pictures of birthdays etc."*. Just a few mothers said that they only share children pictures within a certain age range as babies look similar and thus their privacy is not invaded: *"The child soon looks quite different"*.

5 Discussion

In the following, we relate our findings to extant research and discuss the implications for research and practice. The goal of our research was to unveil parents' decision-making process along with its antecedents when sharing photos of their children on SNS (RQ1). Moreover, we were seeking to identify strategies mothers are applying to reduce the perceived costs for their child when disclosing their photos on SNS (RQ2).

In total, 11 antecedents for parental sharing have been identified. 4% of our participants were unable to think of any costs whereas 36% were only stating concerns. Among the latter 41% are concerned of their children's privacy. In order to mitigate the perceived costs, mothers are following different strategies like appropriateness and identifiability.

By conducting a qualitative research study [16] we provide a deep understanding of the costs, benefits and cost-mitigating factors perceived by parents based on an open-ended survey study among 220 participants. Thereby, we contribute to IS research in

two ways: First, we expose that the disclosure decision for child photos is different from self-disclosure previously investigated in IS privacy research [12] as parents weigh their own benefits with the costs for others. Particularly, they focus on the perception of privacy risks for others instead of ones' own privacy risks. Parents are solely concerned about the privacy risks of their child, whereas self-disclosure decisions are usually affected by the intrapersonal trade-off between ones' own privacy risks and benefits [5]. Although, past research has shown that individuals are far less concerned about others' privacy when they feel that they pertain others' information [33], we found contradictious results. Apparently, privacy risks for others associated with the disclosure of photos might be dependent on the closeness and thus the relationship to the other person. As parents are obliged with the responsibility to care for their children, our results show that a great share (36%) of our participants can only associate costs with parental sharing.

Narratively showing that parents apply cost-mitigating strategies to reduce the perceived privacy risks of their child constitutes our second theoretical contribution. By doing so, we shed light on the guidelines parents apply when they reveal personal information about their family members. These guidelines are consistent with Communication Privacy Management theory (CPM) [27]. Apart from the risk-benefit-trade-off, the main element of CPM is that people "… construct rules to determine if and when they will disclose personal information …" [12 p. 337]. Transferred to our results, parents coordinate privacy boundaries by applying certain specification on pictures which they are willing to share on SNS. While parents highlight that they are reluctant to share insensitive information, they avoid to share sensitive information that make their child identifiable. For instance, they tend not to share pictures that are offensive or blameworthy, which obviously applies to naked pictures. But beyond certain rules for non-sharable pictures, parents edit or abstract the information that gets shared. They do so by masking or hiding the face of their kid and by withholding their location data. Applying these privacy boundaries, parents protect their children from privacy invasion while obtaining desired benefits of photo sharing. Although our identified strategies sound reasonable, research found evidence that there is an intention-behavior gap underlying those mitigating factors [15] with parents oversharing photos of children while stating the opposite.

Finally, our qualitative study showed that 3% of mothers share photos of their children because they seek to be envied by others. This sounds surprisingly at first sight, but can be explained by Foster's self-esteem theory [7]. Foster coined this factor competitive axis. It refers to individuals' enjoyment of outperforming others. Individuals present their accomplishments or their superiority over others to be seen as valuable. This competitive axis has been neglected in past research, whereas it is shown that envy is the strongest feeling when using SNS passively [13]. Apart from envy, our results revealed that pride is the major affective factor which drives mothers to disclose photos of their child. Taken together, mothers seem to show their pride while enjoying the pleasure of being envied by others.

Beyond theoretical contributions, we also provide practical implications for policy makers, parents and SNS providers. Policy makers should work on clear regulations to guide parents on when to disclose personal information about their children. Parents

should be made aware that they are obviously sharing information about their child driven by their own benefits like pride by sacrificing risks for their children.

SNS providers can implement features to easily edit photos of children by offering functionalities to conveniently cover faces. Moreover, SNS providers should give parents a check-list at hand, which needs to be considered before sharing pictures. This check-list might include picture requirements like appropriateness, identifiability etc. to avoid parents from sharing potential embarrassing pictures of their children while still profiting from the benefits of parental sharing.

6 Limitations, future research and conclusion

As every research project, our paper is subject to limitations. Firstly, we focused exclusively on mothers living in Germany or Austria in our research sample. As females in general and mothers in particular are the more frequent users of SNS, they are assumed to be oftentimes confronted with the decision to share photos of their children. By doing so, we excluded fathers and did not consider cultural differences. To be able to transfer our knowledge to parents in general and fathers in particular, our results should be validated with a broader sample.

As extant research did not provide adequate insights on the disclosure formation process of parents, we relied on a qualitative approach. This constitutes our second limitation. Unlike quantitative methods, qualitative research is biased in the direction of the foreknowledge and the subjective interpretation of the content [36]. We were trying to mitigate this disadvantage by having two researchers coding the dataset in parallel. The predominant critic of qualitative research is its issue of generalizability [4]. Given that sharenting is still an emerging phenomenon in research, with concerns related to others' privacy as a new determinant and existing theories lack in terms of offering a comprehensive set of factors that individuals might consider when making the decision of parental sharing, an exploratory qualitative study offered a rich mechanism to elicit these factors. Future research can base their assumptions on these factors to test the model using a quantitative study while enhancing generalizability of our results.

To conclude, sharenting is discussed controversially as parents have to balance their benefits and their imminent right to share with their children's interest in privacy. Our results show that mothers undergo a complex decision process between benefits for themselves and risks for their children. In total, 11 antecedents have been identified. In order to reduce children's privacy costs, mothers are applying creative strategies like hiding faces with emoticons. Additionally, two 'deadly' sins (own pride and others' envy) have been found to drive parental sharing. SNS providers can build on our results to better guide mothers in their decision process. For research, we provide a comprehensive overview of antecedents for sharenting highlighting the multitude of factors affecting the decision to share information about children.

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Trust the Experienced? Investigating the Effect of Experience on Decision Making in the Crowd

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Abstract. Companies increasingly use the crowd for collective decision making. Currently the most popular approach used to aggregate multiple decisions is majority voting. This approach however can lead to suboptimal outcomes by, on the one hand, neglecting different levels of individuals' experiences and, on the other, ignoring decision biases to which individuals are prone. As an alternative to simply averaging judgements, researchers have proposed weighted models that favor more experienced judges in the crowd. However, previous research is inconclusive as to whether more experienced judges are any better at avoiding decision biases. To shed light on this question, we conduct several experiments using the well-established bias known as the anchoring effect. Results indicate that a greater level of experience does not decrease reviewers' tendency to follow the displayed anchor, and consequently does not reduce their proneness to decision bias.

Keywords: Crowdsourcing, anchoring effect, biased decision, experience.

1 Introduction

With the advent of online ideation communities, the challenge of effectively screening a large number of ideas is more relevant today than ever [1]. The crowd is increasingly used not only to generate new ideas but also to evaluate these ideas, which can be numerous [2]. The method of using a large number of judgements - the so-called wisdom of the crowd - offers several advantages since it i) maximizes the amount of information that a decision draws upon, given the sheer diversity of information backgrounds that a large number of different people bring to a decision and, ii) it reduces the potential impact of 'outliers' - extreme decisions based on unreliable or simply inaccurate information sources. The currently favorite application for using the wisdom of the crowd approach is to simply average the judgements of each individual decision in the crowd [3]. Though, this can lead to suboptimal outcomes since it neglects external information such as experience [4]. As an alternative to simply averaging individual judgements, researchers have proposed weighted models that favor more experienced judges in the crowd (e.g. [5]). The assumption behind this approach is that more experienced judges are less likely to be biased in their decision making. However, previous studies on decision making in the offline context show

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contrasting results. While some studies indicate that knowledgeable people are less influenced by biases (e.g. [6]), others show contrasting results, suggesting that even knowledgeable people with experience in a given context are significantly biased (e.g. [7]). With respect to these conflicting results, we want to shed light upon the question of whether more experienced people in the crowd are less likely to make biased decisions. Hence, we aim to answer the following research question:

Are more experienced people in the crowd less inclined to make distorted decisions?

To answer this question, we use the established anchoring effect [8] in experiments on a commercial crowdworking platform, giving the crowd 80 different business model ideas to rate. We implement the anchor, i.e. information about previous rating results, using it as a treatment, and analyze the effect on individual raters' decisions. We then ask each individual rater about her background experience in several dimensions such as business models, the product category (perfume) and their experience in retail and analyze the effect of experience on the occurrence of the anchoring effect. Results indicate that experience in different dimensions does not decrease the probability to follow the anchor and therefore does not protect against distorted decisions.

2 Related Literature

2.1 Anchoring Effect in Decision Making

The anchoring effect describes the disproportionate influence of an initially presented value on decision makers [8]. The occurrence of this effect has been shown in a variety of different domains such as general knowledge [9] or probability estimation [10]. Previous studies show that both uninformative as well as anchors with informational relevance to the task itself can influence the decision. In a classic study, [8] randomly generated anchor values by spinning a wheel of fortune between 0 and 100 and afterwards asked the participants to estimate the percentage of African countries in the United Nations. The given anchor values had a strong influence on their following estimation, since high anchor values led to significant higher estimations than low anchor values [8]. Another study found that the estimation of an athlete's performance could be anchored by the number on his jersey [11]. Anchors with relevance to the task can also lead to the anchoring effect: in an example from the legal domain, higher damage awards were obtained when higher compensations were requested in court [12].

2.2 Influence of Experience on Anchoring Effect

Previous literature on the influence of experience on the anchoring effect show contradictory results. On the one hand one could argue that people with high expertise should have greater knowledge and experience, which would mean they would be less influenced by the anchors provided. This is supported by research which shows that both people with high certainty about an answer [10] and with greater relevant knowledge are less influenced by anchors [6]. On the other hand, it could be argued that the underlying mechanisms to the anchoring effect - notably the "conformity

search" [10] and "selective accessibility" [13] - are such fundamental cognitive processes that people regardless of their experience and knowledge could fall victim to this effect. Previous research also supports this position, indicating that people are influenced by anchors regardless of their experience ([14], [7]).
Thus, research in the field shows contradicting results, on the one hand indicating that experienced people are less influenced by the anchoring effect while others show the anchoring effect to be a robust effect in human decision making regardless of the experience of decision makers.

3 Methodology

To answer our research question we design an experiment which enables us (1) to analyze the occurrence of the anchoring effect in idea evaluation on a crowdworking platform and (2) to investigate whether experience might protect people from being influenced by the anchoring effect. The ideas in our experiment were taken from previous research [15], in which students generated business model ideas for perfume in a classroom experiment. All ideas are presented in the same way, consisting of the nine elements of the Business Model Canvas [16]. We designed evaluation tasks on *Crowdflower*, a commercial crowdsourcing platform. We divided the ideas into eight blocks of ten ideas each and randomly assigned each idea to one block. Each participant had to rate the displayed ideas on a seven-point scale in terms of creativity, novelty and usefulness [17].
To avoid the occurrence of a learning effect and potential rating bias through users who assign themselves to several tasks in succession, we allowed each participant only to assign themselves to the job once. Each block of ideas was evaluated by twenty different contributors, each earning 0.50€ for the evaluation of one block of ideas (= ten ideas). We calculated the average rating of each idea based on crowd evaluation. This part of our experiment represents the control condition in which each individual had to evaluate the ideas without the display of an anchor. To analyze the influence of the given anchor and of the experience on the anchoring effect, we designed two additional experiments with two different treatments, enabling us to investigate the anchoring effect. First, we designed an experiment *(Crowd_Anchor)* where the information about the previous evaluation resulting from the control condition of each idea was displayed above the rating scale. Second, we designed another additional experiment *(Random_Anchor)* where the only difference was that for the displayed rating, each idea was assigned a randomly generated rating between 1.0 and 7.0. The general task design of the control condition was retained for both additional experiments.
Further, all participants had to answer a short survey with respect to their experience in addition to the evaluation task. Experience can be defined as the acquisition and cumulative knowledge of reality, mechanisms, rules, and procedures related to a specific domain [18]. To address different dimensions of individuals' experience, we ask each participant about their experience regarding the following dimensions: Context/market mechanism, platform experience, product knowledge and business models. After the idea evaluation was completed, we further asked each subject about their confidence in evaluating the displayed business model ideas. All scales ranged

from 1 = “Not at all” to 7 = “Absolutely agree”. Further, since we need a benchmark for idea quality to know whether the randomly assigned rating of an idea strongly deviates from a more professional evaluation of idea quality, we recruited two experts to evaluate the ideas, one from our university’s entrepreneurship center and another who works as a senior in-house consultant in a large corporation. Experts commonly represent a benchmark since they are characterized by their experience and typically consider relevant characteristics such as feasibility and business potential when evaluating ideas [19].

4 Results

4.1 Analyzing the General Occurrence of an Anchoring Effect

To analyze the general occurrence of an anchoring effect, we first calculated the average rating of each idea in each experimental condition. Table 1 presents the descriptive statistics for all 80 ideas for the control condition *(No_Anchor)* as well as both experimental conditions.

Table 1. Descriptive Statistics

Condition	Obs.	Mean	Std. Dev.	Min.	Max.
No_Anchor	80	4.58	.412	2.60	5.87
Crowd_Anchor	80	4.59	.479	3.35	5.5
Random_Anchor	80	4.39	.745	2.60	5.87

To investigate the general occurrence of the anchoring effect, we first analyzed the distributions of individual ratings from each experiment (Figure 1). As can be seen, the given distributions differ depending on whether and which anchor was shown in the condition. For example, in experiment 2 we can see a “range reduction effect” with people tending to provide a rating close to the average rating of experiment 1. In contrast, if showing a randomly generated anchor in experiment 3, we see a much broader distribution.

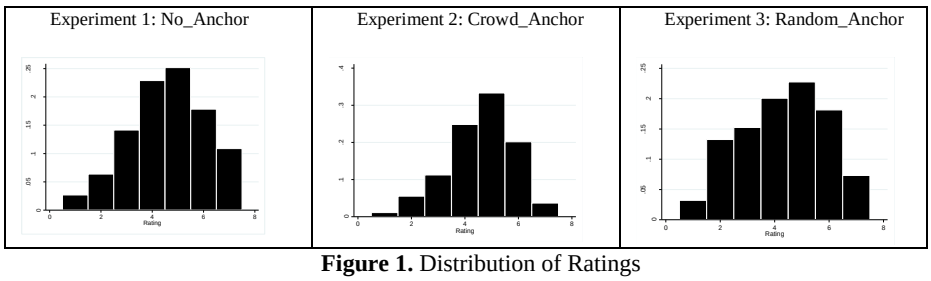

Figure 1. Distribution of Ratings

In addition to a visual inspection of the distributions, we use a common measure of the distance between two distributions, the Kolmogorov-Smirnov statistic. The Kolmogorov-Smirnov statistic between two cumulative distributions is defined as the maximum absolute difference between two distributions.

Table 2. K-S Statistics for Comparison of Distribution

Conditions	Difference (Combined K-S)
No_Anchor - Crowd_Anchor	.0716 (.001)**
No_Anchor - Random_Anchor	.0851 (< .001)***
Crowd_Anchor - Random_Anchor	.1378 (< .001)***

Note: *p <.10; **p < .05; ***p< .01

Results (Table 2) indicate statistically significant differences in the distribution of ratings for all experiments. We can assume, therefore, that a general anchoring effect occurred in experiment 2 and experiment 3, resulting in a significantly different rating behavior displayed by participants.

4.2 Analyzing the Anchoring Effect Depending on Experience

To analyze whether more experienced people are less inclined to be influenced by the displayed anchor, we further investigate the ratings of experiment 3, where we displayed a randomly generated rating between 1.0 and 7.0 for each idea. Although the probability is quite low, it still could be the case that even the random rating reflects the professionals' rating of the idea (= experts' rating) and therefore, following the anchor might only represent a rational decision. To address this issue, we only analyze ideas where the difference between the displayed anchor and the experts' rating was ≥ 2, which means that for example an anchor of two or lower was assigned to an idea rated four by the experts. In sum, we analyzed 740 observations. We used a logistic regression with dependent variable =1 if the person's rating was consistent with the displayed anchor. Due to the fact that people could only rate integers (for example: 4) while the anchor was provided as a float (for example: 4.2), the dummy variable is =1 if the person's rating was closer to the provided anchor. If the anchor was 4.4, for example, and the person rated the idea with 4, the dummy variable would be 1. In contrast, if the provided anchor was 4.6, the dummy variable would be 1 if the person rated the idea with 5 since this value is closer to the provided anchor than 4. To avoid multicollinearity in our model, since some variables consisted of several items, we conducted a principal component analysis [20] to summarize multi-item variables. Thus, we consider the following model [21]:

$$Y^* = \beta_0 + \beta_1 Mem_i + \beta_2 BMC_Exp_j + \beta_3 Perf_Exp_j + \beta_4 Retail_Exp_i + \beta_5 Conf_Rating_j + \varepsilon,\ Y = 1[Y^* > 0].$$

Mem_j represents the reported length of membership on the platform of a person. Further, BMC_Exp_j captures the multi-items for the reported experience in business models, while $Perf_Exp_j$ captures the different items for the reported experience and knowledge of perfume. $Retail_Exp_i$ represents the reported experience in months of a participant working in retail, while $Conf_Rating_j$ covers the reported confidence of the participant when evaluating the business model ideas. Results (Table 3) indicate that experience in different dimensions do not significantly decrease the probability to follow the displayed anchor. In other words, higher levels of experience do not increase protection against making a distorted decision following a randomly generated anchor.

Table 3. Results of Logistic Regression

Variable	Coef.	Std. Dev.	z	P > |z|
Mem_i	.0096	.0066	1.45	.147
BMC_Exp_j	-.0423	.1278	-.33	.740
$Perf_Exp_j$	-.0029	.0880	-.03	.974
$Retail_Exp_i$	.0001	.0018	.08	.937
$Conf_Rating_j$	.2292**	.1380	1.66	.097
Constant	-2.859***	.7665	-3.73	.000
Controls[1]	✓			

Notes: *p < .10; **p < .05; ***p < .01; [1]Gender and age

Surprisingly, results indicate that people who follow the displayed anchor feel more confident about their rating. One possible explanation for this result could be the so-called "conformity bias" [22], meaning that when people become uncertain about what to do, they are more likely to depend on others for the answer. Hence, when participants in our experiment rated the idea conform to the displayed anchor, they feel more confident about their decision since it seems to be in line with previous others.

5 Conclusion

In this study we investigate whether more experienced people in a crowd are less prone to distorted decision making. Our results indicate that experience in different dimensions does not decrease the probability to follow an anchor and therefore does not protect against distorted decision-making. We can conclude, therefore, that anchoring has a robust effect on human decision making regardless of the different experience levels of decision makers. Our study contributes to the body of literature on aggregating multiple judgements in crowdsourcing as well as to literature on the anchoring effect. In addition to contributing to research, our results also have managerial implications for task designers in crowdsourcing, since our results illustrate that weighted mechanisms to aggregate multiple judgements can also lead to biased results. However, we also acknowledge certain limitations, for example, the specific task assigned to the crowd (evaluation of business model ideas for perfume). Thus, we suggest that additional studies with other ideas or tasks should be conducted to investigate whether the effect is constant for different tasks or types of ideas. In the future, we seek to gain additional insights into the reasons for distorted decision making. Another focus could be to develop potential solutions in crowdsourcing task design aimed at minimizing distorted decisions and de-biasing decision making.

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Extracting the Wisdom from the Crowd: A Comparison of Approaches to Aggregating Collective Intelligence

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Abstract.
To benefit from crowdsourcing, companies are increasingly required to employ mechanisms for aggregating the multiple opinions generated in this process. Previous research, however, has raised concerns with the currently most popular method used for this purpose: majority voting. We conduct an experiment to compare different aggregation methods and measure their performance. Our results confirm these concerns and identify other, confidence-based aggregation approaches that provide significantly better results in identifying the right answer. Moreover, by differentiating between different levels of question difficulty, we find that the average confidence approach provides the highest percentage of correctly identified answers across different categories of questions. Our findings both extend the existing literature on aggregation approaches used for collective intelligence, and offer practical insights. Since we use a crowd on a commercial crowdsourcing platform, our results offer valuable insights for companies using or planning to use a crowd for collective intelligence.

Keywords: Crowdsourcing, collective intelligence, wisdom of the crowd, aggregation approaches.

1 Introduction

Crowdsourcing is a large and growing phenomenon [1]. It is defined as "[…] *the act of taking a task once performed by an employee and outsourcing it to a large, undefined group of people external to the company in the form of an open call*" [2]. One application of crowdsourcing is so-called crowd voting, in which a large number of people are recruited on online platforms to give their opinion on various topics [3]. Applications of crowd voting include political and economic forecasting, public policy, or evaluating nuclear safety [4]. Firms also increasingly employ mechanisms for aggregating multiple opinions, especially when navigating markets that are difficult to predict (e.g., [5], [6]).

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The concept of crowd voting is generally based on the wisdom of the crowd effect, which posits that the aggregated opinion of the crowd is superior to any individual opinion, even those of experts [7]. However, one major challenge when drawing on the wisdom of the crowd is how to aggregate the different, heterogeneous opinions for the best and most meaningful overall results. Currently, the most popular way to aggregate a multitude of opinions is a democratic voting procedure, in which all opinions are simply aggregated without using any weighting or filtering of judgements [8]. However, this method has serious limitations. The literature finds that, for example, individuals' judgements are frequently too extreme, that they are overconfident in their reported rating ability, or that their judgments are biased by the anchor effect [9], [10]. Another reason why crowds' wisdom might fail is because the aggregate estimate was largely distorted by a systematic group bias or by a large number of uninformed judges [11]. This leads us to the following research question:

Which approach for extracting wisdom from the crowd yields the best and most reliable results in the context of crowd voting?

Previous studies suggest different approaches for aggregating multiple judgements, including a new and promising alternative approach, the so-called *surprisingly popular approach*. As the name suggests, this approach is based on selecting the answer that is unexpectedly more popular than people predict it to be [4]. While this approach has haled to good and reliable results in one prior study [4] which used selected offline crowds (students and dermatologists), it has not yet been tested with a real-life anonymous online crowd. Hence, our study aims to investigate whether the *surprisingly popular approach* also leads to good and reliable results when used with a more diverse, anonymous online crowd on a commercial online platform. We then compare this new approach with other aggregation mechanisms used in this context to investigate which approach provides the best and most reliable results.

2 Background

2.1 Wisdom of the Crowd

The wisdom of the crowd effect has a long history and has attracted the attention of scholars for a considerable time (e.g. [12], as an early example) including current researchers (e.g. [13]). The general idea of this effect is simple and can be described as follows: when predicting an unknown outcome (for example the weight of an object), the central tendency of different, individual estimates represents the true value of the unknown outcome more closely than any one individual estimation [14]. In comparison to a single individual estimation, this approach offers several advantages because it i) maximizes the amount of information available for the decision, estimation, or prediction task; ii) reduces the potential impact of extreme or aberrant sources that rely on faulty, unreliable, and inaccurate information; iii) increases the credibility and validity of the aggregation process by making it more inclusive and ecologically more representative [15]. Previous literature [16] suggests that there are conditions that are

necessary for a crowd to be wise: i) the diversity of the crowd, ii) a particular kind of decentralization and iii) the independence of judgements. In the online contexts, the third condition especially is often violated since, if information is provided, people can easily observe the decision made by others, leading to decision making influenced by a previous decision maker [17]. Literature demonstrated that even a mild social influence can undermine the wisdom of the crowd effect for simple estimation tasks [18]. However, if the conditions described above are met, previous literature suggests that the average of the judges - the wisdom of the crowd effect - beats the average judge [8]. Estimations derived from a large heterogeneous group has even been found to outperform samples of homogeneous experts [7], [18].

2.2 Aggregation Mechanisms

The reason why groups outperform individuals is based on the statistical principle that aggregation of imperfect estimates reduces error, resulting in better and more reliable results [19], [20]. As mentioned in the introduction, due to the popularity of crowdsourcing, the methods used to aggregate multiple opinions for collective decision making has come under scientific scrutiny (e.g. [14]), in particular the popular democratic method which merely calculates the average of judgments. Its limitations include cognitive decision biases and lack of relevant knowledge on which individuals in the crowd base their decision-making [11], [21]. To overcome this limitation, different additional approaches have been developed (Table 1), including: Majority voting (MV), confidence weighted (CW), confidence only (CO), average confidence (AC), and surprisingly popular (SP). In the following, we briefly explain each of these approaches.

Table 1. Different aggregation mechanisms

	MV	CW	CO	AC	SP
Input	Multiple judgements	Multiple judgements, confidence		Confidence of the judgements	Multiple judgements, predicted popularity
Key numbers	Multiple judgements	Weighted number judgements	Number of judgements with confidence = 100%	Average confidence	Actual and predicted popularity
Decision criteria	Majority of judgements	Majority of weighted judgements	Majority of 100% confident judgements	Highest average confidence	Actual popularity > predicted popularity
Literature	[22]			[23]	[4]

Majority voting (MV) is the simplest approach to aggregate multiple judgements. The only input needed are the judgements of the crowd. The decision for one possible answer is based on the majority of votes for this answer.

The *confidence weighted* (CW) approach, in contrast, requires the confidence of each judgement as an additional input. By including the confidence of an answer it is possible for participants to signal their confidence level when answering the question.
Similarly to the confidence weighted approach, the *confidence only* (CO) approach also includes the confidence of each judgement. However, the confidence only approach solely includes judgements by participants with very high levels of confidence (confidence = 100%) in their ability to identify the correct answer. In contrast to the other approaches described above, the *average confidence* (AC) approach is solely based on the confidence of judgements to identify the correct answer. The decision criteria is based on the highest average confidence for a possible answer. In other words, this approach identifies the answer representing the highest average confidence as the correct answer.
The *surprisingly popular* (SP) approach is a relatively new approach, developed by Prelec at al. [4]. In contrast to other methods, this also takes into account the predicted popularity of an answer. Apart from asking each individual to judge which answer is the correct one, participants are then asked to predict what percent of the crowd they think will give a certain answer, for example, whether the statement is true. The decision for identifying the best answer is made by comparing the actual popularity of an answer given by the crowd with the predicted popularity. The algorithm identifies an answer as correct when its actual popularity is higher than the predicted popularity, hence the method's name, "surprisingly popular". To illustrate this approach, we use the following example: if we ask the crowd whether a saxophone is a brass instrument, we assume that the majority of judgements would answer "yes" since a saxophone is made of sheet metal. Hence, people who answer "yes" would also predict that most of the other individuals would give the same answer. However, a person with more knowledge in this topic area would know that the sound of a saxophone is generated by a wooden reed, which is why it is classified as a woodwind instrument. Therefore, this person would answer "no" and in addition, would also predict a high percentage of people who would answer with "yes" since she assumes that this specified knowledge is not widely shared.
Previous literature already investigated different approaches for collective decision making. Most related to our study is that by Prelec et al. [4] who compared the results of majority voting, surprisingly popular, confidence weighted and confidence only approaches. Their findings show that the surprisingly popular approach leads to the best and most reliable results [4]. However, participants used in this study have mainly been offline crowds (students) or homogeneous crowds (dermatologists), labeling specific images displaying benign and malignant lesions [4]. Therefore our study aims to compare the performance of five different approaches for aggregating multiple judgements by using a heterogeneous crowd on a commercial online crowdsourcing platform.

3 Experimental Design

To investigate which approach leads to the best and most reliable results, we designed an experiment on the online crowdsourcing platform *Crowdflower*. In line with

previous literature [4], we designed a task consisting of 35 factual questions of general knowledge, including the categories geography, music, literature, sports, politics and history. The questions were a subset of true/false quizzes from the quiz site *Sporcle*[1]. Since we used a commercial online crowdsourcing platform, the jobs offered here are usually business related tasks. To avoid that our tasks appear unnatural as well as to avoid experimenter demand effects [24], we told the subjects in our instructions that we work for an institute dealing with the general education of the population in Germany.

In a first step, we conducted a pilot experiment with the aim to differentiate the levels of question difficulty. We conducted this pilot experiment for two reasons: First, by differentiating between levels of difficulty we could ensure that each participant had to answer questions on a comparable level of difficulty. By so doing, we aimed to avoid subjects getting frustrated when facing too many questions they would find difficult. Second, the differentiation of difficulty enables us to further investigate how different approaches to aggregate the judgements perform for different levels of question difficulty.

We divided the questions into two blocks of 20 questions each, including five questions that were assigned to both blocks of ideas since we needed to have two equally sized blocks of 20 ideas each. We randomly assigned each participant to one of the two blocks of questions. Each contributor had to answer whether the proposed statement was right and if they answered that the statement was wrong, an additional answer field popped up, asking them to submit the right answer. Participants were not able to assign themselves to the task several times. Each participant received a monetary reward of 0.15€. In sum, 64 different subjects participated in this pilot. Based on the percentage of correct responses to the questions, we divided the questions into three different categories of difficulty (Table 2).

Table 2. Categories of difficulty

Categories	Percentage of correct answers	Number of questions
Easy	> 75%	13
Medium	75% - 50%	11
Difficult	< 50%	13

Based on the results of our pilot experiment, we designed the main experiment of our study. We formulated our instructions in line with our pilot experiment. Further, we adopted the type of questions to test the performance of the *surprisingly popular* algorithm by formulating each question as a statement where each subject had to decide whether the statement was right or wrong (in line with [4]). For example, one statement was: "A saxophone is a brass instrument" followed by the question, whether this statement is right or wrong. In addition, we also asked each subject how confident they felt in answering this question. Subjects could respond in integers varying from 50%, which is equivalent to a coin toss, meaning that they have been totally uncertain, to

[1] http://www.sporcle.com

100% which would indicate that they have been absolutely certain about their answer. We then asked each subject to think about other people's answer to this question and to predict the percentage of people who would give a certain answer, for example that the statement is true, varying from 1%, indicating that almost no other person said the statement is true, to 100%, indicating that all other persons would rate this statement as true. We informed the subjects that about 100 other subjects would answer the same questions to simplify the prediction of what percent of people would guess the answer as true (Figure 1). This design enables us to investigate different aggregation mechanisms since we monitor the majority voting of the crowd, the confidence levels of each question for the crowd, and the opportunity to apply the *surprisingly popular* algorithm by asking subjects about other people's belief in respect of the answer. Hence, we are able to analyze the results of five different aggregation mechanisms.

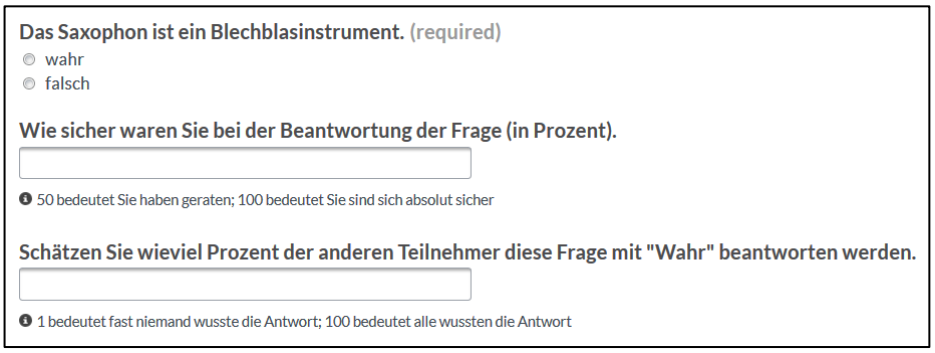

Figure 1. Example of a question

Since it would be unreasonable to ask each subject to answer all 35 questions, we split the questions into two blocks of 20 questions each based on our categories of difficulty. Because we could not divide 35 questions into two blocks of 20 ideas each, we equally filled the missing places with easy questions into both blocks to obtain equally sized question blocks. We added eight easy questions to each block. Since both categories of "medium" and "difficult" questions consist of odd numbers, we assigned six medium and six difficult questions into block one and five questions from the category "medium" as well as seven questions from the category "difficult" into question block two. We further developed a linear optimization model to compare the difficulties of questions in each block based on the exact percentage of correct answers given in the pilot experiment. The optimal solution found by the model excluded two questions from the category "easy". This seems acceptable, because all aggregation mechanisms should find the correct answer for these questions anyways. Finally, we controlled whether difficulties of questions within the first and the second half of each block of questions was comparable, in order to avoid, for example, assigning several difficult questions in succession.

In sum, 206 subjects (74.4% male) on average 37.9 years old, participated in our experiment, with 100 answering the questions in block 1, and 106 subjects answering the questions in block 2. Each participant received a monetary reward of 0.20€ for answering the block of questions. Participants also rated the clarity of instructions and

the payment on a five point scale, with five indicating the best possible value. As the clarity of instructions was rated as 4.3 and payment rated as 3.8, we concluded that participants were generally satisfied with the task design.

4 Results

4.1 Overall Performance

In a first step, we compare the overall performance of each approach without differentiating between difficulties of questions. Performance in this context is measured by the percentage of correctly identified answers when using different approaches to aggregate the judgements. Figure 2 shows that the *majority voting* approach provides the lowest percentage of correct answer (62%), while the *average confidence* approach provides the highest percentage of correct answers (97%).

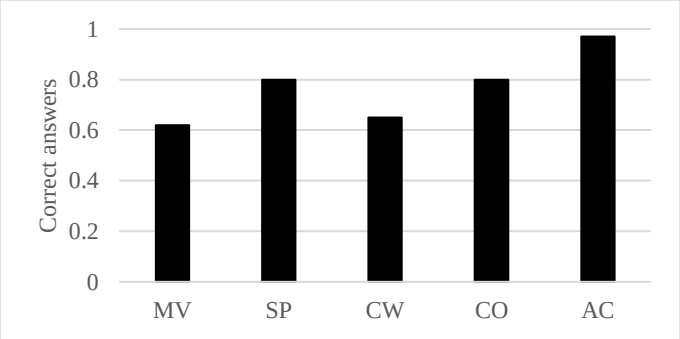

Figure 2. Overall performances

In a next step, we compared the uplift, i.e. the increase of performance between the different approaches, to aggregate the answers. Since the *majority voting* approach is the most commonly used approach in practice [8], and the overall worst performing approach, we calculated the differences between the performances of the *majority voting* and the other four approaches.
Following previous literature [4], we used two-sided matches-pair tests [25], [26] to compare the number of correct answers, hence the increase in performance of the different approaches compared to the *majority voting* approach.

Table 3. Increasing performance compared to majority voting approach

	Surprisingly Popular (SP)	Confidence Weighted (CW)	Confidence Only (CO)	Average Confidence (AC)
Perf. Uplift	+ 17.1%	+ 2.8%	+17.1%	+ 34.2%
P-Value	0.115	0.804	0.115	0.000

The *average confidence* approach generated the highest and the only statistically significant increase in overall performance compared to the *majority voting* approach (Table 3). However, taking into account the relatively small number of questions (n=40), the p-values for both the *surprisingly popular* as well as the *confidence only* approach come close to the allowable upper boundary of $p = 0.1$, indicating a significant increase compared to the *majority voting* approach.

Following previous literature [4], we further calculated classification accuracy by using categorical correlation coefficients such as Cohen's kappa [27] as well as Matthews correlation [28] which allows frequencies of different correct answers to be imbalanced, resulting in high percentage agreement driven by chance. In line with the results mentioned above, the *majority voting* approach shows the lowest percentage of agreement while the *average confidence* approach shows the highest agreement with the correct answers (Table 4). All levels of agreement for the different approaches are highly statistically significant, indicating that the agreements were not driven by chance.

Table 4. Cohen's Kappa for each aggregation approach

	Agreement	Expected Agreement	Kappa	Std.Err.	Z	P-Value
MV	62.86%	43.10%	0.347	0.128	2.71	0.003
SP	80.00%	49.47%	0.604	0.155	3.89	0.000
CW	65.71%	44.16%	0.386	0.133	2.89	0.001
CO	84.85%	50.51%	0.693	0.165	4.19	0.000
AC	97.14%	55.84%	0.935	0.168	5.54	0.000

Finally, the Matthew correlation coefficients (MCC) further confirm the results, indicating the weakest correlation coefficient for the *majority voting* and in contrast, the highest correlation for the *average confidence* approach (Figure 3).

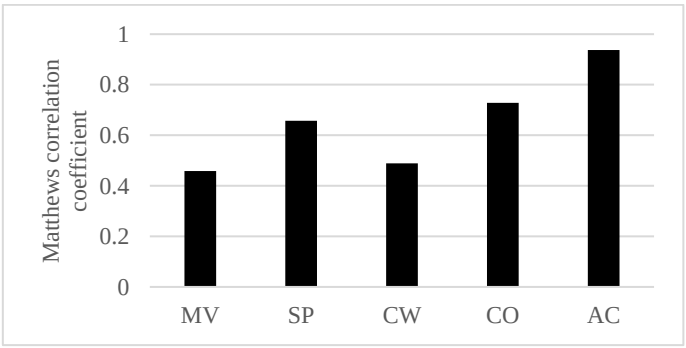

Figure 3. Matthews correlation coefficients

4.2 Further Analyses

We conducted further analyses to investigate how the different approaches perform for questions depending on the level of difficulty of questions. Because all approaches

performed well for easy questions with almost all participants having given the correct answers for this category of questions, we further analyzed the performance of the different approaches for the difficulty levels "medium" and "difficult". When only investigating the performance for the questions in the "medium" category, all approaches perform better compared to the overall performance (Figure 4). In line with the overall performances, the *majority voting* is outperformed and leads to the weakest percentage of correctly identified answers. Further, both the *surprisingly popular* algorithm and the *average confidence* approach provide 100% correct answers.

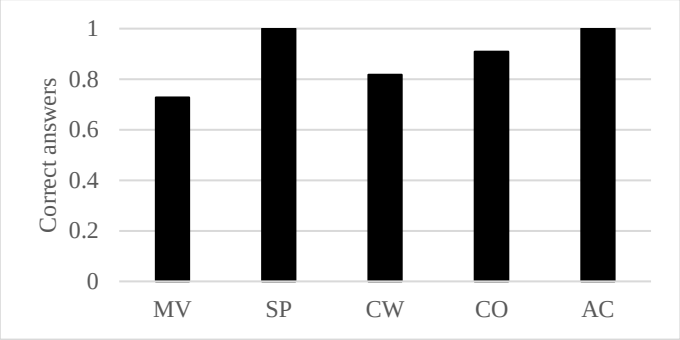

Figure 4. Performance for questions of difficulty category „medium"

Taking the above results into account and comparing them with the overall performances, we assume that the lower overall performances should mainly be driven by the performances for the difficult questions. Hence, we additionally analyze the performance for the most difficult questions.

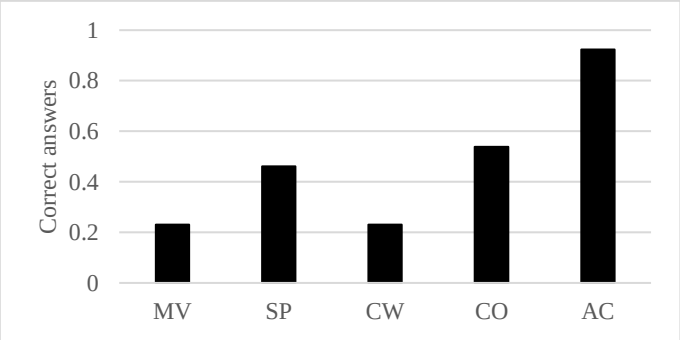

Figure 5. Performance for questions from the category "difficult"

Despite the average confidence approach, all other approaches perform much worse compared to the overall performance (Figure 5). More specifically, the *average confidence* approach provides significantly better results (+38.4%, p= 0.03 by two-sided matches-pair test) than the second best approach, the *confidence only* method. Again, *majority voting* is outperformed by all others approaches analyzed in our study. Hence we can conclude that the average confidence approach leads to the best and most

reliable results, providing the highest percentage of correct answers across all different categories of questions.

5 Conclusion

With the rise of crowdsourcing, the importance of collective decision making has increased and firms increasingly employ mechanisms to aggregate multiple judgements [6]. However, the currently most popular method to aggregate multiple judgements, the *majority voting* approach, is simply aggregating all judgements without taking account of the confidence or expertise of participants. Since this approach carries several limitations and tends to lack reliability [8], we investigated a number of other approaches to aggregate a large number of judgements and compared their performance with each other. Moreover, we differentiated different categories of difficulties for the questions asked and investigated the performances of the different aggregation methods depending on question difficulty. Results indicate that the *average confidence* approach provides the best results across all different categories of questions while the *majority voting* provides the lowest percentage of correctly identified right answers. In contrast to previous literature [4], the *surprisingly popular* approach did not provide the highest percentages of correctly identified right answers in our study. Explanations for this result can be twofold: Compared to the offline experiments conducted in previous research [4], we used a much more heterogeneous and anonymous crowd. In contrast to the crowd used in an offline context, e.g. when asking dermatologists to answer several questions, the crowd used in our experiment had no information about other participants, for example about their educational background. Hence, the crowd was not able to predict the popularity of the answer across the whole crowd correctly since the participants had no information about the level of knowledge of other participants. Second, for the same reason of being unable to estimate the knowledge level of other members in the crowd, people might overestimate the collective intelligence, also leading to wrong results. However, in contrast to the confidence based approaches in our study (CW, CO and AC), the *surprisingly popular* approach needs approximately fitting predictions of the popularity of answers which seems hard to guess for an anonymous crowd.

Our study contributes to literature in several ways. First, we contribute to the literature on collective intelligence by comparing different approaches to aggregating multiple judgements. Our results confirm existing concerns regarding the *majority voting* approach and reinforce the need to develop other, more reliable methods for collective decision making. Second, in contrast to previous studies [4], we use a heterogeneous online crowd on a commercial crowdsourcing platform. By doing so, we apply a very practical approach since not every company has the opportunity to recruit its own internal crowd to answer their questions. Using external crowdsourcing platforms with millions of potential contributors offers a valuable alternative for companies to use almost unlimited personnel resources. The difference in relative performance for an online setting compared to the previously examined offline settings might suggest that

different aggregation methods could differ in performance based on the composition of the crowd. Apart from contributing to literature, our results also have managerial implications for companies currently using or planning to use crowd voting for collective intelligence. Companies should avoid using a simple majority voting approach since it may not lead to reliable results. Accordingly, companies should employ approaches that take an additional input into account, for example, by applying confidence based methods which offer the advantage of including participants' confidence or expertise in their judgements. Finally, when aggregating results companies should consider the origination of the crowd, since it could influence the reliability of the chosen aggregation method. While our study provides important insights relevant for research and practice, we acknowledge certain limitations that ought to be considered. First, the questions used in our experiment are very specific, in order to see if the results are generalizable, further research is needed. Nevertheless, we suggest to carry out additional studies with other types of crowd voting tasks to investigate the influence of the composition of the crowd on different aggregation methods. Second, due to the online setting of the experiment, we cannot rule out that some of the participants look up answers on the internet. However, the design of our experiment allows us to track this behavior to some extent, by counting how often the window with the questionnaire got sent to the background. There seems to be no systematic differences between the different blocks. We hope that our work will open up new avenues for future research, investigating new ways to aggregate multiple judgements and extract the wisdom from the crowd.

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Conceptualizing IT Resilience: An Explorative Approach

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Abstract. Modern technologies such as mobile phones and wearables are increasingly embedded in our daily life which makes detachment almost impossible. Therefore, understanding personal characteristics that allow individuals to buffer negative effects is an important tool to reduce negative consequences of technology use. Extant literature on technostress provides initial insights into how individuals are able to handle stressors. However, important constructs have not yet been investigated. We contribute to existing literature on technostress by proposing IT resilience as a new construct that can be considered a coping mechanism for technostress. We present the results of an explorative factor analysis (n=80), which suggest that IT resilience is a multi-dimensional construct with three sub dimensions: bounce back, self-efficacy, and coping. We conclude with a discussion on how to include IT resilience in theory development and human centric design.

Keywords: IT Resilience, Technostress, Explorative Factor Analysis

1 Introduction

Information Technology (IT) is a fundamental part of our daily life and is integrated into our daily routine. Mobile technologies such as mobile phones or tablets in particular are widely used and are, thus, object to a great number of research [1]. Emerging technologies including affective technologies [2], wearables [3], or smart textiles [4] are further contributing to the omnipresence of IT.

As a consequence of this development, Information Systems (IS) research has not only recognized positive aspects of IT but also revealed potential pitfalls. In this vein, the 'dark side of technology' [5] has emerged as an important research area within the (IS) discipline. Within this movement, technology-induced stress (i.e. technostress) has been introduced and analyzed from various perspectives [6–8] in order to investigate causes and consequences of technology-related stress and its outcome.

Despite the increasing efforts to understand technostress both research and practice see a high number of individuals that are affected by technology-induced stress. The impact of technostress becomes visible with regard to mobile phone use [9, 10]. The prevalence of technostress is unfortunate because it has a negative influence on productivity [11], job satisfaction [8], and job performance [8]. Therefore, both organizations and individuals can benefit from avoiding technostress.

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Since technology is a growing aspect of our daily life, individuals rely on effective strategies in order to reduce negative influences such as technostress. Therefore, it is imperative to investigate individual characteristics that are effective tools to counteract technostress and can later be used to design technology. However, current literature only provides initial insights into individual characteristics in the context of technostress [12]. Without investigating potential characteristics, it is difficult to reduce technology-induced negative consequences.

In this context, the purpose of this study is to expand the current body of knowledge by conceptualizing a new individual characteristic, namely IT resilience. Resilience has gained a lot of attention in stress-related domains (see for instance [13]). Unfortunately, it has not yet been adapted for the IS domain. In this paper, we present the results of an Exploratory Factor Analysis (EFA), which provides evidence that IT resilience reflects three dimensions: bounce back, self-efficacy, and coping. Taking all of these into account, this paper seeks to adopt resilience for the IT domain.

This paper is structured as follows. First, we review existing literature on resilience and provide an overview of its central characteristics and demonstrate the relationship between resilience and the IT domain (section 2). Next, we summarize our scale development procedure (section 3). In section 4, we present our research methodology and the results of an EFA. This paper concludes with a discussion of the results, its implications on theory and technology design, and provides fruitful avenues for future research by taking into account current limitations.

2 Related Work

The term resilience originates from material sciences to describe the property of an object [14]. It is especially used to describe how an object behaves under pressure and whether it is able to "bounce back" into its original state. The concept of resilience can easily be observed in mattresses. Putting a mattress under pressure deforms its shape (usually into a U-form). Due to its design, however, a mattress is able to "bounce back" into its original form.

This example can be applied to how an individual perceives stress. In other words, a high degree of resilience enables an individual to return to an initial state (i.e. a balanced state). Since being resilient is an important aspect of modern life, psychology and sociology have already adopted this notion and defined it as the ability or the measure of coping with stress to support resistance or bounce back in stressful situations [15, 16]. Note that resilience as a concept is not about being invulnerable to negative effects but the ability to overcome and manage stress (perception).

Despite numerous attempts to conceptualize resilience (in psychology and sociology) a common definition does not yet exist. Therefore, we refer to a widely adopted notion (e.g. [17]) that can be adopted for IS literature [18] and which summarizes core aspects used in other studies (e.g. [15]). Accordingly, resilience can be defined as "an individual's positive psychological state of development that is characterized by the following (a) having confidence (self-efficacy) to take on and put in the necessary effort

to succeed at challenging tasks; (b) having a positive attitude (optimism) towards succeeding now and in future; (c) keeping track of goals and when necessary, readjusting paths to achieve goals (hope) in order to succeed; and (d) when faced with problems and adversity, sustaining and bouncing back (resiliency) to attain success." [18]. In the following, we refer to this notion acknowledging that resilience is related to self-efficacy, a positive attribution, focus on goals and the ability to bounce back.

As described above, resilience refers to a set of individual features that are relevant when dealing with environmental stress-related effects. For the IS discipline, the most important environmental aspects are technology-related. Therefore, technology use as well as technological characteristics can trigger stress perception. Based on this notion, we define IT resilience as follows: IT resilience is a set of individual features that allows an individual to absorb negatively perceived external influence factors that are induced by information technology and allows returning to an initial state. We refer to Luthans, Youssef and Avolios (2007) definition [18], to juxtapose resilience with IT resilience.

Table 1. Resilience and IT Resilience

Themes	*Resilience [18]*	*IT Resilience*
Self-Efficacy	"having confidence (self-efficacy) to take on and put in the necessary effort to succeed at challenging tasks" [18]	confidence (self-efficacy) in working with **(mobile) technologies** regardless of the situation (stress, challenging tasks, errors), respectively the ability to adapt to these situations-
Positive attribution	"making a positive attribution (optimism) about succeeding now and in future" [18]	being optimistic about finding solutions for problems as well as being adaptable towards **technology-induced** stress, problems or tight deadlines
Preserving towards goals	"preserving towards goals and when necessary, redirecting paths to goals (hope) in order to succeed" [18]	Keeping track of **technology-related goals (e.g. use behavior)** and if necessary readjusting paths to achieve goals by having structured plans
Bounce back	"when beset by problems and adversity, sustaining and bouncing back and even beyond (resiliency) to attain success."	when faced with **technology-related problems (e.g. technostress)** and adversity, sustaining and bouncing back to succeed as well as cultivating social contacts and keeping a work-life-balance.

3 Scale Development Procedure

3.1 Review of existing scales

Previous literature has provided numerous measurement scales for resilience that have been established for specific targets (c.f. Table 2). Resilience has its root in (clinical)

psychology to understand how individuals and groups are dealing with diseases. Therefore, it is not surprising that a great number of scales are focusing on clinical aspects (e.g. [16, 19]). Existing scales are also diverse with regard to its target group. For example, measurement scales have been specifically developed for adults (e.g. [15, 20]), children (e.g. [21, 22]) or the elderly (e.g. [19]). Similarly, the scales are targeting different domains including workplaces (e.g. [23]) or clinical applications (e.g. [16]). There are also different scales with regard to the underlying unit of analysis. Some scales have been developed to assess the individual (e.g. [15, 24]), others for group evaluations (e.g. [20, 25]) and organizations (e.g. [23]).

Table 2. Overview (adopted and extended from [17] and [26])

	Name		*(number of) dimensions*
Individual	CD-RISC [15]	(5)	personal competence, trust / tolerance /strengthening effects of stress, acceptance of change and secure relationships, control, spiritual influence
	Dispositional resilience scale [27]	(3)	commitment, control and challenge
	RSA [24]	(5)	personal competence, social competence, family coherence, social support, personal structure
	RS [28]	(2)	personal competence, acceptance of life and self
	Brief Resilience [16]	(1)	ability to bounce back or recover from stress
	Ego Resilience [29]	(4)	confident optimism, productive activity, insight and warmth, skilled expressiveness
	READ [30]	(5)	personal competence, social competence, structured style, family cohesion, social resources
Group	FRAS [20]	(6)	family communication and problem solving, utilizing social and economic resources, maintaining a positive outlook, family connectedness, family spirituality, ability to make meaning of adversity
	CCRAM [25]	(5)	leadership, collective efficacy, preparedness, place attachment, social trust
Organizational	BRT-53 [31]	(2)	planning, adaptive capacity
	BRT-13B [32]	(2)	planning, adaptive capacity
	RAW [23]	(7)	living authentically, finding your calling, maintaining perspective, managing stress, interacting cooperatively, staying healthy, building networks
	Team Resilience Scale [17]	(4)	group structure/enabling structure, mastery approaches, social capital, collective efficacy

Although various scales have been developed for resilience, none of them acknowledges the role of IT. Against this background, we develop a new scale for IT resilience in the following.

3.2 Preliminary measurement instrument for IT resilience

Since resilience has already been established in other domains, our scale development procedure does not start with a blank slate. In other words, we adopt items from existing instruments. For this preliminary study, we identified 30 items from existing scales to cover all dimensions of resilience as proposed earlier. More specifically, we included existing items for self-efficacy. Since previous literature considers self-efficacy to be a core aspect (e.g. [18]), there is no available scale on the individual level. In order to maintain content validity, we therefore adopt an IS-specific scale [33] to capture this aspect. In the context of resilience, being able to rely on one's instinct is related to self-efficacy. Therefore, we included another five items from an existing scale to capture this specific aspect as well [15]. Next, we adopted nine items from the brief resilience scale [16] and from the RAW scale [23] in order to cover the ability to "bounce back". Then, we included three items from the resilience work scale [23] to include coping. Since literature in this context often refers to hardiness (e.g. [19, 34]), we also included four items to include this aspect of coping. To include the ability to focus on goals, we included items proposed by Friborg et al. [24]. After identifying the relevant constructs and items, the sentences were adapted for the IT context by introducing sentences as well as slightly adopting the measurement items. We particularly paid attention to simplifying the questions to avoid misunderstandings. To ensure that the participants understand the context, we ask them to imagine situations from work where IS use has caused problems. An overview of all measurement items used in this study can be found in the following table (Table 3).

Table 3. Measurement Instrument

ID	*Adapted item*	*Reference*
In situations where stress is caused by technology in general or technology use, …		
RES1	… I tend to bounce back quickly.	[16]
RES2	… I have a hard time making it through those situations.	
RES3	… It does not take me long to recover.	
RES4	… It is hard for me to snap back.	
RES5	… I usually come through those times with little trouble.	
RES6	… I tend to take a long time to get over it.	
When using my technologies, …		
CP2	...I make sure I take breaks to maintain my strength and energy.	[23]
CP3	...I am careful that they do does not dominate my personal life.	
HD1	...I am able to adapt to changes.	[15]
SE1	...I am confident in working with them.	[33]
SE2	…I feel comfortable with them.	
SE3	…I am sure I can work with them.	
SE4	…I can work with them even if no one tells me how to do it.	
SE5	…I can handle them better than most.	
When things go wrong or I have problems in using technologies, …		
BB1	...they usually overshadows the other parts of my life.	[23]
BB2	...they don't ever "faze me" for long.	

BB3	...they drag me down.	
CP1	...I have developed some reliable ways to relax.	[23]
HD2	...I can deal with whatever comes.	
HD3	...past success gives me confidence for them.	[15]
HD4	...I have close and secure relationships.	
INST1	…I can make unpopular or difficult decisions.	
INST2	…I prefer to take the lead in problem solving.	
INST3	…I see the humorous side of things.	[15]
INST4	…coping with this stress strengthens me.	
INST5	…under this pressure, I focus and think clearly.	
SST1	…I prefer to have structured plans.	
SST2	…I maintain daily rules even in difficult situations.	[24]
SST3	…and I have a goal, I do my best to attain it.	
SST4	…regular rules make my daily life easier.	

4 Research Methodology

4.1 Data collection and descriptive statistics

The data was obtained via an online questionnaire shared on different social media platforms like WhatsApp and Facebook. The survey was accessible for two weeks and a total of 177 people participated. Since technology induced stress is not limited to defined working hours, we excluded participants that are not using their mobile technologies outside their regular working hours for work-related purposes (45 participants). After removing incomplete observations as well as outliers, the final sample yielded 80 observations. Hence, the sample size exceeds the suggested requirements for an EFA [35]. An overview of the descriptive statistics is provided in Table 4.

Table 4. Descriptive Statistics

Age	*n*	*%*	*Working Hours*	*n*	*%*	*Gender*	*n*	*%*
18-30	58	74,3	<30	33	42,8	male	38	48,1
31-40	10	12,8	31-40	24	31,2	female	41	51,9
41-50	8	10,3	>41	20	26,0			
> 50	2	2,6						

4.2 Data analysis

We used an EFA in order to address our research objective. Both the Kaiser-Meyer-Olkin (KMO) measure of sampling adequacy (.693) as well as the Barlett test of sphericity ($\chi^2 = 760{,}49$, $p < .000$) support the use of an EFA. Since the objective of this research is the development of an IT resilience scale with few meaningful components, we used a principal component analysis (PCA) for this purpose [36].

We analyzed the item correlations in order to reveal non-correlated (< .3) or too highly correlated (>.9) items. As a result, we dropped items with correlations that are

too low (SST3, INST2). No items were excluded due correlations that are too high. Next, we analyzed the anti-image matrix and excluded all items that are below .5. To that end, we further dropped ADP4 (.467), SST1 (.421), SST4 (.398), and CP1 (.487). Therefore, 24 items remained for further analysis.

The results of the EFA (24 items, KMO = .780, Barlett test of sphericity (χ^2 = 816,323, $p < .000$), Eigenvalue ≥ 1) indicate that out of seven factors, only four factors explain more than ten percent of variance. Therefore, we decided to continue our analysis with four factors.

Next, the EFA was conducted with a pre-defined number of four factors. Again, we analyzed the anti-image matrix and excluded items with loadings below .6. As a consequence, we dropped CP3 (.561). Furthermore, we dropped HD2 due to cross loadings on two factors. As a consequence, only three factors remained explaining more than ten percent of variance. This step is also supported by the results of the scree plot. Finally, we dropped INST1, INST5, ERS1, and CP2 due to too low factor loadings (<.5). Our final scale includes three factors with 17 items. The construct correlations of the identified constructs are shown in Table 6. All constructs have a significant correlation between .3 and .5.

Table 5. Measurement Instrument

ID	*Factor 1*	*Factor 2*	*Factor 3*	*Cronbach's α*	*IT Resilience*
RES2	,752				
RES3	,708				
RES4	,653				
RES5	,776			.846	
RES6	,633				
BB1	,590				
BB2	,554				
BB3	,644				
HD1		,586			.859
ADP1		,804			
ADP2		,698		.808	
ADP3		,854			
ADP5		,661			
HD3			,709		
HD4			,609	.676	
INST3			,728		
INST4			,698		

Table 6. Correlations between the Constructs

	(1) Factor 1	*(2) Factor 2*	*(3) Factor 3*
(1) Factor 1	1	,316**	,437**
(2) Factor 2	,316**	1	,344**
(3) Factor 3	,437**	,344**	1

4.3 Interpretation of the identified factors

Factor 1 describes the ability to bounce back when technostress occurs. Consequently, we label this factor "bounce back". This dimension of resilience is in line with previous literature (e.g. [16, 23]) describing one of the most discussed aspects of resilience: the ability to recover from technology induced stress [16, 17, 19]. At the heart of this construct is the ability to survive this adversity and return to the previous level of functioning. The bounce back factor has a reliability of α=.846 and consists of eight items. These eight items make the most extensive factor of the IT-resilience measurement scale proposed here.

Factor 2 describes the ability to believe in one's own skills and to work with (mobile) technology in every situation. In line with related IS literature, this factor is labeled as "self-efficacy". The second factor has an α = .808 and includes five measurement items. Most items used here are adopted from the self-efficacy scale [33] and the CD-RISC scale [15], which is in line with other operationalizations of resilience.

The last factor (factor 3) describes the ability to handle negative aspects and problems of technology use by seeing things in a humorous way and having social support. Therefore, we label this factor as "coping". The factor has an internal consistency of α=.676 and uses four measurement items. Since this is an explorative study, the value of α is sufficient (e.g. [37]) and allows for further interpretation. Note that the number of items is imbalanced. Since each item loading is above .4, the distribution of items is not an issue (e.g. [38]).

The results of our factor analysis suggest that IT resilience has three dimensions: *bounce back, self-efficacy* and *coping***.** The results highlight the fact that a positive attitude and social support have a positive influence on resilience. Furthermore, the results in table 7 emphasize that this attitude can support the ability to bounce back. This is in line with previous (non IS) literature that has conceptualized resilience in a similar way [16, 17, 19].

5 Discussion

The research objective of this paper is the conceptualization of resilience for IS research. The results of the survey data indicate that IT resilience can be conceptualized with three dimensions: bounce back, self-efficacy, and coping.

The dark side of technology is increasingly acknowledged in IS research [5, 39]. This paper contributes to that research stream by providing a new construct – IT Resilience – that can be used to explore negative consequences of technology use. Existing literature has already investigated the role of coping mechanisms [12, 40]. IT resilience is able to extend these insights and expand on previous literature.

With the individualization of IS [41, 42] technology use is becoming omnipresent. This development has caused a movement towards the conceptualization of new constructs. For example, IT identity has been proposed [43, 44] to capture the omnipresent, inseparable interaction with IT. Similarly, psychological ownership of technology has been proposed [45–47] to explore what happens when technology is used beyond specific boundaries. With this development, negative consequences are inevitable. In this

light, new constructs are needed that allow the analysis of contemporary use behavior. Promising constructs that have the potential to do so have been proposed (see for instance mindfulness [48, 49]). IT resilience expands existing efforts by offering a new lens to analyze use behavior in light of negative consequences. Therefore, it is can be used in combination with related constructs such as IT identity [43, 44] or psychological ownership [45–47].

Note that IT resilience as introduced here is multi-dimensional. Therefore, it shares the common characteristic of multi-dimensional constructs, including the ability to explain phenomena of interest more comprehensively. Against this background, IT resilience a promising candidate for a multi-dimensional construct that can be adopted for existing as well as future research areas. For example, studies that have already looked at coping mechanisms [40] can refer to IT resilience to gain deeper insights.

Although IT resilience is a primarily psychological construct, it is an appropriate perspective to enhance human centric design. Existing literature points out that psychological and biological aspects are important aspects when it comes to technostress [50]. On a conceptual level, extant literature proposes the notion of an Explanatory Design Theory (EDT) [51, 52] to investigate such relationships, i.e. the relationship between design features and effect variables such as technostress. Acknowledging that technology design is a potential cause for negative consequences [53], IT resilience as proposed here is an important aspect that can be included in design theories (on the effect side). IT resilience can also inform a designer on how to design an IT artifact. For example, *bounce back* mechanisms can be included in technology design to enhance the overall IT resilience of a user. We can find related examples in e-mail systems that employ automatic answer mechanisms. In summary, design theories can draw from IT resilience to either build design features or to include the construct on the effect side, which makes this construct relevant for design science.

6 Outlook and Limitations

Just like every piece of research, this study has limitations that pave the way for future research. Because IT resilience has not yet been adopted for the IS domain, this research is exploratory in nature. Therefore, future research can draw from these insights to go one step further by means of confirmatory investigations such as confirmatory factor analysis or embedding IT resilience in IS theories. Moreover, future research may further investigate IT resilience by analyzing the concept of coping from an emotional and problem-focused point of view. In the same vein, future research needs to investigate IT resilience within different groups. This research builds upon a sample with a high number of young people. However, previous literature has shown that IS-related phenomena such as IT resilience can differ between groups. With regard to IT resilience, this heterogeneity might also become relevant for different age groups for example.

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Self-tracking or Not? That is the question. Item Generation for Construct Development

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Abstract. Self-tracking describes the measurement efforts of an individual towards collecting, storing, analyzing, as well as reflecting and acting upon data on personal activities. Technological innovations enhance the current trend for individuals to collect data of private activities such as walking, eating, expenditures, or resource consumption. Yet, despite predictions of such an emerging trend, many users show contradictory behavior (refuse to buy a device, stop using it). Thus, scholars increasingly attempt to explain this contradicting behavior. First approaches from adoption theory and cognitive dissonance theory encompass the concept of attitudes. I aim to enhance empirical research in this context by developing a specific attitude towards self-tracking scale that can be used in surveys with private individuals. In this research-in-progress-paper, we present domain specification and a first set of 65 items derived from 24 explorative interviews.

Keywords: Self-tracking, Quantified Self, Attitudes, Item Generation, Construct Development

1 Introduction

Information systems (IS) find their way into private lives with individuals tracking and analyzing data concerning e.g. sleep patterns, nutrition, expenditures, or physical activity [1]. Research [1–3] and practice [4] recognize the potential of self-tracking technology to become a major emergent trend and mainstream technology. For example, market research institutes predict that 160-245 million wearables will be sold in 2019 [5] and already between 2014-2015 their adoption has already doubled [6]. Yet, research [1, 7] and practice [6] acknowledge many barriers at different stages of self-tracking which encompass design and functionality issues or the motivation and attitude of individuals that leads to contradicting behavior (purchase refusal, discontinuance). In this sense, research investigates several theoretical explanations and models (such as cognitive dissonance or adoption models) for contradicting reactions to computer mediated self-tracking activities that also contain the established concept of attitudes [2, 3]. Considering the factors that lead to contradicting behavior, the price appears to be the most important factor. Then, other factors follow that can be described as attitude (tracking device helps to be more productive, no utility is seen, usage is unforeseen, etc. [6]).

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For this reason, I take on and extend the first attempt from Baumgart [8], who try to explain contradictory reactions from self-tracking users with cognitive dissonance theory. However, we focus on one basic component that has been used efficiently in psychology and IS research for years to understand human behavior: the concept of attitudes. Due to the fact, that existing IS models and theories originate from a largely organizational and professional context [9], they need to be updated because in the private context – where still a majority of self-tracking appliances are used – other factors determine human behavior [10]. As the major data collection instrument in IS relies on surveys [11], I want to build an attitude scale from scratch and therefore, ask the following questions for this research-in-progress (1) and the overall attitude development project (2):

(1) What are the unique attitudes that individuals share who (a) use and (b) who do not use self-tracking devices and applications?

(2) How can we measure these attitudes in a reliable and valid way?

For full disclosure, please be aware that the work at hand is the second article reporting on the status of our overall project, already presented in [12].

2 Theoretical Background

Self-tracking describes the measurement efforts of an individual towards collecting, storing, analyzing, as well as reflecting and acting upon data on personal activities [1]. Examples encompass nutrition, fitness, or expenditure tracking. In literature, synonyms such as quantified self, lifelogging, self-experimentation, self-monitoring, and self-measurement are being used. Individuals have been self-tracking personal data with - manual techniques (e.g., with paper and pen, weight scale) for more than decades [13]. Now, with the trend of digitalization and miniaturization, self-tracking is enhanced by technology-based devices which ease the tracking process, such as pedometers (www.Fitbit.com) or energy consumption trackers (www.amphiro.com).

One major issue within research is to understand self-tracking behavior for different domains. Interesting topics in IS research concern adoption or continuous usage of self-tracking devices for health, fitness, and well-being [2]. This is very restrictive to one domain of application although many other interesting domains exist (such as finances, resource consumption, etc. [14]). Additionally, IS adoption research, in particular, aims for a more quantitative measurement. The advancement from an interpretivist to a positivist paradigm is a natural step within science and reflects maturity [15]. Yet, as for now, scholars engaged into the adoption and continuous usage of self-tracking technologies only started to revisit and adapt current IS theories (theory of planned behavior) and models (discontinuance model) predominantly in a conceptual and interpretivist manner [3, 8, 10] (interviews, content analysis of presentations, observations, etc.).

At this point, scholars have enhanced and sometimes tested a short range of methods and theories to better understand self-tracking behavior. Baumgart [8], for example, used cognitive dissonance theory to explain the experienced controversial reactions to self-tracking devices. She shows that individuals often experience cognitive dissonance

when they find out that they do not reach their goals. One of three possible ways to reduce this dissonance consists of changing attitudes (as an environmental cognitive element). Baumgart [8] calls for more quantitative studies to test their model. An attitude scale could support such research efforts to engage into quantitative testing. For that reason, we intend to focus on attitudes within our research.

For understanding behavior in social psychology, attitudes are a central phenomenon. Attitudes are defined as "an individual's positive or negative feelings (evaluative affect) about performing the target behavior" [16] and originate from social psychology. The concept of attitudes has influenced explanatory theories of behavior in many disciplines for decades [17]. Amongst others, IS adoption research applies the concept of attitudes to explain IS usage and adoption [17, 18] and scholars call for more reconsideration of the attitude construct in research.

Existing attitude scales are often used for individuals already using a well-understood and defined technology. However, the phenomenon isn't that clear to individuals. Some are already self-tracking when stepping on a scale each morning, but they might not be aware of that while answering a survey on self-tracking. Thus, we aim to developed a specific attitude construct (e.g. towards the Internet or knowledge sharing [19, 20]).

For those reasons, we will develop a measurement construct from scratch for investigating the attitudes towards self-tracking (no matter if technologically or manually). The following section summarizes the construct development method that structures our overall project. In specific, we focus on domain specification and item generation as first steps for the construct development.

3 Methodology

The construct development process is based on the major phases from Smith et al. [21]. The first stage encompasses: domain specification, item sample generation, content validity assessment, and model specification - a more detailed description can be found in [12]. For this paper, the first two steps will be presented. Transcripts from explorative interviews and a literature review serve as a basis.

Lewis et al. and MacKenzie et al. [22, 23] describe the **domain specification** on different levels. Lewis et al. [27] suggest working on (1) the premise (purpose and/or importance), (2) the conceptual definition, and (3) a list of dimensions. MacKenzie et al. [28] only focus on the conceptual definition and describe four major factors that are subject of the construct conceptualization: (a) Examination of "the focal construct in prior research or by practitioners", (b) specification of "the nature of the construct's conceptual domain", (c) specification of "the conceptual theme of the construct", and (d) definition of "the construct in unambiguous terms". Both definitions and descriptions will be used for my domain specification.

Then, **item generation** follows. For example, literature reviews and interviews help to formulate and gather a first set of items. Such qualitative data is analyzed by content analysis. Such a technique "uses a set of procedures to make valid inferences from text" (Weber 1990). It encompasses document selection (newspapers, transcripts, etc.) and

sampling, (text) encoding/categorization, interpretation, and quantitative/qualitative analysis. Succeeding to select the sources for a content analysis, coding is a focal step of content analysis. It also includes interpreting textual content and allocating a specific code to the text passage.

As a next step, we derive items from 213 pages of written transcripts from 24 explorative interviews. Further information on the interviewees and the interview selection can be found in [12]. Three individuals independently reviewed the transcripts and each conducted one content analysis iteration for all interviews. Two iterations were based on a paper-pen method and another one via computer assisted analysis with MAXQDA 12 (software was not available before). The transcripts were coded according to several categories: text passages and statements concerning the interviewee's as well as a third person's (1) positive feelings and opinions on self-tracking activities, (2) negative feelings and opinions on self-tracking activities, and (3) activities and experiences with self-tracking. The results of two iterations were manually merged and possible statements were formulated – either the formulation of the participant or slight adaptions from the researchers were used. All possible statements were collected in an Excel file (608 statements in total). I categorized the statements according to different topics (such as security, control, goal, or number affinity). For each topic, I counted the number of statements and flagged them as relevant when per topic more than seven statements existed (75% of the topics had more than seven items and this should cover the most important aspects). Thus, I selected those statements and topics (30% of all possible statements) and carefully chose two until four statements per category for the final list (e.g. duplicates were deleted). Then, the third iteration served as validation of the final item list. Due to the different sources of the coded material no interrater reliability is calculated – however, the merging process of the first two iterations revealed a high level of accordance (in the case of disagreements, both researchers discussed the inclusion or exclusion of a text passage in order to find consensus). The next section presents our results for domain specification and item generation originating from interviews.

4 Results

For construct conceptualization, we first elaborate on (1) the premise. The purpose of the construct consists of measuring attitudes (positive and negative feelings, thoughts, opinions, or behaviors) toward self-tracking. The attitude construct may enhance IS research on self-tracking and therefore help to understand why some people are more prone to use self-tracking devices than others. The construct can also be used in different circumstances such as adoption and continuance research.

Concerning the (2) construct conceptualization, (a) a literature review did not disclose specific construct definitions. Scholars considered only other constructs (e.g. motivation, intention, perceived usefulness, self-control). For that reason, our first set of items only originates from explorative interviews. (b) Then, our construct represents the following type of property: positive and negative feelings about self-tracking (self-measurement, storage, reflection, analysis, acting). These feelings are measured on an

individual level. (c) The necessary and sufficient attributes encompass the three major components of attitudes: affective, cognitive, and conative ones [24]. They also describe the multiple dimensions of the construct. In addition, we suppose that the construct is stable over a certain time but they can be changed and influenced externally and internally [24]. Furthermore, the construct can be used in different situations and is not limited to a specific self-tracking application domain). (d) Finally, we suggest defining the construct with the following definition: *The attitude towards self-tracking is a pre-disposition to respond (affectively, cognitively, or in a conative way) in a favorable or unfavorable way to actions or objects implying one or more of the following self-tracking components: self-measurement, data collection/storage, analysis, reflection, and behavioral change concerning private activities.* (3) The dimensions will be elaborated through factor analysis at a later step in time.

ID	category	Item
1	habit	I measure things (my weight, well-being, gas consumption, expenditures) regularly.
2		I do self-tracking in other domains of life.
3		Self-tracking is like a ritual.
4	hedonic	Being precise is fun.
5		Self-tracking is enjoyable.
6		Self-tracking delimits fun.
7		I have fun taking measurements.
8		I have fun with my own data.
9	interest	I am interested in self-tracking.
10		Self-tracking is interesting.
11		I am intersted in facts about my personal activites.
12	medical	Self-tracking is extremly useful for medical problems.
13		Measurements do not treat a sick person, it's people.
14		I have no health problems so I do not need self-tracking.
15	moti-vation	I have no motivation to self-track.
16		Self-tracking motivates me to change things (healthier lifestyle, more activities, mindfulness
17	need	I do not need self-tracking.
18		Self-tracking leads to zero insights
19		Self-tracking does not provide me anything.
20		Self-tracking has many advantages.
21	privacy & security	I do not want to be recorded all the time because I want my privacy.
22		I do not want to share any data about my private life.
23		I cannot allow myself to gather data on specific topics.
24		I do not like self-tracking because all data can be missused.
25		Self-tracking data is sensible.
26	quantifi-cation affinity	I like to engage into measuring things.
27		Some things are not measurable.
28		I am interested in collecting data.
29		I like numbers
30		I have a high affinity towards numbers.
31		Numbers are interesting.
32		Graphs and statistics do not satisfy me.
33	self-opti-mization	Self-tracking helps me to achieve my goals.
34		I am interested in getting feedback on my behavior.
35		I like self-tracking because it makes my performance more tangible for myself.
36		Self-tracking helps to control things better.
37		It is easier for me to fulfill my goals with facts and numbers on my performance (quantification)
38		I like to achieve goals.
39		Goal setting and checking pushes me.
40		Goal setting helps me to improve.
41		Self-tracking helps me to increase my performance.
42		I like to see my progress.
43		I like self-tracking because i can share my data on
44		I do not like self-tracking because I do not want to be
45		Self-tracking makes bad concious.
46		It is unpleasant to find out things about my private life.
47		I like to measure/note things such that I do not forget anything.
48		Self-tracking helps to rembember.
49		Self-tracking helps for self-observation.
50		Self-tracking helps me to learn more details about my behavior.
51		Self-tracking helps me to be reflective about my life/activities.
52		Self-tracking helps me to find out what I can do to feel better.
53		I do not need self-tracking to find out, what I can do to feel better.
54		Health and well-being cannot be controlled.
55	social	I like to talk about my data.
56		I like self-tracking because i can share my data on performance then more easily.
57		I like to compare my performance with others.
58		I do not need self-tracking because I do not want to compare myself with others.
59	technical	I like self-tracking devices
60		Self-tracking and automatic feedback is comfortable.
61		I have always liked to create excel sheets about different
62		The easier it is to engage into self-tracking, the more I do it.
63	time	I do not have time for tracking.
64		Self-tracking is time-consuming.
65		I want to spend my time on other things than self-tracking.

Figure 1. Collection of possible items for the attitude towards self-tracking scale

Figure 1 shows the final list of items as selected with our qualitative analysis method. The selected statements were regrouped into eleven major categories describing the

content of the statements. Most statements describe attitudes towards self-tracking in the context of self-optimization. Then, quantification affinity, hedonic, social, technical, interest-related, medical, motivational, and need-related items follow.
Rather negative attitudes involve statements about privacy and security as well as the time (effort). Further research consists of content validation, purification of the set of items, and final statistical validation.

5 Discussion and Conclusion

In this paper, our interviews contribute to qualitative insights on the self-tracking phenomenon [25]. Furthermore, we refine the explanatory perspective from other scholars by focusing on attitudes and hopefully help to enhance their models [2, 8]. We expect the overall project to contribute to quantitative research on the use of such self-tracking devices [2, 3, 10]. Practice can profit by better understanding potential users and better support the mass distribution of such devices.

We tried to minimize the limitation of subjectivity by increasing transparency (transcribing the interviews) and objectivity (analyzing the interviews in three iterations). We are aware that several biases might influence the results especially the interviewees responses (social desirability, self-presentation, or participation bias). Furthermore, the interview sample is rather small and not representative. However, after a certain number of interviews there were no more extensive new insights for item generation.

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Acceptance by Design: Towards an Acceptable Smart Glasses-based Information System based on the Example of Cycling Training

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Abstract. Smart glasses-based information systems have the potential to support cycling training and other tasks which require high attention, by the presentation of relevant information into the user's field of view to reduce (road) risks through less distraction and a hands free navigation. Nevertheless, when introduced in 2012 to the consumer market smart glasses faced acceptance problems. Therefore, acceptance is a crucial requirement in the system design. Making use of a Design Science Research approach, acceptability design requirements are derived and integrated into the design phase. This set of requirements for smart glasses-based information systems contributes to theory while specific design requirements and a design proposal for an accepted system contribute to the field.

Keywords: Smart Glasses, Acceptance, Design Requirements, Acceptability Requirements, System Engineering, Cycling, Training support.

1 Smart Glasses based Information Systems in Cycling

Smart glasses show high potential for the business market. The context sensitive information provision into the user's field of vision combined with hands free control enables a pervasive and appropriate information provision without media disruption and limited mobility [1]. Therefore, application scenarios in several sectors e.g. health, technical service, production or logistics have been identified and are current research topics to the field of IS [2]. Hence, producer of smart glasses focus with the functional design on business needs.

Nevertheless, the pervasive information provision has potential to improve processes in private use. A promising consumer use case for smart glasses is training support in cycling. The status quo in cycling training already contains a variety of devices for the digital information provision as navigation devices, heart rate monitors, speedometers and further performance data monitors. The devices are mounted on the handlebar consequently, cyclists have to look down to gather their information or control the devices. Thereby, those training support devices cause distraction from roads and traffic and such devices propose are a risk for accidents. To encounter these risks information provision and device control must be integrated into the cyclist's field of view. Smart

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glasses meet these requirements by displaying the information into the corner of the cyclist's field of view (the traffic is not overlaid with digital objects) and enable a hands free control [3].

Nevertheless, smart glasses are currently not widespread on the consumer market, as user are concerned about social consequences of the usage [4]. Thus, this innovative technology faced acceptance barriers when first introduced in 2012. Therefore, a user centric design is a necessity for the development of a marketable product in the sports market. Technology acceptance is a crucial factor for innovative technologies to cross the chasm into the mainstream market and is assumed as a more decisive factor than a products usability [5]. Against this background, our research is guided by the questions (RQ1) *What are user requirements for a smart glasses-based information system to support cycling training?*, (RQ2) *How to design an accepted system corresponding to these requirements?* and closely connected to that (RQ3) *Which factors influence the acceptance of the regarding system?*. Addressing the research questions three expert interviews and an online survey (participants n = 100) have been conducted. Thereby, this paper contributes to the knowledge base of DSR by including acceptance factors into the engineering of a smart glasses-based system. The design and description of an artifact is a theoretical contribution itself [6].

Approaching with DSR as research strategy the paper is structured as follows: In section 2 related work is reviewed to outline the problem class of Smart Glass acceptance, followed by the illustration of the research method in section 3. Afterwards we derive user requirements in section 4. The aligning design requirements are stated in section 5 which are discussed in section 6. To conclude the findings an outlook for further research is given in section 7.

2 Smart Glasses Adoption and Technology Acceptance

Smart glasses-based information systems have been successfully designed for industrial use cases utilizing design requirements and principles [7], [8]. Smart glasses can restructure processes and support information intensive tasks in an ergonomic way as they present context sensitive information directly into the user's field of view, and facilitate a hands free navigation [1]. The information retrieval in the field of view and hands free navigation is beneficial for cyclists, too as it has the potential to reduce distraction and thereby road risks. So far, user requirements and design principles for such a system are not found in literature. Evidence for the usefulness of Information display in the field of view instead of conventional dashboards can be found regarding automobiles. To reduce road risks head-up displays, which are displaying the relevant information in the windscreen are replacing conventional dashboards and infotainment displays in cars [3]. Thereby the driver can retrieve the required information in the field of view. The distraction of a car driver when looking down to the dashboard or infotainment screen is comparable to cyclists monitoring their training information on their handlebar in road traffic. Nevertheless, smart glasses have faced acceptance problems since their first introduction by Google in 2012 due to privacy concerns and reservations in communication with smart glasses wearers [4]. Consequently, smart

glasses wearers have been insulted as “Glassholes”. Therefore, we conclude that there is a lack of social acceptance. Due to that matter, corresponding measures to ensure acceptance is a crucial factor for the system design. Technology acceptance itself is a well studied field in IS, with validated models to measure the user’s attitude such as the renowned Technology Acceptance Model (TAM) [9] and its derivatives like the Unified Theory of Acceptance and Use of Technology (UTAUT) introduced by Venkatesh et al. (2003). Nevertheless, common models do not take smart glasses specific characteristics such as the high integration of hardware and software into account. These characteristics make it on the one hand, hard to distinguish whether the user evaluate the comprehensive system, the hard- or software and on the other hand, are not addressed in current acceptance models. Therefore, the established models might lack a comprehensive understanding of the acceptance factors for such systems. Acceptance models focusing on pervasive computing in general take the ubiquity of a smart glasses-based system into account such as the UTAUT2 extension presented by Segura and Thiesse (2015). Nevertheless, joining the measurement of the acceptance, attitude specific design requirements are required to address acceptance barriers and improve the system. The knowledge base of IS [1] and the smart glasses manufacturer themselves [10] focus on functional design and do not provide design principles or at least requirements to improve the acceptability of smart glasses-based systems.

3 Research Strategy and Path of Knowledge

3.1 Making use of Design Science Research

To provide a problem-based approach of conceptualizing a smart glasses system in the cycling domain, the paradigm of Design Science Research (DSR) was chosen. We followed a DSR approach presented by Hevner (2004) to ensure rigor and relevance of the artefacts [11]. Thereby, we applied DSR by first collecting requirements from experts through interviews, as well as from survey respondents of an online questionnaire. To be certain that the designed system will be accepted among the potential users, we derivate specific acceptability requirements as we deploy an acceptance model for smart glasses among potential users in the requirement analysis. These requirements are then aggregated and consolidated to meta-requirements (MR) and finally a mock-up is conceptualized. To acquire rigorous outputs two evaluation activities are included in this approach. According to Sonnenberg and vom Brocke (2012) design specifications are evaluated through surveys to obtain validated design specifications, as well as the instantiation of an artifact with a prototype to proof the applicability of an artifact [12]. Following the argumentation of Thomas (2009) an executable model is a feasible prototype, as the implementation is a technical activity [13]. Therefore, the design requirements derived from the expert interviews are validated and completed through an online survey. Secondly, a prototype is conceptualized through a mock-up to evaluate the suitability, operationally and feasibility of the artifact before we carry out a technical instantiation. The course of action is integrated into the three cycle view of DSR [14] that is presented in figure 1.

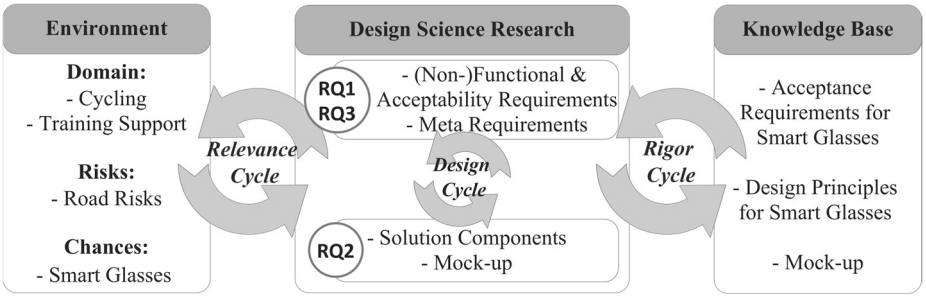

Figure 1. Design of an acceptable smart glasses-based information system

3.2 Deduction of Requirements through Expert Interviews

Following the approach of Myers and Newman (2007) we conducted three semi-structured interviews with experts in cycling training to structure the problem space and deduct relevant aspects for the online survey [15]. Therefore, we asked the experts about the areas problems in cycling training, benefits of smart glasses in cacling training, ergonomic design of smart glasses, required functionalities and market entry barriers. The experts were chosen according to the following attributes: (1) comprehensive domain knowledge in cycling training, (2) marketing knowledge or experiences with the market launch of products and (3) IS specific knowledge. The interviewees are experienced cyclists (6 to 14 years), with two of them having racing experience. Interviewee A is a junior brand manager and participates in cycling races for 8 years. Interviewee B is an information scientist with experience in software development and a cyclist for 6 years. Interviewee C is a business student with 14-year experience in race cycling and a certified trainer for cycling as well as a cycling race team leader. The interviews aim to structure the problem space and derive a set of requirements for smart glasses-based systems as a cycling training support according to research question RQ1. Afterwards we transferred the findings into survey questions in two different ways: (i) either as contingency questions to validate measures, e.g. price acceptance, and (ii) as open-ended questions to validate and complement the experts statements. The exploration of the problem space through expert interviews and thereon the design of the online survey is exemplarily illustrated in table 1 followed by a further description of the resulting online survey (section 3.3).

Table 1. Derivation of survey questions from expert interviews

Research Question	Analysis Dimension	Interview Question	Survey Question	Question Type
RQ1	Functional Design	Which functions are demanded?	Which of the following functions do you require?	Contingency Question

3.3 Extension of Requirements through an Online Survey

The online questionnaire consists of two parts, (a) the validation and complementation of the functional and non-functional requirements that we identified in the expert interviews and (b) the structured questionnaire from an established acceptance model. The questions that we derived from the interview's insights are stated in table 1 (c.f. section 3.2.). Therefore, the questionnaire contains open-ended, contingency and closed-ended questions. Open-ended questions were deployed to validate and extend requirements or information needs. To collect data about price acceptance, the duration of cycling training or validate specific requirements we used contingency questions. We applied closed-ended questions for the second part of the questionnaire referring to the user acceptance, which are responded through a 6-point Likert rating scale with endpoint labeling. To avoid a bias of the respondents and facilitate a statistical evaluation, the gradations between (1) strongly disagree to (6) strongly agree are labeled with numbers. Responses to open questions are qualitative analyzed and aggregated to response classes [16].

Introductory a demonstration video of the use case is shown, followed by demographic questions and about the status quo of digital training support. Then, experience with monitoring devices, resulting road risks and required training data is focused. Afterwards the (non-) functional requirements derived from the interviews are reviewed. Aiming at a high acceptability of our solution components, the questionnaire is supplemented with an acceptance questionnaire to provide insights on RQ3. Therefore, our approach followed the UTAUT 2 adoption of Segura and Thiesse (2015) by adapting their questionnaire to the context of smart glasses-based information systems in cycling. Therefore, the acceptance of such an ubiquitous system is measured with conventional acceptance measures as stated in UTAUT2 [17] and extended by three pervasiveness-related variables: Ubiquity, Unobtrusiveness and Context Awareness [18]. The question sets are merged in an anonymous online questionnaire. The sample has been acquired in relevant social media groups and in race cycle teams making use of the snowball effect. The majority of the respondents are male (96 %) amateur cyclists (82 %), are either between 25 and 39 years old (39 %) or 40 and 59 years old (38 %) and have more than 6 years of cycling experience. The share of male participants is higher compared to the statistical distribution of cyclists in Germany, 73 % of them are male and 23 % female [19], which could distort the findings as it is not an average sample. A vast majority (96 %) is using digital devices to monitor their training. Most of the participants (89 %) are familiar with smart glasses even though they did not test them so far. Overall, 100 participants conducted the full questionnaire.

4 Form and Function of a Smart Glasses-based System for Cycling

4.1 Derivation of User Requirements

Functional Requirements. According to Niemöller et al. (2017), requirements for smart glasses-based information systems are differentiable into functional (F) and non-functional (NF) requirements. The functional design requirements define system functions and components, which are identified in the expert interviews and the online survey (c.f. table 2). According to the interviewees, the smart glasses are a beneficial and innovative human-computer-interface with the opportunity to integrate necessary information into the cyclist's field of view. Therefore, the experts specified 26 functional requirements regarding features for the general design of smart glasses (F1 – 14) as well as training and context-specific requirements (F15 – 30). In the online survey, the participants confirmed 13 of the experts' functional requirements and added four further requirements.

Table 2. Functional requirements

#	Functional Requirement	Expert Interviews	Online Survey
F1	Price	X	X
F2	Customizable presentation of information	X	
F3	Battery run-time	X	X
F4	Display readability	X	X
F5	Connection to social media (e.g. Strava)	X	
F6	Smart Notifications	X	X
F7	Breaking resistance	X	
F8	Weather resistance	X	X
F9	External information processing	X	
F10	No heat generation	X	
F11	Alternative device controls (voice, buttons, gesture)	X	
F12	Weight of the device		X
F13	Size of the device		X
F14	Individual information objects		X
F15	Navigation	X	X
F16	Timekeeping	X	X
F17	Wattage monitoring	X	X
F18	Heart rate monitor	X	X
F19	Pedal frequency monitoring	X	
F20	Distance monitoring	X	X
F21	Speedometer	X	X
F22	No overlay of information into real world objects	X	
F23	No camera	X	
F24	Look-through display	X	

#	Functional Requirement	Expert Interviews	Online Survey
F25	Clip-on solution	X	X
F26	Display illumination dimmable	X	
F27	Distance measurement between cyclists	X	X
F28	Connectivity to telemetric devices	X	
F29	Alternative interfaces (ANT+, Bluetooth, WiFi)	X	X
F30	Changeable spectacle lenses (solar lenses, prescription lenses)		X

Non-Functional Requirements. The experts further stated non-functional requirements that describe quality attributes for a smart glasses-based information system in cycling, which are not addressing specific technical functionalities, (c.f. table 3). Pursuing with non-functional requirements in the online survey, five of the expert's requirements have been confirmed. Although, half of the participants (44 %) do not agree that their current monitoring devices, such as speedometers and are a distraction, almost a third (30 %) experienced incidents or crashes caused by a distraction due to monitoring devices. Situation descriptions given can be aggregated to (i) configuration of a device and (ii) limited field of view as the cyclist looked down to the handlebar to retrieve information. Consequently, smart glasses should not limit the (NF2) field of view of the cyclists and allow an (NF8) simple control.

Table 3. Non-Functional requirements

#	Non-Functional Requirement	Expert Interviews	Online Survey
NF1	Reduced distraction	X	X
NF2	Unrestricted field of view	X	X
NF3	Simple design of information objects	X	
NF4	Ergonomic fit	X	
NF5	Compliance with traffic regulations	X	
NF6	Unobtrusive design	X	X
NF7	Simple handling	X	X
NF8	Simple device control	X	X

Acceptability Requirements. Taking user acceptance as a crucial success factor for the launch of a smart glasses-based system in end-user business, acceptability requirements (AR) are differentiated as a further category of system requirements. We analyzed the acceptance model deployed in the online survey with a structured equation model to identify significant influence factors on the user acceptance and thereby deduce areas of development. Therefore, we further examined the significant influencing factors, shown in figure 2. *Ubiquity* (UBI) as the continuous provision with relevant information, *Unobtrusiveness* (UNO) addressing the hardware as well as a discrete interaction with the device and *Context Awareness* (CAW) to provide contextual information in dynamic manner have an indirect influence on the acceptance

of a smart glasses-based information system for cycling. Further, the factors *Performance Expectancy* (PE), *Social Influence* (SI) and *Hedonic Motivation* (HM) have a significant influence on *Behavioral Intention* (BI) and thereby on user acceptance.

These factors are further investigated in connection with the free text fields and the (non-) functional requirements resulting in the deduction of 10 acceptability requirements (c.f. table 4). Therefore, we deployed a qualitative content analysis [16] to aggregate the statements into requirements. Two of the resulting requirements, (AR6) Price and (AR5) Unobtrusive design, are stated by the participants already as non-functional requirements and have been additionally verified through the acceptance model. Overall 74 % of the cyclists rate a smart glasses-based support in cycling training as beneficial. The respondents specified three reasons to reject such a system. First they are (AR1) satisfied with the current devices, secondly (AR2) they are apprehensive of road risks caused by the distraction of and thirdly, participants assume smart glasses would be (AR3) uncomfortable to wear.

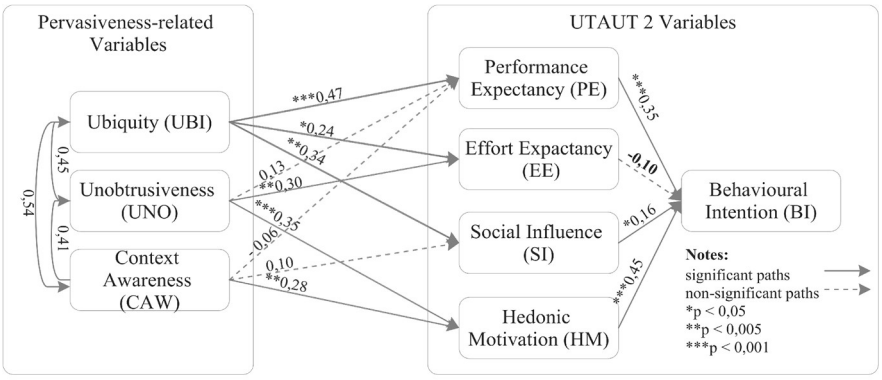

Figure 2. Structural equation model to analyze acceptance questionnaire

The survey participants require (AR4) ubiquitous information provision during the training with an (AR7) automatic adaption to the environment in terms of illumination or highlighting sufficient measures. Thereby the system has to be a (AR8) support for the achievement of training goals. Further, the acceptance of the potential users is influenced by the (AR6) price of the product (average price = 264 €), the (AR9) approval of the users social environment and the (AR10) enjoyment experienced during usage. Regarding the acceptance barriers known in literature, we have found no evidence regarding privacy concerns, but implications that the social acceptance is crucial. These findings are supported by (non-) functional requirements as AR2, AR3, AR5, AR6 and AR7 can be mapped to the previously identified requirement set. Regarding the initial motivation to reduce distraction by implementing a smart glasses-based system (AR2) is major requirement for the whole system design.

Table 4. Acceptability requirements

#	*Acceptability Requirement*	#	*Acceptability Requirement*
AR1	Degree of innovation	AR2	Distraction
AR3	Physical influence	AR4	Ubiquity of relevant information
AR5	Unobtrusive design	AR6	Price
AR7	Automatic adaption to environment	AR8	Support for goal achievement
AR9	Approval of social environment	AR10	Enjoyment

4.2 Derivation of Meta Requirements

The structured design requirements (functional, non-functional and acceptability requirements) are aggregated to meta-requirements that are the design goals for the conceptual artifact in the form of a first instantiation (c.f. section 4) [6]. The overall 16 meta requirements and the corresponding design requirements are stated in table 6. Strong meta requirements, which meet functional, non-functional as well as acceptance requirements are (MR3) safety and compliance of the information system, the system's (MR8) ergonomics and (MR12) unobtrusiveness. Meeting at least two types of design requirements, (MR2) usability, (MR4) a minimalistic information display, (MR9) the price, (MR11) ubiquity and (MR13) context awareness are identified.

Table 5. Aggregation to meta requirements

#	*Meta Requirement*	*Corresponding Requirements*		
		Functional	*Non-Functional*	*Acceptance*
MR1	Interfaces	F5, F28, F6, F29		
MR2	Usability	F11	NF7, NF8	
MR3	Safety & Compliance	F24, F27	NF1, NF2, NF5	
MR4	Minimalistic information display	F22, F23	NF3	
MR5	Robustness	F7, F8		
MR6	Display of telemetric data: (distance, wattage, pedal frequency, etc.)	F15, F16, F17, F18, F19, F20, F21		
MR7	Customization	F2, F25, F30, F14		
MR8	Ergonomics	F10, F9, F12, F13	NF4	AR3
MR9	Price	F1		AR6
MR10	Battery run-time	F3		
MR11	Ubiquity		NF1	AR2, AR4
MR12	Unobtrusiveness	F13	NF6	AR3, AR5
MR13	Context awareness	F26, F4		AR7
MR14	Social influence			AR9
MR15	Hedonic motivation			AR1, AR10

#	Meta Requirement	Corresponding Requirements		
		Functional	*Non-Functional*	*Acceptance*
MR16	Performance Expectancy			AR8

5 Design of a Smart Glasses-based System for Cycling

To translate the meta-requirements into action solution components are developed as stated in table 6. As the meta requirements and solution components are defined on a general level, a transmission to other use cases than cycling is feasible.

Table 6. Solution components meeting meta requirements

#	*Solution component*	*Specification*	*Meta Requirements*
D1	Interoperability	Interfaces to connect with telemetry instruments and social (i.e. STRAVA) and smart notifications.	MR1, MR6
D2	Robustness	Weather and impact resistance.	MR5
D3	Ergonomically design	External battery and information processing to avoid heat generation. Balanced weight.	MR8, MR10
D4	Minimalistic design	Small and light Hardware as a clip-on solution or with changeable spectacle lenses. Simple and customizable information display. External information processing.	MR4, MR12
D5	Usability	Multiple device controls and simple handling.	MR2
D6	Acceptance	Integration of social platforms, Gamification applications and customizable surfaces for enjoyment. Price range 264 - 400 €.	MR9, MR11, MR12, MR13, MR14, MR15, MR16
D7	Display	Highly readable color display. Look-through display at the corner of the field of view. Context aware display illumination.	MR3, MR12
D8	Monitoring information	Sufficient information for the training is easy accessible. The scope, amount and type of information objects is customizable.	MR6, MR7, MR16

The user retrieves training relevant information from a minimalistic dashboard. Further information objects or smart notifications are accessible additional tabs, like the displayed navigation map. The training data collected during usage can be shared directly on social media platforms or an online training monitoring studio to keep track of training goals. The system is easy to use, especially to control via voice command.

Relating to the hardware, processor and battery are located in a separate module within a weather and impact resistant case. The look-through display is a clip-on solution which can be used with convenient sports goggles and assures an ergonomic

positioning in the corner of the user's field of view. Considering the current smart glasses models available on the market, e.g. Vuzix M300, Recon Jet or Google Glass 2, none meets the derived hardware requirements stated above (c.f. F3, F7, F8, F10, F25). Therefore, the development of a new device is required to correspond to the requirements and ensure the acceptance of the system.

6 Conclusion and Outlook

To conclude our findings, smart glasses-based systems still suffer acceptance problems. Even though, they bear the potential to reduce road risks the state of the art of current hardware and its functionalities as well as wearing comfort are barriers for the acceptance. Deploying a DSR approach, we stated the user's design requirements and transformed them into meta-requirements for smart glasses-based systems (RQ1). Afterwards we addressed the actual design and development of smart glasses-based systems, as we derived corresponding solution components (RQ2) to design a smart glasses-based information system to support cycling training. To assure user acceptance for the system specific acceptance requirements have been identified and integrated into the system design (RQ3). The major fields of improvement address the connectivity of the smart glasses such as connections to existing training periphery and a social media integration, as well as hardware adjustments such as a clip-on solution to use the system with any sports goggles and an external battery to reduce weight. Further evaluations are required at this point to establish design principles to consider the acceptance from the beginning. The findings are transferable to other sport disciplines like MTB, Triathlon, Running, Skiing and on a more abstract level to industry, e.g. logistics or technical customer service. Further research is required to evaluate and complement these findings in service and industry sector. The postulated product specifications for a smart glasses-based information contributes to the field as a mandatory prerequisite for the design of an according system. Furthermore, user acceptance is a crucial factor in design of smart glasses-based systems in technical customer service [1]. As evaluated through the mock-up prototyping the acceptance requirements contribute to theory as they integrate user acceptance successful into early stages of the design cycle. To determine and influence relevant acceptance factors for smart glasses-based systems further investigation is required. Additionally, further iteration cycles are necessary to improve the design and acceptability of the introduced system and thereby, to derive design principles. Hence, the influence of additional acceptance factors, for example privacy should be taken into consideration [20]. Furthermore, the implementation of the outlined system and further evaluation is necessary to examine the user experience and evolve an ergonomic and beneficial design. Additional research is required to discuss the implications on a more general level.

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How to motivate consumers to test electric vehicles – An approach to design consumer interfaces to foster innovation adoption

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Abstract. Electric mobility is a current example of an innovative technology facing innovation resistance by consumers despite being an important strategy towards sustainable mobility. In this study the design of a consumer web interface incorporating elements from behavior change research to support overcoming resistance towards innovations, is introduced. An experimental study is conducted to test the influence of the proposed design strategies that are implemented in a rental car booking website. Results show a significantly positive effect of leveraging social influence and providing targeted information about the innovation on consumers' decision to test an innovation.

Keywords: Electric Mobility, Innovation Adoption, Sustainability, Persuasive Technology

1 Introduction

Even though people tend to be pro-innovative, many consumers resist certain innovations even if they are considered as superior to entrenched alternatives [1]. One explanation lies in the fact that adopting innovations often threatens consumers to change established routines and to put in effort to adapt their behavior to the changed situation [2]. The electric drive technology is a prominent current example of an innovation facing consumer resistance despite being an effective strategy towards more sustainable mobility [3], [4]. Being a promising approach to solve the problem of fossil fuel dependency, and to reduce exhaust and noise emissions, electric cars offer important benefits in contrast to gasoline or diesel cars. Still, resistance among consumers exist, also because most consumers have prejudices against electric cars arising from uncertainty considering their driving range or recharging infrastructure [5]. This study investigates how the perception of electric cars can be improved, and innovation trial among consumers promoted by incorporating elements from behavior change research (Choice Architecture [6], Persuasive Technology [7], Commitment and Compliance Gaining [8], etc.) in the design of a digital consumer interface. Innovation promotion, in this context, means to better highlight environmentally-friendly alternatives and motivating consumers to consider more sustainable options

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while ensuring freedom of choice. Booking an electric rental car serves as specific use case in our study.
We therefore formulate the following research question:
RQ: How can we design electric car choice settings such that the decision for innovation trial is more likely?
The remainder of the paper proceeds as follows: Section 2 introduces theoretical foundations relevant for this study. Section 3 reviews related work. In section 4, our research model and hypothesis are introduced. Section 5 describes the experimental study to test the hypothesis. Section 6 summarizes the findings of our research and section 7 and 8 close the paper with a discussion of the topic and its contribution.

2 Theoretical Background

The following chapter introduces fundamentals on innovation resistance and the role of innovation trial for adoption. As we want to positively influence consumer's behavior towards innovation trial, we additionally present, behavior change theories and research streams concentrating on the promotion of behavior change.

2.1 Resistance Towards Innovations and Innovation Trial

Innovation decision process models [9] assume consumers to follow a certain structure when deciding upon adopting an innovation. Roger's process consists of five stages from (1) knowledge, (2) persuasion, (3) decision, (4) implementation to (5) confirmation. This process is primarily influenced by adopter-specific (e.g. risk aversion, cognitive rigidity), situation-specific (e.g. budget restrictions, shopping environment) and innovation-specific factors (e.g. the adopter's perception of the innovation) [9]. Innovation resistance can occur as outcome of any stage of the adoption process. Passive innovation resistance results from a generic tendency of consumers to resist innovations and is a potential outcome of the knowledge stage, whereas active innovation resistance is a result of an unfavorable innovation evaluation and thus an outcome of the persuasion stage [10]. Passive innovation resistance is driven by adopter-specific factors such as personality traits leading to an inclination to resist changes [11] or situation-specific factors like status-quo satisfaction [10]. New technologies usually require consumers to change existing behaviors and habits, and can accordingly cause resistance [12]. The higher the degree of change or discontinuity the innovation evokes, and the more it conflicts with prior belief structures, the higher is the resistance to the innovation. Hence, new technologies, like electric cars, are associated with high discontinuity [6], [7].

Following Roger's adoption process model, trial is part of the awareness-interest-evaluation-trail-adoption sequence and therefore a common pre-stage to adoption [9]. Trialability refers to the degree to which an innovation can be tested on a limited basis [14]. Trial allows users to self-inform about the innovation performance and to experience benefits while using it [15]. Trial can increase the perceived ease of use of an innovation, which relates to the extent to which someone believes that the usage of

a system is free of effort [16], and can accordingly positively influence the intention to adopt the innovation [17].

2.2 Guiding Decision Makers' Behavior

Behavior is defined as a person's observable response to internal or external events [10-11]. The way behaviors are formed, changed and predicted is subject of several psychologic theories. Theories explaining the determinants of behavior and seeing attitude as a predictor of future behavior are proposed by Fishbein and Ajzen [20] (Theory of Reasoned Action), Ajzen [21] (Theory of Planned Behavior), and Bandura [22] (Social Cognitive Theory), amongst others. The opposite research stream, which is explaining how the performance of certain behaviors can change related attitudes, is represented by the Cognitive Dissonance Model [23] and the Self-Perception Theory [24], for example. Behavior change theories are complemented by the Transtheoretical Model [25], which explains the stages that an individual passes when changing or forming a behavior. Considering the way information receivers process persuasion messages, dual process models, comprising the Elaboration Likelihood Model [26] and the Heuristic Systematic Model [27], distinguish between two ways of information processing. The central route of information processing is chosen, when systematically focusing on the content of an information, whereas the choice for the peripheral route refers to making decisions based on available heuristics or cues.

Strategies to non-coercively change human behavior are presented in several research areas. Choice Architecture–a concept in the field of behavioral economics–reflects the idea that people's choices are influenced by the design of a decision situation [6]. Compliance gaining techniques [8], [28], [29]–rooted in social psychology and adapted in marketing–aim to change behavior by eliciting cognitive dissonance [30]. With concepts like Gamification [31], [32], Persuasive Technology [7] and Human Behavior Change Systems [33]–emerging from Information Systems research–we can observe a growing interest in digital approaches to induce behavior change.

3 Related Work

Behavior change strategies are applied and tested in various context with a particular focus on health-related behavior [34-36] and sustainability promotion [37-39]. In the domain of innovation resistance, Kuester et al. [40] demonstrate the effectiveness of defaults in helping to overcome innovation resistance. With regard to overcoming resistance towards electric mobility, Wolf et al. [4] propose an agent-based model simulating the effects of policy interventions and social influence on transport mode preferences. A gamification based approach visualizing their individual benefits to users is introduced by [41]. Stryja et al. [42] demonstrate the effects of applying choice architecture tools to the case of electric car selection. Related work is limited in the fact that only simulations are applied and that they rely on the willingness of consumers to proactively inform themselves about the benefits of electric vehicles. Our study contributes by proposing the design of a consumer web interface based on integrated

knowledge from behavior change research, and evaluating its effect on innovation trial decisions. We consequently design and model a concrete decision situation in which consumers need to decide upon testing an innovation.

4 Research Model

This study aims to apply theoretical knowledge on innovation resistance and behavior change to the design of a consumer web interface that non-coercively motivates consumers to overcome their passive innovation resistance. The interface is implemented in such a manner, that decision makers are encouraged to consider and select innovative options instead of directly rejecting them. Accordingly, the dependent variable in our research model is the decision to select or reject the innovation in a trial situation. For the purpose of this study, we draw upon tools from Choice Architecture, Persuasive Technology and Compliance Gaining Theory, as this specific combination of tools from decision-situation design, IT-based persuasion, and marketing adequately reflects our use case of booking rental cars. In particular, we propose the implementation of four behavior change design strategies, *Salience, Commitment with Labeling*, *Social Influence* and *Information Provision* in a rental car booking website aiming to encourage users to choose electric cars over conventional ones. Their theoretical derivation is explained in the following.

Salience. Salience refers to the *"translation of choice-related information into a format that is manageable by a cognitive system with limited capacity for information processing and representation"* [43]. Cognitive effort of decision-making is associated with the identification of best options and underlying tradeoffs, as well as with the decision for one specific option [43], [44]. When cognitive resources and attention are restricted, humans mainly focus on the most salient cues for deciding upon their behavior. Choice Architecture proposes mechanisms like setting defaults or structuring complex choices that aim to make desired options more salient and consequently keep the effort that is associated with decision-making low [46]. Studies on the effects of minimizing conscious effort demonstrate positive effects on behavior change [43], [45]. We therefore expect that:
Hypothesis 1 (H1): Designing the consumer web interface in a way that the innovation is more salient will positively affect the decision for innovation trial.

Commitment with Labeling. The effect of commitment and compliance-gaining strategies–especially on environmentally friendly and sustainable behavior–has been demonstrated in several studies [29], [47-49]. Commitment is considered as strategy leading to an enduring change in behavior, as people committing to a certain behavior are likely to adhere to their decision [29]. Labeling–working in the way that people are being labeled as the kind of person who normally performs the target behavior–can be used as strategy to stimulate commitment [51]. Pallak [50] furthermore shows a strong effect on commitment-making when people are labeled as public-spirited, fuel-conserving citizens. We therefore expect that:

Hypothesis 2 (H2): Labeling decision makers as the kind of person that performs the target behavior will positively affect the decision for innovation trial.

Social Influence. Social influence is a psychologic phenomenon occurring in response to social forces [28]. Social influence is defined as change in an individual's attitudes, behaviors or beliefs due to external pressure. People tend to look for social proof and rely on their environment for cues on how to act, think and feel [52]. Social norms are considered as underlying concepts for behavior changes under influence of other people [28]. Normative influence and peer pressure make it more likely for a person to adopt a target behavior [53]. Previous studies also demonstrate the effect of social influence on the promotion of sustainable behavior [52], [53]. We therefore expect that: *Hypothesis 3 (H3): Designing the consumer web interface to leverage social influence, will positively affect the decision for trial decision.*

Information Provision. Next to personal characteristics or social system variables, a consumer's decision to adopt an innovation is influenced by the perceived characteristics of the innovation [9]. Providing decision-makers with targeted information that allow them to adequately evaluate the advantages of an innovation at the time of the decision can influence their decision behavior [43]. With the provision of information, the direct route of persuasion [26] is chosen, which aims to persuade users by appealing to intelligence and reason. On condition that users have the potential to evaluate the content of the persuasive message, direct persuasion is shown to lead to more enduring behavior change than indirect persuasion [53]. We therefore expect that: *Hypothesis 4 (H4): Providing targeted information about the innovation at the point of decision will positively affect the decision for innovation trial.*

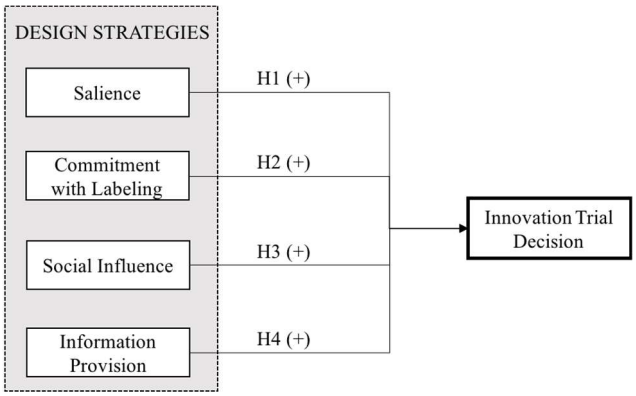

Figure 1: Research Model

In summary, we propose the design of a consumer web interface based on the behavior change design strategies *Salience*, *Commitment with Labeling*, *Social Influence* and *Information Provision.* The research model is tested in an experimental study which will be described in the following section. Figure 1 depicts the hypotheses and the research model addressed by our research design.

5 Experimental Study

5.1 Procedure and Treatment

The research model is tested in a laboratory experiment with a within-subject design to control for individual preferences and experiences with electric vehicles. Treatment variables are *Salience, Commitment with Labeling*, *Social Influence* and *Information Provision*. To minimize carry-over effects, the sequence of treatments is set in such a manner that treatments, which only rely on situational cues are presented first (*Salience*, *Commitment with Labeling*). Treatments that provide information, which could later be memorized by participants, are presented afterwards (*Social Influence*, *Information Provision*).

Within the experimental procedure, participants are presented five different scenarios describing non-private travel set-ups. Each scenario describes a route starting and ending in a German city with a two-day stay in another city in at most 82km distance from the starting and ending one. By limiting the travel distance and setting the stay at the destination to at least 24 hours, it is ensured that all scenarios are feasible with electric as well as conventional cars. Dates, cities, as well as the number of passengers are varied to a certain extent to keep up participants' attention during the experiment. Within the scenario description, participants are informed about their task to decide for a specific car, a hotel category as well as a food category. Hotel and food categories (high and low class) and according prices are given before the decision for a rental car is made to ensure that participants are fully aware of all costs and options when choosing a rental car. Participants are given a fixed budget forcing them to make trade-offs between car, hotel and food.

After each scenario description, the participants are directed to an instance of a rental car booking website. The first rental car booking website does not contain any treatment, thus the choices made in the first cycle can be used as control group results. The treatment variables *Salience*, *Commitment with Labeling*, *Social Influence* and *Information Provision* are implemented into the rental car booking website in cycle two to five. After a welcome page–where dates, and pick-up and return stations should be entered–a list containing 15 cars, independent of the treatment, is shown to the participants. To control for individual tendencies towards a vehicle category (small car, medium-sized car, limousine etc.), each category contains at least one electric, gasoline and diesel powered vehicle. All vehicles within one category are the same price to ensure that prices do not influence the engine choice. Furthermore, car colors are kept neutral in white or silver.

Treatment 1, *Salience*, is implemented into the rental car booking web application by highlighting one electric car model as suggestion on top position. In treatment 2, *Commitment with Labeling,* participants are shown a slogan next to the electric car models which labels people choosing these alternatives as eco-friendly drivers. *Social Influence* is integrated in the form of other clients' statements on their electric drive experience. Treatment 4, *Information Provision,* lists important information on available electric car models (e.g. driving range) and provides a charge station search algorithm.

Following the vehicle choice, preferences in hotels and food categories are inquired. After the selection tasks, the participants are guided to a questionnaire which collects demographic data, experience with and attitude towards electric car usage, and the innovation resistance.

5.2 Measurement of Variables

The experiment is implemented using Brownie, a Java-based software for NeuroIS experiments [56]. We therefore measure the dichotomous dependent variable–the innovation trial choice–by tracking the booking choices from the logging files. Within the questionnaire, attitude towards electric cars and innovation resistance are measured with seven items based on Wixom and Todd (2005) and Ram (1989) on a 7-point scale.

5.3 Sample

The experiment is conducted at a behavioral laboratory in Germany. 66 students from a large German public university are invited to participate in the pretest. Participants are neither informed about the content nor the goal of the experiment. The experiment is conducted within four sessions, three of them with 20 participants and one with six participants. Each participant receives a compensation of 10 EUR at the end of the experiment session. Additionally, a coupon with the value of 50 EUR valid for exactly one of the chosen car models is raffled to incentivize participants to reveal their true preferences. This is communicated to the participants within the task description at the beginning of the experiment. Participants are between 18 and 39 with an average of 23.25 years (SD = 3.912). 60.6% are male. 83% of the participants do not own a car. Car sharing and rental car services are used by 44% and 37% of the participants, respectively. The mean attitude towards the usage of electric cars within the total sample is 5.626 (SD=1.020) (scale from 1 to 7 with 1 indicating a very negative attitude towards usage) and mean innovation resistance is 2.782 (SD=0.928) (scale from 1 to 7 with 7 indicating very high resistance towards innovations) with a standard deviation of 0.928.

6 Results

Prior to the evaluation, we conduct a logic check to examine if participants had chosen within their given budget. One data point is excluded from analysis because of budget overrun. We furthermore check, whether participants have paid attention to the information provided to them in treatment 4. We therefore determine the subset of participants ($T4_{adjusted}$; n=34) that have spent more than 10 seconds concentrating on the treatment. The shares of electric and conventional cars chosen under the influence of the four treatments is indicated in Table 1. When no treatment was applied, 54% of the participants selected the electric car. Most electric cars were chosen in the treatment *Social Influence* with a share of 75.38%.

Table 1: Share of Electric and Conventional Cars Chosen with Respect to Treatment

	No treatment	*Salience (T1)*	*Commitment w. Labeling (T2)*	*Social Influence (T3)*	*Information Provision (T4)*	*Information Provision ($T4_{adjusted}$)*
Electric vehicles chosen	53.85%	64.62%	69.23%	75.38%	63.08%	73.53%
Conventional vehicles chosen	46.15%	35.38%	30.77%	24.62%	36.92%	26.47%

We calculate a chi-squared test of independence to test for a statistically significant association between the treatments and the innovation trial decision. The chi-squared test of independence shows significant p-values for *Social Influence* ($p<0.05$) and *Expertise Demonstration* in the subsample ($T4_{adjusted}$) ($p<0.05$). The Phi-coeffients of *Social Influence* (0.225) and *Expertise Demonstration* (0.239) indicate a moderately positive association between the choice of electric cars and the application of treatments.

Table 2: Results of Chi-Squared Test of Independence

	Pearson's Chi-squared test		*Pearson's Chi-squared test with Yates' continuity correction*		*Phi-Coefficient/ Cramer's V*	*Contingency Coefficient*
	X^2	*p-value*	X^2	*p-value*		
T1:	1.560	0.211	1.146	0.284	0.110	0.109
T2:	3.250	0.0714	2.633	0.105	0.158	0.156
T3:	6.594	0.010**	5.686	0.017*	0.225	0.220
T4:	1.140	0.286	0.792	0.374	0.094	0.093
$T4_{adjusted}$:	4.446	0.035*	3.513	0.061	0.239	0.232
*p<0.05 **p<0.01 ***p<0.001						

The McNemar test supports the results of the chi-squared test of independency. Compared to the results of the no-treatment control group, the test indicates statistically significant asymmetries on the contingency table diagonal for *Social Influence* ($p<0.05$) and *Information Provision* ($p<0.05$) (Cf. Table 3).

Table 3: Results of McNemar test

	McNemar's X^2	*p-value*
Control group – T1	1.714	0.190
Control group – T2	3.375	0.066
Control group – T3	5.633	0.018*
Control group – T4	1.136	0.286
Control group – $T4_{adjusted}$	5.333	0.021*
*p<0.05 **p<0.01 ***p<0.001		

The switching rate from a conventional car in the no-treatment system to an electric car in the system with *Social Influence* or *Information Provision* is significantly higher than the reciprocal switching rate. *Commitment with Labeling* (T2) is significant at the 10% level ($p<0.05$).

7 Discussion

Our results show an increase in the number of electric cars chosen under all four treatments, compared to the control group. With 53.86%, the control system already achieves a comparatively high share of electric vehicles chosen. Leveraging social influence and providing targeted information about the innovation has significant positive effects on sustainable innovation trial decisions. We can therefore support H3 and H4. In the form of norms, social influence is an integral part of theories in Behavioral Sciences (e.g. Theory of Reasoned Action, Theory of Planned Behavior, Social Cognitive Theory), which further supports our findings. *Information provision* only shows significant effects, when the information that is provided is paid attention to. Dual process models that distinguish between two different ways of human information processing can give rough indications. These models state that only in combination with high motivation and ability to process given information, a central route information processing and attitude change may take place. Furthermore, there is a raise in the number of electric cars chosen between the control system and under the influence of the treatments *Salience* and *Commitment with Labeling* but without being statistically significant. We accordingly cannot find support for H1 and H2 in our data. It is important to consider that in the case of *Commitment with Labeling* the formulation of the label highly influences the effectiveness of the mechanism. Further testing with alternative wordings is suggested. In addition, allowing active or public commitment-making [57] might further increase its impact on behavior change.

8 Conclusion

In this study, we propose the design of a consumer web interface which motivates users to select sustainable innovations. We apply behavior change strategies synthesized from Persuasive Technology, Choice Architecture, and Commitment and Compliance Gaining research to the case of rental car booking. Results indicate that leveraging social influence and providing information about the innovation are effective strategies to positively influence innovation trial decisions. The finding corresponds with results from other studies which emphasize the power of social influence and tailored information to achieve behavior change [51- 52]. Making the innovation more salient to minimize the effort associated with deciding upon innovation trial, and labeling users as sustainable drivers led to an increasing number of electric cars chosen, but results are not statistically significant.

Our study is limited by the size of its sample (n=66). Furthermore, the study sample consisting of students, is very homogeneous and characterized by low average age and lower innovation resistance. Results can serve as indication and extending the study

sample to other user groups may lead to more comprehensive results. Besides these limitations, our study contributes to theory and practice. First, it integrates knowledge from social psychology, behavioral economics and information systems research, and combines findings in the design of supportive behavior change systems. In particular, testing design strategies for behavior change systems that promote innovation trial contributes to the body of knowledge of both, persuasion research and innovation resistance theory. Second, we shed light into possible application areas of persuasive consumer interfaces to promote the adoption of sustainable innovations.

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Designing Human-Centric Information Systems: Towards an Understanding of Challenges in Specifying Requirements within Design Thinking Projects

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Abstract. Design-inspired approaches to problem-solving, like design thinking, have been gaining rising recognition as a way to create human-centric solutions. A design thinking project provides a guiding, yet not rigid framework to explore and specify requirements for the development of a new product or service. We investigate the challenges concerned with specifying requirements in design thinking projects with the purpose of laying the groundwork for creating solutions to these challenges. We find that design thinking supports the process of discovering requirements but leads to challenges stemming from the design thinking process. We identify conclusions for practice and suggestions for further research to create better human-centric information systems in the future.

Keywords: *design thinking, specifying requirements, human-centric IS*

1 Introduction

Digitalization is setting new agendas in almost every industry. The uncertainty in managing complex challenges within rapidly changing environments has prompted organizations to rely on human-centric and design-inspired approaches to create superior value for their customers. In this context, the notion of design thinking as a "way of finding human needs and creating new solutions using the tools and mindsets of design practitioners" [1:24] has become popular outside design professions and has left first traces in the digital and business world. Procter & Gamble, IBM, Deutsche Bank, and SAP internalized design thinking principles with proven success and are now considered poster children of the movement [2], [3], [4].

The guiding principle of design thinking – to create human-centric solutions that address real user needs – helps in the early stages of (new) product development to address "wicked problems" and develop a vision on how a solution should meet user needs [5]. Design thinking elicits those (hidden) needs and requirements, leveraging a holistic approach with a wide toolset of qualitative research methods and a series of low fidelity prototypes [6]. During a design thinking project, many digital and non-digital artefacts evolve. They express the identified user needs, insights, learnings, and design decisions. For reasons of speed, project teams capture and specify mentioned

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artefacts in a mainly unstructured form, e.g., through post-its, pictures, and low-fidelity prototypes during the process and text documentations on the occasion of specific milestones. This predominantly informal and unstructured mode of specifying requirements can be critical for two reasons which are strongly interlinked. First, it can hinder the team's ability to reflect and build on intermediate outputs and make decisions for further activities. Thus, it might result in a less desired prototype and, eventually, in a less desired product on market. Second, it also decreases the quality of the outcome when the final prototype is insufficient in explaining (1) certain design decisions made for the prototype and (2) the contextual details, in particular, when handed over to other teams for implementation (i.e., often software engineers) that are not able to revisit activities of the design thinking team. The lack of information might then lead to the creation of a less desirable product not fulfilling all relevant needs [7-9]. As a consequence, the innovative vision might not be able to develop its full potential because its realization does not conform to the elicited requirements of the design thinking team.

This study focuses on understanding the challenges of design thinking teams concerned with specifying requirements. It does not address the specific handover challenges from design thinking teams to software engineers, which have been discussed in prior research [7-9, 10], but rather focuses on the challenges within design thinking. The handover challenge can, of course, then (partially) be a result of the aforementioned one. We build our research on a multi-case study and analyse the data of five project teams. They approach a problem statement given by a corporate sponsor with the use of design thinking in a university context. We investigate the activities of specifying requirements to create solutions and the challenges that the teams face in doing so within the design thinking project setup. The paper is organized as follows: First, we establish the theoretical background of the study by drawing on literature about elements and methods considered essential in design thinking and their role in eliciting and specifying requirements for digital solutions. Next, we describe our research approach, case selection, data sources and collection, and data analysis. Then we report our findings. Finally, we provide suggestions for further research activities.

2 Theoretical Background: Design Thinking

Following the recent call of Yoo to "advance the intellectual foundation of design thinking" [11:v] for IS research, we aim to connect the key principles of design thinking (e.g. focus on user experience, future-orientation) to IS research. As such, we recognize the growing interest in design thinking as a subject for research.

Design thinking is best viewed from a trans-disciplinary perspective. The origins of design thinking date back to the late 1960s. Ever since then, design academics have been generating an extensive research history on mental processes that underlie design activities and their transformation into normative guidelines for creative problem solving [12]. These studies have been broadening the scope of design beyond the boundaries of product styling to a way of thinking that can be universalized for various disciplines. Looking at the user, use, and utility of a software product through the lens

of design thinking can support IS development by enabling teams to invent new constructs and artefacts. As the quality of an information system can be judged according to the extent it meets its original purpose, human-centric design cannot only help to define the purpose but also its shape [6].

Design thinking process models, accompanied by a set of design tools, can provide a supportive framework for exactly this endeavor. Because of the clear instructions of those models, they are often utilized to conduct design thinking projects. This paper draws on a prescriptive process model that has been adapted from a design thinking course program at Stanford University (also called ME310). Figure 1 shows design thinking as a combination of a micro- and macro-process.

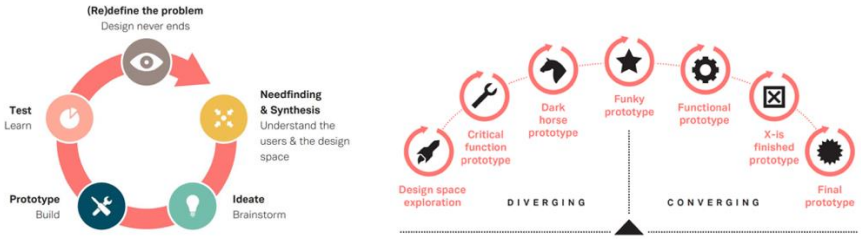

Figure 1. Design Thinking micro (left) and macro process (right), adapted from the course program at University of St.Gallen (http://dthsg.com, accessed on 24 September 2017)

The micro-process is integrated into a broader milestone model (i.e., the macro-process) and repeated in each phase. The macro-process includes an extensive pre-research phase (i.e., the design space exploration) and six different prototyping phases, which eventually merge to one final prototype. The creation of prototypes is not necessarily an expression of converging to a pre-defined solution from project start to end, it represents rather a diverging approach to iteratively question prior assumptions in order to create solutions that go beyond existing alternatives. In this respect, the mainly diverging character of design thinking differs significantly from the converging tendency of agile software development approaches. Iterations are carried out whenever and wherever necessary as they are essential to adapt to new information and gain deeper insights. Accordingly, the trial-and-error-principle of "fail early and often" is frequently adopted to encourage rapid learning from short project cycles [2].

Despite its guiding process model, the design thinking framework is flexible in terms of accommodating diverse perspectives and adapting to changing requirements. While methodological support on design thinking is widely available, there is a lack of guidance for effectively specifying and documenting artefacts and requirements in design thinking projects. This paper takes into consideration the following definition of requirements as "the descriptions of services that a software system must provide and the constraints under which it must operate." [13]. By doing so, requirements can be seen on different abstraction levels, from very high-level statements of service descriptions down to detailed specifications of certain functions or algorithms. There is a common understanding to differentiate requirements according to their nature. User requirements reflect the needs, desires, and stated functionalities of a software system.

System requirements express services needed from a technological view for the system to operate successfully. And lastly, software requirements specify the architecture of the software system in detail. On a more granular level, the requirements engineering community demands for requirements that are unambiguous, correct, complete, concise, feasible, understandable, and consistent [14].

The growing research effort in design thinking takes mainly two directions in the field of IS: (1) how IT and IS can support design thinking practices by generating new tools, and (2) how design thinking can support problem-solving in the IS context. The latter is subject of this study where related work is rather scarce. Prior research has acknowledged how design thinking can help in specifying requirements, mainly by conducting first small-scale experiments or cases in specific industries (e.g., [15], [16], [17]). For this study, results of research efforts at the Hasso-Plattner-Institute are particularly of interest. Häger et al. have shown that design thinking faces integration challenges when it comes to handing over prototypes to implementation and have called for an integrated approach of design thinking and Scrum to combine idea generation (design thinking) and product development [10]. In addition, Beyhl et al. have pointed out the challenge of documenting and traceability in design thinking projects, which is defined as "the ability to describe and follow the life of a requirements, in both a forwards and backwards direction" [18], [7-9]. Building on this knowledge base, we created our study. We adopt requirements specification as a key concept and explore how design thinking projects apply this for creating human-centric solutions. We look at five projects to identify challenges in the process of specifying requirements.

3 Research Context and Methodology

Our research adopts a multiple-case study approach and follows the guidelines of Yin [19] as it is particularly suitable for addressing the exploration of the research question: What are the challenges of specifying requirements within design thinking projects? The cases derive from a one-year university course as a part of which teams take on a design challenge provided by a corporate sponsor and guided by the design thinking framework introduced in Section 2. All corporate sponsors were either long-standing partners of the university or undertook a comprehensive onboarding process into the design thinking program to build up trust with the teaching team. We chose a multiple-case study approach as the cases we present are mainly replications of each other. This way, we expect better generalizable and more robust results for our findings [20]. We analysed five cases referring to five design thinking project teams (Table 1).

Table 1. Case details

Case	A	B	C	D	E
Team size	6	3	7	3	7
Corporate Sponsor	Alpha, Germany	Beta, France	Gamma, Germany	Delta, Germany	Epsilon, Colombia
Type of Industry	Pharma	Pharma	Pharma	Financial	Financial
# of employees	~ 50'000	~ 110'000	~ 48'000	~ 142'000	~ 50'000
# of prototypes	33	32	32	28	22
Final prototype	Chatbot	Smartwatch App and CRM Plug-in	Platform and Hardware	Smartphone App	Service, Smart-watch, and App

We selected five out of nine projects following the criterion that all the projects were addressing digital challenges. All teams consisted of business master students and, depending on the corporate challenge, included students from design, business informatics, and engineering. The students had no or little prior experience in applying the presented design thinking framework, however, they shared the experience of the same course content as a common background. To evaluate our research question, we collected multiple sources of evidence consisting of (1) project documentations, (2) physical artefacts, and (3) participant-observations (see Table 2).

Table 2. Sources of evidence (SoE)

Name	Type	Short Description	Number	Audience
Source of Evidence 1 (SoE1): Text and Visual Documentations				
One-page Summary ("One Pager")	Text and pictures	Short description of project status after each milestone	6 per case	Corporate Liaison Teaching Team
Intermediate Documentation I	Text and pictures	Insights and learnings from first two milestones (35-120 pages)	1 per case	
Intermediate Documentation II	Text and pictures	Learnings from Darkhorse and Funky phases in the form of a booklet	1 per case	
Final Documentation	Text and pictures	Guidelines to understand the final prototype (40-140 pages)	1 per case	
Pictures	Photos	Photos of prototypes and other outputs	>1000 (all)	
Videos	Video	Video shows the final prototype	1 per case	
Source of Evidence 2 (SoE2): Physical Artefacts				
Prototypes	Physical and digital	Low to high resolution representations of ideas	147 (all cases)	Corporate Liaison
Source of Evidence 3 (SoE3): Participant Observations				
Weekly Review Meetings	Lecturer Notes	Weekly one hour review with each team on progress and content	28 per case	Design Thinking Teams
Weekly Lectures	Lecturer Notes	Weekly 2-3 hour lectures	32 (all cases)	
Regular Performance Reports	One page from lecturer	Assessment of each team with an evaluation of their performance	6 per case	

We examined project documentations (SoE1) with the help of document analysis which is the "systematic procedure for reviewing or evaluating documents—both printed and electronic" [21:27]. We chose this approach because our topic is concerned with specifying requirements and we see all documentation produced within the project as an indicator for evaluating our case question. Our available data has a broad coverage over the entire project time in multiple settings and scenarios, which makes analysing documents advantageous for our purpose [19]. Across all cases, we reviewed 45 documentations and more than 1000 pictures. We especially looked at the following questions: Which requirements are specified and how? How understandable and complete are they? Are context requirements captured? In addition, we leveraged prototypes as a complementary data source (SoE2). In design thinking, prototypes are per se expressions of elicited requirements and design decisions, which makes them a vital part in the evaluation within our research. To this purpose, we evaluated how and which requirements were expressed as prototypes. Third, we leveraged participant-

observation to gain insights about possible challenges (SoE3). The data sources we used were mainly notes and observations from review meetings about process struggles, team dynamics, and content discussions. Three of the authors were lecturers and coaches in this course drawing from multiple years of experience in applying design thinking in university-level projects and corporate settings.

We chose to draw on multiple sources of evidence with the aim of data triangulation to support construct validity for our findings [19]. Subsequently, we followed a structured procedure for each source of evidence. We applied content analysis to identify findings and used cross-case synthesis to derive the challenges to specify. In particular, two of the authors started to derive the challenges independently from each other by examining the documents. They identified relevant passages and deduced them overarching themes in the topic of requirements specification. Then, the two engaged in discussions about the challenges to iterate and merge their first set of challenges. The third author acted as a sparring partner in the process of shaping the final set of challenges to provide quality assurance and objectivity. Figure 2 visualizes the above described procedure and provides the transition to the next chapter that will conclude the observed practices and challenges in capturing requirements.

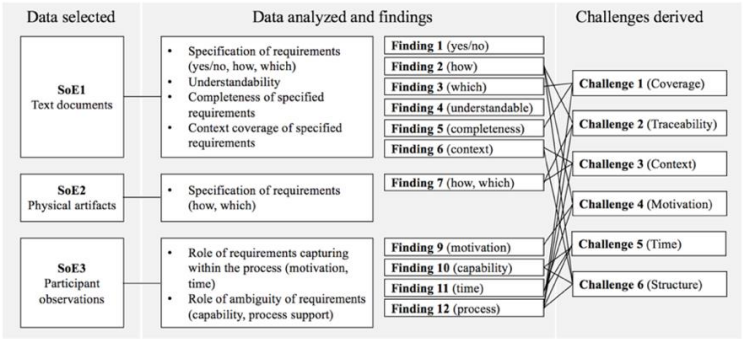

Figure 2. *Convergence of multiple sources of evidence (adapted from [19:117])*

4 Research Findings: Derived Challenges and Practices

4.1 General Findings

In all cases, the teams did capture and specify requirements throughout the course. Each team used different ways of specification all of which were generally understandable in form and expression. An explicit listing of requirements can be found in Case A and D, e.g., the final documentation of A states: *"requirements are derived from Alpha's initial brief, legal constraints in the industry, user interviews, Alpha staff interviews, and various kinds of testing"*. The requirements were structured into functional, experiential, and physical requirements. Each specification was further divided into (1) requirement, (2) metric, and (3) rationale as the example shows: (1) *"The solution must be available in the user's native language"*, (2) *"The solution should be translated to the native language of Alpha's main target markets,"* and (3) *"Our user tests showed*

us that patients have immense difficulty using a service if it's not offered in the language they're used to." Furthermore, in Case D pictures of the prototype were used to show functionality and user requirements. The specification structure looks as follows: (1) issue description, (2) user quote, (3) need, (4) requirements derived. The other cases (B, C, E) use expressions like "features", "functions", "experiences" and "implications" to address the topic of requirements. In addition, prototypes served as a useful purpose to apprehend requirements. Namely, a prototype can take the form of a visual documentation and, thus, should be able to express requirements in a concise and understandable manner. Not all prototypes were self-explanatory though, and several needed further explanations to comprehend their purpose.

4.2 Output-Related Challenges

Challenge 1 (Coverage): Strong focus on user requirements while neglecting software and system requirements. The better and clearer the requirements the easier it is to implement them in the state of the intended purpose. During our analysis, we found a strong focus on specifying user requirements, which was one of our questions for SoE1 and SoE2 ("Which requirements are specified?"). Across all cases we see at least 80% of requirements addressing users, their needs, insights, and learnings from prototype testing. This finding is supported by notes from review meetings where discussions mainly revolved around user needs and how to transfer them into solutions. For example, a protocol of Case C includes the question *"How can we transfer the need for trustworthy information sources into a product feature? I don't know how to do that in the best way"*. Cases C and E address user requirements only, while documentations of Cases A, B, and D also show implications for software requirements, mainly in the appendix of such documentations. These made up the other 20% of the requirements documentation. The specification of system requirements was neglected completely. This finding is not surprising as the paradigm of human-centric design is the foundation of all activities in design thinking, putting the (potential) user in the role as a recurring sparring-partner for prototype testing. Still, feasibility and viability should be considered as well [2]. The lens of feasibility demands an exploration of organizational capabilities and technological options to translate the human-centric requirement into actual products and services. We see potential for design thinking to increase focus on this topic when evaluating prototype options for next steps in the process.

Challenge 2 (Traceability): Weak links between needs, insights, learnings, and requirements. Being able to trace back requirements to insights, needs, and learnings from testing helps to revisit previous decisions and to understand better the intended purpose of a solution. All sources of evidence (SoE1-SoE3) point out that achieving traceability seems to be a challenge in design thinking projects. Across all cases, the final documentations showed the most specific and traceable connection between need and (iterated) requirement, however, not always comprehensibly. We want to highlight the following evaluation notes from one lecturer in regard to the final documentation of Case E: *"The final prototype comes a bit out of the blue. [...] Which needs are addressed by which feature of the prototype is unclear."* Notes from review meetings

show similar uncertainties when asking *"Where does this idea come from?", "What is the need?"* (Case B, C). A good example provides Case A, which matched detailed requirements descriptions to a step by step journey of the user going through all screens of the prototype. Links to previous prototypes show the rationale for changing requirements. Case C provides another good example, where the team visualized the evolution from intermediate to final prototype for a better traceability between need and solution (Figure 3). The team added descriptions to explain which elements were transferred further and deducted implications for the final prototype. Traceability from final documentation to intermediate project results appears to be an important issue with varying results. We have seen good examples in our cases that can serve as benchmarks in the future. Nevertheless, notes from review meetings of the project have shown the teams' struggle and confusion in the attempt to recap and build on previous findings and specified requirements. We will pick this up again when discussing our observations for Challenge 6.

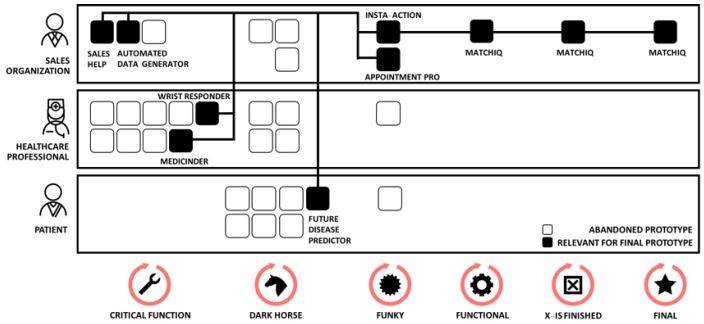

Figure 3. Evolution from intermediate prototypes to a final prototype (adapted from final documentation of Case C)

Challenge 3 (Context): Lack of formalizing context requirements. Contextual information and requirements help to create a holistic view of the entire systems landscape (e.g., in terms of constraints or system goals). Design thinking leverages a 360-degree approach (by multiple perspectives) to address the problem and solution space of the design challenge and, thus, aims to generate an integrated vision of the challenge and its context. Cases A and E used personas and empathy maps to set the user's context of the solution, e.g., in Case B, an element of the platform solution is a status function for doctors in which, similar to a frequent flyer program, they get points that translate into benefits. To put this into context, the team has specified the reason: *"we chose this solution according to the preferences of two target countries, where, unlike in Switzerland, the visit of sales representatives is appreciated as personal and individual attention of company Beta. Thus, novel digitization efforts are harder to argue. This is why we wanted to incentivize using our platform in a comprehensible manner"*. Despite design thinking being virtually predestined to elicit, and specify context requirements, we can determine a lack of formalized context requirements in all cases. A consistent way in specifying these requirements according to the context of

the three dimensions of desirability, viability, and feasibility is lacking. This missing methodological support causes a lack of information in later implementation stages. Again, this finding can be related to the structural discussions in Challenge 6.

4.3 Process-Related Challenges

Challenge 4 (Motivation): Lack of motivation to specify requirements systematically. Although discovering needs and eliciting requirements is part of the design thinking process, documenting them in a systematic manner was found to be challenging. The deeply explorative approach of design thinking demands a multitude of sources and tools to create a multitude of artefacts, not yet knowing which ones will be the most relevant in later stages. But relying on implicit knowledge in a sea of analog and digital artefacts constitutes the risk of losing information. In general, the teams in our cases saw less of a contribution in specifying the requirements for themselves than for the teaching team and their corporate sponsor. The main motivational factor was the fact that a part of the grading in the course was based on the quality of the prototypes and their written deliverables. In addition, they also mentioned a feeling of obligation towards their corporate sponsor to specify findings for their later usage (A, B, C). To tackle this issue, three teams assigned a specific documentation role within their team. The teams that did not do this (B, E) showed particular weaknesses in the completeness and understandability of requirements specifications.

Challenge 5 (Time): Lack of time to specify requirements systematically. The element of available time is a crucial factor in all design thinking projects. Evidence for challenges in regard to time is mainly derived from weekly review meetings with the teams (Figure 2). One team member, for example, stated, *"the design thinking project is a marathon in the speed of a sprint"*. According to sources from review meetings (A-E), team members stated that they were aware that someone should document continuously, but failed to do so due to a permanent lack of time. The teams reported to prioritize time for *"real work like conducting user research or building the next prototype"* over specifying requirements in a systematic manner. This triggers a similar observation to Challenge 4 (motivation) as the task of specifying requirements is seen as a timely activity that gets de-prioritized under time pressure for *"more important things."* However, an indication that a more systematic approach could be beneficial, shows the following reflection statement from Case A: *"The fact that we had eight whole months to burn, often allowed us to slip into sluggishness, which really showed in our lackluster results in the winter period, and I feel that our indecisiveness cost us the chance to develop a proof of concept that actually validated ALL, not just most, of our claims and theories about the potential of chatbots in patient support"*.

Challenge 6 (Structure): Knowledge is implicit or captured on Post-its while adequate tool support is missing. In design thinking projects, there is no pre-defined structure on how, when, and which requirements to specify. Hands-on activities like building, testing, and experimenting are the preferred choices to gain insights and

feedback from users. In all cases, observed practices for specifying requirements take a multitude of forms: working artefacts are mainly Post-its, sketches, pictures, low resolution prototypes, digital shared notes (e.g., on Trello), and a loose collection of word documents in a team share storage; official documentation purposes are usually addressed by natural language in text form, a high-fidelity prototype, and a final video to provide context. Creating prototypes is an evolving process and a way of "thinking with hands," where the team can reflect on an idea. However, often decisions on changes are not made explicit. This supports the finding that much knowledge stays implicit. Frameworks like personas, service blueprints, and empathy maps are commonly used to synthesize data from field research; adequate tools in the design thinking context for deriving and specifying requirements are lacking though. The "informal world of design thinkers" [7:167] (and, in the long-term, also the more formal world of software engineers) might benefit from a non-intrusive tool that fits to the "rough and dirty," explorative working mode of design thinkers. The combination of a prototype, showing links to previous prototypes and findings together with natural language specifications of requirements could serve as a first idea into this direction.

5 Discussion

Prior literature has acknowledged the challenges in specifying requirements in design thinking projects [7-9]. Our paper advances the understanding of this problem with data from a multi-case study of five design thinking projects. The results of our study show that some of the challenges can be considered as rather generic problems that also occur in other project-related teamwork (especially Challenges 4 and 5). The other challenges, however, suggest a strong association with the specific design thinking methodology. In this context, we find Challenge 1 as very IS-specific, whereas the other challenges (2, 3, 6) could also be transferred to other project setups that don't deal with creating and designing IS. Since we set out to create a holistic picture of the challenges to specify requirements in design thinking projects to create human-centric IS, we see all of our findings as relevant for scholars and practitioners alike. Practitioners can gain valuable insights to avoid or weaken aforementioned challenges, which can be influential for the success of a design thinking project. Academics benefit in many ways. First, our findings contribute to the body of knowledge for design thinking and IS research. Second, we believe that this paper will contribute to the understanding around aligning design thinking with later staged software development approaches. Third, Yoo suggests that "IS scholars can help design thinking practice by inventing new constructs, models, methods, and instantiations" [11:v]. Our research points to a specific area of future research, i.e., to enhance existing or creating new methods and tools for specifying requirements in such explorative approaches as design thinking.

Our paper is not without limitations. Yin stresses biased selectivity [19] as one flaw of analysing documents for research. Although it can be considered advantageous that our cases were conducted in the same setting, it can also be argued that the available documents are strongly aligned with the university's design thinking approach and its specific assessment policies for the course. In addition, the specific team staffing (students from different backgrounds and universities), the form of the corporate

briefing, and the teaching team's coaching support should be considered as influencing factors on the derived challenges when transferring our findings to other (corporate) settings. Nevertheless, the entire course setup is crafted in a way that creates conditions that are as "real" as possible. Taking Sun and Kantor's [22] "three realities"-paradigm (real users, real problems, and real systems) for a naturalistic evaluation in IS projects as a reference, our course does address real problems from corporations (and not fictional ones) and applies real systems (i.e., the design thinking methodology with conducting real field research and user testing to create real solutions). We see "real users" as debatable, since our project teams are composed of students who can be more compared to external consultants than to internal project members of an organization. The latter ones for instance, often face internal politics or stakeholder management issues that we believe to be influencing design thinking projects immensely in "real corporate settings". Therefore, we encourage to analyse teams in actual organizational settings, allowing us to identify organizational specific challenges. Nevertheless, we still believe that the access to confidential data in the study outweighs the limitation because it led to a deeper understanding of the output- and process-related challenges.

6 Conclusion

We contribute to theory and practice on how to design and develop human-centric information systems by framing and discussing the problem of requirements specification in the context of design thinking projects. Although our results reflect the possibilities of design thinking to define human-centric solutions, our research reveals six challenges for specifying requirements, three of them related to the output of design thinking: (1) Design thinking teams focus on the specification of user requirements, while software and systems requirements are widely neglected; (2) the central outputs of design thinking projects (i.e., needs, insights, and requirements) are insufficiently linked with each other and, therefore, traceability is limited or even impossible for further use; and (3) the lack of formalized context requirements is limiting the use of project results in later implementation stages. Furthermore, we discovered three challenges relating to the process of design thinking itself: (4) Team members are hardly motivated to specify requirements systematically, (5) perceive the specification of requirements as an extra effort that shortens the already limited work time, and (6) lack in adequate tool support for specifying and structuring (implicit) team knowledge.

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Das Smartphone als Steuerungseinheit im Smart Home: Determinanten der Nutzung am Beispiel von Smart-TVs

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Abstract. Mobile Endgeräte wie Smartphones werden immer häufiger zur Vernetzung und zur Steuerung von digitalen Haushaltsgeräten eingesetzt. Sogenannte Remote Control Applikationen ermöglichen die zentrale Steuerung über ein einziges mobiles Endgerät und ersetzen zunehmend herkömmliche Steuerungssysteme. Doch welche Determinanten die Akzeptanz und Nutzung von Remote Control Applikationen beeinflussen, ist bisher unklar. Am Beispiel einer TV-Remote Control Applikation wurden affektive, kognitive und konative Determinanten identifiziert, die die Nutzung von Remote Control Applikationen fördern oder hemmen. Um alle Phasen des Akzeptanzprozesses bestmöglich zu erfassen, wurden eine Tagebuchstudie und qualitative Interviews durchgeführt. Die explorativen Untersuchungsergebnisse zeigen, dass der empfundene Nutzen von Zusatzfunktionen und die Möglichkeit der Ansteuerung von mehreren Geräten über eine Applikation die Nutzung fördern. Die Zufriedenheit und die Habitualisierung mit der traditionellen Steuerungsmöglichkeit dagegen hemmen das Wechselverhalten und mindern die Nutzungsabsichten für das Smartphone als zentrale Steuerungseinheit.

Keywords: Digitalisierung des täglichen Lebens, Tagebuchstudie, Smart Home, Digital Natives.

1 Einleitung

In vielen Lebensbereichen nehmen wir eine zunehmende Digitalisierung wahr. Ein durchschnittlicher Nutzer besitzt mittlerweile eine Vielzahl von digitalen, vernetzten Haushaltsgeräten [1]. Alltagsgegenstände werden entsprechend mit Prozessoren, Vernetzungsmöglichkeiten und Sensoren ausgestattet, um diese „intelligenter“ zu gestalten. Mit der Digitalisierung von Geräten des täglichen Gebrauchs verändern sich auch die Steuerungs- und Bedienmöglichkeiten der Nutzer. Mit der steigenden Verbreitung von mobilen Endgeräten bieten Hersteller vermehrt die Steuerung ihrer Geräte über Remote Control Applikationen (RCAs) an. Diese RCAs können Geräte

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über Funkverbindungen (z.B. WLAN) aus der Ferne steuern. Sie sind für eine Vielzahl von Betriebssystemen verfügbar und können in verschiedenen Anwendungsgebieten, wie Unterhaltungselektronik und Fahrzeugtechnik, eingesetzt werden. RCAs ermöglichen es, dass Nutzer ihre Heizungs- und Lichtanlagen sowie Haushaltsgeräte von der Kaffeemaschine bis hin zur Waschmaschine über mobile Endgeräte steuern können. Die Verfügbarkeit von Internetverbindungen, zusammen mit dem Wandel der Preisstrukturen für Datenverbindungen, unterstützen die Akzeptanz von RCAs und fördern die Bedeutung von mobilen Endgeräten als zentrale Steuerungseinheit im Smart Home. Trotz des faktischen Mehrwerts von digitalen Steuerungsmöglichkeiten mittels RCAs gegenüber herkömmlichen Alternativen, gibt es bisher kaum Forschung im Hinblick auf die Akzeptanz und das Wechselverhalten von Nutzern. Bisherige Studien zu RCAs nehmen überwiegend die gestaltungsorientierte Perspektive ein und adressieren Designelemente und ihre Wirkung [2]. Es gilt daher, ergänzend aus einer verhaltensorientierten Perspektive das Nutzungsverhalten zu untersuchen, um die Determinanten zu identifizieren, die die Akzeptanz von RCAs beeinflussen und die Wechselabsicht von herkömmlichen Steuerungssystemen zu RCAs fördern oder hemmen, um Implikationen für zukünftige Entwicklungen ableiten zu können. Die Forschungslücke und die Relevanz der Ergebnisse für die Praxis begründen die Wahl der Forschungsfrage: *Welche Determinanten beeinflussen die Nutzung von RCAs als zentrale Steuerungseinheit für Smart-Home-Geräte?*
Diese Studie analysiert den Nutzer mit seinen Bedürfnissen und Verhaltensweisen innerhalb der Heimautomatisierung. Damit ist die Forschungsfrage in dem noch jungen Forschungsfeld „Digital Life“ verortet [3, 4]. Die Analyse des Zusammenspiels von digitalen Geräten im Haushalt mit interaktiven digitalen Steuerungssystemen zeigt, wie Informations- und Telekommunikationstechnologien in die Lebensbereiche der Nutzer eindringen und allmählich die physische Welt zu einer digitalen transformieren. Durch diese Durchdringung werden Verhaltensabläufe verändert und neue Routinen adaptiert. In dieser Studie möchten wir die Einflussfaktoren, die bei der Nutzungsentscheidung eine Rolle spielen, abbilden und das Verhalten von Nutzern während der Wechselphase von einer herkömmlichen Steuerung zu einer Steuerung über das Smartphone erfassen. Als Untersuchungsgegenstand wurden TV-RCAs ausgewählt, um anhand dieser Applikation beispielhaft die Nutzung von RCAs zu untersuchen. Internetfähige Fernseher, sogenannte Smart-TVs, sind über RCAs steuerbar. Diese RCAs wurden entwickelt, um die Interaktion zwischen dem Nutzer und dem Smart-TV zu verbessern [2]. Neben den Funktionen einer herkömmlichen Fernbedienung bieten RCAs zusätzliche Funktionen, wie zum Beispiel eine Gesten- oder Sprachsteuerung.

2 Theoretischer Hintergrund zur Analyse des Nutzungsverhaltens

Verschiedene theoretische Perspektiven werden in der IS-Forschung angewandt, um die Akzeptanz und Nutzung neuer Dienste und Technologien zu verstehen. Unterschiedliche Modelle wurden postuliert, um die Nutzungsabsicht, basierend auf der Wahrnehmung der technologischen Leistung und den eigenen Kompetenzen (z.B.

TAM/UTAUT), sowie basierend auf sozialen und kognitiven Determinanten des Nutzers (z.B. TRA/TPB), zu erklären [5, 6]. Diese Modelle beschreiben überwiegend die Akzeptanzabsicht und nicht tatsächliches Nutzungsverhalten. Diese Akzeptanztheorien haben sich bei der Analyse von einzelnen Applikationen oder Technologien bewährt. Sie berücksichtigen aber, aufgrund dieser isolierten Betrachtungsweise mögliche Einflussfaktoren von Vorgängertechnologien nicht umfassend. Die Akzeptanz einer Technologie impliziert hingegen oftmals das Ersetzen einer anderen, bereits genutzten Technologie. Eine potenzielle Ursache dafür, dass Nutzer nicht zu einer neuen Technologie wechseln, kann in der etablierten Nutzung einer Technologie begründet sein [7, 8]. Folglich können RCAs nicht isoliert betrachtet werden, denn potentielle Nutzer von RCAs werden bei ihrer Nutzungsentscheidung typischerweise verfügbare Alternativen, wie die Steuerung des Fernsehgerätes mit der Fernbedienung, in ihre Nutzungsentscheidung einbeziehen. Um die Abhängigkeiten abbilden zu können, bietet es sich an, das Wechselverhalten der Nutzer als Rahmen zu verwenden, da es im IS-Kontext schon wiederholt angewandt wurde [8]. Die Forschung zum Wechselverhalten nimmt eine duale Perspektive ein und umfasst sowohl die Vorteile eines Wechsels als auch deren Nachteile. In dieser Studie werden fördernde und hemmende Determinanten identifiziert, die die Nutzung des Smartphones als Steuerungseinheit im Haushalt beeinflussen. Der antizipierte Mehrwert des neuen Anwendungssystems und die Verlustempfindung durch den Wechsel, kann durch diese duale Perspektive berücksichtigt werden.

Darüber hinaus zeigt die IS-Literatur, dass die Determinanten der Akzeptanz von Technologien primär deduktiv abgeleitet werden und somit weitere Faktoren, die im privaten Umfeld auf die Technologienutzung einwirken könnten, unberücksichtigt bleiben [9]. In reinen Befragungen kann das Nutzungsverhalten meistens nur retrospektiv erfasst werden. Erwartungen, Einstellungen und Entscheidungen können sich während des Akzeptanz- und Nutzungsprozesses verändern [10]. Um die bedeutsamsten Determinanten ableiten zu können, ist es notwendig, den gesamten Prozess, von der Erwartungshaltung an die RCA bis hin zur Nutzung oder zum Abbruch der Nutzung (siehe Abbildung 1), zu betrachten. Wir integrieren in unserer Untersuchung motivationale Determinanten der Nutzung und untersuchen den Bewertungsprozess anhand kognitiver Determinanten (gedankliche Steuerung), affektiver Determinanten (Gefühle) und konativer Determinanten (Verhaltensweisen), da diese die Einstellungsbildung beeinflussen können [11, 12].

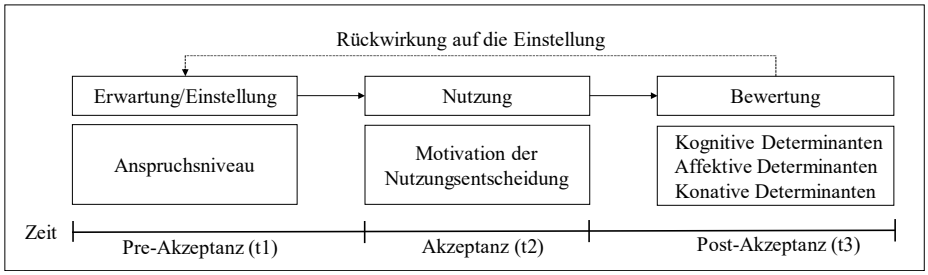

Abb. 1. Theoretischer Rahmen zur Analyse der Nutzung

Bevor eine Nutzungsentscheidung getroffen wird, bilden Nutzer Erwartungen an die Technologie, die durch das Anspruchsniveau der Nutzer beeinflusst werden [13]. Bei der Akzeptanz einer Technologie sind die Nutzer vor allem an dem Neuen interessiert [14]. Mit zunehmender Erfahrung wird die Attraktivität des explorativen Verhaltens weniger Einfluss ausüben und es werden eher funktionale Werte auf die Nutzungsentscheidung einwirken [15].

Die Bewertung des neuen Anwendungssystems ist aus der Verknüpfung von kognitiven, affektiven und konativen Prozessen erklärbar. Diese sind bei der Ableitung von fördernden und hemmenden Determinanten des Wechsels zu der RCA zu berücksichtigen [11, 12]. Im Bereich IT-Nutzung beeinflussen die kognitiven Determinanten, wahrgenommene Nützlichkeit und wahrgenommene Bedienbarkeit, die Verhaltensabsicht entscheidend [15, 16]. Individuen werden eine Technologie nur nutzen, wenn diese ihnen einen Vorteil verschafft [10, 17]. Die Akzeptanz einer Technologie ist auch auf affektive oder emotionale Faktoren zurückzuführen [12, 18]. Zufriedenheit wird als affektive Reaktion beschrieben, die aus vorherigen Nutzungserfahrungen abgeleitet wird. Zufriedene Nutzer neigen dazu, weiterhin die Technologie zu nutzen, während unzufriedene Nutzer die Nutzung einstellen oder zu einer anderen Technologie wechseln [17]. Die Nutzung einer neuen Technologie wird auch von konativen Faktoren, wie Gewohnheiten beeinflusst, da durch wiederholte Abläufe Routinen entstehen, die automatisch ohne kognitive Anstrengungen aktiviert werden [19]. Die Habitualisierung mit der alten Technologie und die Wechselkosten, welche bei der Akzeptanz einer neuen Technologie entstehen, können die wahrgenommene Vorteilhaftigkeit der neuen Technologie beeinflussen [8]. Vor diesem Hintergrund berücksichtigt diese Studie die tatsächliche Nutzung einer RCA, um die Determinanten der Nutzung von RCAs umfassend beschreiben zu können.

3 Methodik

Bei Untersuchungen in einem noch relativ unerforschten Bereich werden vorwiegend qualitative Methoden zur Exploration des Untersuchungsgegenstandes eingesetzt. Da es bisher wenig Vorarbeiten zu den Nutzungsdeterminanten und der Akzeptanz von RCAs gibt, wurde ein qualitatives Forschungsdesign ausgewählt. Hinzu kommen Aussagen der Methodenliteratur, die dazu anregen, qualitative Methoden für die Entdeckung von Faktoren zu nutzen [20]. Diese Aussagen entsprechen dem Ziel dieser Studie, nämlich induktiv Determinanten zu identifizieren, die die Akzeptanz und Nutzung einer RCA beeinflussen [20]. Als Verfahren der Stichprobenauswahl wurde das theoretische Sampling eingesetzt, das auf die konzeptuelle Repräsentativität der Ergebnisse abzielt und somit für die Forschungsfrage geeignet ist [21]. Um tatsächliches Nutzungsverhalten untersuchen zu können, wurden acht Probanden ausgewählt, die einen Smart-TV und ein Smartphone besaßen und bereit waren an einer umfassenden Tagebuchstudie teilzunehmen. Die Probanden haben je nach Smartphone-Betriebssystem (iOS oder Android) und Hersteller ihres Smart-TVs (Samsung oder Sony) unterschiedliche RCAs verwendet. Eine Übersicht der Stichprobe ist in Tabelle 1 dargestellt.

Tabelle 1. Überblick über die Charakteristika der Probanden

Proband	*1*	*2*	*3*	*4*
Alter	25	18	20	26
Bildung	Mittlere Reife	Realschule	Fachhochschule	Universität
Beruf	Angestellter	Auszubildender	Student	Ingenieur
Fernsehkonsum (Std/Woche)	14-15	14	20	8
Anzahl Apps	10	20-30	10-15	20
Anzahl genutzter Apps	5	5-8	5-7	4-5
Proband	*5*	*6*	*7*	*8*
Alter	24	30	26	29
Bildung	Abitur	Mittlere Reife	Universität	Universität
Beruf	Student	berufstätig	Ingenieur	Pressesprecher
Fernsehkonsum (Std/Woche)	14-15	10-15	5-7	12
Anzahl Apps	70-80	30	152	15
Anzahl genutzter Apps	15	15	40	5

Die qualitativen Daten wurden in einem dreiteiligen Untersuchungsdesign erhoben, um alle Phasen der Akzeptanz von der Erwartungsbildung bis hin zur tatsächlichen Nutzung in die Untersuchung einbeziehen zu können [10, 22]. In einem ersten Schritt wurden anhand von teilstrukturierten Interviews die demografischen Angaben und Nutzungsgewohnheiten abgefragt sowie Fragen zu den Erwartungen und Einstellungen der Probanden gegenüber der RCA gestellt (z.B. aus dem Leitfaden: Was erwarten Sie von der RCA, die Sie kommende Woche testen werden?). Eine anschließende einwöchige Tagebuchstudie, basierend auf dem Interval-Contingent-Design [23], erlaubte es, die in der Nutzungsentscheidung involvierten motivationalen Prozesse zu erheben. Den Probanden wurde es freigestellt, die herkömmliche Fernbedienung oder die RCA auf dem Smartphone zur Steuerung des Smart-TVs zu verwenden. Als Erhebungsinstrument wurde die Paper&Pencil Methode und keine Online-Befragung durchgeführt, damit sich die Erhebungsmethodik und der Untersuchungsgegenstand nicht gegenseitig beeinflussen konnten. Die Probanden wurden gebeten, jedes Mal, wenn sie den Smart-TV bedienen, zu vermerken, welche Steuerungseinheit sie benutzt haben und aus welchem Grund (z.B. aus dem Tagebuch: Haben Sie die RCA, die Fernbedienung oder beides zur Steuerung ihres Smart-TVs benutzt?). Der wahrgenommene Nutzen und die hemmenden Faktoren wurden mit den zu vervollständigenden Statements „mir ist positiv aufgefallen“ und „mir ist negativ aufgefallen“ erhoben. Diese Selbstdokumentation ermöglichte den Zugang zu dem Verhalten der Probanden in der alltäglichen Nutzungssituation [23]. In einem abschließenden Post-Interview wurde die Tagebuchstudie nachbesprochen (z.B. aus dem Leitfaden: Wie war die Woche mit der neuen App?). Die Fragen ermittelten, ob die Erwartungen der Probanden an die Nutzung der RCA erfüllt wurden (z.B. aus dem Leitfaden: Wurden Ihre Erwartungen von letzter Woche erfüllt?), welche Determinanten die Nutzung beeinflusst haben und ob die Absicht besteht, die RCA weiterhin zu nutzen. Die Interviews wurden anhand eines Leitfadens geführt, welcher offene Fragestellungen zuließ und den Probanden die Möglichkeit gab, ihre

Wahrnehmungen zu beschreiben. Die Auswertung der Transkripte erfolgte nach Mayring [20] und ermöglichte einen interpretativen Zugang zu den Daten. Im Rahmen der Inhaltsanalyse wurden die Aussagen der Probanden konsolidiert und zu dem Akzeptanzprozess (Erwartung an die Nutzung, Nutzung und Bewertung der Nutzung) sowie zu den fördernden und hemmenden Nutzungsdeterminanten zugeordnet.

4 Ergebnisse zur Nutzung von Remote Control Applikationen

Die Ergebnisse der dreiteiligen Erhebung wurden zu acht übergeordneten Ergebnisthesen zusammengefasst.

4.1 Erwartung und Einstellung

Die Erwartungen an die Nützlichkeit der RCA werden in Relation zur Fernbedienung, basierend auf kognitiven und konativen Determinanten gebildet. Nach dem Anspruch der Probanden sollte die RCA mindestens die Fernbedienung ersetzen und den Steuerungsprozess vereinfachen. Hier ist tendenziell der Einfluss der Gewöhnung an das Altsystem auf die Erwartungen an die neue RCA zu erkennen: *„Mit der App kann man dann den Fernseher steuern, die hat dann die gleichen Funktionen wie meine normale Fernbedienung auch“* (Pre-I. 2). Ein Proband äußerte sich folgendermaßen: *„(..), dass ich dann quasi eine Fernbedienung auf dem Smartphone habe und die Fernbedienung kann dann vorne am Fernseher liegen bleiben“* (Pre-I. 1). Die Erwartungen der Probanden waren geprägt von rationalen Task-Technology-Fit-Überlegungen, die insbesondere die funktionalen Werte wie Nützlichkeit und Bedienbarkeit in den Vordergrund stellten: *„Meine Erwartung ist, dass die App schnell hochfährt, dass ich mich gut zurechtfinde, dass sie leicht zu bedienen und übersichtlich ist, und dass die Verbindung zwischen Smartphone und Smart-TV kein Problem ist“* (Pre-I. 7). Die Probanden erwarteten von der RCA Zeitersparnis und Mobilität im Alltag: *„(..), dass es im Alltag leichter wird, das Gerät zu steuern, und dass ich mir Zeit spare oder, dass es gemütlicher ist“* (Pre-I. 2) und ein anderer Proband erwartete, dass es *„Zusatzfunktionen gibt*“ (Pre-I. 5). Bei der Umstellung der Nutzungsgewohnheiten von der Fernbedienung auf die RCA wurden von einigen Probanden keine Schwierigkeiten erwartet, da sie sich sehr sicher im Umgang mit Apps und neuer Technik fühlten: *„Glaub ich jetzt nicht für mich, weil ich kenne mich eigentlich schon besser aus mit den Apps und allem“* (Pre-I. 3). Dennoch antizipierten einige Probanden mögliche Änderungen von erlernten Verhaltensmustern und erwarteten beispielsweise: *„(..), dass die Anordnung der Knöpfe vielleicht anders ist, dass die Funktionen vielleicht auch anders hinterlegt sind“* (Pre-I. 5). Die Ergebnisse bestätigen, dass die Erwartungen des Nutzers an die RCA auf Grundlage der alternativen Möglichkeiten abgeleitet werden. Die Nutzer bewerten nicht nur spezifische Funktionen der neuen RCA, sondern berücksichtigen in der Erwartungsbildung auch Funktionen und Verhaltensmuster der herkömmlichen Steuerung. Die Nutzung des Smartphones als Steuerungseinheit ist somit abhängig davon, ob die RCA bereits vorhandene Steuerungsmöglichkeiten ersetzt oder mittels der RCA Geräte im häuslichen Bereich

bedient werden, die bisher noch nicht steuerbar waren. **Ergebnis 1:** Die erwartete Nützlichkeit von RCAs wird in Relation zu dem herkömmlichen Steuerungssystem gebildet und beeinflusst, als Erwartungshaltung, die Nützlichkeit von RCAs.

4.2 Nutzung

Die Ergebnisse der Tagebuchstudie zeigen, dass die Bereitschaft, die RCA zu nutzen, von der empfundenen Innovationsfreude abhängt [24]. Dieses Interesse an neuen Technologien wurde von Proband 7 beschrieben: *„mir macht es Spaß, ich beschäftige mich auch viel mit Technik. (..) Da bin ich gerne am Ausprobieren, beim Basteln und am Überlegen, wie man Dinge lösen könnte"* (Post-I.). Diese Neugierde an dem Neuen ist insbesondere in der Akzeptanzphase von Technologien ersichtlich: „*Ich such auch immer nach neuen interessanten Apps. Lade mir viele Apps runter, lösch aber auch die, die mir nicht gefallen relativ schnell wieder"* (Post-I. 7). Im Laufe der Zeit schwächt die erste Neugierde ab und andere Faktoren wie erlernte Verhaltensweisen oder die Nützlichkeit der RCA werden für die weitere Nutzung entscheidender: „*Mit der Zeit sieht man dann, dass es doch nicht so praktisch ist. Also das ist halt die Neuigkeit"* (Post-I. 4). Die längerfristige Nutzung der RCA konkurriert mit unbewussten, gewohnten Verhaltensmustern, denn der Begeisterungseffekt der Funktionen verliert rasch seinen Reiz: *„Die Bedienung der App ist am Anfang ungewohnt, wobei - es stört anfangs nicht, weil man so neugierig ist und wissen will, ob es mit dem Handy genauso funktioniert"* (Post-I. 6). Die Ergebnisse offenbaren, wie wichtig ein beständiger hedonistischer Nutzen für die Nutzung der RCA ist. Die Aufrechterhaltung von Interesse und Neugierde sind sogar bei einer RCA mit vornehmlich utilitaristischer Auslegung relevant und beeinflussen den Wechsel. **Ergebnis 2:** Innovationsfreude beeinflusst die Nutzung von RCAs positiv.

4.3 Bewertung der Nutzung

Kognitive Determinanten. Die Bedienbarkeit wird im Laufe der Zeit weniger wichtig, da die Nutzer gewohnt sind, mit Apps umzugehen: „*wenn man die App das erste Mal nutzt, dann muss man sich erst einfinden, aber dann ist es eigentlich relativ einfach"* (Post-I. 3). Die Umstellung ist damit keine hemmende Determinante, die dem Wechsel entgegensteht. Die Nützlichkeit ist hingegen auch nach der Akzeptanzphase ein einflussreiches Nutzungskriterium. Wenn Funktionen beeinträchtigt sind, dann ist es wahrscheinlich, dass zu einer alternativen Steuerungsmöglichkeit zurückgegriffen wird. Die Ergebnisse zeigen, dass einige funktionale Wertdimensionen erst während der Nutzung relevant wurden, und im Vorfeld, bei der Erwartungsbildung, überwiegend nicht im Bewusstsein der Nutzer waren. Die Probanden erkannten, dass die Vernetzung nur vorhanden ist, solange der Smartphone-Akku geladen ist: „*Als der Akku von meinem Smartphone leer war. (..) Da war es dann schon wieder Gewohnheitssache, dass ich den Fernseher wieder mit der Fernbedienung steuere*" (Post-I. 6). Das ähnliche Layout der Steuerungsfunktionen wurde von den Probanden geschätzt: „*Die Abbildung der Fernbedienung finde ich sehr gelungen, dass man das Layout von der realen, physischen Fernbedienung wiederfindet"* (Post-I. 7). Vor dem Hinblick der fehlenden

Haptik, wurde die Möglichkeit der Gestensteuerung positiv bewertet: „*Die Gestensteuerung funktioniert ohne direkte Sicht auf den Smartphone Bildschirm"* (Post-I. 7). Der wahrgenommene Nutzen wurde somit durch Zusatzfunktionen beeinflusst: *„das mit den Sendern fand ich sehr cool (..), dass man die Favoritenliste speichern kann"* (Post-I. 6). Gestensteuerung, Personalisierung und die Möglichkeit, die App als Second Screen zu nutzen, werden als Mehrwert von RCAs empfunden: „*Ich würde die App nicht nur benutzen, weil ich sie auf dem Handy habe, sondern die App muss einen praktischen Nutzen haben (..) sie muss deutlich mehr können als die Fernbedienung"* (Post-I. 5). Die Ergebnisse zeigen, dass die Wahrnehmung der funktionalen Werte der RCA, aufgrund der tatsächlichen Nutzungserfahrungen, abgewogen werden und der Zusatznutzen gegenüber dem herkömmlichen Steuerungssystem, zu der Akzeptanz beiträgt. **Ergebnis 3:** Die wahrgenommene Nützlichkeit der Funktionen beeinflusst die Nutzung von RCAs positiv.

Weiterführend wird deutlich, dass die Zukunft von RCAs aus Nutzersicht nicht in fragmentierten Insellösungen liegt, sondern die Digitalisierung von Geräten des alltäglichen Gebrauchs das Bedürfnis nach einer konsolidierten Steuerungseinheit schafft. Der Nutzen der RCA ist abhängig von der Anzahl an Geräten, die über dieses Anwendungssystem gesteuert werden können. Proband 2 beschrieb den Mehrwert einer Integration mehrerer Steuerungsmöglichkeiten in einer RCA folgendermaßen: *„wenn man durch eine App mehrere Geräte steuern kann, würde ich die App bestimmt noch öfter verwenden"* (Post-I.). Auch Proband 8 war der Meinung, dass ein Nutzen durch eine „Steuerungszentrale" entsteht: „*wenn die App drei Fernbedienungen ersetzen würde, dann wäre das ein riesen Mehrwert* (Post-I.). **Ergebnis 4:** Die Bedienung von mehreren Geräten im Haushalt über eine einzige konsolidierte Steuerungseinheit beeinflusst die Nutzung von RCAs positiv.

Die Bedeutung des Smartphones als Steuerungseinheit im Haushalt hängt entscheidend davon ab, ob Geräte im Haushalt, die bisher noch nicht ortsunabhängig steuerbar waren, mittels der RCA bedient werden können. Der Nutzen basiert somit auf dem jeweiligen Nutzungskontext. Proband 4 befürwortet daher, dass er den Fernseher von jedem beliebigen Ort aus bedienen kann: *„dass ich dann Programme aufnehmen kann, von dort wo ich gerade bin*" (Post-I.). Darüber hinaus bietet eine ortsunabhängige Steuerung über eine zentrale RCA die Möglichkeit, effizient die Haushaltsgeräte zu nutzen und zu kontrollieren: „*Ich kann die Geräte meinem Tagesablauf anpassen, beziehungsweise ich muss nicht das Gerät vor Ort bedienen, sondern kann es von einem entfernten Ort aus machen (..) das erspart mir Zeit"* erklärte Proband 5 (Post-I.) und Proband 7 beschrieb: „*Ich sehe einen großen Komfortgewinn, der darin liegt, dass ich im Prinzip von überall (..) mein Haus steuern kann"* (Post-I.). Die Wahrnehmung, dass die RCA eine ortsunabhängige Steuerung ermöglicht, wirkt positiv auf die Wechselabsicht von herkömmlichen Steuerungssystemen zu RCAs. **Ergebnis 5:** Die ortsunabhängige Steuerung von Geräten im häuslichen Bereich beeinflusst die Nutzung von RCAs positiv.

Affektive Determinanten. Den Ergebnissen entsprechend nehmen Individuen subjektiv unterschiedliche Wertdimensionen wahr und bewerten diese in Abhängigkeit zu ihren Erwartungen und Vorstellungen. Proband 3 erwartete beispielsweise, dass die

RCA die Fernbedienung substituieren wird. Diese Erwartung hatte sich für ihn nach der Nutzung bestätigt: *„Im Großen und Ganzen kann die App die Fernbedienung ersetzen"* (Post-I.). Im Gegensatz zu der Konfirmation von Erwartungen konnten auch positive Diskonfirmationen, *„Die App ist wie die Fernbedienung und hat noch mehr Zusatzfunktionen und deshalb ist die App besser als die Fernbedienung"* (Post-I. 2) und bei unzureichender Erfüllung von Erwartungen negative Diskonfirmation entstehen. Proband 1 nannte die Gewohnheit und fehlende Funktionen als Treiber seiner Unzufriedenheit: *"Zum einen ist es eben einfach die Gewohnheit und zum anderen sind es zum Teil die fehlenden Funktionen an der App, die jetzt einen Mehrwehrt zu einer klassischen Fernbedienung wären. Das fehlt einfach"* (Post-I.). Proband 3 beschreibt die Zufriedenheit mit der herkömmlichen Technologie: *„Ich glaube, dass ich bei meiner Fernbedienung bleibe, (..) weil man braucht die Fernbedienung nicht neu verbinden. Das ist ein Vorteil"* (Post-I.). Diese Aussagen sind ein Hinweis darauf, dass die Grundfunktionen und Zusatzfunktionen den Annahmen der „Zwei-Faktoren-Theorie" von Herzberg [25] entsprechen, bei der fehlende Hygienefaktoren zu Unzufriedenheit führen und nur vorhandene Motivatoren, entsprechend der Erwartungshaltung, zu der empfundenen Zufriedenheit beitragen. **Ergebnis 6:** Die Zufriedenheit mit der herkömmlichen Steuerungsmöglichkeit beeinflusst die Nutzung von RCAs negativ.

Aus der Intention zur Weiterempfehlung der RCA können Rückschlüsse auf die Zufriedenheit gezogen werden. *Individuen entwickeln eine positive Einstellung gegenüber der Technologienutzung, wenn ihr soziales Umfeld der Nutzung zustimmt und diese befürwortet [5]. Es zeigt sich, dass Digital Natives keinen Konformitätsdruck verspüren, sondern eher die Rolle eines Technologiepioniers und Meinungsführers in ihrem sozialen Umfeld übernehmen:* *„Es ist halt einfach nett, wenn man mal zeigt, es gibt so eine App und die funktioniert auch gut"* (Post-I. 5). Sie teilen die Freude an der Nutzung der Technologie mit Anderen und nutzen den Neuigkeitswert, um einen gewissen Status in einer sozialen Gruppe zu erlangen [26]: *„Ich hab es denen sofort gezeigt, (..) und das ist einfach ein tolles Gefühl. Ich werde die App nicht löschen"* (Post-I. 4). **Ergebnis 7:** Die Rolle des Nutzers in seinem sozialen Umfeld beeinflusst die Nutzung von RCAs positiv.

Konative Determinanten. Die Probanden beschrieben auch die Vor- bzw. Nachteile der neuen Anwendungsweise in Bezug auf das Layout und die fehlende Haptik. Das fehlende haptische Feedback der Smartphone-Oberfläche wurde als Umstellungsschwierigkeit wahrgenommen: *„Die Bedienung hat mir sehr gut gefallen, (..) wenn man von der Gegebenheit absieht, dass man haptisch kein Feedback hat"* (Post-I. 7). Proband 3 war der Meinung, dass er bei der Fernbedienung bleiben wird, *„weil das ist man gewohnt und man weiß, wo man hindrücken muss"* (Post-I.). Die Routinen, den Fernseher zu bedienen, sind über einen längeren Zeitraum erlernt und beeinflussen, nach der anfänglichen Neugierde, die Nutzungsentscheidung. Proband 1 drückte diesen Sachverhalt aus: *„Dann kommt wieder die Gewohnheit ins Spiel"* (Post-I.). Auch Proband 5 erkannte diese innere Disposition: *„Wenn man seine Fernbedienung gewohnt ist, dann ist es eigentlich so eine Selbstverständlichkeit"* (Post-I.). Die Gewohnheit an die herkömmliche Technologie hat tendenziell einen negativen Einfluss auf die Wechselabsicht: *„Ich glaube, dass ich bei meiner Fernbedienung*

bleibe, weil (..) das ist man gewöhnt" (Post-I. 3). Die Tagebuchstudie offenbarte, dass nach einer Woche die kontinuierliche Nutzungsabsicht noch bestand, aber sich zunehmend abschwächte. Nach einem Monat nutzte nur noch eine Minderheit die RCA. Diese Argumentation wird unterstützt durch das Phänomen, das Apps häufig ausprobiert werden und nach kurzer Nutzungsdauer wieder gelöscht bzw. nicht mehr genutzt werden und die Individuen zu ihrem früheren Nutzerverhalten zurückkehren. **Ergebnis 8:** Die Gewohnheit, die herkömmliche Steuerungsmöglichkeit zu nutzen, beeinflusst die Wechselabsicht zu RCAs negativ.

5 Zusammenfassung der Ergebnisse

Aus den Ergebnissen konnten wir, mittels der induktiven Vorgehensweise, Determinanten der Nutzung einer zentralen digitalen Steuerungsmöglichkeit identifizieren. Die Analyse der Erwartungen der Probanden an die RCA zeigt, dass wenn Nutzer eine Vorgängertechnologie wahrnehmen, die funktional ähnliche Aufgaben erfüllen kann, die neue Steuerungsmöglichkeit, immer in Relation zu dieser, bewertet wird. Dieses Ergebnis bestätigt die Annahme, dass eine isolierte Betrachtung der RCA die Wirklichkeit nicht umfassend beschreiben kann. Die Ergebnisse zeigen auch, dass die Nutzungsabsicht abhängig von der subjektiven Erwartungshaltung der Nutzer ist. Werden, basierend auf dem Vorgängersystem, hohe Erwartungen an die Nützlichkeit der RCA gebildet, wird der Vorteil von RCAs geringer eingeschätzt. Die Grundfunktionen der Fernbedienung wurden von den Probanden vorausgesetzt, und ein Fehlen dieser Funktionen führte zu Unzufriedenheit bzw. zu einer Nichtnutzung oder Löschung des neuen Dienstes. Die Tagebuchstudie und die Begründung der Nutzung zeigen, dass die fördernden Determinanten der Wechselabsicht durch kognitive Determinanten geprägt sind. Die Ergebnisse machen deutlich, dass die Nutzer die Ansteuerung von mehreren Geräten über ein Anwendungssystem wertschätzen. Die RCA wird positiv bewertet, wenn Geräte ortsunabhängig gesteuert werden können. Außerdem beeinflusst die empfundene Bestätigung durch Pionierverhalten im sozialen Umfeld und Innovationsfreude die RCA Nutzung positiv. Die hemmenden Determinanten umfassen die allgemeine Zufriedenheit und die Gewohnheit mit dem herkömmlichen Steuerungssystem.

6 Fazit, Limitationen und Ausblick

Zusammengefasst geben diese Ergebnisse auf der Ebene des Individuums nützliche Implikationen für Entwickler und Anbieter von Smart Products und Services. Ein besseres Verständnis derjenigen Faktoren, die zur Beendigung oder Förderung der Nutzung von RCAs führen, kann Unternehmen helfen, für neue Entwicklungen zu lernen. Alle Probanden sind der Ansicht, dass eine RCA in Zukunft eine effizientere und flexiblere Lösung im Vergleich zu herkömmlichen Steuerungssystemen bieten würde, wenn eine zentrale und ortsunabhängige Steuerungsmöglichkeit von Geräten über eine RCA gegeben ist. Folglich könnten mobile Endgeräte zukünftig eine bedeutende Rolle im Haushalt einnehmen und nicht nur als Kommunikations-

instrument, sondern auch als universelle Steuerungseinheit von digitalen Geräten fungieren. Durch die Berücksichtigung der verschiedenen Akzeptanzphasen in einem Längsschnittdesign können die Einflussfaktoren theoriebildend hergeleitet werden, die mit einer Fokussierung auf eine Phase nicht berücksichtigt worden wären. Damit adressiert diese Studie die Forderung von Wu et al. [9], vermehrt qualitative Forschung zu nutzen, um die „Black Box" der Akzeptanzfaktoren zu untersuchen und berücksichtigt basierend auf dem Rahmenmodell von Sorgenfrei et al. [22] mehrere Phasen des Akzeptanzprozesses. Schlussendlich ermöglichten uns die technologieaffinen Probanden erste Einblicke in die Verhaltensweisen von Nutzern im Smart Home [27].

Bei der Interpretation der Ergebnisse sind Limitationen zu berücksichtigen. Weiterführende Forschung sollte die Ergebnisse ergänzen und weitere Nutzungsbereiche untersuchen. Darüber hinaus weist eine qualitative Auswertung eher auf Tendenzen hin [20]. Aus diesem Grunde empfehlen Kaplan und Duchon [28], ergänzend auf quantitative Forschung zurückzugreifen, um die Ergebnisse zu verallgemeinern und abzusichern. Daher sollten die identifizierten Determinanten in einem zweiten Schritt quantitativ überprüft werden.

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Preventing Over-Spending: Increasing Salience of Credit Card Payments through Smartphone Interventions

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Abstract. Credit card related over-spending represents not only an issue on the individual level, but also a growing societal burden. For example, consumers spend over $70bn in interest fees annually in the US alone. As mobile-mediated information systems have been proven effective in behavior change interventions, this study investigates the efficacy of a novel smartphone application to increase the salience of credit card usage. It seeks to motivate credit card users to save money by lowering expenditures, a desirable behavior preventing possible over-spending. In particular, the app suggested weekly saving goals and measured the respective effect of increased transaction salience on spending behavior. The preliminary results from the pre-study cohort (N=95) suggest that increased salience significantly lowers expenditures. We plan a large-scale study (N>1'000) to further examine the relationship between transaction salience and spending volume for low-transparency payment methods such as credit cards.

Keywords: Credit Card Transaction Salience, Exceptional Purchases, Goal-Setting, Financial Literacy

1 Introduction

Most developed countries have witnessed a decline in the use of cash in favor of credit cards and other digital payment forms [1]. The latter provide benefits for customers, *e.g.* forgoing cash withdrawals and the possibility to conveniently track expenses, maintaining digital budgets, thereby informing purchasing behavior adjustments. However, literature provides growing evidence that consumers are more likely to overspend with digital payment forms. People who use cash on average tend to spend less, are more cost-focused, and are less likely to accrue debt compared to credit card users [2]. The rise of credit cards is also reflected in a 36% increase in total outstanding credit card debt in the US between 2000 and 2015 to a level of $925bn [3]. An estimated one third of households carry forward at least some credit card debt from month to month [4], while median income levels have stagnated [5]. These numbers suggest that consumers increasingly use credit cards and debt as an alternative source of income, leaving them more vulnerable to financial hardships, *e.g.* job loss [6]. Aspects related to credit card usage, such as over-spending, carrying forward debt to the following month, and general worry about credit card debt, have been identified as important

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stress factors [7, 8]. Thus, when deciding whether to use credit cards, consumers face a trade-off between greater convenience and transparency, or financial discipline. We are collaborating with a card issuer to address the outlined trade-off by increasing transaction salience via feedback loops within a mobile app, thus helping people gain better control over their spending.

2 Theoretical Background

2.1 The Effect of Payment Channels on Salience of Spending Behavior

Research has shown that a chosen means of payment affects consumer choice and price sensitivity. Studies attribute this phenomenon to consumers' 'pain of payment', which is more prominent when paying with cash, compared to more abstract, digital means of payment [9]. The burgeoning adoption of digital payment forms, however, impair the consumer's ability to record and recall transaction information in his consciousness, commonly referred to as decreased salience [10]. This effect is all the more pronounced for credit cards, where the purchase and wealth depletion events are temporally decoupled. This decreased salience, temporal disconnect and monthly transaction aggregation make credit cards a less transparent means of payment than cash, adding to the challenge for consumers to intuitively learn from and adapt their spending behavior [9, 11]. As a wide-spread low-salience payment form, credit cards have received a lot of attention in marketing and consumer behavior research, typically concluding that people exhibit a strong tendency to spend more for the same items than they would have when using cash, as consumers focus more on product properties than on costs when using digital payment methods. Studies have shown this effect for various products, *e.g.* treats and luxury items [9, 10, 12, 13].

2.2 Mental Accounting, Narrow Choice Bracketing, and Exceptional Purchases

Besides the aforementioned negative behavioral changes when switching from cash to credit card payment, consumers are further influenced by mental biases including mental accounting and narrow choice bracketing leading to costly purchase decision-making [14], specifically, when confronted with exceptional (*i.e.* infrequent, unusual) purchases [15]. Scholars argue, that for ordinary (*i.e.* frequent, usual) expenses such as groceries or phone bills, consumers are comparatively proficient at forecasting and managing expenses, as well as mitigating financial distress by using simple preventive techniques like leaving a financial buffer [15]. In contrast, the projection and management of exceptional expenses is more challenging, since they are often regarded in an isolated fashion (narrow choice bracketing), and their frequency is underestimated [15]. Because of this narrow framing of exceptional transactions, there likely are no prior purchases that would deplete the mental category budget. This leads to consumers granting themselves greater financial slack, and ultimately overspending on exceptional expenses [15, 16]. The situational context of transactions as being of ordinary or

exceptional nature hence plays a role in spending behavior, and should thus be taken into consideration when designing interventions aiming to prevent over-spending.

3 Research Model

This study investigated the effect of increased credit card transaction salience on credit card spending compared to the within-subject baseline. Increasing the salience of previous transactions has been shown to affect individuals' decision-making for subsequent purchases [11, 15]. Furthermore, credit cards generally exhibit lower salience than cash, making it harder for consumers to intuitively learn from previous purchases [9, 11]. We hence hypothesize that manipulating transaction salience will be an effective means to influence consumers' credit card spending. Research suggests that individuals might be more proficient in predicting ordinary expenses than exceptional ones, making them particularly prone to over-spending in the latter category [15]. We therefore introduced a high-salience condition in three groups, in which we particularly highlighted either ordinary expenses (T2), exceptional ones (T3), or both categories equally (T1). Our study thereby manipulated the salience of specific groups of transactions and measured the efficacy thereof in terms of reducing participants' total credit card spending, as compared to a control group, which did not receive the salience manipulation. However, the implementation of said experiment design required participants in the treatment groups (T1, T2, T3) to review and classify every credit card transaction. Because this task in itself arguably increased transaction salience, we also tested this task in isolation without increasing transaction salience any further during a two-week warmup period (medium salience). We further hypothesize that frugality will negatively moderate the reduction in spending since frugal consumers are known to be disciplined with their spending, hence any further consumption restriction will be harder to accomplish [17]. Similarly, scholars argue that compulsive buying behavior is in parts rooted in low levels of self-efficacy, therefore goal attainment guidance might lead to stronger behavior adjustments than for non-compulsive buyers [18]. Moreover, individuals with more stable consumption patterns, *i.e.* high regularity of baseline spending, will arguably have an easier time drawing conclusions and adjusting their behavior based on our interventions as compared to those with highly irregular spending patterns; we argue that for individuals with higher baseline variance, more specific action guidelines might be necessary to achieve a behavior change. In addition, individuals with higher previous spending have arguably more room to reduce their spending, hence the baseline spending was introduced as a

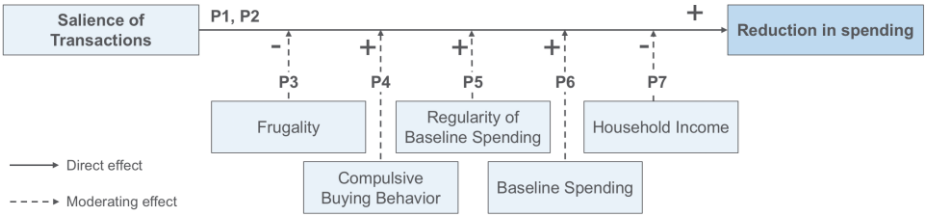

Figure 1. Research Model

further moderating variable. Finally, economists have established that consumption is positively correlated with household income; we thus argue that the efficacy of our consumption-reducing intervention might be moderated by household income, albeit we suspect the true nature of the moderation to be non-linear, *i.e.* our interventions might be most pronounced for the middle class, while showing weaker effects both at the lower and upper ends of the income spectrum. Figure 1 summarizes our research model that tests a total of seven propositions, two of which evaluate the direct effect of our salience manipulation towards the dependent variable, reduction in spending (P1 – P2), whereas the remaining propositions (P3 – P7) test moderating effects:

P1. By having to reflect on every purchase through a binary categorization task (T1, T2, T3 during warmup), people will spend less[1] compared to a control group without this task in the same period.

P2. Participants in the high-salience setting (T1, T2, T3 after warmup) will spend less than the control group in the same period.

P3–P7. Frugality (P3), compulsiveness (P4), regularity of baseline spending (P5), total baseline spending (P6), and income (P7) will moderate the reduction in spending.

4 Experiment Design

While a lot of research in Behavioral Economics is conducted with surveys or in controlled lab environments, we wanted to investigate the efficacy of our interventions through a quasi-experimental setup in a real-world environment over a sufficient period of time, which we argue will yield more insightful findings. To investigate our research propositions, we thus designed a field study following a controlled randomized trial

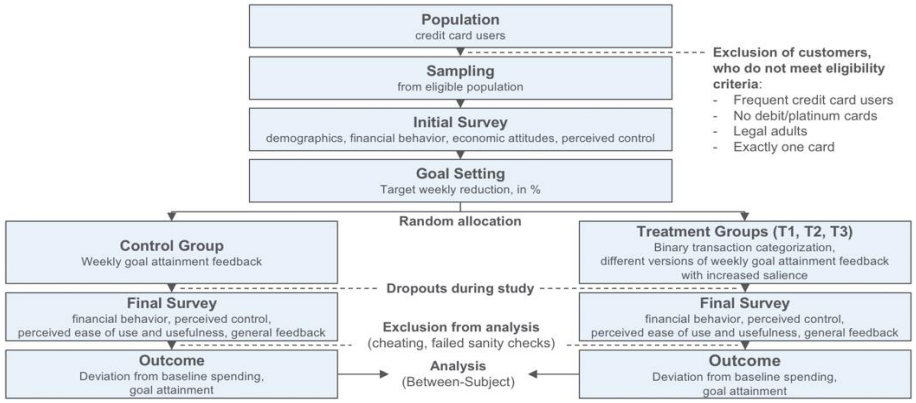

Figure 2. Experiment Design

approach with a sample of at least 1'000 Swiss credit card users, as summarized in Figure 2. A rather extended study duration of 14 weeks (two-week warmup period plus 12 feedback cycles) was chosen to ensure that the study could measure medium-term

[1] For all propositions, we compared the weekly spending observed during the study with the respective participant's baseline (previous 52-week mean spending).

reactions to feedback. Participants were asked to download a mobile app (offered for iOS and Android, in English, German, French, and Italian), which was then linked to their existing credit card. Inside the app (see Figure 3), users received condition-specific instructions on how to use the app. They were also prompted to fill out a 19-item questionnaire and to define a weekly spending goal, which remained adjustable. Goal-setting was included to provide a meaningful experience for all participants including the control group. As a default goal, the app suggested a 15% spending reduction compared to the individual baseline. Since the efficacy of goal-setting in behavior change interventions has been proven in other domains such as energy consumption [19, 20], we incorporated goal-setting for all groups without further testing its effects. The initial survey inquired demographic data, financial behaviors (*e.g.* existence of a household budget), as well as economic attitudes (frugality, compulsiveness [17, 18]), allowing us to conduct a follow-up subgroup analysis. Furthermore, the credit card firm provided us with 52 weeks of baseline data (weekly cumulative spending) for each opted-in user. All treatment groups received push notifications prompting them to categorize new transactions as 'ordinary' or 'exceptional'. When no new transactions were processed on a particular day, categorization reminders were sent. These notifications were sent out at most once a day, only between 8am and 10pm (to minimize interferences), and included information about transactions that remained uncategorized. For example: "Please categorize your new transaction at Grocery Store X over CHF 49.99 as well as Y previous transactions".

Our study manipulated transaction salience in three levels – from low (control group) to high: During the warmup period, the study design was identical for participants across all treatment groups (T1, T2, T3) due to the absence of feedback. They needed to review and categorize every transaction, without receiving direct goal attainment feedback (medium salience). After the warmup period, participants started to receive push notifications that included personalized goal attainment feedback (high salience). The treatment difference between T1, T2, and T3 lied in the exact content of said

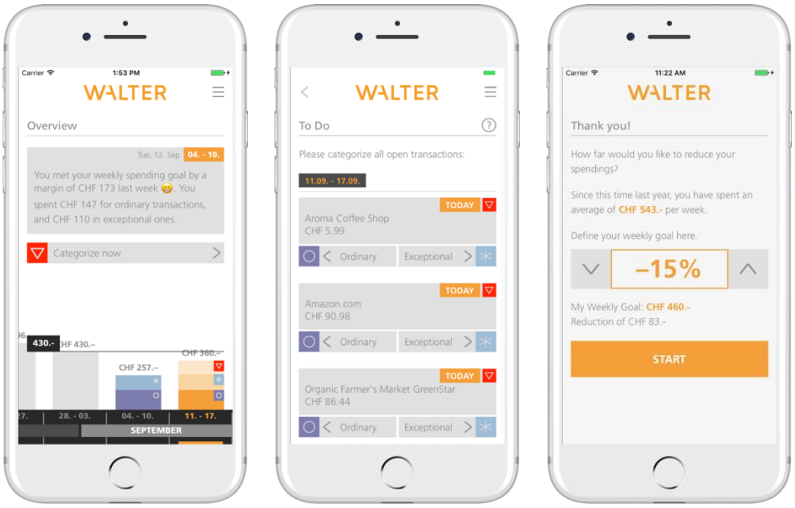

Figure 3. Mobile app: i) goal attainment feedback, ii) expense categorization, iii) goal setting

feedback, as described in the previous section. In contrast, control group participants did not need to categorize transactions at any point. After the warmup period, they received goal attainment feedback on their weekly expenditure, without any focus on a particular expense type. Including a control group was also crucial to control for seasonal effects. In addition, all participants begin the study within a 7-day period, and we deliberately planned the study in a somewhat regular phase of the year, *i.e.* outside major holiday seasons. We also statistically controlled for variables such as occupation, household size, number of transactions per week, and share of wallet. In the final survey, we ask participants to estimate the number of transactions made in the previous seven days as a manipulation check. From the credit card firm we received statistics regarding demographics as well as cumulative weekly spending, which allowed us to gauge the regularity of weekly spending (σ/μ=1.0113, n=74'097). Based on comparable field studies, *e.g.* [19, 21], we conservatively assumed to achieve a 5% decrease in spending in at least one of the treatment groups. An a-priori power analysis with G*Power yielded an estimated total target sample size of 185 at a power level of 0.95. Since our study requires active participation over three months, we aim for a total sample size of at least 1'000 individuals in the beginning, to err on the side of caution. From a population of more than 70'000 eligible credit card users, email invites will be sent to a random subset, whereas the conversation rate is estimated based on prior experience of our partner company. Once customers download the app and agree to participate in the study, they are randomly assigned to one of the four groups.

5 Status Quo and Outlook

We are currently running a pre-study with 95 individuals, who volunteered to sign up from a pool of 495 people (members of our extended research team and employees of the card issuer). The participants do not necessarily match the inclusion criteria applied in our main study, in particular the requirement of being frequent credit card users, and the sample may not be representative of the entire customer base. Moreover, the pre-study cohort did not have a warmup period, *i.e.* they received feedback starting from the first week. Users directly involved in the design or conduct of this study have been excluded from the analysis. Nonetheless, the observations of the first eleven weeks of our pre-study offer encouraging preliminary insights regarding the efficacy of our interventions. Across the sample, consisting of 822 completed weekly budgets, the mean spending-to-baseline ratio was M_{Total}=.858 (SD_{Total}=1.094), *i.e.* participants reduced their weekly spending by 14.2%, on average. While seasonal effects might play a role in this overall reduction, the control group ($M_{Control}$=1.115, $SD_{Control}$=1.574, $n_{Control}$=284) actually increased their spending by 11.5%, while all other groups decreased their spending compared to the previous year (M_{T1}=.736, SD_{T1}=1.149, n_{T1}=231; M_{T2}=.721, SD_{T2}=1.204, n_{T2}=172; M_{T3}=.703, SD_{T3}=.793, n_{T3}=135). An ANOVA test revealed significant differences between groups (F=5.846, p<.001***). Follow-up pairwise t-tests suggest that all treatment groups differed significantly from the control group (Control-T1: t=3.156, p=.002**; Control-T2: t=3.005, p=.003**; Control-T3: t=3.562, p<.001***), while no effect was found between the treatment

groups. If found to be as effective in our main study, with a more representative sample, we believe that such digital interventions could provide a blueprint for helping people navigate the challenges arising from using digital payment channels, and guide user behavior in general. In future work, we plan to investigate the effect of increased salience not only on actual changes to spending behavior, but also on consumers' perceived control over their expenditures.

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The What and How of Smart Personal Assistants: Principles and Application Domains for IS Research

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Abstract. Digitization brings new possibilities to ease our daily life activities by the means of assistive technology. Amazon Alexa, Microsoft Cortana, Samsung Bixby, to name only a few, heralded the age of smart personal assistants (SPAs), personified agents that combine artificial intelligence, machine learning, natural language processing and various actuation mechanisms to sense and influence the environment. However, SPA research seems to be highly fragmented among different disciplines, such as computer science, human-computer-interaction and information systems, which leads to 'reinventing the wheel approaches' and thus impede progress and conceptual clarity. In this paper, we present an exhaustive, integrative literature review to build a solid basis for future research. We have identified five functional principles and three research domains which appear promising for future research, especially in the information systems field. Hence, we contribute by providing a consolidated, integrated view on prior research and lay the foundation for an SPA classification scheme.

Keywords: Smart Personal Assistants, Context-awareness, Literature Review

1 Introduction

The digital age brings new possibilities to ease many activities of our daily life. Modern systems that assist us conducting particular tasks, we refer to them as Smart Personal Assistants (SPA), rely on emerging technologies, such as natural language processing and artificial intelligence. They pave the way for increased quality in private life and work, while the meaning of 'quality' depends on the user's context: in work environments, adaption to tasks and individuals' characteristics may lead to increased productivity and safety for physically demanding jobs. In a private context, however, SPAs such as Google Assistant, Amazon Alexa, Microsoft Cortana or Samsung Bixby are designed to increase users' comfort and livability. Recent studies show that these systems are increasingly becoming part of many people's everyday lives: the worldwide number of SPA users is expected to grow from 390 million in 2015 to 1.8 billion in 2021 which will result in a total revenue increase from $1.6 billion to $15.8 billion [1]. Thereby, current use cases for SPA are manifold and range from reciting weather information to (autonomously) operation smart home devices [2].

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Although the development and dissemination of SPAs has just gained momentum due to the launch of Amazon Echo products running Alexa, IS research seems to just recently discover the objectified combination of artificial intelligence (AI), machine learning, voice recognition and other recent technologies as promising research area. This is surprising, since assistive technology is far from being a novel topic. For example, assisted driving has already leveraged many potentials of digital technologies and is now reinventing itself by the means of AI and machine learning. From a research perspective, much 'groundwork' has been conducted in the fields of formal and applied computer science, e.g., by investigating and developing intelligent agents [3]. Furthermore, human-computer interaction (HCI) research has analyzed user behavior towards SPAs that offer multiple forms of interaction [4, 5].

However, since the core of the information systems (IS) discipline is concerned with information technology in use [6], we argue that it is able to make great contributions to SPA research by mining theoretical, empirical and design knowledge. Hence, the purpose of this paper is to establish a common and solid foundation for future SPA research in IS. Therefore, we conducted a systematic literature review and present selected findings, i.e., fundamental principles and domains where further research appears to be promising. With our review, we contribute to IS but also to adjacent disciplines by providing an integrative view on what is now and next in SPA research. Since especially recent research is inextricably linked with current practical advancements, our work may also help practitioners to obtain lexical clarity as well as an overview on opportunities and open questions regarding SPAs.

The paper is structured as follows. Section 2 introduces the basic concepts and terms around SPAs that guide our literature review which is described in section 3. We present our findings, namely basic principles and application domains, in section 4 and discuss them along with additional unanswered questions in section 5. We conclude with limitations and an outlook to future research in section 6.

2 Smart Personal Assistants

Although SPAs – especially for private purposes – are a very new development, they relate their smartness to certainly not new concepts. One constituting factor of SPAs is context-awareness. Context according to Dey and Abowd [7, p. 3 f.] *"is any information that can be used to characterize the situation of an entity. An entity is a person, place, or object that is considered relevant to the interaction between a user and an application, including the user and applications themselves"*. In order to improve the interaction between humans and computers, context-aware computing (i.e., a system's using of context to provide relevant information and tailored services to humans) presents a promising method to support individuals in daily life [8].

Today, the implementation of context-aware computing is possible via personal assistants known as User Assistance Systems, virtual agents or SPAs, such as Google Assistant, Amazon Alexa, Microsoft Cortana or Samsung Bixby. Although they all belong to the class of context-aware systems, there are considerable differences between them. Maedche et al. [8] suggest a classification based on two dimensions: (1)

the degree of intelligence of the system and (2) the degree of interaction implemented by the system. In contrast to basic systems characterized by a low degree of interaction and low degree of intelligence, advanced systems are characterized by more sophisticated features. They allow users to decide whether to follow the assistance, provide a high extent of context-aware and proactive assistance, include adaptation capabilities, and detect users' needs [8].

In this paper, we mainly focus on anticipating systems because the aforementioned SPAs heavily rely on context information, anticipation and rich interaction. Such systems are characterized by high degrees of both intelligence and interaction and can be distinguished from basic systems by a high degree of context awareness as well as a high dialogue competency. On top of that, they anticipate future situations and adapt their capabilities to the needs of the users and their situations.

There are also other features which can be used to delimit SPAs. For instance, Purington et al. [9] examined Amazon's Alexa on the basis of four different dimensions including degree of personification, degree of sociability, integration and technical qualities and issues. The degree of personification refers to the extent to which the technology is personified by the user. The degree of sociability is the extent of interaction. Integration is the system's ability to connect with other entities. Finally, technical qualities and issues refer to the performance of the system's tasks, e. g., the extent to which the system gives intelligent responses to humans' voice requests. However, further steps are needed for conceptualizing SPA principles and domains.

3 Method

To identify functional principles and outline application domains, we conducted a systematic literature review [10, 11]. According to Cooper's taxonomy [12], we focus on outcomes of SPA research papers, their underlying theories and practical applications. The goal of the review is to find principles and application domains by integrating prior findings using a concept matrix for literature organization. Given this goal, we do not espouse any position and provide a neutral perspective on the status-quo to general and specialized scholars in the field of SPA research. Furthermore, our literature review is exhaustive since we conducted open database searches. However, it is also selective to the field of IS, the scope of our research, and rules for in- and exclusion of articles as described below. The literature search was conducted in September 2017. A prior informal literature search revealed keywords for the open database searches [8, 9, 13–15] which resulted in the search phrase ("smart assistant" OR "conversational agent" OR "virtual assistant" OR "assistance system" OR "personal assistant"). The phrase was adapted to fit databases' syntactic requirements. The open database search was constrained to title, abstract, keywords and a publication period from 2000 to date. Databases include *AISeL, EBSCO Business Source Premier, ScienceDirect, IEEE Xplore, ACM DL* and *ProQuest* as common for IS, HCI and computer science. The open search resulted in 2802 hits. Titles, abstracts and keywords were screened regarding potential fit to the purpose of the study. In detail, articles are explicitly included if they relate to the substance of IS and either fit or contribute to

(i.e., extend, challenge, detail) our understanding of principles and application domains. Articles are explicitly excluded if they refer to distinct research fields such as assisted or autonomous driving (e.g., ecodriving), technical assistance for children, elderly or impaired (e.g., computer-generated voice for speechless), non-technical assistants (e.g., human personal teachers) or assistive systems in a sociological or political meaning (e.g., social assistance). However, since we are aware that including such articles may be promising for the advance of research on smart assistants, we briefly touch connections to the core of our study in the discussion section. We furthermore excluded rather technical descriptions (e.g., the development of SPA architectures) and formal models for SPA (component) development (e.g., formalized functioning of multi-layer voice recognition components). Screening was conducted by two researchers independently and resulted in 354 articles that appeared relevant for our goal. By thoroughly reading the full texts, the number of contributions has further been reduced to a manageable amount of 185. A backward and forward search as well as an open search on Google Scholar confirmed our assumption that our review results are saturated and computer science, IS and HCI articles are sufficiently represented. Table 1 lists the number of search results after each review phase.

Table 1. Literature search results[1]

Database	*Total hits*	*After Screening*	*Relevant*
AISeL	26	20	14
IEEE XPlore	1074	110	62
ACM DL	800	123	53
EBSCO Business Source Premier	136	27	14
ScienceDirect	672	63	41
ProQuest	94	11	1
Total	**2802**	**354**	**185**

Two independent researchers derived SPA principles and application domains by first identifying specific SPA mechanics and use cases which were further clustered, generalized, compared, discussed, and unified. Due to space limitations, we cannot illustrate each of the 185 articles. Hence, we demonstrate our core results, i.e., principals and application domains, providing reference to representative papers.

4 Results

4.1 Principles of Smart Personal Assistants

Context-awareness. While clarity of the term context-awareness suffers from vague definitions and understandings of context, most work on SPAs (inherently or explicitly) claim that identification, processing and use of contextual information are substantial

[1] A concept matrix that provides a detailed list of the reviewed articles and relations to our results is available at: http://downloads.wi-kassel.de/MKWI18/Knote_et_al_Appendix.pdf

to refer to these class of systems as ‘smart’ assistants. Based on prior definitions [7, 16–18], we understand context as all aspects of an entity’s (i.e., a person’s, place’s or object’s) physical and logical environment. This may comprise various properties that can be captured by sensors, such as location, temperature, humidity, calendar entries or other entities nearby. Hence, a context-adaptive system is able to detect and react to context (changes) by taking appropriate actions. In addition, a system is context-adaptive, *“if it uses context to provide relevant information and/or services to the user, where relevancy depends on the user’s task.”* [7, p. 6]

For the case of SPAs, *context detection* is usually enabled by acoustical and/or optical sensors, such as microphones and/or cameras, which are often combined with GPS, temperature or humidity sensors. Being part of a ‘social network’ of objects (e.g., smart home appliances) and people [19], data communicated to an SPA can also be considered context information, as they may help form a picture of the environment. Since SPAs are designed to support people conducting a particular task [8], personal data is often collected (e.g., filtered from voice commands) and used to provide assistance which is individualized to the user’s habits, abilities, preferences, goals and intentions [20]. This, however, leads to yet unresolved security, privacy and trust concerns which, according to the well-known causal relationship between distrust and lower levels of IT artifact use, is likely to impede SPA success [21]. To investigate *context reaction* of SPAs, it appears useful to distinguish between *what* is subject to reaction and *how* this reaction appears. While the subject of SPA actions usually depends on the task the user is assisted in (see section 4.2), reaction appearance is dependent on given hardware and software actuators (which in turn is related to the system’s embodiment and multimodality), self-evolution capabilities and deepness of entity network or platform integration. Hence, a myriad of possible reactions exists, including voice and/or interface responses [3], smart objects control [22], purchase process activation [13] and other combination that assist users in a particular task.

Self-evolution. Many authors refer to SPAs using the word ‘agents’ [e.g.,4, 5, 14, 15]. Apparently, these contributions especially aim to point out the SPA as an autonomous entity which is capable of perceiving and taking actions within its environment to achieve a certain goal [23], which in this context is to assist the user conducting a specific task. However, the ways how these systems attempt to achieve their goal heavily vary. Russel and Norvig provide a classification scheme for intelligent agents which comprises five groups depending their capabilities: simple reflex agents, model-based reflex agents, goal-based agents, utility-based agents and learning agents [23]. While all agents are able to autonomously detect and take actions within their environment, simple reflex agents do so by applying a set of ‘if-then rules’ to determine suitable actions for the detected situation. Model-based reflex agents add complexity through a model, which is explaining and predicting ‘how the world works’. Although this allows the agent for rudimental self-reflection, it chooses an action in the same way as a simple reflex agent. Goal-based agents additionally hold a set of desirable outcomes and thus may choose an action which reaches the goal state. On top of this, utility-based agents allow for differentiated measures on how desirable a goal state is. It chooses an action based on its utility function as it compares the current and stored

alternative states. However, although these approaches provide appropriate logics for rather predictive and observable environments, unexpected effects can be handled through goal or utility models as they follow a predefined set of possible conditions (i.e., 'the reality'). In case unknown context variables are detected or known variables attain yet unknown values, the system should be flexible enough to dynamically adapt its behavior according to the 'critic' on how it performs (i.e., self-evolution). Hence, learning agents contain a separate learning element which is responsible for behavior adaptation, while the performance element chooses which actions to take.

The results of our review show, that in the last few years, an increasing number of SPAs have appeared that can (at least to some degree) be considered learning agents. Taking Amazon's Alexa as a prominent example, the agent handles opaque utterances with lexical approximation. If the user does not disconfirm to Alexa's response, the SPA's learning unit stores new pronunciation characteristics and thus evolutes its natural language processing abilities. However, AI research on self-evolution mechanisms is still in its infancy but is currently gaining momentum through the success of SPAs and advances in machine learning.

Multimodality. Authors often classify SPAs according to their dominant mode of interaction (e.g., conversational agents [4] or voice and vision personal assistant [24]). Our results reveal, that many SPAs are referred to as multimodal, meaning the ability to receive input and/or deliver output in more than one way [4]. In most SPAs, graphical user interfaces (GUIs) are combined with voice recognition and natural language processing abilities [3]. However, there is a multitude of possible interaction behaviors which an SPA might employ, such as eye motion, gestures, facial expressions or even emotional or cognitive states [4, 25]. The major goal of multimodality is to combine signals different from different communicative channels so that users impute a certain degree of intelligence or smartness to the SPA which thus leads to greater comfort and enjoyment due to entirely new possibilities (e.g., hands-free smart home control) [4]. Multimodality can either be implemented in a unidirectional or a bidirectional manner. Unidirectional multimodality implies, that SPAs may either receive input via different channels but can only respond or take actions via a single actuator (e.g., gesture and cognitive state input, voice output) or vice versa (e.g., voice input, output by controlling smart objects, voice and facial expression). Bidirectional multimodality combines different input modes with a multitude of output modes. However, our results show that multimodality is intertwined with anthropomorphism and context-awareness. For example, in order to respond to a voice command with a friendly smile, the detectability and interpretability of spoken natural language is an equally important prerequisite as it is the appropriate representation of a smile on an artificial human face [5].

Anthropomorphism. Further, literature proposes anthropomorphism to be an additional key principle of SPAs, referring to the assistant aspect of the SPA [26], that is *"a conscious mechanism wherein people infer that a non-human entity has human-like characteristics and warrants human-like treatment"* [9, p. 2854]. The degree of anthropomorphism might differ heavily in SPAs, also depending on the provided user interface. When considering SPAs like Alexa or Siri, that focus on voice almost alone,

research around the theme of conversational agents tended to the already mentioned multimodal developments, with a focus upon anthropomorphism and embodiment with virtual characters [4]. Anthropomorphism raises the expectations of more human behavior and responses [21]. For instance, several studies found first evidence for that human-like features of Siri or Alexa make users assign human traits to their IT artifacts and also making them more user friendly [9, 21]. However, such a humanness also may lead to unrealistic expectations of the systems capabilities and, thus, leading to dissatisfaction when expectations are not met [4, 21]. Attached to these discussions are virtual characters, their embodiment and according emotions in SPAs. While a lot of past research focused on interactive characters with a varying degree of similarity to humans, i.e., from cartoon-like characters to virtually human-like characters [27], also robots are used for the embodiment of human-like characteristics [28]. To implement such characteristics, research focused on delivering natural gestures with virtual characters [29], affective emotions based on user behavior [30] or humor [31] that is also a significant component of systems like Siri and Alexa [4].

Platform integration and extensibility. While for example Alexa is certainly designed from scratch with an ecosystem integration, other products as well as areas of application (see in the next section) lack such forms of integration, thus, frustrating customers. For example, the study of Cowan et al. points out that Siri is very limited to the Apple ecosystem and opening by default only Apple apps while also being limited to Apple devices [21]. However, rich ecosystems enable new affordances for an integration of SPAs [22], especially when considering Internet of Things (IoT) solutions like smart home appliances or smart shopping like the Amazon dash button, where the SPA takes a stationary hub position in the service ecosystem. Though, such new affordances also raise questions concerning forensics and other legal questions. As such, multimodality and "always-on" features as well as its integration in the cloud ecosystem highlight that confidentiality of data is very vulnerable [32].

4.2 Application Domains of Smart Personal Assistants

Daily life and family. The revolution of SPAs was essentially influenced by their use in private life, e.g., for tourism, shopping or smart home purposes. Early IS research focused especially on shopping and e-commerce with the concepts of recommendation agents and according algorithms to assist shopping tasks and make them more productive [e.g., 27], while also focusing on the consequences for trust development as well as technology adoption [15]. A special case of commerce is tourism that greatly profits from gathering contextual data supplied by various databases and ecosystems to provide more in-situ support in traveling new places [33]. Recently, IS research also took mobile shopping assistants into account while showing that technologies like RFID are more favorably in terms of technology adoption while they also imply perceptions of security risks [13]. This certainly applies also to the case of smart homes where the multimodality and ecosystem integration offers new affordances that also relate to privacy issues. Though, such approaches have potential to make life more convenient, especially for elderly people and the case of assisted living [22].

Work support. Great potentials are anticipated in practice and research for using SPAs in supporting work processes. As such, in manufacturing systems, human errors in critical situations are avoided by extending the intelligence of humans in order to make informed decisions [34]. This is especially prevalent when considering heterogenous worker types, e.g., freshmen, experienced and impaired workers that present specific challenges for the workplace that could be supported by SPAs [35]. While freshmen and impaired workers might profit from direct assistance, experienced workers can qualify for more demanding jobs, thus changing the role how we work. SPAs could take a significant and coordinating role in cyber-physical systems and profit from the smartness of the workplace [36]. Though, when taking obligations into account, the massive account of collected personal data in the workplace might be used for purposes of worker assessment, failure rates etc., as such privacy-related issues of these invasive technologies in the workplace arise [37].

E-Learning. Another important domain is the application of SPAs in different roles for the purpose of learning that is supplemented by IT, i.e., E-Learning. Possible application examples can be derived from concepts such as scaffolding or tutoring [38], where learning processes of individuals are supported by the active use of IS, for example directly in the work-process. A typical example is manufacturing supplemented by SPAs for maintenance purposes [39]. Workers are supported in maintaining a machine while the SPA also supports the worker to learn special procedures in the maintenance process, dependent on prior knowledge. When considering the principles of SPAs, context-awareness is therefore oftentimes derived concerning dispositional factors of the individual such as prior knowledge and needed support level but also dependent on the work process [40]. When considering self-learning capabilities, SPAs might rely on learning analytics that adapt and learn on the basis of formative assessments to provide for example guidance in the learning process or stress relief in exams [41]. Although multi-modality is rarely considered for learning purposes, there are solutions for considering augmented [42] or more simple approaches to learn with SPAs such as QR-codes [43, 44]. Concerning anthropo-morphism, SPAs in the learning domain are oftentimes designed with avatars that embody cartoon characters to avoid similarities with teachers and convey a gamified support. In contrast, SPAs in other contextual situations also often embody a human-like educator to convey a more personal, serious and affective way in teaching [30, 44].

5 Discussion

The goal of our review was to provide an overview on functional SPA principles and promising application domains for IS research. Hence, we conclude that there is rapid development in the topic and hope, that IS researchers hold the pace of advancements in HCI and computer science. However, there are also numerous unanswered questions, to which IS is predestined to find answers. First, IS can be the perfect nucleus to research on the balance between assistance, agency and autonomy of digital entities and possible effects to individuals and the society. While assistance, i.e., supporting humans

to conduct particular tasks, is currently acknowledged as higher-order goal, agency may also mean to operate in the user's stead, which can be desirable in dangerous, hazardous and risky environments, but may be of unpredictive outcome in cooperative tasks. Thus, balancing autonomy, as the degree to which a system is self-operating and self-evolving (i.e., self-evoluting) and controllability is a highly situation and task-specific endeavor which calls for further research effort. Second, a multitude of questions regarding privacy, security and trust towards SPAs remain yet unanswered [45]. Our review reveals further several blind spots, e.g., the consideration of platforms and ecosystems for the use of SPAs in various application domains. When taking a look at Amazon Alexa and the Echo ecosystem, it is kind of obvious that the SPA is centered around a vivid ecosystem that includes various parties (e.g., skill creators, hardware developers, or car manufacturers with own ecosystems) in the value creation process, thus, building a strong service system. Third, questions arise, why the success of SPAs for private use did began with Alexa and not with the first-mover Siri. Cowan et al. offer an interesting thought that relate to the mobile use of Siri and the barriers of social embarrassment when using SPAs in the public [21]. That may not relate to the success of stationary settings such as Alexa and other SPAs in work settings. Last but far not least, there is still no consensus about how anthropomorphic SPAs and robots may be, so they are accepted by a wide variety of users and do not scare or frighten them [21].

6 Limitations, Future Research and Conclusion

Our review paper is in conclusion not without limitations. We excluded well-established research fields, e.g., assisted driving or support for the impaired, although we believe, that IS can learn from advances in these fields, i.e., when taking the SPA principles for everyday application into account. Additionally, we are aware that this classification is only one way how to structure research on SPAs and reflects a discussable basis. However, we have made the first systematic step with respect to existing authorities and contribute by bringing a certain conceptual clarity and highlighting whitespots regarding SPA research. Our principles must be understood as continuums for characteristic attributes. Hence, in each category, different nuances or sub-categories exist, which must further be distinguished to establish a taxonomy and classify existing SPAs according to their attributes by future research. Our paper provides a first summary of research and a systematic approach to generalize findings from IS, HCI, computer science and other fields. Hence, we contribute to understanding this new class of IT artifacts and, thus, offer starting points for future IS research

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Forming Affect, Behavior, and Cognition with Gamification: The Case of an Austrian Tourism Advergame

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Keywords: Gamification, Affect, Behavioral Intention, Cognition, Tourism

1 Introduction

Information and Communication Technology (ICT) has enabled the development of gamification, i.e., "the use of game design elements in nongame contexts to engage users" [1, 2, p. 268]. Specifically, ICT research on gamification in a marketing context shows that a major purpose of gamification is to support branding and other customer-oriented marketing goals [3]. The objective of this study is an exploration of the outcome of an advergame on customer's attitude formation through the conceptual lens of the ABC model of attitudes. Advergames are serious games with marketing and promotion intent where brands or products appear with a specific relation to the game [4]. Present research on advergames refers to analyses of different game designs [5], but does not yet shed enough light on its impact on customer behavior. By obtaining deeper insights into affective, behavioral, and cognitive responses to an advergame, this study seeks to investigate the role of advergames in a tourism marketing context.

2 Related Work

2.1 Gamification in a Service Marketing Context

In a service marketing view, gamification is a process of gamifying, i.e. enhancing a core service with motivational affordances in order to invoke gameful experiences and further behavioral acts [3]. In this context, gamification can be implemented as gamified applications [1] or serious games that can both be initially a core service which is later gamified. Whereas gamified applications are characterized by game design elements in a nongame context, serious games are full-fledged games whose main purpose is not to entertain, but to educate, inform, motivate etc. [6]. Serving mainly hedonic values such as fun, enjoyment, and playfulness [2], gamification can

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particularly support product and service categories that are themselves hedonic in nature. As a result, tourism companies are increasingly engaged in gamification.

2.2 Attitude Formation in Gamification

Individuals can form their attitudes based on three components in the ABC framework [7]. The ABC model of attitudes assumes that attitudes are formed of affect, behavior and cognition [8]. The importance of these ABC components varies with their respective importance for the individual and the situational context in which decision making occurs. As playing a game is hedonic and takes place in a highly involved context, gamification provides emotional attachment to a service that leads to forming positive attitudes towards it [9].

3 Research Methodology

Given the early stage of research in the field and the lack of empirical evidence on user interaction and behavior in advergames, this study is exploratory. A qualitative in-depth research design was used to establish a first understanding of possible effects of advergames on consumer behavior variables.

3.1 Data Collection and Sample

Data collection took place by semi-structured in-depth interviews. The context of research is the advergame "Austria Snapshot Adventure". Data collection consisted of four steps: (1) the participants' prior knowledge about Austria was recorded, (2) the participants were requested to play the advergame "Austria Snapshot Adventure", (3) the respondents were asked for the recall and recognition of various items that appeared in the advergame, (4) the respondents were interviewed about their learning and cognition, feelings, interactions with the advergame, and behavioral intention. The sample was recruited from international students studying at a large Austrian university who have stayed in Austria no longer than one year. The final sample size was determined by the degree of saturation in the data [10]. This procedure resulted in a total of 16 interviews. The sample consists of four male and twelve female respondents aged between 20 and 25 years from Asia, Australia, the EU, and USA.

3.2 Data Analysis

The recorded responses were transcribed and coded with NVivo. We conducted open, axial, and selective coding [11] whereby we used literature as an analytical tool during the data analysis [12]. The categories that were obtained from coding are separated into cognitive, affective, and behavioral responses whereby behavior consists of two dimensions, i.e., intention to visit destinations and interaction with the advergame. During final selective coding, we unified all categories around the visiting intention that was identified as being influenced by the other categories.

4 Results

4.1 Affective Responses

To explore affective responses, the interviewees were asked about their feelings and experiences during and after playing the advergame. The most frequently mentioned feeling was fun, followed by curiosity about shown destinations, joy and happiness. The majority of reported negative feelings such as frustration are due to perceived lacking performance or difficulty of the advergame.

4.2 Behavioral Responses

The first component of behavioral responses refers to the behavior during the play of the advergame. Only a minority of the respondents collected additional information about the destination and used the interactive element of taking a snapshot and sharing it with others on social media, as they were not aware of them or do not take snapshots while playing in general. The second aspect of behavior relates to the intention to visit the destinations shown in the advergame. Half of the respondents report that they intend to visit destinations that appeared in the advergame. Their intention to recommend visiting Austria as a tourist destination is mainly based on their belief that Austria is generally interesting to visit.

4.3 Cognitive Responses

For ten respondents, the advergame was able to increase awareness of destinations. Further, some interviewees point out that repeated playing of the advergame will strengthen the awareness of destinations that were not known before or strengthen their memories about places they have visited. The respondents whose awareness was not increased by the game mainly point at the focus on playing that prevented them from perceiving the surrounding destinations. When it comes to learning, respondents reported that they learned about less well-known or marketed destinations and that the advergame increased their familiarity with Austrian destinations in general.

5 Discussion

The results show that if a tourist destination decides to use gamification in promotion it should consider several issues: (1) as visiting a tourist destination represents a need to create hedonic experience it should focus on providing affective responses in users; (2) creating positive feelings after playing the advergame motivates users to engage and express intention to visit certain tourist destinations; (3) with creating behavioral response and forming intention users develop beliefs that certain tourist destinations are worth visiting; (4) users' focus on rewards can motivate them to collect points and progress through the game, however, that can prevent them from focusing on exploring the surroundings and creating attitudes towards the shown destinations.

6 Conclusion

Following the understanding that gamification can be applied in a game context, the study investigated an advergame's potentials to form key attitudinal factors, i.e., affect, behavior, and cognition towards tourist destinations. The results confirm the notion of the ABC model but at the same time show that human-computer interaction in an advergame plays a key role. Limitations are related to the student sample, thus a study among real tourists would achieve more generalizable findings. While this study is exploratory in nature, it should be complemented by causal research and respective quantitative studies. Future research should also consider the perception of game design as it may drive evaluations of functionality. Finally, the advergame should be tested in neighboring countries to reveal whether it motivates users to visit Austria.

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Paid Content - Eine empirische Untersuchung zu redaktionellen Sportinhalten

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Abstract. Der Beitrag analysiert Erfolgsfaktoren bei der Einführung von paid content Modellen bei redaktionellen online Sportinhalten. Basierend auf einer Literaturanalyse, wird der Frage nachgegangen, was ein paid content Modell erfolgreich macht, und welche Charakteristika notwendig sind, um eine breite Akzeptanz bei Nutzern zu erzielen. Anhand von acht aus der Literatur abgeleiteten Faktoren wie beispielsweise Abrechnungsmodell, inhaltlicher Mehrwert, paywall-Typ und usability der Website wird eine empirische Untersuchung durchgeführt. Die Ergebnisse der Online-Befragung lassen darauf schließen, dass die abgeleiteten Ausprägungen einen positiven Effekt auf den Erfolg eines paid content Modells zu redaktionellen Sportinhalten haben.

Keywords: Paid content, Sportinhalte, Sportnachrichtenportal, Information System Design, Informationssysteme

1 Einleitung

Das Internet hat die Mediennutzung nachhaltig verändert. Grund dafür sind die zunehmende Verfügbarkeit hochwertiger Bewegtbild-Inhalte im Netz sowie immer leistungsfähigere mobile Endgeräte mit umfangreichen technischen Möglichkeiten [1-5]. Diese Entwicklung lässt generell Printmedien an Reichweite verlieren. Nun stellt sich die Frage, wie klassische Zeitungsverlage auf diesen Trend reagieren sollen. Es ergibt sich für Anbieter redaktioneller Medieninhalten („content“) die Herausforderung, ihr Geschäftsmodell und im Besonderen das Erlösmodell zu hinterfragen und auf Nachhaltigkeit zu prüfen [6]. Wenngleich „Nachrichten“ als öffentliches Gut betrachtet werden und argumentiert wird, dass diese für den Endverbraucher kostenlos zur Verfügung stehen sollen, sind sich Verlage einig, dass qualitativ hochwertiger Content nicht oder nur mit großer Anstrengung ausschließlich durch Werbung finanziert werden kann, und Konsumenten einen direkten finanziellen Beitrag leisten müssten. Dies gilt ganz besonders dann, wenn die Querfinanzierung der Online-Angebote durch sinkende Einnahmen im Offline-Bereich nicht mehr möglich ist [7].

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Die bestehende Forschungslücke hinsichtlich der Untersuchung aktueller Erfolgsfaktoren bei redaktionellen Inhalten bildet den Ausgangspunkt des vorliegenden Beitrags, in dem paid content anhand einer empirischen Untersuchung auf einem Sportportal analysiert wird. Es wird der Forschungsfrage nachgegangen, welche signifikanten Erfolgsfaktoren hinsichtlich Produktausprägungen und Demografie bei der Einführung von paid content Modellen bei redaktionellen online Sportnachrichten zu beachten sind. Vor diesem Hintergrund erfolgen im nächsten Kapitel eine auf relevante wissenschaftliche Literatur aufbauende Beschreibung der empirischen Untersuchung sowie eine Diskussion der Resultate der durchgeführten Umfrage zu paid content für redaktionelle online Sportnachrichten. Der Beitrag endet mit einer kurzen Schlussbetrachtung.

2 Empirische Untersuchung

2.1 Literaturanalyse und Formulierung der Forschungshypothesen

Mittels Literaturanalyse soll zunächst der aktuelle Forschungsstand zur Thematik erhoben und evaluiert werden. Für die Suche nach relevanter Literatur wurden die Datenbanken „EBSCOhost“, Springerlink, ACM, Wiley und IEEE herangezogen. Dabei wurden Kombinationen der Suchbegriffe „paid content“, „paywall“, „newspaper paywall“, „willingness to pay“„WTP”, „metered”, „premium”, „fee-based”, „success” und „success factor” für die Abfragen eingesetzt. Um die Relevanz der Ergebnisse zu erhöhen, wurde die Aktualität der Beiträge berücksichtigt. Durch die Literaturanalyse wurden unterschiedliche Erfolgsfaktoren für den Einsatz von paid content festgemacht, die in Tabelle 1 dargestellt sind.

Tabelle 1. Ergebnisse der Literaturanalyse

Erfolgsfaktor	*durchgeführte Methodik/Autor*
Abrechnungsmodell (EK vs. Abo)	Literaturanalyse [6], Theoretische Überlegungen [7]
Angebotene Zahlungsform	Literaturanalyse [8]
Art der paywall (hart, metered, freemium)	Theoretische Überlegungen [9]
Demografische Faktoren	Case Study (Datenanalyse) [10], Quantitative Befragung [11, 12]
Einzigartigkeit des Inhalts	Case Study [13], Interviews [14]
Kategorie des Inhalts	Literaturanalyse [15], Case Study (Datenanalyse) [16, 17],
Mehrwert des Inhalts	Interviews [18], Literaturanalyse [19], Datenanalyse [20]
Stärke der Medienmarke	Theoretische Überlegungen [21]
Design und usability	Datenanalyse [22]

Einige Studien untersuchen Eigenschaften potentieller Nutzern, die Einfluss auf Zahlungsbereitschaft für redaktionelle online Medien haben [10, 11, 12]. Basierend auf

Ergebnissen einer Umfrage und unter Anwendung einer Regressionsanalyse untersuchte Goyanes [11] persönliche Eigenschaften, welche die Zahlungsbereitschaft für paid content erhöhen, und kommt zu dem Ergebnis, dass sich geringeres Alter, hohes Einkommen, eine höhere Bereitschaft Nachrichten online zu konsumieren als über Printformate und allgemeines Interesse an Nachrichten positive Auswirkung auf die grundsätzliche Zahlungsbereitschaft für paid content hat. Zudem wirkt sich auch die Nutzung von Social Media positiv auf die Zahlungsbereitschaft aus. Chiou und Tucker [12] untersuchten die Demographie von Webseitenbesuchern von lokalen Nachrichtenportalen in den USA vor und nach der Einführung einer paywall und stellten fest, dass insbesondere die Besuche von jungen, männlichen und schlecht verdienenden Bevölkerungsgruppen nach der Einführung abnahmen. Sie kamen im Bereich des Alters und des Geschlechts auf ein genau gegenteiliges Ergebnis Goyanes [11, 12]. Eine eindeutige Aussage kann in diesem Zusammenhang somit nicht getroffen werden.

Wolk und Theysohn [22] analysierten die Zugriffe von 118 Webseiten die Inhalte gegen Bezahlung anbieten (nicht nur beschränkt auf rein redaktionelle Angebote). Gemessen an visits und page impressions pro User analysierten sie mittels statistischer Methoden den Zusammenhang mit 16 Produkteigenschaften auf Basis der Hypothese, dass höhere Zugriffszahlen auch zu höheren Umsätzen aus paid content Angeboten führen. Hier zeigte sich, dass eine gute Auffindbarkeit bei Suchmaschinen („accessibility“ und „relevance“), die Interaktivität und die allgemeine Qualität des Angebots sich positiv auf die visits auswirkten. Positiv auf die page impressions pro User und somit auf die Verweildauer auf der Seite wirkten sich vor allem die Vertrauenswürdigkeit des Angebots, die Interaktivität, Personalisierungsmöglichkeiten sowie ein übersichtliches Design aus.

Keinen messbaren positiven Einfluss hatten Faktoren wie das angebotene Abrechnungsmodell [6, 7], unterschiedliche Zahlungsmöglichkeiten [8] oder der Angebotspreis. Bei der Art der paywall wird grundsätzlich zwischen drei Varianten unterschieden: die harte paywall gilt als die stärkste paid content Form. Sie ermöglicht ausschließlich Nutzern, die bezahlt haben, Zugang zu content. Bei dem metered Modell wird von Usern für Inhalte Geld verlangt, wenn seine Nutzung innerhalb eines bestimmten Zeitabschnittes einen gewissen Schwellenwert übersteigt. Beim „freemium“ Modell ist ein Basisangebot an Inhalten kostenfrei und nur exklusiver oder besonderer content wird hinter eine Bezahlschranke gelegt [9].

Etwas breiter gefasst beeinflussen also vor allem der Mehrwert des Inhalts (Personalisierung, Relevanz, Vertrauenswürdigkeit etc.) [18, 19, 20] und usability (passendes Design, Auffindbarkeit etc.) [22] den Erfolg. Überhaupt scheint es naheliegend, dass der „Mehrwert des Inhalts“ ein wesentlicher Erfolgsfaktor ist, wenngleich „Mehrwert“ auf unterschiedliche Art und Weise interpretiert wird. Grundsätzlich zeigt Kvalheim [16] zahlreiche Quellen auf, die vor der Einführung des Internets entstanden sind und sich mit der grundsätzlichen Frage auseinandersetzen, was eine Nachricht überhaupt „berichtenswert“ macht, also einen Mehrwert darstellt. Dabei werden unter anderem die Eigenschaften Häufigkeit, Eindeutigkeit, Wichtigkeit, Relevanz, Unterhaltungswert und Neuheit genannt. Außerdem wird darauf eingegangen, dass diese Kriterien auch kommerziell verwertbar sein müssen. Bezogen

auf online-Nachrichten stellen Flavián und Gurrea [18] in ihrer Arbeit fest, dass – im Gegensatz zu gedruckten Medien, der Mehrwert Nachrichten online zu konsumieren allgemein stärker im Rahmen der Aktualität, sowie in der Möglichkeit der Suche nach speziellen Inhalten liegt, und weniger im Bereich von Unterhaltung oder aus persönlichen Gewohnheiten. Neben inhaltlichen Kriterien ist dabei auch die Einzigartigkeit des Inhalts bedeutend (dieselben Informationen dürfen an anderer Stelle nicht frei verfügbar sein). Wenn ein Unternehmen nach der Einführung einer paywall aber weiterhin dieselben, teilweise von Nachrichtenagenturen übernommenen Inhalte anbietet, wie die Untersuchung am Beispiel des contents von welt.de zeigte, zeigen sich negative Auswirkungen auf die Zahlungsbereitschaft. Hinsichtlich der Kategorien von Inhalten, die für paid content Angebote in Frage kommen, kann festgestellt werden, dass das Internet im Vergleich zu offline Quellen stärker dazu genutzt wird, spezialisierte Inhalte zu bestimmten Themen zu finden, die nicht nur „General Interest", sondern „Special Interest" sind. McDowell [20] erklärte am Beispiel von Fox News, dass Medienmarken, die spezialisierte Inhalte zu einem Thema anbieten, bei entsprechender Differenzierungsstrategie, Marktanteile etablierter Anbieter gerade in Nischenmärkten an sich ziehen können.

Für die Beantwortung der Forschungsfrage mit Bezugnahme auf redaktionelle Sportinhalte wurden die aus der Literatur abgeleiteten Erfolgsfaktoren herangezogen. Vor diesem Hintergrund wurden die in Tabelle 2 abgebildeten Hypothesen aufgestellt.

Tabelle 2. Hypothesen

Hyp.	*Aussage*
H1	bei paid content Angeboten ist das Design von geringerer Bedeutung als der Inhalt
H2	ein freemium Modell hat bei Nutzern eine höhere Akzeptanz als ein metered Modell, dieses hat eine höhere Akzeptanz als eine harte paywall
H3	Nutzer bevorzugen Abonnements über Einzelkäufe
H4	hochwertige journalistische Inhalte sind im Bereich eines paid content Angebots für Nutzer wichtiger als alle anderen untersuchten Ausprägungen der Variable „Mehrwert des Inhalts"
H5	die Einzigartigkeit des Inhalts ist für den Erfolg eines paid content Modells von wesentlicher Bedeutung
H6	positive Markenwahrnehmung ist für den Erfolg eines paid content Modells von wesentlicher Bedeutung
H7	die angebotenen Zahlungsformen sind für den Erfolg eines paid content Modells von wesentlicher Bedeutung
H8	niedriges Alter, ein hohes Einkommen sowie eine hohe Ausbildung wirkt sich positiv auf die Bereitschaft aus, für redaktionelle online Sport-Berichterstattung zu bezahlen

2.2 Aufbau des Fragebogens und Darstellung der Ergebnisse

Für die empirische Untersuchung wurde eine Online-Befragung durchgeführt. Der Fragebogen wurde auf einer content Plattform platziert. Dabei wurden die Besucher der

Webseite mittels frequency-capped pop-up auf der Startseite bzw. mittels Integration eines Bausteins auf diversen Unterseiten zur Teilnahme aufgefordert

Der Fragebogen bestand aus insgesamt 36 Fragen in 9 Frageblöcken. Mit Ausnahme von Frageblock 1 (soziodemografische Faktoren) und einzelnen Ja/Nein-Fragen, wurden Einstellungen an Hand einer Likert-Skala („stimme zu“, … „stimme nicht zu“) abgefragt. Alternativ wurde die Möglichkeit eingeräumt keine Antwort zu geben („weiß nicht/keine Antwort“). Außerdem wurden soziodemografische Faktoren (Alter, Ausbildung, Einkommen) das Interesse an Sport allgemein, sowie die Häufigkeit der Nutzung der Plattform und anderen Medien mittels kategorialer Angaben abgefragt, um in der Auswertung daraus Zusammenhänge auf Zahlungsbereitschaft und Präferenz für einzelne Produkteigenschaften ableiten zu können. Im zweiten Frageblock wurde die allgemeine Einstellung zu den Variablen „Mehrwert des Inhalts“ und „usability der Webseite“ abgefragt, ohne in der Fragestellung auf paid content Angebote einzugehen. („Grundsätzlich ist mir bei redaktionellen Medien die im Internet über Sport berichten wichtig: „hohe journalistische Qualität“, „Kommentare und Meinungen von bekannten JournalistInnen“, etc.). Die Variablen wurden anhand verschiedener Ausprägungen operationalisiert (Tabelle 2). In Frageblock 3 wurden Ausprägungen zur Einstellung der Variablen „Einzigartigkeit des Inhalts“ (Anzahl der Angebote, um sich online zu informieren, Qualität der Angebote, Qualitätsunterschied zwischen den vorhandenen Anbietern von redaktioneller online Berichterstattung) und „Stärke der Medienmarke“ (Aussagekraft der Marke über Inhalt und Qualität eines Mediums) operationalisiert. Im Frageblock 4 wurde die grundsätzliche Zahlungsbereitschaft abgefragt. Nur wenn die Frage mit „Ja“ beantwortet wurde, wurden die folgenden Frageblöcke (5-7) ausgespielt. In Frageblock 5 wurden die Variablen von Frageblock 2 mit einem Hinweis auf ein paid content Modell abgefragt (Tabelle 1). So konnten Unterschiede in Präferenzen für kostenfreien und kostenpflichtigen Inhalt untersucht werden. In Frageblock 6 wurde die Bedeutung der Variablen „Einzigartigkeit des Inhalts“ (Voraussetzung für Bezahlung, dass Inhalte nicht an anderer Stelle kostenfrei verfügbar sind, Einschätzung über Verfügbarkeit und Qualität von kostenfreien Alternativen) und die Bedeutung der „Stärke der Medienmarke“ (Voraussetzung von Markenbekanntheit und positiver Markenwahrnehmung für Zahlungsbereitschaft) mit klarem Bezug zu einem paid content Modell abgefragt. In Frageblock 7 wurden Präferenzen für die „Art der paywall“, sowie für das „Abrechnungsmodell“ abgefragt. Hierzu wurde eine konkrete Frage zur Einstellung pro möglicher Produktausprägung, d.h. metered Modell, freemium Modell und harte paywall bzw. Einzelkauf und Abonnement gestellt. Zum Abschluss wurden Einstellungen und Präferenzen für Zahlungsmittel abgefragt, der Erfolgsfaktor „angebotene Zahlungsmittel“ dahingehend operationalisiert, dass abgefragt wurde, ob Nutzer immer nur eine, oder aber auch mehrere unterschiedliche Zahlungsmethoden benutzen. Daraus lässt sich ableiten, ob die angebotenen Zahlungsmittel tatsächlich ein relevanter Erfolgsfaktor sind.

Im Rahmen der Online-Befragung haben 838 Personen die Umfrage begonnen, wovon 463 Fragebögen bis zum Ende ausgefüllt wurden. Teilnehmer wurden durch kleine Sachpreise zur Teilnahme motiviert. Tabelle 3 gibt einen Überblick zur Einstellung zu Produkteigenschaften ohne Hinweis auf paid content. Für die folgenden statistischen Testverfahren wurden die Variablen positiv auf Normalverteilung

überprüft und es wird unterstellt, dass es sich bei der durchgeführten Umfrage um eine Zufallsstichprobe handelt. Um die Hypothese H1 zu untersuchen, wurden die Ausprägungsgruppen „Inhalt“ (G1) und „Design“ (G2) der abgefragten Variablen mittels ANOVA analysiert, um signifikante Unterschiede zwischen den einzelnen Ausprägungen festzustellen. Basis waren alle Datensätze von Nutzern, die die Frage nach der grundsätzlichen Zahlungsbereitschaft (Frageblock 4) mit „Ja“ beantwortet haben, denn nur diesen Nutzern wurde auch die Frage nach den Präferenzen mit Hinweis auf ein mögliches paid content Angebot gestellt. Wie das Ergebnis des F-Tests (Tabelle 4) zeigt, wird die Vermutung bestätigt, dass signifikante Unterschiede zwischen zumindest zwei Ausprägungen der untersuchten Variablen bestehen. Um die Forschungshypothese zu beantworten, werden in der Folge durchschnittliche Mittelwerte der Ausprägungsgruppen „Inhalt“ und „Design“ (MW1, MW2) über die Antwortwerte der Probanden zu den einzelnen Variablenausprägungen gebildet und ebenfalls mittels ANOVA untersucht. Wie der über dem gewählten Signifikanzniveau liegende p-Wert in Tabelle 4 zeigt, besteht zwischen den Mittelwerten der Antworten zu der Variable „Mehrwert des Inhalt“ und „Design und usability“ kein signifikanter Unterschied. Die Hypothese muss also verworfen werden, es kann nicht geschlussfolgert werden, dass Inhalte wichtiger sind als Design.

Tabelle 3. Einstellung zu Produkteigenschaften ohne Hinweis auf paid content

Präferenz	*Skala 1-4*	*δ*	*δ relative (%)*	*Präferenz*	*Skala 1-4*	*δ*	*δ relative (%)*
Einfache Auffindbarkeit von Inhalten	1,38	0,65	47,18	Tablet optimiert	1,65	0,88	53,47
hohe journalistische Qualität	1,47	0,66	44,94	highlight Videos	1,67	0,86	51,60
umfangreiche Hintergrundinformationen	1,54	0,69	45,09	Smartphone optimiert	1,95	1,00	51,49
nicht zu viel Werbung	1,55	0,86	55,41	Statistikdaten	2,01	0,91	45,08
livestreams	1,56	0,81	52,03	live Ticker	1,65	0,88	53,47
schnelle, aktuelle und kurze Newsbeiträge	1,57	0,72	45,94	redaktionelle Videos	2,23	0,99	44,61
übersichtliches und ansprechendes Design	1,62	0,73	44,95	JournalistInnen Kommentare	2,50	0,98	39,14

Um die Hypothese H2 zu beantworten, wurde eine einfaktorielle ANOVA zwischen den Ausprägungen „metered modell“ (G5), „freemium modell“ (G6) und „harte paywall“ (G7) der Variablen „Art der paywall“ durchgeführt. Die Analyse zeigt, dass es zwischen den Gruppen jedenfalls signifikante Unterschiede in der Verteilung der Mittelwerte gibt, zahlungsbereite Nutzer bevorzugen also zumindest ein Modell gegenüber den jeweils anderen. Da „freemium“ den geringsten Wert und somit die

höchste Zustimmung aufweist, wird, um eine Rangfolge der Ausprägungen festzustellen, eine ANOVA zwischen „metered“ und „freemium“ durchgeführt. Das Ergebnis zeigt, dass ein signifikanter Unterschied in den Präferenzen besteht, Nutzer bevorzugen ein freemium Modell gegenüber einem metered Modell. Daraus kann geschlussfolgert werden, dass Nutzer eher bereit sind, für qualitativ hochwertige Inhalte zu bezahlen, als, unabhängig von der Qualität, nur auf Basis der quantitativen Nutzung des Angebots. Eine Analyse zwischen „metered Modell“ und „harte paywall“ wurde ebenfalls durchgeführt, die Ergebnisse waren in diesem Fall nicht signifikant, eine klare Aussage welches der beiden Modelle in diesem Fall bevorzugt wird, kann also nicht getroffen werden. Die Hypothese kann also für den ersten Teil angenommen werden, für den zweiten Teil muss sie verworfen werden.

Tabelle 4. Anova: Einfaktorielle Varianzanalyse zwischen den Gruppen

Streuungsursache	*Quadrat-summen (SS)*	*Freiheits-grade (df)*	*Mittlere Quadrat-summe (MS)*	*Prüfgröße F*	*P-Wert*	*Kritischer F-Wert*
Unterschiede zw. G1,G2	53,979	12	4,498	5,954	≤0.000	1,763
Innerhalb der Gr. G1, G2	705,669	934	0,756			
Gesamt	759,647	946				
Unterschiede zw. MW1,MW2	0,396	1	0,396	1,167	0,28167	3,906
Innerhalb MW1,MW2	48,929	144	0,339			
Gesamt	49,325	145				
Unterschiede zw. G3, G4	47,099	8	5,,887	7,472	≤0.000	1,953
Innerhalb der Gr. G3, G4	508,984	646	0,788			
Gesamt	556,082	654				
Unterschiede zw. G5,G6,G7	8,550	2	4,275	3,77	0,02456758	3,037
Innerhalb der Gr. G5,G6,G7	248,338	219				
Gesamt	256,887	221				
Unterschiede zw. G5,G6	5,297	1	5,297	4,927	0,02798216	3,906
Innerhalb der Gr. G5,G6	156,973	146	1,075			
Gesamt	162,27	147				
Unterschiede zw. G8,G9	29,097	1	29,097	22,678	≤0.000	3,906
Innerhalb der Gr. G8,G9	187,329	146	1,283			
Gesamt	216,426	147				

In Bezug auf die Variable „Art des Abrechnungsmodells“ wurde hinterfragt, ob Nutzer es vorziehen singulär für einzelne Inhalte zu bezahlen („Einzelkauf“) oder eher ein Abonnement („flat fee“) abschließen würden. Auch hier wurde eine einfaktorielle

ANOVA zwischen den jeweiligen Antwortwerten durchgeführt. Das Ergebnis in Tabelle 4 zeigt einen signifikanten Unterschied zwischen den Gruppen „Einzelkauf“ (G8) und „Abonnement“ (G9), wobei zahlungsbereite Nutzer ein Abonnement klar gegenüber Einzelkäufen bevorzugen. Dies bestätigt auch die Überlegungen die aus der Literatur abgeleitet werden konnten. Die Hypothese H3 kann also angenommen werden, Abonnements scheinen potenziell mehr Erfolg zu haben als Einzelkäufe.

Für das Bestätigen oder Verwerfen der Hypothese H4, wurden, analog zur Herangehensweise von H1, gezielt gewisse Ausprägungen der Variablen „Mehrwert des Inhalts“ aus Frageblock 5 herausgenommen und zu zwei Kategorien „hochwertige journalistische Inhalte“ und „andere Inhalte“ zusammengefasst. Datengrundlage waren erneut alle Nutzer, die grundsätzlich bereit wären für paid content zu bezahlen. Der Antwortwert „weiß nicht/keine Antwort“ wurde nicht berücksichtigt. Zuerst wurde wieder eine einfaktorielle ANOVA über die Ausprägungen „hochwertige journalistische Inhalte“ (G3) und „andere Inhalte“ (G4) durchgeführt, dann eine weitere ANOVA zwischen den jeweils über die Antwortwerte der Nutzer gemittelten Gruppen MW3 und MW4. Das Ergebnis zeigt, dass die Unterschiede zwischen den einzelnen Ausprägungen jedenfalls signifikant sind. Die Unterschiede der beiden zusammengefassten Gruppen sind jedoch nicht signifikant, es kann keine signifikante Aussage getroffen werden, welche der beiden Kategorien für die Probanden wichtiger sind, die Hypothese wird verworfen. Allerdings kann ergänzend festgehalten werden, dass die Ausprägung „JournalistInnen Kommentare“ eine niedrige Zustimmungsrate hat (Mittelwert: 2,055) und dieser den Durchschnittswert der Gruppe „hochwertige journalistische Inhalte“ deutlich negativ beeinflusst. Würde diese Ausprägung nicht in die Gruppe aufgenommen, würde der Mittelwert der beiden verbleibenden Ausprägungen 1,425 betragen und wäre bei einem Alpha von 0,05, wesentlich niedriger (und damit wichtiger) als die anderen Ausprägungen.

Um eine alleinstehende Aussage zu überprüfen – dies gilt auch für die Überprüfung aller weiteren alleinstehenden und nicht vergleichenden Hypothesen – wurde als Methode die Bildung eines 95%-Konfidenzintervalls gewählt. Sofern ein Antwortwert von 2,0 bei der oberen Grenze nicht überschritten wird, wird der untersuchten Variablen eine signifikante Bedeutung beigemessen. Um diese Aussagen weiter zu überprüfen, wurde jeweils auch ein einseitiger T-Test auf den Mittelwert 2,0 durchgeführt um eine mögliche Signifikanz klarer darzustellen. Anders ausgedrückt wird die Hypothese angenommen, wenn, auf Basis der Stichprobe, mit einer 95 prozentigen Wahrscheinlichkeit der Mittelwert der Antwortwerte zumindest 2, also über der Antwort „stimme teilweise zu“ liegt. Datengrundlage für diese Auswertung zur Hypothese H5 waren die Antworten auf die Frage zur Variablen „Einzigartigkeit des Inhalts“ aus Frageblock 6. Auch hier gilt, dass nur diese Probanden die Frage beantworten konnten, wenn sie die Frage nach der grundsätzlichen Zahlungsbereitschaft mit „Ja“ beantworteten. Um das Ergebnis E1 der Tabelle 5 besser interpretieren zu können, hier der genaue Wortlaut der Fragestellungen: „Grundsätzlich wäre ich bereit, für redaktionelle Berichterstattung im Internet zu bezahlen, Voraussetzung für eine Bezahlung ist aber, dass die angebotenen Inhalte nicht über einen anderen Anbieter kostenfrei konsumiert werden können.“ Diese Frage wird von den Probanden ganz klar positiv beantwortet. Die Hypothese kann also bestätigt werden.

Mit derselben Datenbasis wie bei H5 wurden für die Beantwortung von H6 ein 95%-Konfidenzintervall sowie ein einseitiger T-Test durchgeführt. Die Ergebnisse zu E2 (Tabelle 5) zeigen, dass die Hypothese klar bestätigt werden kann, der beobachtete Wert liegt signifikant über dem festgelegten Grenzwert des Mittelwerts von 2,0. Eine positive Markenwahrnehmung ist für Personen die an einem Kauf interessiert sind also eine wesentliche Voraussetzung um für ein paid content Modell zu bezahlen.

Für die Beantwortung dieser Hypothese H7 wurden die Antworten auf die Frage, die allen Nutzern gestellt wurde, die angegeben haben, im Internet schon einmal bezahlt zu haben, herangezogen: „Ich finde es wichtig, dass unterschiedliche Zahlungsmittel (z.B. Kreditkarte, SOFORT Überweisung, EPS, PayPal, Bezahlung über Rechnung, Bezahlung über Apple/Google, etc.) von Anbietern im Internet angeboten werden." Mit diesen Antworten wurden wieder ein 95%-Konfidenzintervall und ein T-Test gegen den Mittelwert 2,0 durchgeführt. Das Ergebnis E 3 (Tabelle 5) ist eindeutig signifikant, es kann also die Schlussfolgerung gezogen werden, dass die angebotenen Zahlungsmittel ein wesentlicher Erfolgsfaktor sind. Die Forschungshypothese kann also angenommen werden. Interessant ist jedenfalls auch noch eine Betrachtung der Antworten zu den weiteren Fragen dieses Frageblocks um die Aussagen zu spezifizieren. So haben bereits 88,2% der Befragten schon mehrere Zahlungsformen im Internet genutzt, 72,2% stimmen der Aussage zumindest teilweise zu, dass sie nicht immer dasselbe Zahlungsmittel im Internet verwenden (Mittelwert: 1,76). Allerdings haben auch schon 77,6% einmal einen Kauf im Internet nicht abgeschlossen, weil keine präferierte Bezahlart angeboten wurde.

Tabelle 5. Konfidenzintervall, T-Test

Variable	*Anzahl (n)*	*Median*	*Mittelwert*	*Standard-abweichung*	*Konfidenz-intervall 95%*	*Obere Grenze*	*Untere Grenze*	*T-Test (p-Value) against μ=2*
E1_EINZ_ART_INH	74	1,00	1,297	0,711	0,163	1,461	1,134	0,00000
E2_POS_MARKWERT	74	1,00	1,685	0,949	0,218	1,903	1,467	0,00313
E3_ZAHLMIT_WICHT	407	1,00	1,265	0,673	0,154	1,420	1,111	0,00000

Um für die Hypothese 8 den Einfluss einzelner demografischer Faktoren auf die Zahlungsbereitschaft zu analysieren, wurde als statistische Methode eine logistische Regression durchgeführt, da es sich bei der abhängigen Variablen („Ich bin bereit für redaktionelle Sportinhalte im Internet zu bezahlen" – „Ja" oder „Nein") um ein rein kategorial skalierte Variable handelt. Die Berechnungen wurden mit Hilfe eines kostenfreien Add-Ins für Microsoft Excel durchgeführt, das Konfidenzintervall für die Signifikanz der Ergebnisse wurde mit 95% angegeben. Bei der Variable „Einkommen" war es möglich, den Antwortwert „keine Angabe" auszuwählen. Sämtliche dieser Angaben wurden, um Vergleichbarkeit herzustellen, mit dem Mittelwert der abgegebenen Antwortwerte in die Berechnung mit einbezogen. Als Datengrundlage wurden alle Datensätze herangezogen, die den Fragebogen bis zum Ende ausgefüllt haben. Die Ergebnisse für die unabhängigen Variablen „Alter", „Ausbildung" und

„Einkommen“ – alle ordinal skaliert, wobei ein hoher Wert jeweils für einen höheren Wert der Variablen steht – sind in Tabelle 6 dargestellt. Der Output zeigt, dass zwischen der Zahlungsbereitschaft und sämtlicher Variablen ein positiver Zusammenhang besteht. Je höher also Alter, Ausbildung und Einkommen sind, desto größer die Wahrscheinlichkeit, dass Nutzer auch tatsächlich für ein paid content Angebot bezahlen. Allerdings ist dieser Zusammenhang sowohl bei „Alter“, als auch bei „Einkommen“ nicht signifikant, bei „Ausbildung“ schon. Gemäß der korrekten Interpretation aus statistischer Sicht, kann also nur geschlussfolgert werden, dass die Ausbildung die Zahlungsbereitschaft positiv beeinflusst, pro abnehmender Ausbildungsstufe lt. der Antwortwerte nimmt die Wahrscheinlichkeit zur positiven Zahlungsbereitschaft um 61,3% ab. Die anderen Ausprägungen haben keinen signifikanten Einfluss auf die Zahlungsbereitschaft. Die Hypothese muss also verworfen werden, die Ergebnisse einiger bisheriger Untersuchungen zu diesem Thema können nicht bestätigt werden.

Tabelle 6. Logistische Regression

	coeff b	*s.e.*	*Wald*	*p-value*	*exp(b)*	*lower*	*upper*
Intercept	-4,050	0,759	28,487	0,000	0,017		
ALTER	0,107	0,106	1,031	0,310	1,113	0,905	1,369
AUSB	0,478	0,146	10,703	0,001	1,613	1,211	2,147
EINK	0,041	0,114	0,128	0,720	1,042	0,833	1,304

2.3 Interpretation der Erkenntnisse und Limitationen

Grundsätzlich konnten, mit Ausnahme des Faktors „Kategorie des Inhalts“, welcher auf Grund der Rahmenbedingungen der Umfrage nicht überprüft werden konnte, mit der zu Grunde liegenden Erhebung zahlreiche Ausprägungen der aus der Literatur abgeleiteten Erfolgsfaktoren untersucht werden.

Für die Erfolgsfaktoren, bei denen bei einer Einführung zwischen klar definierten Ausprägungsalternativen gewählt werden muss, können jeweils klare Empfehlungen ausgesprochen werden. Bei der Wahl des Abrechnungsmodells ist eine nicht-nutzungsabhängige, periodische Abrechnung signifikant zu bevorzugen. Bei der Entscheidung für eine bestimmte Art der paywall wird das freemium Modell bevorzugt. Bei ersterem werden theoretische Überlegungen und praktische Beobachtungen zum Großteil bestätigt. Bei zweiterem lässt sich aus der Literatur sowie aus der Praxis keine eindeutige Tendenz erkennen, die Ergebnisse dieser Untersuchung waren dennoch signifikant. Hinsichtlich des Einflusses von demografischen Faktoren auf die Zahlungsbereitschaft hat die Analyse der bisherigen Literatur kein eindeutiges Bild ergeben. Dieser Eindruck wurde von dieser Untersuchung bestätigt. Neu war jedenfalls der signifikant positive Einfluss des Ausbildungsgrades auf die Zahlungsbereitschaft. Insbesondere aus praktischer Sicht herauszuheben sind die Erkenntnisse über die verwendeten Zahlungsmittel und dabei insbesondere die Information, dass der Großteil der Nutzer mehrere Zahlungsmittel verwendet, das „richtige“ aber jedenfalls für einen positiven Kaufabschluss wesentlich ist.

Die Erkenntnisse der empirischen Untersuchung unterliegen Einschränkungen, die in der Interpretation zu beachten sind. Die empirische Untersuchung spiegelt die Sicht der Nutzer wider, Einschätzungen von Medienunternehmen fließen bei der genutzten Methode nicht mit ein. Die Größe der Stichprobe (n=463) Nutzern ergibt bei einer Grundgesamtheit von ca. 6 Mio. Internetnutzern in Österreich eine Schwankungsbreite von ca. 5%. Einige statistische Analysen wurden auf Grund des Umfragesetups allerdings nur mit den Antworten der zahlungsbereiten Nutzer durchgeführt (n=74), Hinsichtlich der Einbindung der Umfrage ist relevant, dass diese ausschließlich über sogenannte desktop devices, also nicht über mobile Endgeräte, abgerufen werden konnte. Einschränkend ist zudem festgehalten, dass es auf Grund der gewählten Forschungsmethodik nicht möglich ist eine Aussage über die Rangfolge der Erfolgsfaktoren festzulegen.

3 Schlussbetrachtung

Die Frage nach erfolgsversprechenden Gestaltungsoptionen für Geschäftsmodelle bei redaktionellen Inhalten ist sowohl für die akademische Welt als auch für die Medienbranche von großer Bedeutung. Der Beitrag zeigt, dass für die Einführung von paid content Modellen bei redaktionellen online Sportinhalten mehrere Erfolgsfaktoren relevant. Aus einer Literaturerhebung abgeleiteten Faktoren wurden anhand einer empirischen Untersuchung im Rahmen dieses Beitrags analysiert. Die Ergebnisse der Studie zeigen, dass die abgeleiteten Charakteristika einen positiven Effekt auf den Erfolg eines paid content Modells haben können. Weitere Forschungsansätze in diesem Bereich könnten sich vor allem mit der Rangfolge der Erfolgsfaktoren beschäftigen, um verstärkt vergleichende Aussagen zu ermöglichen. Außerdem sollten vergleichbare Studien auf mehreren Portalen durchgeführt werden, um festzustellen, ob die Ergebnisse auch breitere Gültigkeit haben. Zusätzlich sollten die Erfolgsfaktoren auch aus Sicht von Medienunternehmen und nicht nur aus Sicht der Nutzer theoretisch und praktisch analysiert werden um auch ein betriebswirtschaftliche Perspektive zu gewinnen. Zuletzt könnte auch die Bedeutung von weiteren Erfolgsfaktoren untersucht werden. Eine breite Einführung von redaktionellen paid content Modellen ist zwar derzeit noch nicht erkennbar. Im Rahmen dieses Beitrags wird jedoch am Beispiel redaktioneller Sportinhalte dargestellt, welche Faktoren aus Sicht der Nutzer grundsätzlich für den Erfolg derzeit wichtig sind – und so ein Beitrag zur wissenschaftlichen Aufarbeitung des Themas paid content geleistet.

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IKT-gestütztes betriebliches Umwelt- und Nachhaltigkeitsmanagement

Teilkonferenzleitung

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Informations- und Kommunikationstechnologie im Fokus der Nachhaltigkeit − Eine experimentelle Untersuchung zur Akzeptanz nachhaltiger Smartphones

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Abstract. Informations- und Kommunikationstechnologie steht immer mehr im Fokus des Nachhaltigkeitsmanagements. Die Technologieakzeptanzforschung kann hierbei einen wichtigen Beitrag leisten, indem bestehende Modelle um Nachhaltigkeitsaspekte erweitert werden. In dieser Arbeit wird erstmalig ein Erklärungsmodell entwickelt, dass die individuelle Einstellung der Verbraucher gegenüber Nachhaltigkeit und die Wirkung des sozialen Umfelds in das Modell integriert. Zur Validierung des Modells wurde ein Experiment mit 418 Teilnehmern via Online-Fragebogen durchgeführt. Es konnte gezeigt werden, dass Nachhaltigkeitsaspekte in der Produktgestaltung von Smartphones vom Nutzer positiv wahrgenommen werden, dass jedoch noch weiterer Aufklärungsbedarf über Umweltauswirkungen und Arbeitsbedingungen in der Smartphone-Industrie besteht.

Keywords: Technologieakzeptanz, nachhaltige Smartphones, Experiment.

1 Einleitung

Der Begriff der Nachhaltigkeit ist erstmals auf der Brundtland-Konferenz der Vereinten Nationen definiert und zugleich zur wissenschaftlichen Betrachtung aufgerufen worden [1]. In der Folge ist das Feld der Nachhaltigkeitsforschung entstanden, mit dem weitverbreiteten Grundsatz ausgeglichener ökonomischer, ökologischer und sozialer Faktoren [2]. Im Forschungsgebiet der Technologieakzeptanz hat dieser Aspekt jedoch bisher wenig Beachtung gefunden [3]. Ein Ansatz zur Betrachtung von Nachhaltigkeitsaspekten in Bezug auf Technologieakzeptanz findet sich bei [4], die den Einfluss von Nachhaltigkeitsfaktoren auf die Akzeptanz von Haushaltsgeräten untersucht haben.

Für Produkte aus dem Bereich der Unterhaltungselektronik, wie zum Beispiel Smartphones, ist eine Fokussierung auf Aspekte der Nachhaltigkeit in der experimentellen Technologieakzeptanzforschung bisher nicht zu beobachten. Dass Hersteller von Smartphones sich ebenso nur vereinzelt an Nachhaltigkeitsaspekten bei der Produktgestaltung orientieren, zeigen aktuelle Studien und Berichterstattung zu den Arbeits- und Produktionsbedingungen [5,6] sowie dem Ressourcenverbrauch

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[7,8] bei der Herstellung von Smartphones (z.B. Ausbeutung und Kinderarbeit in Kobaltminen im Kongo, Kauf Seltener Erden von korrupten Regierungen, die damit Kriege finanzieren, inakzeptable Arbeitsbedingungen, da Arbeiter giftigen Stoffen wie Quecksilber und Arsen bei der Produktion von Smartphones sowie dem Recycling von Wohlstandsmüll ausgesetzt werden, etc.). Diese negative Berichterstattung wirkt sich faktisch kaum auf die Verkaufszahlen [5] aus. Dies führt zu der Forschungsfrage: Welchen Einfluss haben Nachhaltigkeitsaspekte auf die Akzeptanz von Smartphones? Das Ziel dieser experimentellen Untersuchung ist somit, ein Erklärungsmodell zu entwickeln, das den Einfluss von Nachhaltigkeitsaspekten auf die Technologieakzeptanz am Beispiel von Smartphones abbildet.

2 Forschungsmethodik

2.1 Forschungsdesign

Zu Beginn dieser Forschungsarbeit wird eine Literaturrecherche nach [9,10] mit Fokus auf nachhaltige Technologieakzeptanz, in Bezug auf Smartphones durchgeführt. Ferner werden Forschungsarbeiten identifiziert, die ein Erklärungsmodell zum Einfluss von Nachhaltigkeitsaspekten auf die Technologieakzeptanz von Konsumenten thematisieren. Hierbei wurde mit Hilfe des nachfolgenden Suchstrings verfahren:

(„Sustainab*“ OR „Green*“) AND („Technology*“ OR „User*“) AND („Acceptance*“ OR „Adoption*“) AND („Smartphone*“ OR „Mobile Phone*“ OR „Consumer Electronics*“).

Es konnten in den Datenbanken SpringerLink, Google Scholar, ScienceDirect und EBSCOhost 18 von 50 Treffern als relevante Quellen identifiziert werden.

Dieser erste Schritt entspricht der *Beobachtung und Induktion* im Sinne des logischen Positivismus [11], siehe Abbildung 1, und wird durch das Kapitel *Verwandte Arbeiten* dargestellt.

Abbildung 1. Prozessschritte im logischen Positivismus [11]

Im zweiten Schritt wird neben der Formulierung von Hypothesen und dem Entwurf eines Hypothesenmodells (siehe 3.1) auch die Messbarkeit bzw. Operationalisierung der aufgestellten Hypothesen bewerkstelligt, um eine objektive Auswertung zu ermöglichen [11]. Der dritte Schritt dient der Datenerhebung und Prüfung der Hypothesen. Dies geschieht auf Basis der Operationalisierung und entwickelter Stimuli (siehe 3.2) durch einen systematischen Experimentaufbau (siehe 4.1). Die Erhebung der Daten findet in dieser Forschungsarbeit durch einen Fragebogen statt

(siehe 4.2). Abschließend werden die Ergebnisse der Versuchsgruppen analysiert (siehe 4.3) und Implikationen diskutiert (siehe Kapitel 5).

2.2 Verwandte Arbeiten

Die identifizierten Quellen lassen sich in drei Kategorien aufteilen: Technologieakzeptanz Nachhaltiger Geräte (1), Technologieakzeptanz von Smartphones (2) und Nachhaltige Smartphones (3).

In Kategorie (1) werden z. B. Erklärungsmodelle für die Akzeptanz von Smart-Home-Systemen beschrieben, die den Ressourcenverbrauch eines Haushalts durch intelligente Vernetzung minimieren sollen [12-14]. Das Technologieakzeptanzmodell (TAM) nach [15] wurde um weitere Determinanten erweitert. [12] fügten intrinsische Faktoren hinzu, während [16] den extrinsischen Faktor der sozialen Norm einbrachten. Darüber hinaus wurden mehrfach ökologische Bedenken zur Erklärung nachhaltiger Technologieakzeptanz herangezogen [13,14].

Arbeiten der Kategorie (2) fokussieren darauf, Erklärungsmodelle für den Nutzungswillen von Konsumenten in Bezug auf Smartphones zu entwickeln [17-21]. Neben diesen auf Produktivität bezogenen Aspekten wurde auch berücksichtigt, dass das Smartphone in den Bereichen Unterhaltung und Freizeit eingesetzt wird [18, 22]. Zumeist wird versucht, diese Besonderheit durch Hinzufügen des Konstrukts Hedonic Value abzubilden [23,24].

Quellen der Kategorie (3) betrachten, z. B. den Produktlebenszyklus [25], den Einsatz des Smartphones zur Nutzung nachhaltiger Transportkonzepte [26] oder die Präferenzermittlung bezüglich einzelner Smartphonekomponenten [27].

Keine der identifizierten verwandten Arbeiten thematisiert den Einfluss von Nachhaltigkeitsaspekten auf die Technologieakzeptanz von Smartphones.

3 Konzeption

3.1 Entwicklung Hypothesenmodell

Grundsätzlich ist das Modell in drei Bereiche eingeteilt. Einerseits existiert die übergeordnete Zieldimension der *Akzeptanz einer Technologie*. Außerdem werden *erwartete Eigenschaften eines Produkts* betrachtet sowie die *spezifischen Eigenschaften eines Individuums*. Je Bereich werden zunächst die einzelnen Konstrukte aus der existierenden Literatur benannt und in ein vollständiges Hypothesenmodell überführt.

Das Konstrukt zur Abbildung der *Akzeptanz einer Technologie* basiert auf den Erkenntnissen von [28], wobei die Variable Behavioral Intention (BI) stellvertretend für die tatsächliche Nutzungsentscheidung steht. Dieses Konstrukt findet bereits Verwendung in prominenten Modellen wie dem Technologieakzeptanzmodell (TAM) [15], der TPB [29] und der UTAUT [30]. Auch Studien zum Thema der Smartphone-Akzeptanz haben dieses Konstrukt, zumindest die BI, übernommen und als signifikant bestätigt [18,23]. Das TAM hat sich wiederholt als robust erwiesen und

wird deshalb oftmals als Ausgangspunkt für Weiterentwicklungen oder neue Modelle genutzt [31,32]. Da das TAM jedoch nur rund 40 % der Varianz erklärt, sind Erweiterungen für spezifischere Forschungsfragen unerlässlich [33].

Ein weiterer Aspekt des Modells bildet die vom Individuum erwarteten *Eigenschaften des Produkts* ab. Als Grundlage dieses Teilbereiches wird die UTAUT nach [30] verwendet. So werden die Konstrukte Performance Expectancy (PE) und Effort Expectancy (EE) übernommen und folgende Hypothesen abgeleitet:

- Performance Expectancy (PE)
  - H1: Der Aspekt der Nachhaltigkeit beeinflusst die PE nicht.
  - H2: Je höher die PE, desto höher die BI.
- Effort Expectancy (EE)
  - H3: Der Aspekt der Nachhaltigkeit beeinflusst die EE nicht.
  - H4: Je höher die EE, desto höher die BI.
  - H5: Je höher die EE, desto höher die PE.
  - H6: Je höher die EE, desto höher die HV.

Im Rahmen der Technologieakzeptanzforschung wurde die Hedonic Value (HV) insbesondere bei Konsumgütern als wichtiger Einflussfaktor für die BI ermittelt [34]. Das vierte Konstrukt der erwarteten Produkteigenschaften ist die Price Value (PV). Diese beschreibt die Abwägung des Individuums von wahrgenommenem Nutzen und den Kosten der Nutzung einer Technologie [35]. Die resultierenden Hypothesen werden den Konstrukten wie folgt zugewiesen:

- Hedonic Value (HV)
  - H7: Der Aspekt der Nachhaltigkeit beeinflusst die HV positiv.
  - H8: Je höher die HV, desto höher die BI.
- Price Value (PV)
  - H9: Der Aspekt der Nachhaltigkeit beeinflusst die PV positiv.
  - H10: Je höher die PV, desto höher die BI.

Des Weiteren sollen *spezifische Eigenschaft des Individuums* im Modell Berücksichtigung finden. Dies geschieht mit Hilfe der Konstrukte Attitude towards Sustainability (AS) und Social Pressure towards Sustainability (SPS). Sie basieren auf der Annahme, dass eine Handlungsintention von der Einstellung gegenüber einer Handlung und sozialen Normen abhängt [28]. Besonders stark ist die Bevorzugung nachhaltiger Produkte bei Statussymbolen [18], zu welchen Smartphones zweifelslos zählen, sodass abschließend die folgenden Hypothesen abgeleitet werden:

- Attitude towards Sustainability (AS)
  - H11: Je höher die AS, desto höher die BI in der Experimentgruppe.
  - H12: Je höher die AS, desto geringer die BI in der Kontrollgruppe.
- Social Pressure towards Sustainability (SPS)
  - H13: Je höher der SPS, desto höher die BI in der Experimentgruppe.
  - H14: Je höher der SPS, desto geringer die BI in der Kontrollgruppe.
  - H15: Je höher der SPS, desto höher die AS.

Die beschriebenen Konstrukte werden für das angestrebte Experiment in Abbildung 2 zu einem Hypothesenmodell vereint.

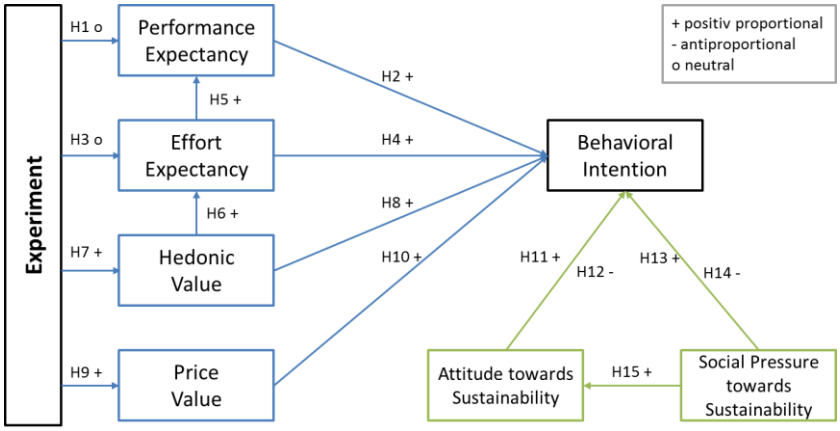

Abbildung 2. Vollständiges Hypothesenmodell

3.2 Operationalisierung und Festlegung der Stimuli

Da es sich bei den Indikatoren ausschließlich um nicht direkt beobachtbare Variablen handelt, wird ein reflektives Messmodell angewendet. Bei diesem werden die Konstrukte als Ursache und die Indikatoren als Folge angesehen [36]. Es ist notwendig, dass pro Konstrukt mehrere Indikatoren bemüht werden, wobei [37] die Verwendung von mindestens zwei Items pro Konstrukt für Mehr-Konstrukt-Modelle empfehlen. Indikatoren werden hierbei mittels siebenstufiger Likert- bzw. Zustimmungsskala gemessen. Jedem Konstrukt werden geeignete Items zugewiesen *(Anhang A)*, wie in Tabelle 1 beispielhaft für *Attitude towards Sutainability* dargestellt.

Tabelle 1: Übersetzte Items der Attitude towards Sustainability (angelehnt an [38])

Chiffre	*Items: Attitude towards Sustainability (AS)*
AS1	Ich glaube, dass ich durch die Verwendung nachhaltiger Produkte zur Reduzierung der Umweltverschmutzung beitragen kann.
AS2	Ich glaube, dass ich durch die Verwendung nachhaltiger Produkte, verschwenderischen Umgang mit natürlichen Ressourcen vermeiden kann.
AS3	Ich glaube, dass ich durch die Verwendung nachhaltiger Produkte zur Schonung natürlicher Ressourcen beitragen kann.
AS4	Ich glaube, dass ich durch die Verwendung nachhaltiger Produkte, die Arbeitsbedingungen der Produktionsarbeiter verbessern kann.
AS5	Ich fühle mich gut dabei, nachhaltige Produkte zu verwenden.

Als vorgeschalteter Teil des Experiments wird den Probanden eine verallgemeinerte Smartphone-Werbung gezeigt, die auf aktuellen Geräteeigenschaften der fünf Top-Hersteller Samsung, Apple, Huawei, Motorola und Xiaomi beruht [39]. Es werden dabei die Produktmerkmale Kamera, Design, Leistung, Spiele, Verbindung, Display, Akku, Sicherheit und Nachhaltigkeit berücksichtigt *(Anhang B)*.

4 Durchführung

4.1 Experimentieranordnung und Messinstrumente

Das Design des Experimentes folgt dem in der Wissenschaft häufig verwendeten *Posttest-Only Control Group Design* mittels Online-Fragebogen [11]. Dieses zeichnet sich dadurch aus, dass das Experiment je Proband einmalig durchgeführt wird. Um statistisch unverzerrte Daten zu erhalten, werden die Teilnehmer des Experiments zufällig einer Experiment- und einer Kontrollgruppe zugewiesen.

Beide Gruppen wurden bezüglich ihrer Einstellung gegenüber dem Thema Nachhaltigkeit befragt und den entwickelten Stimuli ausgesetzt *(Anhang C)*. Die Beschreibung des konventionellen Smartphones wurde für die Kontrollgruppe und die um das Thema Nachhaltigkeit erweiterte Beschreibung wurde für die Experimentgruppe genutzt.

Um die ordnungsgemäße Durchführung des Experiments gewährleisten zu können, wurde ein funktionaler Pretest mit 14 Probanden durchgeführt. Die gewonnenen Rückmeldungen wurden zur Verbesserung des Fragebogens umgesetzt.

Die Experimentdurchführung erfolgte mittels eines Online-Fragebogens, der mit Hilfe der Software LimeSurvey implementiert wurde [40]. Außerdem ermöglicht die Software eine Vorbereitung der Daten für die folgende statistische Auswertung mittels SPSS.

4.2 Datenerhebung und -aufbereitung

Die Teilnehmer wurden via Facebook oder E-Mail zur Teilnahme eingeladen. Die anonyme Teilnahme am Experiment war vom 25.04.2016 00:01 Uhr bis zum 13.05.2016 23:59 Uhr möglich. Neben den Items in Form eines Fragebogens und den beschriebenen Stimuli waren ein einleitender Text, der über Anreize und Vorgehen des Experiments informierte und zum Abschluss der Befragung die Möglichkeit, einen Kommentar zu hinterlassen, Bestandteile des Experiments.

Die 418 Datensätze wurden auf Vollständigkeit und realistische Antwortgeschwindigkeit hin überprüft und bereinigt. Zuletzt wurden die Datensätze der Teilnehmer entfernt, die die Frage „Did you recognize the presented smartphone?“ mit „Ja“ beantwortet haben. Diesem Schritt liegt der Gedanke zu Grunde, dass die Teilnehmer eine vorgefasste Meinung gegenüber dem Stimulus haben könnten.

4.3 Statistische Auswertung

Die bereinigte Stichprobe enthält 138 vollständige Datensätze, die zur Auswertung verwendet werden. Das Sample setzt sich dabei wie in Tabelle 2 zusammen.

Tabelle 2. Samplezusammensetzung

Geschlecht	*Alter*	*Bildungsstand*	*Präferenz*	*Zuordnung*
65% männlich	17-39 Jahre	74% Studierende	41% iOS / (Apple)	55% Kontrollgruppe
35% weiblich	∅ 23,7 Jahre	12% Angestellte	59% Android (Samsung,	45% Experimentgruppe
		14% Schüler und sonstige	HTC, Sony, LG, sonstige)	

Die 23 Items der Umfrage wurden mittels siebenstufiger Likert-Skala ermittelt, wobei die Ausprägung 1 für starke Ablehnung und die Ausprägung 7 für starke Zustimmung stehen. Ein Großteil der Werte liegt oberhalb von 4, teilweise sogar oberhalb von 5. Lediglich Items der PV und PE3 zeigen eine leichte mittlere Ablehnung. Die Items der SPS und PE2 zeigen mit Werten um 4 ein recht neutrales Bild. Die Werte der Kontroll- und Experimentgruppe unterscheiden sich hierin nur marginal.

Die im vorliegenden Experiment genutzten Konstrukte und die dazugehörige Operationalisierung (siehe Kapitel 4.2) sind bewusst für ein reflektives Messmodell entwickelt worden. Die Güte dieses Messmodells ist ausschlaggebend für die spätere Qualität des Strukturgleichungsmodells. Im Fokus stehen dabei Reliabilität und Validität des Messmodells. Dies geschieht mittels explorativer bzw. konfirmatorischer Faktorenanalyse und den Standard Gütekriterien wie Cronbachs Alpha (0,896) und der Inter-Item-Korrelation. Die Eignung des Datensatzes für dieses Vorgehen wurde zuvor anhand des KMO-Kriteriums, einer Korrelationsprüfung, festgestellt (KMO= 0,8).

Zur Bestimmung der Anzahl der Faktoren wurde eine explorative Faktorenanalyse (EFA) über alle Variablen durchgeführt. Hierbei wurden insgesamt 23 Faktoren analog zur Anzahl der Items extrahiert. Ziel ist es, nur Items zu verwenden, die sowohl statistisch als auch theoretisch einem einzigen Konstrukt zugeordnet werden können. Nach [41] ist die Anzahl der Faktoren auszuwählen, die einen Eigenwert größer als eins vorweisen können. In diesem Fall ist dies für eine Faktorenanzahl bis sechs zutreffend. *(Anhang D).*

Durch die konfirmatorische Faktorenanalyse (KFA) werden die Reliabilitäts- und Validitätskriterien der zweiten Generationen geprüft. Dieser Wert konnte mit der Methode Bootstrapping in SmartPLS berechnet werden und sind in Tabelle 3 einsehbar. Der niedrigste ermittelte Wert ist 0,837 für EE4 und der höchste Wert beträgt 0,950 für AS1. Diese Werte sind durchgängig als sehr hoch anzusehen, da üblicherweise ab einem Wert von 0,4 von Reliabilität der Indikatoren ausgegangen wird [37].

Alle untersuchten Dimensionen der Reliabilität zeigen deutlich signifikante Werte, sodass die Reliabilität der Indikatoren und Faktoren des Experiments bestätigt ist. Dies belegt ebenso der Vergleich der Mittelwerte mittels T-Test. Somit sind alle Hypothesen abzulehnen, die eine signifikante Veränderung der Konstruktergebnisse vorausgesetzt haben. Folglich wurden beispielsweise die Hypothesen H7 und H9 abgelehnt, während die Hypothesen H1 und H3 bestätigt wurden.

Tabelle 3. Konstruktreliabilität und -validität zweiter Generation

Konstrukt	***Faktor-reliabilität***	***DEV****	***Levene-Test***		***T-Test***		
			F	*Sig.*	*T*	*d.f.*	*Sig. (2-seitig)*
AS	0,947	0,86	4,37	0,04	-1,94	105,7	0,055
BI	0,933	0,88	0,34	0,56	-0,66	136	0,511
EE	0,914	0,73	1,54	0,22	2,046	136	0,043
HV	0,938	0,84	0,87	0,35	0,737	136	0,463
PE	0,909	0,83	0,53	0,47	1,396	136	0,165
PV	0,933	0,82	0,33	0,57	1,77	136	0,079
SPS	0,92	0,79	3,3	0,07	1,37	136	0,173

**DEV = durchschnittlich erfasste Varianz*

Die übrigen elf Hypothesen betreffen die Beziehungen zwischen den einzelnen Faktoren. Die Zusammenhänge wurden durch die Kleinste-Quadrate-Schätzung mit Hilfe von SmartPLS 3 ermittelt [42]. Im Rahmen dieser Schätzung wurden sowohl die Pfadkoeffizienten als auch die Signifikanz dieser Koeffizienten geprüft, womit z. B. die Hypothesen H2, H4 und H10, H5 und H6 bestätigt wurden. Das Konstrukt SPS hat sich in Bezug auf BI als stark insignifikant (p-Wert: 0,548) gezeigt, wodurch die Hypothesen H13 und H14 zu verwerfen sind. Lediglich der erwartete positive Einfluss des SPS auf die AS zeigte sich über alle Gruppen hinweg als signifikant und mit Werten über 0,366 als aussagekräftig. Hypothese H15 ist damit bestätigt (siehe Abbildung 3).

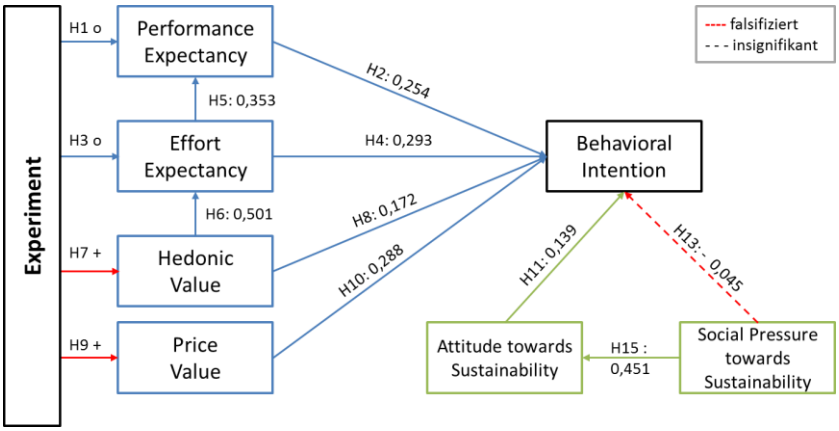

Abbildung 3. Geprüftes Hypothesenmodell mit Pfadkoeffizienten

5 Diskussion

Das geschätzte Gesamtmodell der nachhaltigen Technologieakzeptanz für Smartphones konnte inferenzstatistisch bestätigt werden, obgleich Schwellenwerte für einzelne Gütekriterien (Normed Fit Index und RMStheta für mittlere quadratische Abweichung) nicht erreicht wurden. Dies könnte in Anbetracht der insgesamt recht niedrigen korrigierten R^2-Werte auf weitere bisher nicht in Betracht gezogene Konstrukte zurückzuführen sein.

Alle untersuchten Konstrukte und Zusammenhänge konnten, bis auf die Verbindung von SPS und BI, durch das Experiment bestätigt werden und stellen einen signifikanten Erklärungswert dar. Folglich wirkt sich das Nachhaltigkeitsbewusstsein des sozialen Umfelds auf das eigene Nachhaltigkeitsbewusstsein aus und dieses hat einen signifikant positiven Einfluss auf die Handlungsintention, fördert somit den Erwerb eines nachhaltigen Smartphones.

Außerdem konnten die positiven Einflüsse von PE, EE, HV und PV auf die BI bestätigt werden. Dies könnte darauf hindeuten, dass Nachhaltigkeitsaspekte zwar einen positiven Einfluss auf die BI haben, weil sie z. B. sozial erwünscht sind, jedoch das Ausbleiben dieser Aspekte keinen Einfluss auf die BI hat. Für Smartphone-Hersteller würde dies bedeuten, dass mittels nachhaltiger Produktion ein positives Alleinstellungsmerkmal geschaffen werden kann, ein Ausbleiben eines solchen Schrittes jedoch nicht von den Konsumenten abgestraft würde. Folglich werden Konsumenten zwar Nachhaltigkeitsaspekte positiv wahrnehmen und bewerten, jedoch keine erhöhte Preisbereitschaft gegenüber nachhaltigen Smartphones entwickeln. Denn es konnte außerdem gezeigt werden, dass der Aspekt der Nachhaltigkeit keinen Einfluss auf die PE und die EE hatte. Dies bedeutet, dass auch dem Konsumenten mit erhöhtem Nachhaltigkeitsbewusstsein Leistungsmerkmale bei der Kaufentscheidung wichtig sind.

Die auf ökologische Nachhaltigkeit bezogenen Items AS1, AS2 und AS3 erfuhren große Zustimmung. Auffällig war, dass die Arbeitsbedingungen bei der Produktion nicht als Facette der Nachhaltigkeit wahrgenommen wurden. Dieses fehlende Bewusstsein gegenüber sozialen Komponenten der Nachhaltigkeit ist insbesondere in Verbindung mit Fair Trade Überlegungen ernüchternd. Hier bedarf es offensichtlich erheblich intensiverer (Verbraucher-)Aufklärungsarbeit durch Forschungs- und Bildungseinrichtungen, sowie dem Wissenstransfer über massentaugliche Medien.

6 Fazit

Das Ziel dieser Arbeit war es, ein Erklärungsmodell für Technologieakzeptanz von Smartphones unter Berücksichtigung von Nachhaltigkeitsaspekten zu entwickeln. Es wurde durch systematische Literaturrecherche, Theorieanalyse und theoretisch fundierte Experimentgestaltung die Qualität des methodischen Vorgehens gewahrt. Die abschließend geschätzten Strukturgleichungsmodelle erreichten zwar einzelne Schwellenwerte der Gesamtgüte nicht, dennoch sind die Ergebnisse der inferenzstatistischen Auswertung als positiv anzusehen.

Es lässt sich subsumieren, dass Nachhaltigkeitsaspekte zwar ein positiv wahrgenommenes Merkmal für Smartphones sind und die Nutzungsabsicht steigern, jedoch kein nachteiliger Effekt für konventionelle Smartphones vorliegt. Dies lässt sich ggf. auf unzureichende Information der Verbraucher über Umweltauswirkungen und ggf. schlechte Arbeitsbedingungen in der Produktion konventioneller Smartphones zurückführen. Damit sich eine nachhaltigere Produktgestaltung unter ggf. höheren Kosten zukünftig für Smartphone-Hersteller attraktiver gestaltet, sollte das entsprechende Nachhaltigkeitsbewusstsein beim Verbraucher gefördert werden.

7 Danksagung

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Anhang

Der Anhang ist abrufbar unter folgender URL: http://bit.ly/IKT_Experiment.

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Risikointegrierte Dokumentation umweltrelevanter Prozesse im Betrieb von Offshore Windparks

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Abstract. Offshore Windparks sind aufgrund ihres Standortes im Meer mit besonderer Rücksicht auf die Umwelt zu betreiben. In der 20-25 jährigen Betriebsphase müssen nicht nur Umweltauflagen eingehalten werden, sondern es muss als „Grüne Energie“ auf einen umwelt- und sozialverträglichen Betrieb bei hoher Wirtschaftlichkeit geachtet werden. Etablierte Mechanismen zur Dokumentation der entsprechenden Informationen bestehen derzeit nicht. Eine Möglichkeit der Darstellung ist die Integration der Informationen in Prozessmodelle, wodurch sie nicht nur für Beteiligte transparent gemacht werden, sondern dauerhaft dokumentiert sind und die Einhaltung von Dokumentationsauflagen unterstützen.
Der Beitrag beschreibt an einem Beispiel die Notwendigkeit einer guten Betriebsdokumentation als Basis der Erhebung und Ermittlung von Umweltinformationen. Die Umweltinformationen werden in BPMN-Prozessmodellen abgebildet. Hierbei stehen nicht nur klassische Umweltinformationen im Fokus, sondern diese werden um Umweltrisiken erweitert. Mit der Kenntnis über Umweltrisiken ist es möglich Gefährdungen für die Umwelt frühzeitig zu erkennen und Maßnahmen zur Entdeckung, Abwehr und Verminderung zu treffen sowie angemessene Notfallpläne zu erstellen.

Keywords: Offshore Windpark, Betriebsführung. Prozessdokumentation, Prozessmodellierung, Risikointegration, Prozessrisiko, Umweltrisiko

1 Einleitung

Beim Betrieb und der Instandhaltung von Offshore Windparks (OWP) ist eine Vielzahl an unterschiedlichen Akteuren mit vielen Schnittstellen beteiligt. Eine fundierte Dokumentation und Darstellung der Abläufe, Interaktionen und Abhängigkeiten unterstützen eine reibungslose Umsetzung der Prozesse. Zudem können Gefährdungen, die den reibungslosen Ablauf der Prozesse beeinträchtigen, frühzeitig erkannt und Verbesserungsmaßnahmen ergriffen werden. Als Darstellungsform sind semi-formale grafische Prozessmodelle besonders geeignet. Mit ihnen lassen sich Prozesse für verschiedene Beteiligte übersichtlich und verständlich veranschaulichen, weitere Informationen über mögliche Gefährdungen der Umwelt, des Menschen und des Seeverkehrs dokumentieren und Maßnahmen beschreiben. Hier kommt der

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Dokumentation von Umweltgefährdungen durch den Betrieb und die Instandhaltung von OWP eine besondere Bedeutung zu. Es müssen Genehmigungsauflagen erfüllt werden und deren Einhaltung nachweisbar sein. Vor diesem Hintergrund gewinnt das Umweltmanagement zunehmend an Bedeutung und fordert die Dokumentation bedeutender umweltbezogener Informationen, zu denen einerseits die klassischen Umweltkennzahlen gehören. Andererseits können durch Schwachstellen in den Prozessen Umweltgefährdungen ausgelöst werden. Diese müssen erkannt und adäquat behandelt werden. Mit der Ermittlung von Umweltrisiken in den Prozessen und deren Dokumentation in den Prozessmodellen lassen sich geeignete Gegenmaßnahmen leichter ableiten und die Prozesse gestalten. Den erforderlichen Dokumentationspflichten wird ebenfalls Rechnung getragen. Die Arbeit baut auf dem Ansatz von GREINER zur Definition und Modellierung von Prozessrisiken auf. Umweltziele und Umweltgefährdungen durch Prozesse werden dort aber nicht betrachtet.

In dem Beitrag wird an einem umweltrelevanten Prozess aus dem Betrieb von Offshore Windparks zum einen die gemeinsame Dokumentation von Prozessen und Umweltinformationen vorgestellt. Zum anderen wird aufgezeigt, was Umweltrisiken im Prozessumfeld sind, wie sie ermittelt und in Prozessmodellen dargestellt werden können.

2 Umweltrelevante Prozesse im Offshore Windpark-Betrieb

2.1 Prozesshierarchie des Betriebs von Offshore Windparks

Die Prozesse von Offshore Windparks werden ausgehend von der Projektphase in fünf Ebenen bis auf die Aktivitätenebene in Elementarprozessen verfeinert (s. Abb.1). Über alle Hierarchieebenen hinweg laufen Führungsprozesse (z.B. Umweltmanagement) und Unterstützungsprozesse (z.B. Finanzmanagement), die die Prozesse in den verschiedenen Ebenen unterschiedlich beeinflussen [2].

Die oberste Ebene stellt die Projektphasen des OWP von der Planung bis zum Rückbau dar. Der Fokus liegt auf der Betriebsphase, die weiter unterteilt werden kann in den Betrieb mit Stromproduktion, Stillstand, Modifikation, Instandhaltung und Außergewöhnliche Situation sowie die Betriebsführung (Clusterprozesse). Die Instandhaltung wird weiter in die Hauptprozesse Inspektion, Wartung, Instandsetzung und Verbesserung verfeinert. Diese unterliegen dem gleichen Ablauf und werden in die fünf nacheinander ablaufenden Teilprozesse Ermittlung des Arbeitsbedarfs, Einsatzplanung, Vorbereitung, Durchführung und Nachbereitung unterteilt. Alle Teilprozesse werden dann in Elementarprozessen mit allen Akteuren, Aktivitäten und Interaktionen in Form eines Prozessmodells dargestellt [2]. Abbildung 1 zeigt am Beispiel der Betriebsphase die Prozesshierarchie.

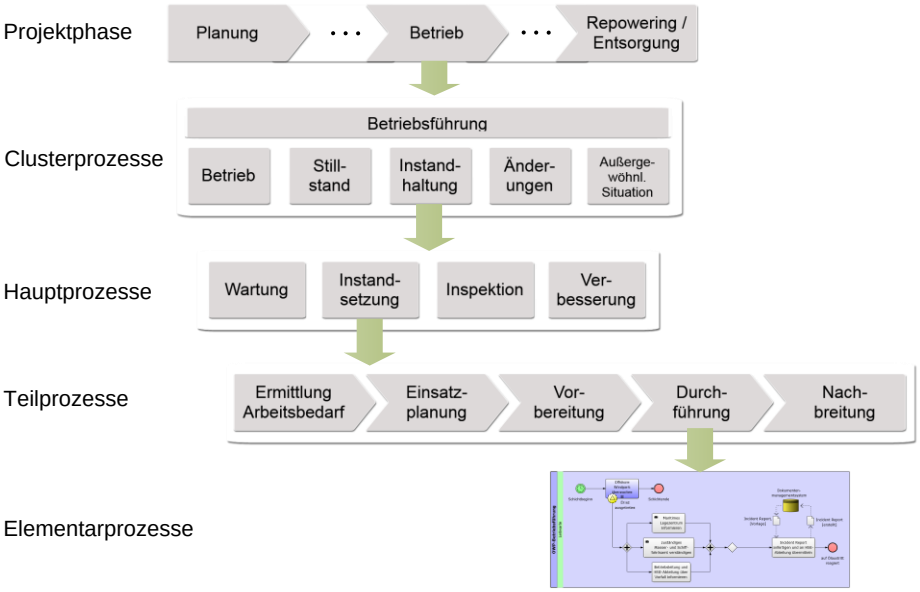

Abbildung 1. Prozesshierarchie für Offshore Windparks am Beispiel Betrieb (Auszug) [2]

2.2 Instandhaltungsprozesse mit Gefährdungspotenzial für die Umwelt

Umweltrelevante Prozesse sind Prozesse mit negativer oder positiver Auswirkung auf die Umwelt. Zu Prozessen mit einem Gefährdungspotenzial für die Umwelt im OWP-Betrieb gehören insbesondere die Prozesse der Instandhaltung, an denen viele interagierende Akteure, Schiffe und Helikopter beteiligt sind.

Die Prozesse der Instandhaltung sind vielfältig und nicht alle als umweltrelevant zu bezeichnen. Eine Gefährdung der Umwelt ist immer dann zu erwarten, wenn sich Menschen, Fahrzeuge sowie Materialien und Betriebsstoffe im OWP befinden. Als umweltrelevant sind u.a. folgende Prozesse zu bezeichnen:

- Transportprozesse per Schiff und Helikopter, durch die es zu Emissionen von Lärm, CO_2 und Schadstoffen kommen kann,
- Durchführung von Arbeiten an den Windenergieanlagen, am Umspannwerk, an den Tagstrukturen und der Innerparkverkabelung, durch die Stoffe in das Meer eingetragen werden können oder Lärmemissionen auftreten,
- Entsorgung von Abfällen, die bei nicht ordnungsgemäßem Umgang in das Wasser gelangen können

Tritt eine Umweltgefährdung, wie z.B. ein Ölaustritt bei Instandsetzungsarbeiten auf, werden Notfallprozesse ausgelöst, die die Meldung der Gefährdung, das weitere Ausbreiten und den Umgang mit der Verschmutzung fokussieren. Diese Prozesse sind der Außergewöhnlichen Situation zuzuordnen.

2.3 Umweltbezogene Prozessrisiken in der Instandhaltung von OWP

Ausgangspunkt der Definition von Umweltrisiken in Prozessen ist die allgemeine Beschreibung von Risiken in Prozessen, wonach die negative Abweichung zwischen dem tatsächlich erreichten Ziel und dem erwarteten Ziel allgemein als Risiko bezeichnet wird [4]. Sie ist in der Regel mit einem Verlust oder Schaden verbunden [5].

Umweltrisiken in Prozessen sind, basierend auf der allgemeinen Definition von Prozessrisiken nach GREINER, besser als „umweltbezogene Prozessrisiken“ zu benennen. Umweltbezogene Prozessrisiken sind Risiken, die sich einzeln oder kumulativ auf die Umweltwirkungen des Prozesses negativ auswirken und zu Abweichungen der aufgestellten Umweltziele und Umweltkennzahlen führen. Je nach Art und Schwere der Umweltwirkung führen diese Risiken auch zu zeitlichen Verzögerungen und zusätzlichen Kosten für Ressourcen durch das Ergreifen von Gegenmaßnahmen, was letztendlich zu unzufriedenen Kunden oder einer schlechteren Prozessqualität führt. Umweltbezogene Prozessrisiken können schleichend über einen längeren Zeitraum oder punktuell, plötzlich auftreten. Sie können im Voraus, unmittelbar mit Eintreten oder verzögert nach Eintreten des Ereignisses sichtbar sein [in Anl. an 3].

Ausgangspunkt der Ermittlung von umweltbezogenen Prozessrisiken sind umweltbezogene Prozessziele, wie bspw. „es darf kein Öl ins Meer gelangen“. Umweltbezogene Prozessrisiken werden vom Management gemeinsam mit dem Umweltmanagement und den Prozessverantwortlichen festgelegt. Zur Beurteilung der Umweltleistung eines Prozesses werden Umweltleistungsparameter, wie z.B. Ölaustrittsvolumen oder CO_2-Emissionen, genutzt. Risikoereignisse, wie das Austreten von Öl, beeinflussen den Prozess und führen zu einer Abweichung vom aufgestellten Umweltziel. Das Ereignis kann ein oder mehrere Ursachen haben. Die Ursachen sind in menschlichen Fehlern, technischen Problemen und Ausfällen oder falsch angewendeten Verfahren sowie in klimatischen Bedingungen oder in umweltbezogenen Änderungen im Unternehmensumfeld zu finden. Die Risikoursache wird mit der Auftritts- und Entdeckungswahrscheinlichkeit quantifiziert [3]. Risikoursachen können dabei in die von ISHIKAWA festgelegten Einflussfaktoren Mensch, Maschine/ Messtechnik, Methode, Material und Mitwelt, die sogenannten „5M“, kategorisiert werden [6]. Die Auswirkungen, auch als Folgen bezeichnet, können sich entsprechend der festgelegten umweltbezogenen Prozessziele äußern. Sie können u.a. auch zu zeitlichen Verzögerungen und höheren Kosten führen. Die Auswirkungen werden mit einem Schadensausmaß, wie bspw. Verschmutzungsgrad des Meeres und Fischsterben, beziffert. Weitere Merkmale umweltbezogener Prozessrisiken sind Maßnahmen zur Entdeckung der Ursache, zur Verhinderung des Ereignisses und zur Verminderung der Auswirkung. Im Risikomaß werden mindestens das Schadensausmaß und die Auftrittswahrscheinlichkeit zusammengefasst. Es erlaubt den Vergleich von Risiken. Abbildung 2 skizziert die Merkmale umweltbezogener Prozessrisiken.

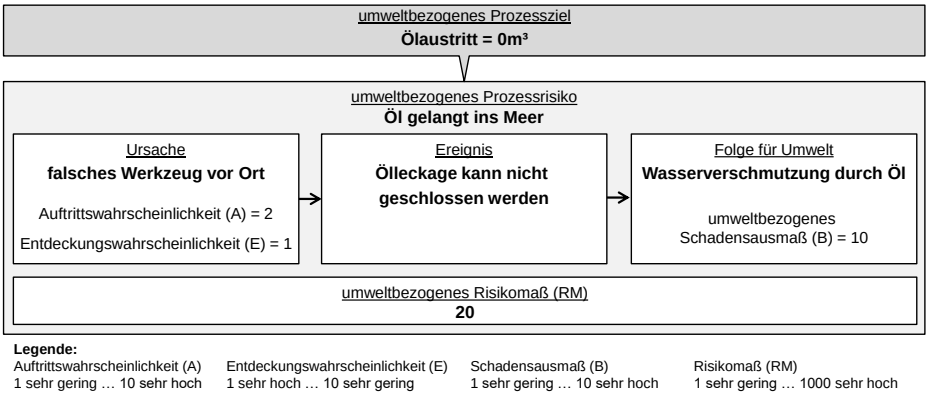

Abbildung 2. Merkmale umweltbezogener Prozessrisiken am Beispiel „Austritt von Öl“ [in Anl. an 3]

Neben den genannten klassischen Risikomerkmalen sind Einflussfaktoren und Risikobeziehungen weitere Merkmale von Risiken [3], die im Umfeld von Umweltauswirkungen durchaus relevant sein können. Sie werden hier nicht weiter behandelt.

In der Regel stehen keine ausreichenden Daten und Informationen für eine statistische Auswertung von Risiken zur Verfügung [7,8], sodass die notwendigen Risikoinformationen mit einem Expertenteam aus dem Prozessumfeld ermittelt werden müssen. Die *Fehlermöglichkeits- und Einflussanalyse (FMEA)* ist hierfür eine etablierte Methode. Mit ihr wird die Ursache-Ereignis-Folge-Verknüpfung ermittelt und je nach Daten- und Erfahrungslage semi-quantitativ oder quantitativ bewertet [9].

Im Folgenden werden am Beispiel „Notfallplan: Gewässerverschmutzung durch Ölaustritt“ bei der Durchführung eines Getriebeölwechsels an einer Offshore Windenergieanlage die Prozessmodellierung, die Modellierung Umweltmanagement-relevanter Dokumente und deren Lenkung, sowie die Modellierung umweltbezogener Prozessrisiken als eine mögliche Dokumentationsform im Umweltmanagement vorgestellt.

3 Prozess- und Risikodokumentation

3.1 Notfallplan „Gewässerverschmutzung durch Ölaustritt“

Während des Betriebs und der Instandhaltung (O&M) kann es zu jeder Zeit zum Austritt von Öl kommen. Dies kann durch Fahrzeuge und Servicetechniker des OWP-Betriebs oder fremdverschuldet sein. Für gewöhnlich wird das Personal der Leitwarte als erstes über den Ölaustritt informiert. Dort wird umgehend die Umsetzung des Notfallplans „Gewässerverschmutzung durch Ölaustritt“ ausgelöst.

Die Leitwarte informiert das Maritime Lagezentrum des Havariekommandos über den Vorfall. Im Falle eines Ölaustritts von mehr als 50 m^3 ist das Havariekommando für die Beseitigung des Öls zuständig. Bei geringeren Mengen kontaktiert das Maritime Lagezentrum die für die Beseitigung zuständige Behörde. Das zuständige Wasser- und Schifffahrtsamt wird ebenfalls durch das Personal der Leitwarte über den Ölaustritt

informiert. Darüber hinaus werden die betriebsinterne HSE-Abteilung und die Betriebsleitung über den Vorfall in Kenntnis gesetzt.

Tritt das Öl von einer Anlage aus, auf der zeitgleich O&M-Maßnahmen durchgeführt werden, unterbrechen die Servicetechniker ihre Tätigkeiten und suchen nach der Leckage. Wird die Leckage gefunden, werden die Servicetechniker versuchen die Leckage zu schließen, um einen weiteren Ölaustritt zu verhindern. Anschließend informieren die Servicetechniker die Leitwarte über den aktuellen Bearbeitungsstand. Abschließend dokumentieren sowohl die Servicetechniker als auch die Leitwarte den Vorfall in einem *Incident Report*.

Eine für die Modellierung von Prozessen, Umweltmanagement-relevanten Dokumenten und umweltbezogenen Prozessrisiken geeignete Sprache ist die *Business Process Model and Notation (BPMN 2.0)*. Sie ist eine semi-formale, standardisierte Prozessmodellierungsnotation, die eine verständliche Definition und Dokumentation von Geschäftsprozessen ermöglicht [1]. Ihre Stärke liegt in der anschaulichen Darstellung von Interaktionen zwischen verschiedenen Akteuren sowie der Modellierung von Fehlerereignissen und Prozessabbrüchen. Diese werden insbesondere bei der Modellierung von Risiken benötigt [3]. Die chronologisch-sachlogische Abfolge von Aktivitäten, Ereignissen und Bedingungen lassen sich mittels Sequenzflüssen beschreiben. Der Austausch von Informationen, Daten, Material etc. zwischen Organisationseinheiten wird über Nachrichtenflüsse dargestellt [1]. Editoren ermöglichen die Modellierung, Dokumentation, Automatisierung und Simulation von Geschäftsprozessen auf Grundlage dieses Notationsstandards. Sie bieten auch die Ausleitung von Prozessen als HTML-Report [11]. Damit ist eine simple Navigation zwischen verlinkten Prozessen möglich, wodurch Schnittstellen zu, Zusammenhänge mit und Abhängigkeiten von vor- und nachgelagerten Prozessen ersichtlich werden. Auch hinterlegte Beschreibungen und Dokumente lassen sich aufrufen, wodurch Verantwortlichkeiten transparent dargestellt und die Dokumentenlenkung unterstützt wird [11]. Formale Sprachen, wie beispielsweise Petri-Netze, sind wenig anschaulich und nicht zur Kommunikation zwischen Prozessbeteiligten geeignet. Die Kommunikation ist aber insbesondere in komplexen Prozessen Voraussetzung für die Aufnahme von Prozessen und deren Risiken [3].

Prozessmodelle bieten den Vorteil einer einfachen Orientierung innerhalb der betrieblichen Prozessstruktur. Dies kommt zum Beispiel bei der Einarbeitung neuer Mitarbeiter zum Tragen. Eine übersichtliche Visualisierung der Geschäftsprozesse ermöglicht einen schnellen Überblick über Aktivitäten, Verantwortlichkeiten, Schnittstellen etc. Zum anderen unterstützen Prozessmodelle Mitarbeiter auch in Situationen, die nur selten auftreten. Hierbei werden Mitarbeiter in die Lage versetzt, sich über nicht-alltägliche Abläufe, Kommunikationswege, Verantwortlichkeiten etc. zu informieren. Solche Prozesse können zudem mit Hilfe von *Process Engines* automatisiert oder teil-automatisiert ausgeführt werden. Nicht zuletzt eignen sich die Prozessmodelle als Kommunikationsmittel zwischen allen Beteiligten vom Management bis zum Prozessdurchführenden. Missverständnisse über Verantwortlichkeiten lassen sich ebenso vermeiden wie sich Unstimmigkeiten in Abläufen aufdecken lassen.

Das BPMN 2.0-Prozessmodell des „Notfallplans: Gewässerverschmutzung durch Ölaustritt“ bei einer Instandsetzung (Abb. 3) zeigt neben dem klassischen Prozessmodell wichtige Dokumente, den Dokumentenfluss und umweltbezogene Prozessrisiken. Die Darstellung der Dokumente und Dokumentenflüsse sowie der Risiken in BPMN 2.0-Prozessmodellen wird in den folgenden Kapiteln detailliert erläutert.

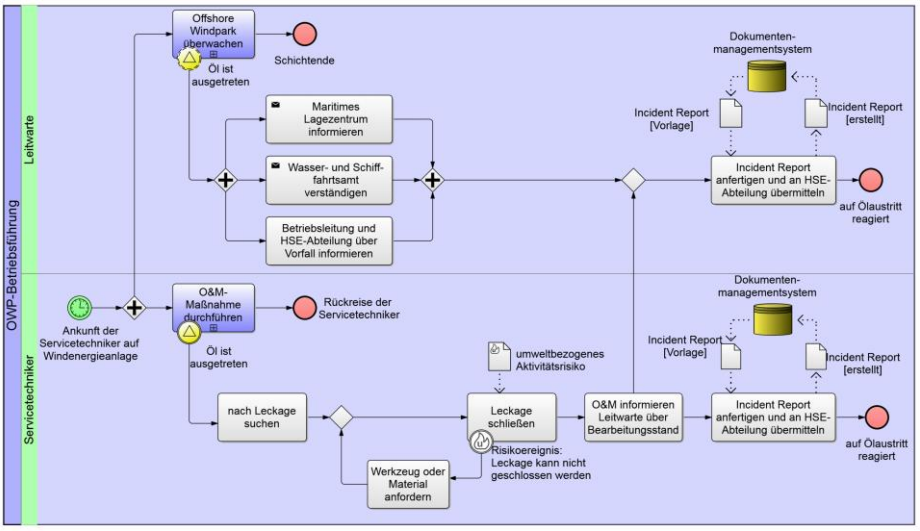

Abbildung 3. BPMN 2.0 - Prozessmodell „Notfallplan: Gewässerverschmutzung durch Ölaustritt“ inklusive Umweltdokumente und umweltbezogene Prozessrisiken (modelliert mit IYOPRO [11])

3.2 Prozessdokumentation im Umweltmanagement

Um Umweltleistungen entsprechend der DIN EN ISO 14001 zu verbessern, müssen Umweltaspekte identifiziert, Umweltauswirkungen gemessen und entsprechende Maßnahmen eingeleitet werden. Hierfür müssen Prozesse, deren Zusammenhänge und Wechselwirkungen dargestellt und mit dokumentierter Information verknüpft werden. Diese dokumentierte Information muss verfügbar und für die Verwendung geeignet sein. Zu dokumentierten Informationen zählen neben der Dokumentation (Informationen, die für den Betrieb der Organisation selbst geschaffen werden) auch Aufzeichnungen (Nachweise über erreichte Ergebnisse) und Prozesse (zusammenhängende und sich beeinflussende Tätigkeiten). Im Rahmen der Notfallvorsorge und Gefahrenabwehr haben Prozesse für die Vorbereitung und Reaktion auf mögliche Notfallsituationen eine besondere Bedeutung. [12]

Die exemplarische Dokumentation des Prozesses „Notfallplan: Gewässerverschmutzung durch Ölaustritt“ in einem BPMN 2.0-Prozessmodell (Abb. 3) erfüllt die Anforderungen der DIN EN ISO 14001 weitestgehend. Der Prozess wird vollständig inklusive Verantwortlichkeiten, Schnittstellen zu und Kommunikationswege mit anderen Akteuren beschrieben. Zudem wird dargelegt, welche Maßnahmen zur Verminderung von nachhaltigen Umweltauswirkungen ergriffen werden müssen.

Das Personal der Leitwarte wird so über ihre Informationspflichten gegenüber dem Maritimen Lagezentrum, dem zuständigen Wasser- und Schifffahrtsamt, der Betriebsleitung und HSE-Abteilung informiert. Die Hinterlegung weiterer Informationen, z.B. Telefonnummern, ermöglicht den Mitarbeitern der Leitwarte zudem unverzüglich und korrekt auf die Notfallsituation zu reagieren.

Entsprechend der DIN EN ISO 14001 müssen bei der Lenkung von dokumentierten Informationen die Verteilung, der Zugriff, die Auffindung und die Verwendung ebenso wie die Ablage, Speicherung und Erhaltung, Überwachung von Änderungen, Aufbewahrung und Verfügbarkeit über den weiteren Verbleib berücksichtigt werden [12].

Die BPMN 2.0 stellt das Modellierungselement "Datenobjekt" zur Verfügung, um physische, elektronische und abstrakte Informationen zu modellieren. Es ist geeignet die Lenkung dokumentierter Informationen und der damit verbundene Dokumentenstatus darzustellen.. In dem Prozessmodell „Notfallplan: Gewässerverschmutzung durch Ölaustritt" wird dieses Modellierungselement für die Darstellung eines anzufertigenden *Incident Report* verwendet (Abb. 4). Incident Reports werden bei Vorfällen mit Personenbeteiligung oder Umweltgefährdung angefertigt und sind somit nicht Teil der täglichen Einsatznachbereitung. Den Datenobjekten können zusätzliche Informationen hinterlegt werden. Bei Dokumenten kann eine Kurzbeschreibung des Dokuments, der Dokumentenartencode (*DCC-document kind classification code*) und ggf. die Systemkennzeichnung und der Ablageort hinterlegt werden. Aber auch Verläufe der Dokumentenlenkung, Verantwortlichkeiten zur Dokumentenprüfung und -freigabe sind zielführende Inhalte. Darüber hinaus können Dokumente mittels einer URL verlinkt und somit direkt aufgerufen werden. Dies bietet sich insbesondere für Dokumentenvorlagen an, da sie umgehend verwendet werden können.

Es werden somit nicht nur Anforderungen des Umweltmanagements nach DIN EN ISO 14001, sondern auch weitere Erfordernisse des Dokumentenmanagements erfüllt. Darüber hinaus wird eine zügige und korrekte Bearbeitung des Vorfalls unterstützt.

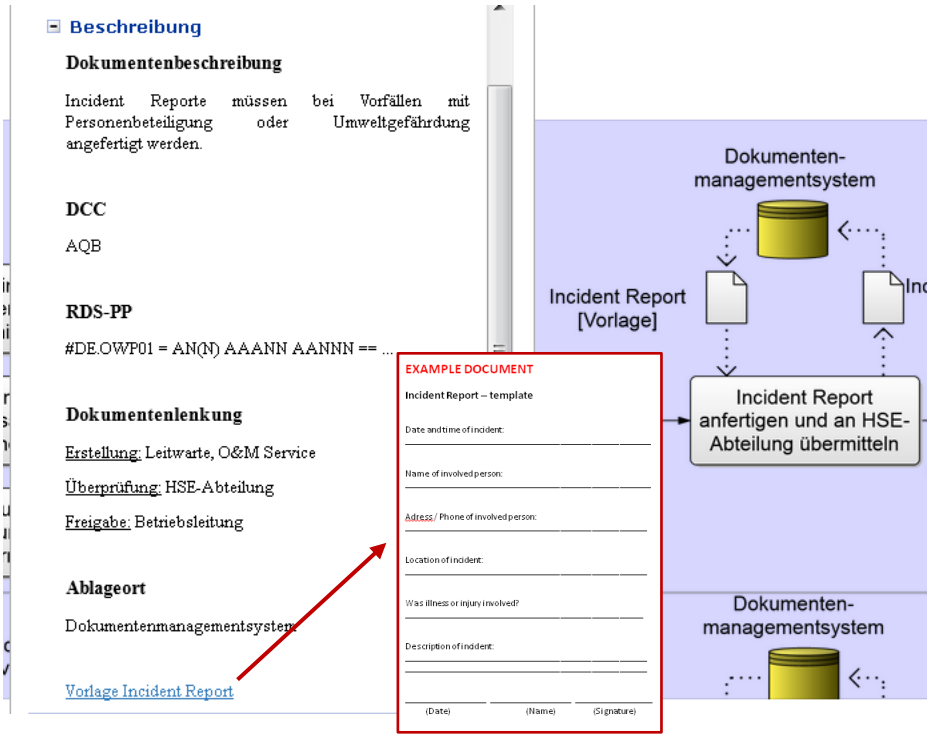

Abbildung 4. Darstellung von Zusatzinformationen von Artefakten und Verlinkungen von Dokumenten in Prozessmodellen

Im Rahmen des Umweltmanagements müssen Umweltleistungen von Prozessen und Anlagen mit Hilfe von Kennzahlen überwacht, gemessen, analysiert und bewertet werden. Daten zur Ermittlung von Umweltleistungen liegen jedoch häufig gar nicht oder in einer nicht verwendbaren Form vor. Für die Ermittlung von Transportmittel-spezifischen CO_2-Emissionen stehen oftmals nicht die tatsächlich zurückgelegten Strecken, Kraftstoffverbräuche oder Fahrgeschwindigkeit der Transportmittel zur Verfügung. Die Vielzahl an beteiligten Akteuren, verschiedenen Dokumenten und Ablagesystemen erschwert das Identifizieren, Lokalisieren und Aufarbeiten der benötigten Informationen und Daten zusätzlich.

Sorgfältig dokumentierte Prozesse ermöglichen es nicht nur die relevanten Informationen an den richtigen Stellen zu dokumentieren und zur Ermittlung der Umweltleistung verfügbar zu machen. Durch eine entsprechende Erweiterung der Prozessdokumentation ist es möglich, dass Informationen, die noch nicht dokumentiert werden, künftig erhoben werden und somit zur Überwachung von Umweltauswirkungen zur Verfügung stehen. Durch die Verknüpfung von Umwelt-kennzahlen mit Prozessen in der entsprechenden Detailtiefe ist es zudem möglich, Ursachen für negative Umweltauswirkungen zu identifizieren, entsprechende Maßnahmen zur Vermeidung abzuleiten und deren Wirksamkeit zu überprüfen. Durch die Erhebung der entsprechenden Informationen ließe sich z.B. kontrollieren, in wie

weit sich eine Verringerung der Fahrgeschwindigkeit der Schiffe, unter Berücksichtigung der Durchführungswahrscheinlichkeiten von O&M-Maßnahmen, auf die CO_2-Emissionen und die Prozessleistung auswirkt.

3.3 Risikointegrierte Prozessmodellierung mit BPMN 2.0

Die Modellierung von Prozessrisiken ist zum jetzigen Zeitpunkt nicht im Modellierungsstandard integriert. GREINER liefert einen anwendungsorientierten Ansatz zur Modellierung von Prozessrisiken in BPMN 2.0-Prozessmodelle, der sich auf umweltbezogene Prozessrisiken übertragen lässt. Grundlage der Risikointegration ist die Nutzung des Artefakts „Datenobjekt“ als Artefakt „Risiko“ zur Abbildung von Risikoinformationen aus der FMEA. Wichtige Risikoereignisse an Aktivitäten können zusätzlich mit risikospezifischen angehefteten Zwischenereignissen und einzuleitenden Gegenmaßnahmen direkt dargestellt werden. Die risikospezifischen Modellierungselemente werden mit dem Symbol „Flamme“ gekennzeichnet. Zur besseren Unterscheidung von Risikoarten kann die Flamme für umweltbezogene Prozessrisiken mit einem „u“ gekennzeichnet werden. Darüber hinaus lässt sich die Flamme zur Darstellung des Risikomaßes in Ampelfarben (grün: geringes Risiko bis rot: hohes Risiko) einfärben [3].

Im Beispielprozess werden mögliche umweltbezogene Prozessrisiken an der Aktivität „Leckage schließen“ mittels der FMEA erhoben und das FMEA-Ergebnis in dem risikospezifischen Datenobjekt „umweltbezogenes Aktivitätsrisiko“ hinterlegt. Kann die Leckage nicht geschlossen werden, wird die Aktivität „Leckage schließen“ abgebrochen. Der Abbruch wird anhand des angehefteten unterbrechenden Risikoereignisses „Leckage kann nicht geschlossen werden“ mit der Folgeaktivität „Werkzeug oder Material anfordern“ modelliert (Abb. 5). In komplexen umwelt-relevanten Prozessen ist mit einer Vielzahl umweltbezogener Prozessrisiken zu rechnen, deren Risikoinformationen modelliert werden können und damit ein umfassendes Bild über die Umweltgefährdungen in einem Prozess geben.

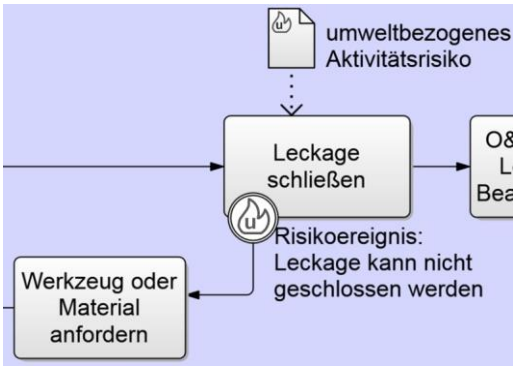

Abbildung 5. Modellierung umweltbezogener Prozessrisiken in BPMN 2.0 [modelliert mit IYOPRO]

4 Fazit und Ausblick

Das dargestellte Anwendungsbeispiel zeigt, wie sich Umweltrisiken in die Prozesse des Betriebs von Offshore Windparks integrieren lassen. Untersuchungen zu umweltbezogenen Prozessrisiken über den gesamten Lebenszyklus von Offshore Windparks liegen zurzeit jedoch nicht vor. Es bestehen somit noch Bedarfe Umweltrisiken von der Produktion über den Bau und Betrieb bis zum Rückbau von Offshore Windparks zu untersuchen. Zudem kommen im Offshore Windpark-Betrieb vielfältige IT-Strukturen zum Einsatz. Bei der Weiterentwicklung der IT-Strukturen und der Festlegung aufzunehmender Daten sollten die Aspekte der Betriebsdokumentation und des Umweltmanagements zukünftig berücksichtigt werden.
Die Ausführungen an dem umweltrelevanten Prozess veranschaulichen, dass eine umfassende Dokumentation von umweltbezogenen Informationen in BPMN-Prozessmodellen umgesetzt werden kann. Es lassen sich sowohl umweltrelevante Dokumente als auch umweltbezogene Prozessrisiken integrieren. Damit wird ein detailliertes Bild über den Einfluss des Prozesses auf die Umwelt erstellt, das die Grundlage für die Entwicklung weiterführender Maßnahmen zur Vermeidung und Entdeckung der Ursachen, sowie zur Verminderung der Auswirkungen ist. Zudem wurde für die BPMN eine Ausführungssemantik festgelegt, sodass Prozessmodelle direkt ausgeführt werden können. Das ist die Grundlage, um Prozesse unter Berücksichtigung der umweltbezogenen Prozessrisiken simulieren zu können. Die Modelle tragen damit zum besseren Verständnis über den Prozess, dessen mögliche Umweltauswirkungen aber auch Auswirkungen ergriffener Maßnahmen bei. Darüber hinaus werden die Dokumentationspflichten des Umweltmanagements erfüllt. Die operative Durchführung der Prozesse wird durch die Bereitstellung und Lenkung von Dokumenten unterstützt. Die Modellierung von Umweltinformationen führt allerdings zu einer höheren Komplexität des Prozessmodells, sodass die erforderliche Modellierungstiefe festzulegen ist und zu modellierende Informationen und Risiken bezüglich ihrer Relevanz auszuwählen sind.

Insgesamt trägt die risikointegrierte Dokumentation umweltrelevanter Prozesse zum IT-gestützten Management von Umweltrisiken bei. Zudem werden Informationen über Umweltaspekte eines Prozesses langfristig zur Verfügung gestellt, die Basis und Absicherung unternehmerischer Entscheidungen sein können. Der vorgestellte Ansatz zur Modellierung umweltbezogener Prozessrisiken und Umweltrisiken muss weiterentwickelt und in Modellierungseditoren umgesetzt werden.

Die Untersuchung von Prozessen und deren Optimierung im Hinblick auf ihren Einfluss auf die Umwelt finden derzeit nur wenig Beachtung in Betrieblichen Umweltinformationssystemen (BUIS). Der vorgestellte Ansatz zur Dokumentation von Umweltrisiken in Prozessen ist ein Teil zur Erweiterung von BUIS um das umweltrisikointegrierte Management von Prozessen.

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Steigerung der Sensibilität für nachhaltige Mobilität durch die mobile Reiseapplikation Guyde

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Zusammenfassung. Der Verkehrssektor ist ein zentrales Handlungsfeld, um die Klimaschutzziele zu erreichen. Informations- und Kommunikationstechnologien spielen eine Schlüsselrolle, wenn es darum geht, das individuelle Mobilitätsverhalten in Richtung einer nachhaltigen Mobilität zu transformieren. Ein besonderes Augenmerk gilt ländlichen Regionen, da Urbanisierung und demografischer Wandel hier langfristig einen großen Einfluss auf Verkehr und Mobilität haben. Die mobile Reiseapplikation Guyde stellt einen Lösungsansatz dar, mit dessen Hilfe Verkehrsteilnehmer Reisen multimodal planen können und gleichzeitig für Themen rund um nachhaltige Mobilität sensibilisiert werden.

Keywords: Nachhaltige Mobilität, Multimodale Reiseplanung, Demografischer Wandel

1 Einleitung

Mobilität ist ein wesentlicher Aspekt einer modernen Gesellschaft und leistungsfähigen Wirtschaft. Zum einen ist ein effizientes Verkehrssystem, das den reibungslosen Austausch von Waren und Dienstleistungen gewährleistet, Voraussetzung für die wirtschaftliche Entwicklung und ein zentraler Standortfaktor. Zum anderen ist Mobilität für den Einzelnen ein Grundbedürfnis, da es einen tragenden Pfeiler persönlicher Freiheit darstellt. Zumeist setzt die Teilnahme am Arbeits- und Gesellschaftsleben voraus, mobil zu sein. Mobilität sichert demnach Wohlstand und ermöglicht soziale Teilhabe [1], [3].

In der derzeitigen Ausprägung ist die Mobilität bzw. ist der Verkehrssektor jedoch nicht nachhaltig und steht in einem Spannungsverhältnis von ökonomischen, sozialen und ökologischen Interessen. Den Vorzügen für Gesellschaft und Wirtschaft stehen negative Auswirkungen auf Mensch und Umwelt gegenüber. So war der Verkehrssektor im Jahr 2015 für rund 18 Prozent der Treibhausgasemissionen Deutschlands

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verantwortlich [2]. Effizienzgewinne werden dabei durch eine stetig steigende Verkehrsleistung kompensiert. Auf den Verkehrssektor in Deutschland entfallen fast 30 Prozent des nationalen Energieverbrauchs [3]. Hinzu kommen negative Auswirkungen auf Umwelt und Lebensqualität zum Beispiel durch Schadstoff- oder Lärmemissionen [4]. Um die nationalen Klimaschutzziele zu erreichen und das Verkehrssystem bis zum Jahr 2050 nahezu unabhängig von fossilen Kraftstoffen und somit weitestgehend klimaneutral zu gestalten, bedarf es großer Anstrengungen. Die Verkehrsprognose 2030 macht den dringenden Handlungsbedarf deutlich: Bis zum Jahr 2030 wird der Güterverkehr um 38 und der Personenverkehr um 13 Prozent zunehmen [5].

Ein wichtiger Hebel, um Mobilität nachhaltiger zu gestalten ist das Verhalten der einzelnen Verkehrsteilnehmer. Ein Blick auf den Modal Split des Personenverkehrs zeigt, dass in Deutschland und in den meisten Staaten der EU der motorisierte Individualverkehr (MIV) einen Anteil von mehr als 80 Prozent hat. Die restlichen 20 Prozent entfallen auf den Umweltverbund bzw. umweltverträgliche Verkehrsmittel (z.B. Bus, Bahn, Fahrrad, Fußwege) [6]. Um das individuelle Mobilitätsverhalten nachhaltiger zu gestalten und die Auswirkungen auf den Klimawandel einzudämmen, sind entsprechende Anreize notwendig. Dazu zählen die Förderung des nichtmotorisierten Verkehrs, des öffentlichen Nahverkehrs sowie der inter- und multimodalen Vernetzung von Verkehrsmitteln [7].

Ziel dieses Beitrags ist es aufzuzeigen, wie es mit Hilfe von Informations- und Kommunikationstechnologien (IKT) gelingen kann, Verkehrsteilnehmer für nachhaltige Mobilität zu sensibilisieren und das individuelle Mobilitätsverhalten entsprechend zu beeinflussen. Ein besonderer Fokus liegt dabei auf der Mobilitätsversorgung in ländlichen Räumen, da hier der Handlungsdruck beispielsweise durch demografische Entwicklungen, größere Entfernungen und dünnere Nahverkehrsnetze besonders groß ist. Im Folgenden werden zunächst die Problemstellung sowie bisherige IKT-basierte Lösungsansätze von Mobilität im ländlichen Raum näher skizziert. Anschließend wird die Reiseapplikation Guyde vorgestellt und in die Mechanismen zur Sensibilisierung der Nutzer für nachhaltige Mobilität durch die App eingeführt.

2 Problemstellung und bisherige Lösungsansätze

Die Megatrends Urbanisierung und demografischer Wandel haben langfristig einen großen Einfluss auf Verkehr und Mobilität. So sind insbesondere ländliche Räume von den Folgen des demografischen Wandels betroffen: Durch die Abwanderung junger Menschen in strukturstarke Regionen und Städte sowie niedrige Geburtenraten nimmt die Bevölkerungszahl in vielen ländlichen Regionen seit Jahrzehnten stetig ab. Dies hat eine deutliche Alterung der Bevölkerung zur Folge: Der Anteil von Senioren ist in vielen ländlichen Regionen überdurchschnitt hoch [8]. Aus diesen Entwicklungen resultieren wiederum besondere Herausforderungen, um die Mobilität der betroffenen Bürger dauerhaft sicherzustellen. Durch die schrumpfende Bevölkerung geht die

Nachfrage nach Gütern und Dienstleistungen entsprechend zurück. In der Konsequenz schließen Einrichtungen der sozialen Infrastruktur, der Versorgung und der Kultur oder wandern in städtische Gebiete ab. Dies führt dazu, dass die Bevölkerung ländlicher Räume immer größere Entfernungen überwinden muss, um ebendiese Einrichtungen nutzen zu können [9].

Die Auswirkungen sind komplex, da aus dem Bevölkerungsrückgang nicht automatisch ein Rückgang des Verkehrs folgt. Vielmehr beeinflussen zum Beispiel die veränderte Altersstruktur oder neue Mobilitätsmuster die Mobilitätsnachfrage. Daher wird es zunehmend notwendiger, auf Aspekte wie Nutzerfreundlichkeit, Barrierefreiheit und altersgerechte Mobilitätsketten zu achten [10]. Vor diesem Hintergrund haben sich in den letzten Jahrzehnten verschiedene Lösungsansätze herausgebildet, um ein ausreichendes Mobilitätsangebot für die Bevölkerung sicherzustellen [11]. Dabei kann zwischen Lösungsansätzen unterschieden werden, die von der öffentlichen Hand oder durch privates Engagement (Zivilgesellschaft und Wirtschaft) organisiert werden. Seitens der öffentlichen Hand haben sich beispielsweise Lösungen in folgenden Bereichen herausgebildet: Neuordnung bzw. Optimierung des Angebotes des öffentlichen Verkehrs (ÖV), flexible Bedienformen im ÖV, Kombination von Personen- und Güterverkehr sowie Verknüpfung von Mobilitätsoptionen. Im Rahmen des privaten Engagements sind etwa Mitnahmeverkehre, Sharing-Modelle, privatwirtschaftliche Initiativen wie Hol- und Bringdienste sowie Mobilitätsangebote auf Basis bürgerschaftlichen Engagements (z.B. Bürgerbusse) zu nennen [9].

Neben diesen Ansätzen haben sich im Zuge der fortschreitenden Digitalisierung und der damit verbundenen Verbreitung von Smartphones verschiedene Mobilitäts-Applikationen am Markt etabliert, die zum Teil auch einen Bezug zu Nachhaltigkeitsthemen haben. Die App „moovel“ des Automobilherstellers Daimler bieten dem Nutzer etwa Zugang zu Mobilität, indem Angebote wie Carsharing, Bahn, Taxidienste, Mietfahrräder und öffentlicher Personennahverkehr kombiniert werden. Nutzer können über die App Verbindungen suchen und bezahlen. Dadurch, dass „moovel“ den Nutzer auf vorhandene Mobilitätskapazitäten hinweist, wird die Auslastung gesteigert und die Umwelt im Vergleich zur Nutzung eines eigenen PKWs weniger belastet [12]. Ein weiteres Angebot bietet Qixxit, eine Reiseplaner-App der Deutschen Bahn, bei der bis zu 15 verschiedene Verkehrsmittel kombiniert werden können. Dieser multimodale Mobilitätsplaner weist bei den verschiedenen Optionen u.a. auch die verursachten CO_2-Emissionen aus und sensibilisiert somit den Nutzer hinsichtlich der Umweltauswirkungen [13].

Diese Beispiele zeigen, dass die digitale Vernetzung ganz neue Zugänge zu Mobilität ermöglicht und die Reiseplanung vereinfacht. Als Alltagsbegleiter und Multifunktionsgerät spielt das Smartphone in diesem Zusammenhang eine Schlüsselrolle, um zeit- und ortsabhängig Zugang zu einer multimodalen Mobilität zu haben [14]. Zu beachten sind dabei die Auswirkungen einer alternden Gesellschaft und die Bedürfnisse von älteren Menschen: Mittelfristig bedarf es immer noch eines parallelen klassischen Zugangs zu Mobilitätsangeboten (z.B. via Aushang), jedoch wird für die heranwachsenden

Senioren-Generationen die Nutzung von Smartphones auch im höheren Lebensalter eine Selbstverständlichkeit sein [9], [17]. Daten des Bundesverbandes Informationswirtschaft, Telekommunikation und neue Medien e.V. (Bitkom) zeigen, dass es bereits eine sehr hohe Affinität unter Senioren hinsichtlich der Nutzung von Smartphones gibt. So nutzen im Jahr 2017 bereits 39 Prozent der Über-65-Jährigen ein Smartphone. Verglichen mit 28 Prozent ein Jahr zuvor ein starkes Wachstum [16].

Wie es mit einer Reiseapplikation gelingen kann, Verkehrsteilnehmern einerseits Zugang zu umfassenden Mobilitätsdienstleistungen (multimodale Mobilitätsauskunft inkl. der Möglichkeit, Fahrgemeinschaften zu bilden) zu bieten und andererseits dabei für Nachhaltigkeitsthemen zu sensibilisieren, wird im folgenden Abschnitt anhand der Mobilitätsplattform Guyde aufgezeigt.

3 Mobilitätsplattform Guyde

Das Guyde-Reiseinformationssystem ist ein System zur multimodalen Reiseplanung für Endkunden, um Reisen unter besonderer Berücksichtigung der individuellen Mobilitätsbedarfe und -möglichkeiten sowie Nachhaltigkeitsbestrebungen zu ermöglichen. Ziel dieses Systems ist es, nachhaltige und innovative Mobilitätsdienstleistungen sowie darauf aufbauende Geschäftsmodelle für den ländlichen Raum zu entwickeln. Im Vordergrund steht dabei, einen gesellschaftlichen Nutzen zu generieren, der zum einen unmittelbar den Bürgerinnen und Bürgern sowie mittelbar der Umwelt zugutekommt.

Anbieterseitig ist das System vollständig in eine operative und analytische CRM-Umgebung integriert [15]. Die Kommunikation zwischen Kunde und System wird durch die mobile Reiseplanungs und -assistenzapplikation Guyde ermöglicht. Die Guyde-App steht als iOS- und Android-Version zur Verfügung. Guyde wurde im Rahmen des Projekts IKTS[1] des Schaufensters für Elektromobilität Niedersachsen in Kooperation mit der Firma c4c Engineering entwickelt. Dabei wurde die Entwicklung einer nativen Version in den Vordergrund gestellt, da auf Reisen, insbesondere in ländlichen Räumen, eine verlässliche Internetverbindung nicht durchgehend gewährleistet ist.

3.1 Nutzeranforderungen

Um mit der Mobilitätsplattform einen Mehrwert und ein maßgeschneidertes Produkt zu schaffen, das die Wünsche und Bedürfnisse der Nutzer insbesondere in ländlichen Räumen bestmöglich adressiert, wurden mit Hilfe qualitativer Forschung und einer quantitativen Befragung zentrale Anforderungen an die Guyde-App erhoben. Für die Erhebung wurden Interviews mit 13 Personen durchgeführt. In fünf Fokusgruppen nahmen weitere 25 Personen teil. An der quantitativen Befragung haben sich insgesamt

[1] http://www.ikts-niedersachsen.de

338 Personen beteiligt. Im Folgenden werden die wichtigsten Anforderungen an das System zusammengefasst [18], [20-21].

Grundsätzlich soll die App verschiedene Verkehrsmittel wie Auto, Bus, Fahrrad und Zug bei der Reiseplanung berücksichtigen. Aus Sicht der Befragten ermöglicht die Wahl zwischen verschiedenen Optionen die Flexibilität und Unabhängigkeit. Zentrale Anforderungen betreffen Mitfahrgelegenheiten, die über die Guyde-App organisiert werden können. Um zum Beispiel Fahrer bzw. Mitfahrer im Vorfeld besser einschätzen zu können, wünschen sich potenzielle Nutzer eine Art Bewertungsfunktion. Über eine solche Funktion soll zum Beispiel erkennbar sein, wie verlässlich und pünktlich eine Person von anderen App-Nutzern eingeschätzt wird. Eine weitere Anforderung betrifft das Zusammenbringen von Fahrern und Mitfahrern. Dieser Prozess sollte komplett über die App abgebildet werden, so dass kein direkter Kontakt mit der jeweils anderen Person aufgenommen werden muss. Durch die Eingabe von Abfahrts- und Zielort sollte es möglich sein, dass Fahrer und Mitfahrer über die App automatisch zueinander finden.

Aus den Ergebnissen der quantitativen Befragung geht hervor, dass über die Hälfte der Personen, die bereits privat organisierte Fahrgemeinschaften nutzen, sich dafür schriftlich über das Smartphone austauschen. Dies lässt vermuten, dass die Bereitstellung der Mobilitätsplattform als App grundsätzlich ein geeignetes Medium ist und auf Zuspruch trifft. Die für die Teilnehmer der Befragung wichtigsten Motive, Mitfahrgelegenheiten zu nutzen, sind neben Geld sparen der Beitrag zum Umweltschutz sowie ein möglichst nachhaltiges Mobilitätsverhalten. Hier gibt es demnach eine Übereinstimmung von Anforderungen und den Zielen der Applikation, nachhaltige Mobilität zu befördern.

Wenn es um die Mitnahme von fremden Personen geht, treibt die befragten Personen der rechtliche Rahmen um. Es herrscht Unsicherheit, ob Mitfahrer legal kostenpflichtig mitgenommen werden können und wie es um Haftungs- und Versicherungsfragen steht. Hier scheint es sich um einen Bereich zu handeln, bei dem eine Hilfestellung durch die App nützlich wäre. Nicht zuletzt spielt das Thema Preissetzung im Rahmen von Mitfahrgelegenheiten eine wichtige Rolle. Jeweils knapp mehr als die Hälfte der Befragten wünschen sich, dass es entweder eine verbindliche Preissetzung (orientiert an den ÖPNV-Tarifen) oder einen unverbindlichen Preisvorschlag über die App als Verhandlungsbasis gibt. Dafür, dass es den Fahrern freistehen soll, ob sie Geld für die Mitfahrgelegenheit verlangen, plädieren 47 Prozent der Befragten.

3.2 Reiseinformationssystem und Guyde-Mobilitätsapp

Das Ziel der mobilen Anwendung ist es, als ständiger Begleiter bei der täglichen Planung und Befriedigung der Mobilitätsbedürfnisse eines Nutzers zu fungieren. Die Anwendung wird dabei stets als intelligentes Hilfsmittel (proaktiv) eingreifen und individuell die Mobilität möglichst effizient gestalten. Funktionen zur Reflexion der eigenen Mobilität werden durch die mobile Anwendung abgedeckt. Dabei stehen stets eine optimale Benutzbarkeit und eine intelligente Informationsselektion im Vordergrund.

Routensuche
Die Routensuche ermöglicht die Spezifizierung unterschiedlicher Parameter. Abgesehen von Orts- und Zeitparametern können Angaben zur gewünschten Routenberechnung gestellt werden, ob z.B. die Ankunft zu einem bestimmten Zeitpunkt erfolgen soll. Zusätzlich kann eine Anzahl an Mitfahrern angegeben werden, sodass z.B. bei einer größeren Gemeinschaft das Auto als Verkehrsmittel nicht mehr berücksichtigt wird, da nicht alle Personen mitfahren können. Durch die Individualisierung des Nutzerprofils kann, bei Angabe mehrerer Fahrzeuge, eine Auswahl für die aktuelle Routensuche gegeben werden, damit die Berechnung der individuellen Kennzahlen in den Dimensionen Kosten und Nachhaltigkeit korrekt erfolgt.

Reiseassistenz
Die Reiseassistenz gibt einen Überblick über die einzelnen Verbindungen der Route (siehe Abbildung 1 auf der nächsten Seite). Dabei wird durch einen kleinen grünen Kreis die aktuelle Verbindung hervorgehoben. Wird eine Teilverbindung ausgewählt, lässt sich dieser Abschnitt auf einer Karte detaillierter anzeigen. Hier besteht wiederum die Möglichkeit, die Reiseassistenz durch in das Smartphone integrierte Kartendienste zur detaillierten Navigation zu starten. Auf der anderen Seite hat der Nutzer weiterhin die Möglichkeit, durch einen Feedback-Button das jeweilige Fahrzeug auf dem Routenabschnitt zu bewerten. Außerdem kann der Nutzer eine aktive Route manuell beenden oder abbrechen. Des Weiteren kann die Route über soziale Netzwerke geteilt werden, um potenzielle Mitfahrer zu werben. Hierfür wurden die Schnittstellen von Twitter und Facebook in die App integriert. Bei erfolgreicher Beendigung einer Route wird der Nutzer anhand der Nachhaltigkeit seiner gewählten Mobilitätsoption bewertet und entsprechend mit Bonuspunkten belohnt. Alle absolvierten Reisen werden historisiert und dem Nutzer über die App zu einer späteren Betrachtung zugänglich gemacht. Dadurch erhält der Nutzer eine bestmögliche Transparenz seines Reiseverhaltens. Außerdem können so später noch Bewertungen der Reise hinzugefügt werden, sofern dies noch nicht durchgeführt wurde.

Guyde soll jedoch nicht nur einen Mehrwert bei der täglichen Mobilitätsplanung und -durchführung bieten. Die mobile Anwendung soll auch dazu verwendet werden, Nutzer in ihrem Mobilitätsverhalten zu beeinflussen. Die App beabsichtigt, Nutzer bei der Wahl ihrer Verkehrsmittel unter den Gesichtspunkten der Nachhaltigkeit zu beeinflussen [15]. So können Nutzer Vorgaben für ihr gewünschtes Mobilitätsverhalten eingeben. Die einzelnen Dimensionen sind Nachhaltigkeit, Komfort, Kosten und Flexibilität.

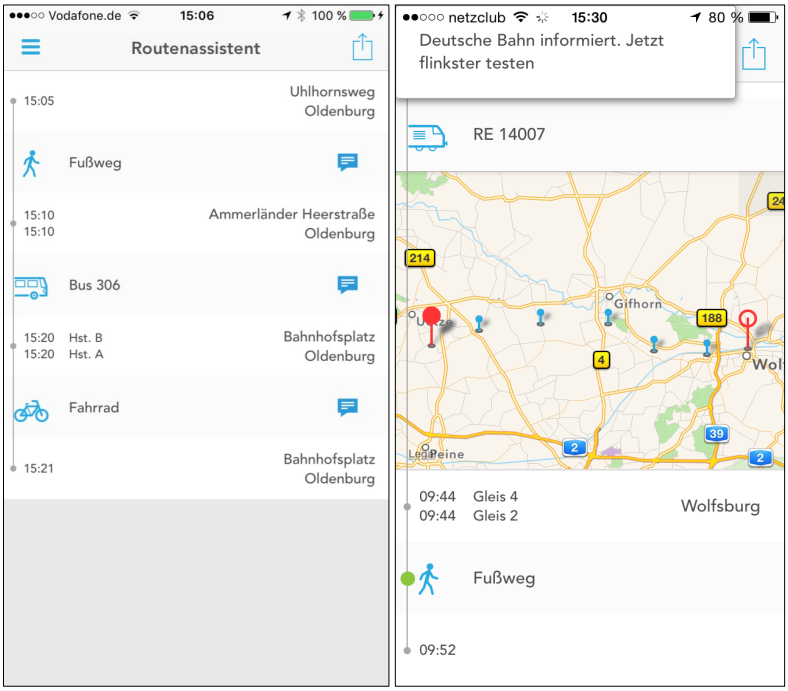

Abbildung 1. Reiseassistenz (links) sowie Benachrichtigung und Reisedetails (rechts)

Die Unterstützungsphasen unterscheiden sich anhand der Kundenaktivität: Plant der Endkunde eine Reise, befindet er sich in der Reiseplanungsphase (pre-trip). Innerhalb dieser Phase werden kontextsensitive Informationen des Nutzers und seiner Umgebung berücksichtigt. Dies umfasst z.B. die individuellen Mobilitätsmöglichkeiten, wie die Verfügbarkeit eines eigenen Pkws, die aktuelle Position oder die aktuelle Wettervorhersage. Hat der Nutzer ein Pkw in seinem Profil hinterlegt, werden die MIV-Abschnitte auf Basis der Kennzahlen des Pkws berechnet, um eine möglichst realitätsnahe Abschätzung der Auswirkungen der individuellen Optionen zu erreichen.

Die aktive Reisephase umfasst die proaktive Unterstützung während einer Reise (on-trip). Dabei wird der Reisende durch eine aktive Reiseassistenz unterstützt, die z.B. den aktuellen Reiseabschnitt anhand der aktuellen Position ermittelt. Gleichzeitig verfügt die Reiseassistenz über die Intelligenz, den zurückgelegten Reiseabschnitt mit der geplanten Route abzugleichen und Handlungsempfehlungen auszusprechen [19]. Weitere Assistenzfunktionen sind innerhalb des Reiseinformationssystems integriert, die über aktuelle Verzögerungen oder interessante Orte (POI) in der Umgebung (bei längeren Umsteigezeiten) informieren können. Während der aktiven Reisephase hat der Nutzer die Möglichkeit, eine Reise manuell zu beenden oder abzubrechen. Die Funktionalität eines Reiseabbruchs ist für die korrekte Berechnung des individuellen Reise- und Emissionsprofils notwendig. Das manuelle Beenden einer Reise führt zum erfolg-

reichen Abschluss einer Reise. Dies kann durch eine nicht erfolgte automatische Detektion der Ankunft am Ziel durch das System notwendig werden, da z.B. die aktuelle Position nicht erkannt wurde. Sollte eine Reise manuell beendet werden, werden dem Reisenden keine Bonuspunkte von dem System zugeteilt, um einen Missbrauch der Funktionalität zu verhindern.

Nach einer erfolgreich abgeschlossenen Route befindet sich der Nutzer in der Nach-Reise-Phase (post-trip). Dabei erhält der Nutzer eine statistische Zusammenfassung seiner Reise, die anhand unterschiedlicher Leistungskennzahlen (KPIs) berechnet wird. Diese umfasst Werte zur zurückgelegten Strecke, der Kosten und der verursachten CO_2-Emissionen. Für besonders nachhaltiges Reisen, entsprechend der verfügbaren Mobilitätsoptionen, werden mehr Bonuspunkte vergeben. Die gesammelten Bonuspunkte können innerhalb der App für mobilitätsbezogene Dienstleistungen eingetauscht werden. Dabei können Gutscheine für Testfahrten mit Elektrofahrzeugen, E-Bikes oder Pedelecs eingelöst werden. Weiterhin ist es möglich, Gutscheine für nachhaltige Mobilitätsdienste zu vergeben (z.B. ÖPNV-Tagesticket, Car-Sharing). Diese Artikel bzw. Gutscheine können zentral durch das angeschlossene CRM-System verwaltet werden.

Auf Basis der durchgeführten Reisen und den zugeordneten Kennzahlen bietet das Reiseinformationssystem ein Berichtswesen für den Endnutzer. Diese sind in der Lage ihr individuelles Reiseverhalten und dessen Trend transparent nachzuvollziehen. Dabei können verschiedene Auswertungsebenen des Mobilitätsverhaltens betrachtet und in Relation zum Durchschnittsverhalten der Plattformnutzer gesetzt werden. Gleichzeitig kann auf der Ebene der individuellen Reiseoptionen das tatsächliche Reiseverhalten zu den schlechtesten und bestmöglichen Reiseoptionen in Relation gesetzt werden. Die Integration des Berichtswesens und des Bonuspunkteshops (siehe Abbildung 2 auf der nächsten Seite) wurde durch die Verwendung von Webviews umgesetzt.

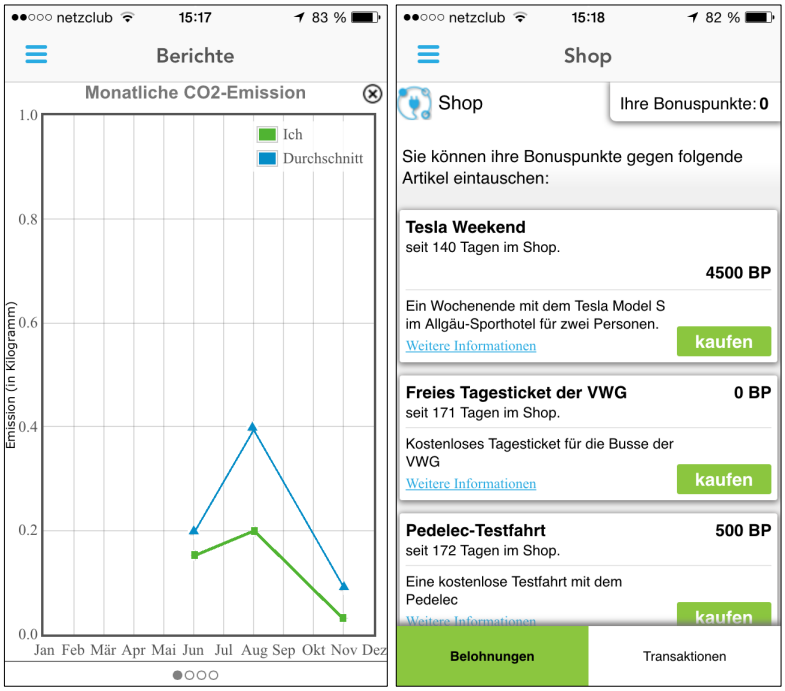

Abbildung 2. Berichtswesen (links) und Bonuspunkteshop (rechts)

Regelbasierte Benachrichtigungen
Benachrichtigungen werden durch Statuscodes innerhalb der Push-Nachrichten klassifiziert und als Grundlage zur weiteren Verarbeitung der Informationen genutzt (siehe Abbildung 1 oben). Die Benachrichtigungen können zu jeder Zeit in der App empfangen werden. Die erste Gruppe umfasst Nachrichten, die zu jedem Zeitpunkt an die Guyde-App bzw. deren Nutzer gesendet werden können. Die Reiseassistenz benachrichtigt z.B. über das Berichtswesen, dass dem Nutzer ein neuer Report zum Mobilitätsverhalten vorliegt. In diese Gruppe fallen außerdem Werbeangebote und Botschaften von Partnerprogrammen. Zusätzlich werden in diesem Rahmen dem Nutzer Empfehlungen für alternative Routen oder Verkehrsmittel vorgeschlagen, sobald eine intelligentere Routenoption vorliegt.

Die zweite Gruppe umfasst Nachrichten, die vor dem Reiseantritt kommuniziert werden. Dazu gehört die Vorstellung des persönlichen Reiseassistenten Guyde sowie verschiedene Warnmeldungen. Die Warnmeldungen unterteilen sich in Warnungen zu schlechten Wettersituationen, Erinnerungen an das Aufladen bzw. Tanken des privaten Pkw, die Erinnerung an einen baldigen Reisestart oder Stauwarnungen. Die dritte Gruppe umfasst Benachrichtigungen, die während einer Reise auftreten können. Dazu zählen Informationen zu interessanten Orten, kommende Reiseabschnitte einer Reise, Stauwarnungen und Wetterwarnungen oder Ausfälle von Verkehrsmitteln des öffentlichen

Personenverkehrs. Die vierte Gruppe umfasst die Benachrichtigungen nach einer erfolgreich abgeschlossenen Reise. Diese umfasst die Anzahl der erhaltenen Bonuspunkte sowie eine Zusammenfassung der zurückgelegten Reise.

Alle genannten Gruppen können durch weitere Benachrichtigungen ergänzt werden, um zukünftige Geschäftsmodelle und Assistenzfunktionen zu unterstützen.

3.3 Förderung der nachhaltigen Mobilität durch „imovative" Geschäftsmodelle

Neben der Mitfahrgelegenheit, werden für die Bürger aus dem ländlichen Raum neue Geschäftsmodelle entwickelt, die auf der Grundlage der durchgeführten qualitativen und quantitativen Befragung basieren. Der Begriff „Imovation" wird im Rahmen des Projektes verwendet und kombiniert die Begriffe „Imitation" und „Innovation". Dabei sollen bekannte erfolgreiche Geschäftsmodelle analysiert und im zweiten Schritt auf die Modellregion angepasst werden [22].

Eines von mehreren Geschäftsmodellen, das im Rahmen des Projekts entwickelt wird, ist der sogenannte Supermarkt-Abholservice. Dieses Geschäftsmodell setzt an den Wünschen und Äußerungen derjenigen an, für die Sicherheitsaspekte sowie die Abhängigkeit von fremden Personen Gründe dafür sind, nicht an Mitfahrgelegenheiten teilzunehmen. Beim Supermarktabholservice werden diese beiden Kriterien verringert. Verschiedene Geschäftsmodelle werden nach und nach in die App integriert. Für den Supermarkt-Abholservice ist es notwendig, dass die Benutzer aus dem ländlichen Raum über die App miteinander sowie mit den kooperierenden Supermärkten kommunizieren können. Als Kommunikationsumgebung wird dabei ebenfalls die mobile Applikation verwendet. Damit der Supermarkt-Abholservice erfolgen kann sind einige Bedingungen erforderlich. Die erste Bedingung ist, dass ein Supermarkt an diesem Geschäftsmodell teilnimmt. Die entwickelten Mobilitätsdienste zielen darauf ab, Umweltfreundlichkeit zu fördern, daher soll vermieden werden, dass der Supermarkt für nur eine Person eine Fahrt durchführt. Um dieses Szenario zu vermeiden findet die Kommunikation zwischen dem Supermarkt und den Bürgern auf der Plattform statt.

Die Bürger aus dem ländlichen Raum können über die mobile Applikation eine Anfrage an den Supermarkt senden, die auf einem Dashboard für andere Personen aus dem ländlichen Raum sichtbar ist. Der Supermarkt prüft intern, ob er die Fahrt durchführen kann oder nicht. Sollte der Supermarkt die Tour anbieten können, gibt der Supermarkt eine positive Rückmeldung. In der Anfrage werden Informationen wie z.B. die Anzahl der Sitzplätze und das Fahrzeug bzw. die Kofferraumgröße angegeben, damit sich die Kunden darin eintragen können. Nachdem die Mindestanzahl der Personen für eine Fahrt erreicht wurde, wissen die Teilnehmer, dass die Fahrt sicher durchgeführt wird. Bis zu einem bestimmten Zeitpunkt können sich die Teilnehmer für die angefragten Fahrten eintragen. Genauso kann dann der Supermarkt Angebote an die Benutzer senden, indem er angibt wann er fahren kann.

4 Fazit und Ausblick

Der vorliegende Beitrag erläutert wie mit einer Reiseapplikation nicht nur Mobilität geplant, sondern durch entsprechende Funktionalitäten gleichzeitig für nachhaltige Mobilität sensibilisiert werden kann. Die Befragung potenzieller Nutzer hat gezeigt, dass insbesondere das Thema Preissetzung relevant ist. Dieser Aspekt wird durch eine entsprechende Funktionalität adressiert.

Geplant ist, die Guyde-App im Dezember 2017 und Januar 2018 mit einem kleinen Kreis von Testnutzern zu testen, der sukzessive erweitert wird. Diese Phase dient in erster Linie dazu, technische Ungereimtheiten zu identifizieren und zu beheben sowie die Benutzerfreundlichkeit zu verbessern. In diesem Zuge soll auch ein Usability-Konzept entwickelt werden. Danach werden nach und nach Bürgerinnen und Bürger eingeladen, die App zu nutzen und Rückmeldungen zu ihren Erfahrungen zu geben,

Zur Integration der oben skizzierten Geschäftsmodelle wird die Guyde-App iterativ um weitere Funktionalitäten erweitert. Für die nächste Iterationsstufe wird eine direkte Kommunikation zwischen den Nutzern umgesetzt. Außerdem wird das Reiseinformationssystem um weitere analytische Berichte erweitert, die eine Vergleichbarkeit auf örtlicher Nähe ermöglichen.

Anerkennung

Dieser Beitrag ist Teil des Forschungsprojektes „NEMo - Nachhaltige Erfüllung von Mobilitätsbedürfnissen im ländlichen Raum“. Das Projekt wird vom Ministerium für Wissenschaft und Kultur Niedersachsen und der Volkswagen-Stiftung durch das Förderprogramm „Niedersächsisches Vorab“ (Fördernummer VWZN3122) gefördert.

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Ein Framework für präferenzorientierte Handlungsempfehlungen zur Effizienzsteigerung von Rechenzentren

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Zusammenfassung. Eine Reihe von vergangenen Studien belegen, dass ca. 50.000 Rechenzentren in Deutschland über 12 TWh beanspruchen, was ungefähr 2% des Gesamtstrombedarfs in dem Land ausmacht. Die Prognosen für das Jahr 2020 belaufen sich sogar auf 14 TWh. Durch Umweltzertifikate wie „Der Blaue Engel“ werden Versuche unternommen, die Energieeffizienz in den deutschen Rechenzentren zu optimieren. Untersuchungen zufolge ist es noch nicht einmal eine zweistellige Anzahl an Rechenzentren in Deutschland, die solche Zertifikate verwenden, da die Präferenz nicht immer auf der Energieeffizienz liegt, sondern auf anderen Belangen, die unabhängig davon eine Effizienz mit sich bringen. Ein Ansatz, mit dem dieser präferenzorientierte Hintergrund zur individuellen Optimierung der Effizienz in Rechenzentren gesteigert werden kann, soll in diesem Beitrag aufgezeigt werden.

Keywords: Rechenzentren, Energieeffizienz, Der Blaue Engel, Effizienz.

1 Einleitung

Rechenzentren sind in der Infrastruktur der deutschen Informations- und Kommunikationstechnik (IKT) von enormer Bedeutung. Heutzutage bilden Rechenzentren die fundamentale Grundlage eines IT-gestützten Unternehmens. Ein Unternehmen aufzubauen bzw. zu führen, ohne die Nutzung eines Rechenzentrums, ist fast schon unmöglich. „Dies ist zum einen durch die strategische Bedeutung einer funktionierenden und gut ausgebauten IT-Infrastruktur begründet. Zum anderen entsteht durch den Betrieb, die Ausstattung, den Bau und die Modernisierung von Rechenzentren eine inländische Wertschöpfungskette in beträchtlichem Maße.“ [1] In Deutschland beanspruchen über 50.000 Rechenzentren gemäß vergangener Studien 12 TWh, was ungefähr 2% des Gesamtstrombedarfs in dem ganzen Land ausmacht, womit das Land als führender Rechenzentrumsstandort in ganz Europa gilt [2]. Den Entwicklungen zufolge ist in dem Jahr 2020 mit einer Prognose von 14 TWh zu rechnen. Zugrunde liegen für diese Entwicklung der Bedarf an Speicherung sowie die Verarbeitung großer Datenmengen als entscheidende Ursache. So lag 2005 der Energiebedarf für die Speichersysteme bei 5% [3] des Gesamtbedarfs, wohingegen der

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Wert sich 2011 schon auf 17% [4] belief. Maßnahmen wie die Betrachtung vor- und nachgelagerter Wertschöpfungsketten sowie die damit in Verbindung stehende sogenannte „Graue Energie“ sollen zum Entgegenwirken bzw. zur Optimierung beitragen, womit eine Steigerung der Energieeffizienz im ganzheitlichen Sinne erzielt werden soll. Der Energieverbrauch der einzelnen Rechenzentren wird derzeit auf Basis des tatsächlichen Stromverbrauchs beim Betrieb des Rechenzentrums ermittelt. Hierbei unberücksichtigt bleibt jedoch die aufgewendete Energie, die für die Herstellung, den Transport, die Lagerung und Entsorgung der Komponenten benötigt wird, was die Untersuchung des gesamten Produktlebenszyklus erfordert. Diese nicht berücksichtigte Energie wird auch „Graue Energie“ genannt [5]. Die Ermittlung dessen ist ein sehr aufwendiges Unterfangen und wird aufgrund dessen häufig ausgelassen bzw. im Bereich der Energieeffizienz nicht beachtet. Ein Beispiel für dieses Thema ist die Herstellung von Anlagen zur Gewinnung von erneuerbaren Energien. Der Energieaufwand, der beispielsweise für die Herstellung von Windkraft- oder Photovoltaikanlagen benötigt wird, ist meistens um ein vielfaches höher als die Leistungsdichte dieser Anlage. Daher ist es nicht selten, dass sich solche Anlagen aus energetischer Sicht erst nach Jahren amortisieren [6].

Der Hintergrund des stetigen Wachstums der Materialien in Rechenzentren wie der Server, Speicher und Netzwerkkomponenten gewinnt immer mehr an Relevanz, wohingegen bisher viele Rechenzentren keine Maßnahmen ergriffen haben, um eine Steigerung in der Energieeffizienz, z. B. durch die Implementierung geeigneter Ansätze, zu erzielen. Dazu liegen intransparente Kriterien wie der unpraktikabel Bestand von Kennzahlen zugrunde, die zur Bestimmung des Energiepotenzials von Rechenzentren nicht weiterhelfen.

Eine Kennzahl für die Bestimmung der Energieeffizienz von Rechenzentren hat der Unternehmensverbund „The Green Grid“ im Jahr 2007 entwickelt. Sie heißt „Power Usage Effectiveness“ (PUE) und gilt als die wohl wichtigste Kennzahl zur Messung der Energieeffizienz in Rechenzentren, dessen Wert eine Aussage über das Verhältnis des Gesamtenergieverbrauchs des Rechenzentrums zum Eigenverbrauch der IT-Komponenten gibt. Dieser Wert ist umso besser, wenn er gegen 1 konvergiert. Beispielsweise würde ein PUE-Wert von 3 als sehr schlecht eingestuft werden, was bedeuten würde, dass ca. zwei Drittel der eingesetzten Leistung für Wärme bzw. die Abführung der Wärme verbraucht werden und nur ein Drittel der Leistung des reellen Verbrauchs von den Rechnern verwendet werden. Heutzutage gilt ein PUE-Wert von 1,3 als ausgezeichnet. Dieses bedeutet, dass 30% der eingesetzten Leistung ineffizient genutzt werden. Der ideale Wert des Power Usage Effectiveness ist 1, was bedeuten würde, dass keine weitere Energie von der Hardware benötigt wird [7]. Der Wert unter 1 wäre gewinnbringend, was z. B. durch die Wiederverwendung erzeugter Wärme realisiert werden könnte, indem z. B. die Heizkosten eines Rechenzentrums eingespart werden. Denkbar ist z. B. mittels der Abwärme angrenzende Bürogebäude oder Lagerhallen zu heizen. Im Umkehrschluss würde sich somit in einer Gesamtbetrachtung des PUE-Wertes ein Wert unter 1 ergeben. Nachteilhaft an dem PUE-Wert ist, dass sich durch die Effizienzverbesserung der IT-Hardware ein schlechterer Wert ergibt, weil der PUE-Wert keine ganzheitliche Aussage über das

Rechenzentrum gibt. Von daher ist die Betrachtung des Gesamtenergiebedarfs sehr wichtig [8].

Außerdem werden durch Umweltzertifikate wie „Der Blaue Engel“ Versuche unternommen, die Energieeffizienz in den deutschen Rechenzentren zu optimieren.

„Der Blaue Engel“ beinhaltet wichtige Kennzahlen, die eine hohe Relevanz als zertifizierter Maßstab darstellen. Das Umweltzeichen hat sich für Betreiber von Rechenzentren, die eine Optimierung in der Energie und Ressourceneffizienz verfolgen, zur Aufgabe gemacht, Zertifizierungen von Rechenzentren durchzuführen, um ein energiebewusstes Rechenzentrumsbetrieb umsetzen zu können [9].

Mit dieser Herausforderung beschäftigt sich die Carl von Ossietzky Universität Oldenburg in der Forschungskooperation des Projektes TEMPRO (Total Energy Management for Professional Data Centers) vom BMWi im Rahmen des 6. Energieforschungsprogramms der Bundesregierung. Neben weiteren akademischen Partnern sowie Industrie- und sonstigen Verbundpartnern im Forschungsprojekt TEMPRO beschäftigt sich die Abteilung VLBA (Very Large Business Applications) der Wirtschaftsinformatik an der Carl von Ossietzky Universität Oldenburg mit dem Arbeitspaket 3 „Informations- und Bewertungsmodelle für die Energieeffizienz in Rechenzentren“[1]. Nicht einmal eine zweistellige Anzahl an Rechenzentren in Deutschland verwendet solche Zertifikate. Gemäß den ersten Untersuchungen und daraus zu entnehmenden Annahmen, die im Rahmen dieses Forschungskontextes ermittelt wurden, deuten die Anzeichen sehr stark darauf hin, dass die Präferenz nicht immer auf der Energieeffizienz liegt, sondern auf anderen individuellen Belangen, die unabhängig davon eine Effizienz mit sich bringen. Aus diesem Hintergrund heraus ist es naheliegend, dass es nicht irrelevant ist diesem Aufschluss eine Bedeutung beizumessen sowie nachzugehen.

2 Optimierung der Energieeffizienz in Rechenzentren

Neben verschiedenen Ansätzen zur Optimierung der Energieeffizienz von Rechenzentren ist das Umweltzeichen „Der Blaue Engel“ ein etabliertes Vorgehen, um eine Zertifizierung energiebewusster Rechenzentren umzusetzen. Betreiber können bereits seit 2011 ihr Rechenzentrum überprüfen lassen, um eine Auszeichnung zu erhalten. Schon fünf Monate nach dem Start stand jedoch fest, dass nur sehr wenige Rechenzentren die Bewertungskriterien erfüllen [10]. Es liegt aber weniger an der Umsetzungsmöglichkeit der Kriterien, denn dieses ist prinzipiell machbar [11], als an der Relation zwischen den Kosten und dem Nutzen, der aus dem Umweltzeichen gezogen werden kann. „Der Blaue Engel“ ist das 1978 gegründete Umweltzeichen des Bundesministeriums für Umwelt, Naturschutz und Reaktorsicherheit. Zweck dieser Auszeichnung ist es, Verbrauchern ein Hilfsmittel an die Hand zu geben, mit dem sie in der Lage sind, durch gezielte Nachfragen umweltfreundliche Produkte zu erkennen und somit zu fördern. Zudem wird damit auch die Umweltbelastung reduziert [12]. In Deutschland sind bislang nur vier Unternehmen, die die Zertifizierung „Der Blaue

[1] http://tempro.uni-oldenburg.de/

Engel“ als energieeffizientes Rechenzentrum erhalten haben [13]. Für die geringe Nutzung gibt es unterschiedliche Gründe. Das Umweltbundesamt hat im Jahr 2014 in einer Onlinebefragung nach der Bekanntheit von Umweltzeichen gefragt. Der Befragte sollte sich zu bestimmten Zeichen und Siegeln äußern, ob sie ihm bekannt sind und wenn ja, ob sie seine Kaufentscheidung beeinflussen. Beteiligt waren an dieser Umfrage über 2.000 Nutzer. Anhand der herausgefundenen Ergebnisse lässt sich eindeutig erkennen, dass „Der Blaue Engel“ vielen bekannt ist, aber nicht sonderlich zu einer Kaufentscheidung beiträgt, was aus der folgenden Abbildung zu entnehmen ist [14].

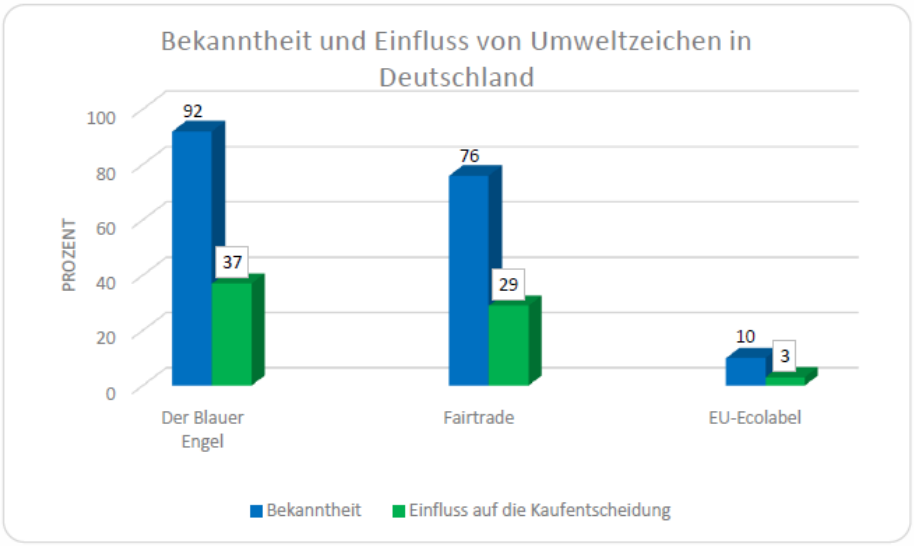

Abbildung 1: Bekanntheit und Einfluss von Produktübergreifenden Labels in Deutschland [14]

Abbildung 1 zeigt den Bekanntheitsgrad sowie den Einfluss auf die Kaufentscheidung von Umweltzeichen. Geprüft wird der gesamte Produktionsweg, bevor die Auszeichnung „Der Blaue Engel“ vergeben wird. Warum deutschlandweit nur so wenige Unternehmen ihre Produkte und Dienstleistungen mit dem Zertifikat „Der Blauen Engel“ auszeichnen lassen, kann nicht eindeutig geklärt werden. Der jährliche Kostenfaktor, der durch die Zertifizierung der Produkte/Dienstleistungen anfällt, wird sicherlich auch eine Rolle in den Entscheidungen spielen. Eine eventuell maßgebendere Rolle werden die Vergabegrundlagen bzw. deren Gültigkeit haben. Die allgemeine Information zur Laufzeit von den Vergabegrundlagen sagt aus, dass das Umweltzeichen prinzipiell nur für einen befristeten Zeitraum vergeben wird. Dieser wird von der Jury des Umweltzeichens beschlossen und liegt in der Regel zwischen 3 und 5 Jahren. Basierend auf dieser Vergabegrundlage erschließt sich die gleiche Laufzeit für den Zeichenbenutzungsvertrag.

Zu den Hauptkriterien des Zertifikats „Der Blaue Engel“ gehören die Überprüfung der Auswirkung auf die Umwelt (Klima, Wasser, Schonung der Ressourcen, etc.), sowie die Auswirkung auf die menschliche Gesundheit [15].

Der Verbraucher wird darauf hingewiesen, dass, wenn er ein Produkt oder eine Dienstleistung erwirbt, die mit dem Zertifikat „Der Blaue Engel“ ausgezeichnet ist, es eine positive Auswirkung auf die Umwelt hat. Anhand der folgenden Beispielkriterien des Umweltbundesamtes werden Produkte und Dienstleistungen für die Vergabe des Zertifikates „Der Blaue Engel“ überprüft:

- Ressourcen bei der Herstellung sparen
- Aus nachhaltig produzierten Rohstoffen hergestellt werden
- Weniger Ressourcen bei Nutzung und Entsorgung verbrauchen, weil sie beispielsweise besonders energieeffizient sind
- Schädliche Substanzen für Umwelt oder Gesundheit vermeiden oder auf ein Mindestmaß beschränken
- Besonders langlebig und reparaturfähig sind
- Sich gut recyceln lassen
- Geringe Emissionen in Boden, Wasser, Luft oder wenig Lärm verursachen
- Ihre Funktion (Gebrauchstauglichkeit) in hoher Qualität erfüllen
  [16]

Darüber hinaus gibt es noch weitere Ansätze, die verfolgt werden, wie z. B. die Entwicklung eines Frameworks, die durch eine Konformitätsprüfung zertifizierter Kennzahlen und einer daraus resultierenden Handlungsempfehlung zur ganzheitlichen Steigerung der Energieeffizienz in Rechenzentren dienen soll. Dieses wird ebenfalls in dem Forschungsprojekt TEMPRO angegangen [17].

Im Rahmen der stetig wachsenden Digitalisierung in Deutschland sind Big Data, mobiles Internet sowie das Internet of Things (IoT) nur drei der größten Themen. Betrachtet man den Aspekt der mobilen Globalisierung, wird schnell bewusst, dass in naher Zukunft eine enorme Menge an Datenstrom zu bewältigen sein wird. Nimmt man Bezug auf die Statistik des „Cisco Blogs Deutschland“, steigt allein der mobile Datenverkehr bis zum Jahre 2019 auf ein monatliches Volumen von 259,8 Petabyte. Das entspricht in etwa 272 Millionen Gigabyte [18]. Um dieses Volumen zu bewältigen, ist ein enormer Mehrbedarf an Rechenleistung erforderlich. Die darauf spezialisierten Unternehmen der IT-Branche befinden sich ständig im Wachstum und investieren stark in den Ausbau der Rechenzentren. Um der Verarbeitung derart großer Mengen an Daten gerecht zu werden, ist der stetige Ausbau der Hard- und Software der Rechenzentren von hoher Bedeutung.

Einem Experteninterview zufolge, das bei einem assoziierten Partner des Forschungsprojektes TEMPRO geführt wurde, dessen mittelständisches Unternehmen ein zertifiziertes Rechenzentrum betreibt, besteht insbesondere bei bestehenden Rechenzentren für die Zertifizierung, z. B. durch das Zertifikat „Der Blaue Engel“, ein sehr großer Aufwand zur Umstrukturierung. Darüber hinaus sind neben dieser Umstrukturierung auch viele Kosten für den finanziellen Aufwand notwendig, die sich nicht rechnen. Außerdem besteht die Befürchtung, dass durch Supercomputer[2] mit höchsten Rechenleistungen Konflikte zwischen Nutzen und Energieeffizienz erzeugt

[2] Supercomputer bzw. Superrechner sind die Bezeichnungen für die schnellsten Rechner in der gegenwärtigen Zeit.

werden. Wenn eine gewisse Rechenpower benötigt wird, könnte das nicht so gut mit der Energieeffizienz verträglich sein [19]. Weitere Beispiele neben Supercomputer sind für solche Hochleistungssysteme Hardwarekomponenten wie In-Memory-Datenbanken[3] etc.

3 Effizienzorientierte Rechenzentren

Die Tatsache, dass bisher lediglich vier Rechenzentren mit dem Umweltzeichen „Der Blaue Engel“ zertifiziert sind und aus den genannten Umfragen bzw. Studien im vorigen Kapitel das sehr geringfügige Interesse hervorgeht, lässt die Annahmen erhärten, dass nicht alle Rechenzentrumsbetreiber an einem zertifizierten Rechenzentrum interessiert sind.

Wie sich außerdem in dem Experteninterview, das am Ende des zweiten Kapitels dieses Beitrages erwähnt wurde, herausstellt, ist die Befürchtung, dass zwischen dem Nutzen und der Energieeffizienz Konflikte erzeugt werden können, was insbesondere die Zweckerreichung von Supercomputern betrifft, dessen Aufgabe z. B. das sehr schnelle Abarbeiten, Rechnen oder Generieren von Daten ist. Dieser Hintergrund deutet sehr stark darauf hin, dass die Präferenz nicht immer auf der Energieeffizienz liegt, sondern auch auf anderen individuellen Belangen, die unabhängig davon eine Effizienz mit sich bringen. Aus diesem Hintergrund heraus ist es naheliegend, dass es nicht irrelevant ist diesem Aufschluss eine Bedeutung beizumessen sowie nachzugehen, wozu in diesem Forschungskontext ein Framework entwickelt werden soll, das für präferenzorientierte Handlungsempfehlungen zur Effizienzsteigerung von Rechenzentren dienen soll und Rechenzentrumsbetreiber bei der Konfiguration ihrer Rechenzentren mit ihren individuellen Effizienzpräferenzen zum Ziel verhelfen soll.

Als ein möglicher Ansatz zur Optimierung soll ein Empfehlungssystem namens *ProDC* (Preference-oriented Data Centers) entwickelt werden. „*Ein Empfehlungssystem (oft auch „Recommender System“ genannt) ist ein System, das einem Benutzer in einem gegebenen Kontext aus einer gegebenen Entitätsmenge aktiv eine Teilmenge „nützlicher“ Elemente empfiehlt.*“ [20] Der Kontext eines solchen Empfehlungssystems besteht aus den folgenden Elementen:

- Benutzerprofil ***P***
  - Explizite Informationen wie Geschlecht, Alter, Interessengebiete etc.
  - Implizite Informationen wie Besuchshäufigkeit einer Website, gelesene Texte, gekaufte Produkte etc.
- Entitätsmenge (*Empfehlungselemente*) ***M***
  - Kontextelemente
  - Z. B. Dinge wie Bücher, Musikstücke, Konzerte, Reisen, Nachrichten, Fachartikel, E-Mails, Fachleute etc.
- Situation ***S***
  - Rahmenparameter der realen Welt

[3] In-Memory-Datenbanken (IMDB) sind Datenbankmanagementsysteme, die den Arbeitsspeicher eines Computers als Datenspeicher nutzen.

  - Z. B. Datum, Uhrzeit, Geoinformation, verwendetest Endgerät des Benutzers, gerade angezeigter Text im Browser des Benutzers etc.
- Empfohlene Elemente ***T***
  - Teilmenge von ***M***
  - Soll Nutzen des Benutzers ***B*** maximieren

Die Aufgabe eines solchen Empfehlungssystems ist formal ausgedrückt folgende Optimierung:

$$\max(Nutzwert(B,K,T)) \text{ mit } K = (P,M,S)$$

Dieser Definition der Nutzwertfunktion kommt offensichtlich eine große Bedeutung zu [20].

Die folgende Grafik veranschaulicht den ganzen Kontext des Empfehlungssystems:

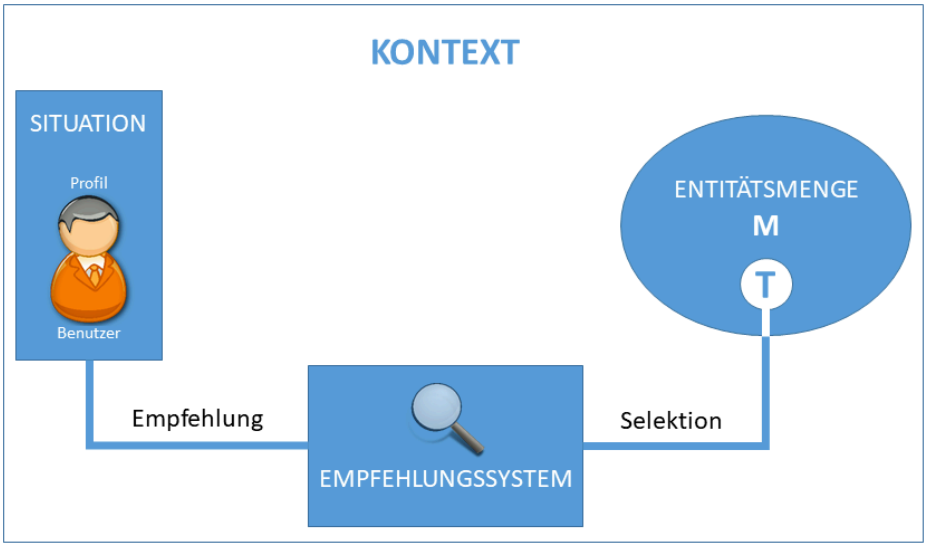

Abbildung 2: Empfehlungssystem [20]

Das Framework *ProDC* soll durch einen Wizard[4] die Anforderungen der Rechenzentrumsbetreiber aufnehmen und gemäß dieser Angaben resultierend eine intelligente Handlungsempfehlung für die Gestaltung des Rechenzentrums basierend auf diese individuellen Ziele ausgeben.

Durch die Umsetzung dieses Frameworks wäre ein denkbares Szenario z. B., dass ein Rechenzentrumsbetreiber, der beispielsweise die Präferenz hat ein energieeffizientes Rechenzentrum zu gestalten, das Framework *ProDC* startet und folgendermaßen vorgeht:

[4] Eine Oberfläche, mittels derer ein Anwender schrittweise durch Dialoge für eine ergonomische Dateneingabe geführt wird.

1. Auswahl des Rechenzentrumtyps „*Energieeffizientes Rechenzentrum*“
    a. Energieeffizientes Rechenzentrum
    b. Hochleistungsrechenzentrum
    c. Langlebiges Rechenzentrum
2. Auswahl des Existenzstatus „*Neu zu gestaltendes Rechenzentrum*“
    a. Bestehendes Rechenzentrum
    b. Neu zu gestaltendes Rechenzentrum
3. Fläche des Rechenzentrums
4. Weitere Parameter
5. Ausgabe / Handlungsempfehlung durch *ProDC* zur Konfiguration eines energieeffizienten Rechenzentrums
    a. Auswahl der Komponente
    b. Anordnung der Komponente
    c. Kennzahlen, die mindestens folgende Werte (z. B. gemäß „Der Blaue Engel“) erfüllen müssen, um ein energieeffizientes Rechenzentrum zu gewährleisten
    d. Weiteres

Für die Entwicklung des Frameworks kommen gegenwärtige Webtechnologien wie HTML 5, CSS und JavaScript zum Einsatz sowie das von Google entwickelte Front-End-Framework „Materialize“[5], was klassische Grundsätze von erfolgreichem Design mit zeitgemäßer Innovation und Technologie verbindet. „Materialize“ wurde außerdem im Rahmen dieses Forschungskontextes gewählt, weil es das Programmieren beschleunigt, das Nutzungserlebnis fokussiert und eine simple Benutzung bietet. Diese Aspekte sind für das iterative Entwickeln in einem solchen Forschungsprojekt sehr entscheidend, wenn es insbesondere um die sukzessive Erweiterung einer solch evolutionären Softwareentwicklung als Beitrag in der Wissenschaft geht.

4 Schlussfolgerung und Ausblick

Dass Ansätze zur Effizienzsteigerung in Hinsicht auf das Energieeinsparpotential von Rechenzentren bestehen, geht durch Maßnahmen wie der Vergabe des Zertifikats „Der Blaue Engel“ sowie des Zertifizierungsprozesses selbst und der Bestimmungsmöglichkeiten durch den Power Usage Effectiveness (PUE) hervor. Das mangelnde Interesse solcher Zertifizierungsmaßnahmen jedoch, das auf eine geringe Anzahl eines zweistelligen Betrages der 50.000 Rechenzentren in Deutschland zurückzuführen ist, lässt nahelegen, dass die Präferenz nicht immer auf diesen Aspekt gelegt ist. Experteninterviews zufolge, die unter anderem aussagen, dass ein Konflikt zwischen Nutzen und Energieeffizienz hervorgerufen werden kann, wenn es z. B. um den Einsatz von Supercomputer geht, mit denen das sehr schnelle Abarbeiten, Rechnen oder Generieren von Daten erzielt werden soll, ist ein Beispiel, das diese Annahme

[5] http://materializecss.com/

begründet. Dieser Herausforderung soll mit der Entwicklung eines Empfehlungssystems namens *ProDC* (Preference-oriented Data Centers) nachgegangen werden. Dieses Framework soll präferenzorientierte Handlungsempfehlungen zur Effizienzsteigerung von Rechenzentren ermöglichen und Rechenzentrumsbetreiber somit bei der Konfiguration ihrer Rechenzentren mit ihren individuellen Effizienzpräferenzen zum Ziel verhelfen. Wichtig ist außerdem in der Entwicklung von *ProDC* die Erweiterbarkeitsmöglichkeit, um z. B. innovative Fortschritte in der Hardwareauswahl etc. in diesem Sektor vorbeugend berücksichtigen und diese Daten in das Empfehlungssystem somit künftig schnell einpflegen zu können.

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Transforming urban public mobility: A systematic literature review and directions for future research

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Abstract. Based on a systematic literature review, this paper develops a conceptual framework summarising the current research on the role of Green IS in improving the sustainability impact of public transport. IS have the potential to induce a shift towards more sustainable transportation by enhancing the attractiveness of public transport, reducing complexity for consumers and building social cohesion. Further, IS play a fundamental role in improving the efficiency of the current public transport system. Both aspects have beneficial impacts on the sustainability of public transport in the form of reduced congestion, better utilization of resources and improved public health. Directions for future research are highlighted.

Keywords: Public Transport, Green IS, Literature Review, Belief-Action-Outcome Model

1 Introduction

More than 70% of European Union (EU) citizens live in urban areas, which produce around 80% of the EU's gross domestic product. As a key component of economic development, transport activity is increasing in these areas, causing a multitude of problems for inhabitants and policymakers [1]. Due to a continued reliance on private vehicles, urban mobility in the EU is increasingly inefficient with delays and congestion costing an estimated 100 billion Euros annually [2], as well as being a major cause of road accidents, pollutants and greenhouse gas (GHG) emissions [3].

The active endorsement of public transport has been identified as a key strategy for reducing GHG emissions from urban transport [3], and the European Commission now strongly encourages the use of public transport as part of its sustainable urban transport strategies [4]. In 2012 alone, 57 billion passenger journeys were completed by local public transport in the EU, pointing to the significant economic share of this sector [5]. At the same time, public transport companies across Europe are under increased economic pressure from rising fuel costs, funding cuts and the development of new mobility trends, such as the growing impact of Information Systems (IS) [6]. Challenging existing business models, changing relationships with customers and producing an exponential growth of data, IS "*have the potential to deliver a*

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revolutionary impact" on public transport [7]. In particular, however, IS may provide a partial solution to many of the transport-related environmental issues introduced earlier in this paper, by raising awareness of environmental issues [8], enabling sustainable mobility services [9], and increasing efficiency of operations [10].

The research field of IS for environmental sustainability (Green IS) has received considerable scientific attention in recent years, including a number of publications focusing on the use of Green IS for sustainable mobility (e.g. [9-11]). However, although the endorsement of public transport has been identified as an expedient strategy towards more sustainable urban transport, this topic appears severely understudied by the IS community. To the best of our knowledge, a holistic systematic review linking the concepts of Green IS and public transport does not exist. This study therefore seeks to examine the following research question:

RQ: How can IS contribute to improving the sustainability impact of urban public transport?

To address this question, we summarise the current state of research by developing a framework explaining how IS influence individuals' shift to more sustainable modes of transport, enhance the efficiency of the public transport system and improve the sustainability outcomes of its operation. In doing so, we build on the Belief-Action-Outcome framework developed by [12]. In addition, this study identifies a number of research gaps in existing literature, which point to directions for future research.

This paper is structured as follows: Section 2 describes the research approach followed for the systematic literature review, as well as introducing the Belief-Action-Outcome framework that structures our review. Section 3 provides the results of the literature analysis. These are discussed with regards to our research question in Section 4, which also provides directions for future research. In Section 5, the paper concludes that Green IS have the potential to induce a shift towards more sustainable forms of transportation as well as improving the efficiency of the current public transport system.

2 Research Method

2.1 Literature Identification

In order to identify how IS contribute to improving the sustainability impact of urban public transport, we conducted a systematic literature review following the procedure proposed by [13]. An initial, explorative keyword search using different combinations of the terms "public transport" and "Information System" as well as synonyms thereof was employed to further define the context of our research question and determine appropriate search terms. The final search string reads as follows: public AND (transport OR transit OR mobility) AND (smart OR digital OR "information system" OR "information and communication technology").

Due to the interdisciplinary nature of our research question, we did not restrict our search to the IS domain but also considered related fields, such as transportation, urban planning and environmental science. The search string was thus applied to title,

abstract and keywords of the following scholarly databases: Ebsco Host (Business Source Complete, GreenFile, Environment Complete), Emerald Insight, Science Direct, Web of Science und AIS electronic library. Due to the emerging nature of our research topic, the search covered academic journal articles as well as conference proceedings. Aiming to represent the current status of research, this study focuses on articles published between January 2013 and June 2017. The literature search was conducted in July 2017 and yielded 1162 records, with duplicates counted multiply.

2.2 Literature Selection

In order to be considered relevant for our research approach, papers had to meet the following conditions:

(1) Papers must have an IS-related focus. We followed the classification of mobility-related IS types proposed by [9] and included papers focusing on aspects of a system (e.g. an algorithm), applications (e.g. a mobile application) or a type of IT (e.g. GPS).
(2) Papers must include sustainability aspects in line with the IS functions outlined in Section 2.3.

In addition, papers were excluded if they focused primarily on personal transport or covered unrelated methods for data analysis (unless this was explicitly linked to sustainability aspects, e.g. analysing smart card data for efficient routing). Scanning titles and abstracts for compliance with these two conditions and removing irrelevant and duplicate entries, we identified 71 potentially relevant papers for further analysis. In cases where publications appeared relevant but were not accessible, we attempted to gain access via scientific communities such as Researchgate or contacting the authors directly, which yielded another 3 articles. Finally, a forward and backward search produced a further 5 articles. The sample for the literature analysis hence consisted of 79 records, which was finally reduced to 56 relevant articles upon analysis of the full text.

2.3 Literature Analysis

Research has established three major approaches for a transformation to a sustainable mobility system: improving the efficiency of current modes of transport (e.g. through green technologies), a modal shift to more efficient forms of mobility (e.g. public transport), and a reduction in the volume of transport (e.g. by reducing urban sprawl) [15, 16]. While a reduction of transport volumes requires major shifts in both societal and individual practices and is thus beyond the scope of this paper, we seek to discover how IS contribute to improving the sustainability impact of public transport by increasing its modal share and enhancing the efficiency of operations.

In order to structure the current state of research accordingly, we hence require a framework that allows the integration of intentions to shift to public transport, of concrete actions by which the public transport system may improve in efficiency, and of the outcomes induced by such changes in intention and behaviour. The Belief-Action-Outcome (BAO) framework developed by [12] provides these conditions and

forms the structural basis of our literature analysis. For the purpose of our research approach, we adapt the BAO model to structure the results of our literature analysis by the following broad concepts:

(1) IS functions increasing individuals' intention to shift to more sustainable modes of transport ("Belief Formation")
(2) IS functions aimed at improving the efficiency of current public transport modes ("Action Formation")
(3) Sustainability outcomes achieved by adoption of Green IS in public transport ("Outcome Assessment")

3 Results

The literature analysis revealed ten major concepts outlining how IS contribute to improving the sustainability impact of urban public transport by forming beliefs, actions and outcomes. These are presented in Table 1 (marked by "x" if discussed by the respective article) and elaborated further in Section 4.

Table 1. Results of the literature analysis

Literature	*Belief Formation*			*Action Formation*			*Outcome Assessment*			
	Enhancing attractiveness of public transport	Reducing complexity for consumers	Building social cohesion & awareness	Improving planning & policy making	Operational optimisation	Interoperability between transport modes & businesses	Reduced congestion	Reduced emissions	Improved utilisation of resources	Improved public health & safety
Bradshaw & Donnellan (2013)	x	x				x				
Ceder (2013)	x				x	x	x	x		x
Cichosz (2013)	x						x	x		x
Coetzee (2013)	x	x				x				
Guili et al (2013)				x	x	x				
Moussa et al (2013)	x	x				x				
Nelson & Mulley (2013)	x	x			x	x	x	x	x	x
Runhua et al (2013)				x	x		x			
Sun et al (2013)	x				x					
Agrawal et al (2014)					x					
Beland (2014)	x		x				x			x
Boccardo et al (2014)	x	x			x			x	x	
Flüchter & Wortmann (2014)			x							
Arena et al (2015)		x		x	x		x			
Bruglieri et al (2015)	x	x			x	x	x	x	x	x
Eom et al (2015)	x				x					
Ferreira et al (2015)	x	x			x	x		x	x	
Garcia et al (2015)	x		x							x
Kapoor et al (2015)	x				x	x	x	x		
Stewart (2015)	x					x	x	x		
Williams et al (2015)	x									x
Ambrosino et al (2016)	x	x				x				x
Baumgartner et al (2016)		x				x	x			

continued on the following page

Literature	*Belief Formation*			*Action Formation*			*Outcome Assessment*			
	Enhancing attractiveness of public transport	Reducing complexity for consumers	Building social cohesion & awareness	Improving planning & policy making	Operational optimisation	Interoperability between transport modes & businesses	Reduced congestion	Reduced emissions	Improved utilisation of resources	Improved public health & safety
Bok & Kwon (2016)	x			x	x				x	
Brauer et al (2016)			x							
Bresciani et al (2016)		x	x							
Cohen-Blankshtain & Rotem-Mindali (2016)	x	x	x							
Davidsson et al (2016)	x		x	x	x		x	x	x	x
Di Pasquale et al (2016)	x	x	x		x	x		x		x
Fahnenschreiber et al (2016)	x	x				x			x	
Garcia et al (2016)		x		x	x	x				x
Handte et al (2016)	x	x								
Karlsson et al (2016)	x	x	x			x				
Lorenzo et al (2016)				x	x					
Sandau et al (2016)				x	x					
Tretsiak et al (2016)					x				x	
Villani et al (2016)					x			x		x
Vitale et al (2016)	x			x	x					
Weng et al (2016)	x			x						
Willing et al (2016)	x			x		x				
Zavaglia (2016)		x		x	x	x	x	x	x	x
Zhang et al (2016)	x			x						
Aleta et al (2017)			x	x		x		x	x	x
Cianciulli et al (2017)	x	x		x	x					
Dia & Javanshour (2017)	x				x		x	x	x	
Guo et al (2017)	x									
Hensher (2017)	x				x		x			
Liu et al (2017)	x		x		x		x	x	x	x
Liu et al (2017)		x	x				x			
Makarova et al (2017)	x				x		x			
Margarita et al (2017)	x		x							
Pinna et al (2017)	x	x				x	x	x		x
Surugiu et al (2017)		x			x	x		x	x	
Szigeti et al (2017)	x				x					
Xiao et al (2017)	x						x			
Yadav et al (2017)		x	x		x	x				

4 Discussion

In order to address our research question, we propose the conceptual framework presented in Figure 1, which summarises the current state of research on sustainability impacts of Green IS adoption in public transport.

4.1 Belief Formation

A major function for inducing a shift to sustainable transport modes lies in the capability of IS to enhance the attractiveness of public transport compared to private

means of transportation. IS play a fundamental role in increasing convenience for consumers by enhancing the travel experience in a number of ways, including, for example, the provision of various booking and payment options, onboard information and entertainment [19, 20, 31] as well as monitoring of air quality, speed and passenger load [51, 53, 69]. Recently, IS have facilitated solutions to the first mile/last mile problem by enabling, for example, the introduction of efficient car, bike or ride sharing systems [25, 44] that are integrated with the public transport system and providing mobility access to handicapped persons [32] or formerly unprofitable areas [17].

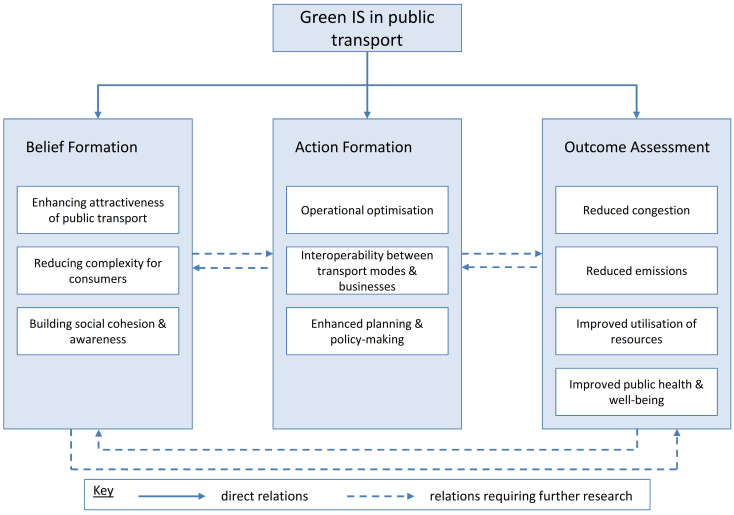

Figure 1. Proposed conceptual framework

Further, IS reduce complexity for consumers by providing personalised and real-time travel information [19, 20, 31], disruption and emergency management [37, 42] as well as the provision of integrated booking and payment options. On a macro level, social cohesion as well as awareness of sustainability impacts of travel choices is achieved by the encouragement of co-travelling [42], apps that reward sustainable travel choices [40] and the influencing of travel behaviour [27, 39].

4.2 Action Formation

A main focus of the reviewed literature lies on the utility of IS for improving the operational efficiency of the public transport system, in particular through efficient route management. This includes the capability of IS to streamline operations by demand-based routing and scheduling [26, 48, 68], utilising real-time traffic information [19, 20, 31], prioritising public transport at intersections [23] and reacting promptly to disruptions and emergencies [37]. In addition, IS facilitate the integration of alternative power sources, such as battery-powered vehicles, into the urban transport system [24]. Through the use of sensors, IS enable the improved

maintenance of infrastructure and vehicles [40], while recent developments such as autonomous vehicles provide scope for eco-efficient driving by removing the impacts of human errors [59, 69]. A major trend can be observed in the increasing interoperability between different modes of transport as well as different transport businesses. IS-enabled concepts such as Mobility-as-a-Service (MaaS) have the potential to transform the public transport sector as a whole by offering tailor-made mobility solutions [47, 61, 65]. On a macro level, planning and policy-making are facilitated, as simulation and modelling options as well as the data acquired through, for example, automatic fare collection systems allow the optimal development of new urban infrastructure [38, 62].

4.3 Outcome Assessment

Inducing a shift to more sustainable modes of transport and increasing the efficiency of the public transport system, the adoption of IS produces a number of sustainable outcomes. Predominant in the reviewed literature is the idea that a shift to public transport reduces the number of private vehicles and thereby reduces congestion [10, 17, 25, 34, 61]. This not only leads to reduced emissions, but also lowers the time spent travelling, which improves the quality of life experienced by urban citizens [17, 29, 42]. The optimisation of the public transport system's operation produces fewer carbon and air pollutant emissions [26, 29, 51], as well as improving the utilisation of resources such as fuel and energy [10, 26, 31, 50, 67]. Overall, public health and well-being are improved by the reduction of road accidents [17, 29, 55, 66] and harmful emissions as well as the social inclusion of disadvantaged and handicapped citizens [32, 35].

4.4 Future Research Directions

Our results also highlight directions for future research, which we have summarised in Table 2 by grouping them into six focus areas based on the PESTEL-framework [71]. These focus areas are: political (P), economic (E), social (S), technological (T), environmental (E) and legal (L). This approach highlights the interdisciplinary nature of sustainable public mobility, calling for research approaches that integrate the perspectives and methods of various domains, while at the same time proposing concise starting points for future research.

In particular, our literature review points to a research gap concerning the interrelations (represented by dashed arrows in Figure 1) between the main concepts (i.e. belief formation, action formation, outcome assessment) of the proposed framework. It remains unclear precisely how individuals' beliefs transform into actions taken with regards to sustainable mobility choices or how feedback loops shape the formation of actions and beliefs. In addition, the outcomes of both shifts towards more sustainable transport options and enhanced efficiency of public transport reported in the literature are rarely quantified. This has implications for urban planners, public transport companies and policy-makers, as the endorsement of certain technologies should depend on their actual sustainability impacts. Finally, a

significant part of the reviewed literature focuses on the development of innovative applications and prototypes aimed at enabling new mobility concepts such as intermodal travel platforms or MaaS. Future research should extend this by focusing on structural, regulatory and ethical aspects to guide the real-life implementation of such services.

Table 2. Directions for future research

Directions for future research	*Focus area*					
	P	E	S	T	E	L
▪ **Technology endorsement:** What technologies should be supported politically in order to harness positive sustainability impacts?	x					
▪ **Regulation of new mobility services:** How will regulatory guidelines need to adapt to changed provider-consumer relationships developing through new mobility solutions?	x					
▪ **Economic feasibility of new mobility services:** How will business models adapt to changed provider-consumer relationships for the provision of innovative mobility solutions? How can IS contribute to economic feasibility of new mobility services?		x				
▪ **Interrelations between beliefs, actions and outcomes:** How do individuals' beliefs transform into actions taken with regards to sustainable mobility choices? How do feedback loops shape the formation of actions and beliefs?			x			
▪ **Ethical aspects of new mobility services:** What ethical aspects need to be considered when introducing new mobility solutions, such as autonomous vehicles			x			
▪ **Usability and technology acceptance:** How are innovative IS solutions in the public transport domain perceived by users? How can prototypical solutions be designed to enable large-scale implementation?				x		
▪ **Quantification of sustainability outcomes:** How can the sustainability impacts of new mobility services be quantified?					x	
▪ **Rebound effects:** What methods are available for modelling potential rebound effects of individuals' travel behaviour?					x	
▪ **Regulation of new mobility services:** How will legal frameworks adapt to changed provider-consumer relationships developing through innovative mobility solutions?						x
▪ **Data security:** What legal issues need to be considered because of the opportunities for data collection and surveillance established by IS?						x

5 Conclusion

Based on a systematic literature review, this paper developed a conceptual framework summarising the current state of research on the role of Green IS in improving the sustainability impact of public transportation. The literature analysis revealed that IS have the potential to induce a shift towards more sustainable forms of transportation by enhancing the attractiveness of public transport, reducing complexity for consumers and building social cohesion and awareness. In addition, IS play a fundamental role in improving the efficiency of the current public transport system by optimizing its operational performance, enhancing planning and policy-making and improving interoperability between different transport modes as well as companies. Both ways of influence have potentially beneficial impacts on the sustainability of public transport in the form of reduced congestion, reduced emissions, better utilization of resources and improved public health and well-being. Future research is

required concerning the political, economic, social, technological, environmental and legal implications of the introduction of new mobility solutions.

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Load distribution strategies for a sustainable IT resources management

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Abstract. The rapid transformation and virtualization strategies of IT resources are evolving all possible fields of IT-industries. With the introduction of cloud computing model, the structural complexity of IT-infrastructures is radically increasing. The engineering process of a system landscape itself is not anymore the central task to optimize but also to efficiently utilize that enormous system landscape. Energy-costs are constantly increasing and to keep low-cost service, IT service providers are willing to investigate their energy efficiency. Moreover, they are recently obliged to reduce their CO_2 emissions under global and governmental pressures. In this paper, we present a holistic view of the virtual machines placement problems, their challenges and currently used solution methodologies, which target reducing energy consumption and aim for a sustainable IT resources management. In addition, we present a case study to demonstrate the role of load distribution strategies in sustainably managing IT resources to reduce energy consumption.

Keywords: Load distribution strategies, sustainable IT resources management, Virtual Machines Placement problem, IT energy consumption.

1 Introduction

The rapid transformation and virtualization strategies of IT resources have been radically evolving all possible fields of IT markets and industries. Nowadays, everything is or might be shifted to the cloud and proposed in the market for different customer sectors as services based on the model of cloud computing. Cloud computing, by definition, is a model for providing a rapid on-demand network access to a shared pool of different computing resources that can be with the minimum administrational effort provisioned and supplied for customers with different needs [1]. Infrastructure, platform and applications are now delivered as services based on the concept of cloud computing. This model triggered a new era of innovation in the IT- industry and raised the competition to deliver better services with the minimal costs.

Using the concept of the cloud allows IT service providers to employ their resources more in new innovations rather being obliged to install and set up the necessary basic hardware and software infrastructure for clients [2]. However, this model has also introduced new challenges in addition to the normal system landscape engineering ones and spotted many new obstacles in dealing with that rapid growth of IT system

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landscapes. The engineering process of the system landscape itself is not anymore the central task to optimize but also to efficiently utilize that system landscape. In other words, reducing the tremendous costs and investments in the IT infrastructure by the IT service providers is not anymore the only concern but rather reducing the energy power consumption and the associated operational costs of that infrastructure. However, the elasticity characteristic of the cloud has also radically raised the complexity of those systems and predicting the current required computational power is rather impossible due to the high heterogeneity of the workload patterns [3].

A recent study revealed, that the electricity consumption of data centers has reported worldwide a tremendous growth in the last years and for instance, between 2005 and 2010 the electrical power consumption by data centers has doubled [4]. Other studies have stressed on the electricity consumption and its large proportion of the overall operational costs of IT services providers, which is estimated to exceed 50 % of the overall operational costs [4, 5]. The central component in these calculations is the active servers, which consume the most electricity in data centers in comparison to other cooling and ventilation components [4]. Some studies showed that a critical number of functional servers in data centers in the USA, for instance, has never been utilized and rough calculations suggest that a total waste of over US- $ 19 billion is encountered per year with a total of 11 million tons of CO_2 emissions [6]. Holding the Service Level Agreement (SLA) has been the most common target objective for many IT service providers. Seizing opportunities to reduce costs and enhancing the enterprise global image under sustainable IT resources management are recently the keys to obtaining a better position in the market in addition to the quality of provided services. Energy costs are constantly increasing and to keep low-cost service, IT service providers are aiming to investigate their energy efficiency. In addition to cost reduction, IT service providers are recently also obliged to reduce their CO_2 emissions under global and governmental pressures [2, 4, 6]. Yet, those facts draw the attention of both industry and academia and give a solid motivation to investigate the energy efficiency of data centers in addition to the ever-observed indicator ‘High Performance’.

In this paper, we will present a holistic view of the virtual machines placement problems, their challenges and the currently used solution methodologies in the literature, which target reducing energy power consumption and aim for sustainable IT resources management. More precisely, the second section comprises preliminaries of the problem and a view on different fields of research that heavily addressing the problem. In the third section, we will present a case study to stress on the necessary simplicity in analyzing the system requirements before designing solution strategies for reducing energy power consumption. Followed, the fourth section contains an implementation overview and the computational results of the conducted simulation study before closing the paper with a conclusion and further research directions.

2 Literature review

Virtual machines live migration is a recent topic in addition to some others, in which the allocation of resources in data centers is investigated to accomplish an efficient

energy consumption by migrating active virtual machines between available physical hosts [7]. A clear definition of the problem has been previously presented and widely discussed under Virtual Machine Placement Problem (VMP) in the literature [8, 9], where virtual machines must be allocated to functional physical hosts using a specific load distribution strategy. The allocation process is successfully conducted only when the required information of a virtual machine and its required computing resources is passed to the load distributor, which allocates it to a functional server, that possesses and can satisfy those requirements [9].

Many similar problems have been previously investigated in the literature and unfortunately proven to be NP-complete even in best scenarios as for instance the bin-packing problem [10] or the identical parallel machine scheduling problems [11]. The bin-packing problem is still, under the formal description, considered to be easier to tackle down than placing virtual machines on physical hosts. Those because a couple of additional constraints by the VMP must be taken into consideration in order to avoid undesired behaviors or instability in the system [9].

An independent stream of research deals explicitly with the live migration process of virtual machines, which focuses more precisely on the migration process itself and how it can be conducted with the minimum downtime of the service to minimize the impacts of migration processes on the system stability and on the signed Service Level Agreement (SLA). In this field, detailed analysis of the migration process in addition to many other implementation concepts is discussed. One of the prior works in this field was presented in [12]. The authors presented a framework and detailed implementation strategy for virtual machine live migration, which minimizes the downtime of the process. They described the migration strategy under six different stages, which might be classified to three main phases in terms of migrating the memory. First is the push phase, in which certain pages of the migrated virtual machine is iteratively pushed to the destination host. The second phase comprises the completion of the copy process of the old Virtual Machine (VM) to the destination host, stopping the old VM and starting the new VM on the new host. In the third phase, after executing the new VM, they make sure that all the required information of the migrated VM have been successfully copied and if not tolerate the missing information and pull them from the old source. Other local resources of the migrated VMs are also directly migrated to the new host to avoid IP forwarding mechanisms, which as they describe might have implication on the system stability. They reported impressive results with a downtime, which did not exceed 60 milliseconds.

The allocation or the placement of virtual machine to which physical host using different load distribution strategies is the oldest field of research that explicitly deals with the VMP problem. Many load distribution strategies have been discussed and presented in the past two decades, since the introduction of distributed computing systems [13–15]. Two main types of load distribution strategies can be distinguished, static load distributors and dynamic load distributors [16]. A well-known example for the static load distributor is the Round & Robin scheduling algorithm [17], which is also classified under load balancing strategies [18]. Static load distributors are often easy and intuitive to implement and possess the advantage of light execution time to take a decision for a new allocation. However, they are on the other hand not aware of

the current load of the different hosts and may lack on performance issues and cause drawbacks in many instances, since they do not observe the dynamic behavior of the system [16]. A dynamic load distributor constantly observes the status of the functional hosts in the system during the operational time to adapt the current best allocation for new machines based on a specific strategy, which can be set differently [16, 18].

For instance, in [19], the authors presented a central dynamic load distribution algorithm. They proposed a load balancing strategy to treat load distribution problem of web-servers application. They defined the incoming requests as a set of jobs that must be allocated to different localhosts or machines. Their strategy constantly observes the current load of the servers in terms of CPU and labels them as heavy, moderate, or high loaded. This information is exchanged with the master server that hosts the load balancer, which initiates migration policies based on those labels until reaching a balanced loaded system. The exchange process is conducted periodically using a 10 minutes interval. They, however, stressed at the end of their study on taking the memory capacity of servers into consideration in the future work.

Since the majority of the problems in this field are quite complex and classified under NP-complete class of problem, the research was more focused on finding and presenting sub-optimal solutions [15]. Consequently, heuristics were the dominant solution approaches to deal with the VMP problem in the past two decades with over 67 % adaptation of the total literature analysis, which has been concluded in the survey presented in [8]. Nevertheless, some attempts to adapt meta-heuristics to investigate load distribution strategies can be found [8]. For instance, [18] presented a solution approach for load balancing using genetic algorithms and presented an analysis on a small scale. The authors considered in their study and computational analysis up to three physical hosts and 48 virtual machines. They formulated a fitness function, which took the CPU and memory utilization into consideration. They compared their results to two other heuristics namely, Round & Robin and greedy algorithm.

Recently, a parallel stream of research in this field has been focused on studying and introducing load distribution strategies, which mainly target energy consumption and adopt it as an objective function to reduce operational costs [2, 5, 8, 20]. For instance, in [2], an energy-aware load distribution strategy has been presented to efficiently manage data centers. The authors presented a sophisticated architectural framework, in which different types of virtual machines with different SLAs are taken into consideration in the allocation decision-making process. A major part of their framework was the presented power model, which they use in their algorithm. They assumed that the CPU consumes the most power in a physical host. Based on that assumption they assigned an estimated fraction of power consumption for every new virtual machine in the system. The precise implementation of their allocation algorithm was based on the Best Fit Decreasing algorithm, which they modified to take decisions based on power consumption of CPU after allocating a machine to it. They reported an extensive analysis based on a simulation study of their work and recorded SLA violations. They compared their strategy with different non-power aware strategy and reported a decrease in energy consumption in comparison to all of them. In the next section, a case study is presented to demonstrate the role of load distribution strategies in reducing energy power consumption by IT service providers.

3 A case study

The major challenge in designing load management strategies lies in understanding the nature of the incoming workload patterns and their characteristics. Since the heterogeneity of the incoming workload patterns is considerably high, the presented solution approaches in the literature are either problem-specific or highly generic. Both types suffer major drawbacks in terms of applicability and designed objective function. In order to manage resources in data centers taking sustainability and energy consumption, predicting the incoming load is very valuable since the scaling process might take time in data centers due to the normal provisioning processes. This could cause either a degradation in the quality of service or an over-provisioning that is associated with additional energy consumption to meet the signed SLAs [21]. Many contributions in this field have been presented using different methodologies starting by traditional statistical methods [22]. Most recently, very sophisticated approaches as for instance machine learning and neural network [23] have been adopted to understand the different incoming workload patterns in data centers. The main goal of those attempts is to increase the efficiency of the automatic scaling in the cloud since it is one of the main advantages of cloud computing [22, 23].

Yet, with the introduction of cloud computing model, businesses are even more motivated to seize the advantages of scalable outsourced IT systems [24]. Those represent a significant proportion of the overall customers by IT service providers [24]. Although the prediction process of the required computational power is quite tedious, this fraction of customers normally generates anticipated request patterns with a stable workload behavior. Their workload behavior might be even predicted on a daily basis using a very naïve approach. The behavior of that customer fraction can be often related to the normal working hours in a company, which outsources its IT system and offers their employees desktop accesses. This implies, that we can even describe their Virtual Machines (VMs) active hours during a day using mathematical distributions. For instance, the employees of a German company should usually fulfill 40 working hours a week. If we assume, that their VMs are active during their working hours, we can roughly predict their required computational power on the real physical host to efficiently allocate them to reduce energy consumption.

3.1 Closed class interactive workload queuing network for IT system landscape

The behavior of the previously fraction of customers by IT service providers can be classified under the closed class interactive workload queuing network, which is presented in [25]. The model is initially introduced for classifying interactive workload patterns of database servers. This class has a certain behavior and characteristics according to the authors, which are summarized in the following:

- The number of customers specifies the workload intensity.
- Number of customers is bounded, known and can be used as a parameter.
- Throughput is calculated after solving that queuing network and based on the customer population of that class.

- After a request is processed, the customer sends the next request after a 'thinking time'.

In order to investigate and further argue the applicability of this concept for a sustainable management of IT resources, a case study is presented. The main motivation behind the case study is to support the previously discussed arguments regarding the used dimension for allocating the resources to the virtual machines. In addition, we want to shade a light on the advantages, which can be seized through using simple information that describe the workload behavior of big customers by IT service providers.

3.2 Problem formulation and objective function

Given a data center, which consists of a set of physical machines and a corresponding queue of clients, which demands a set of virtual machines to be deployed on those hosts. The virtual machine placement problem is investigated and solved based on many objective functions as for instances maximization of the system performance or the minimization of operational costs. The VMP might be formalized in the following:

- Let $H = \{h_1, \ldots, h_m\}$: be a set of m hosts.
- Let $V = \{v_1, \ldots, v_n\}$: be a set of n online virtual machines.
- Let $R = \{r_1, \ldots, r_o\}$: be a set of o resources required for each $v \in V$.
- Let $S = \{s_1, \ldots, s_m\}$:be the set of m values, which represent the shutdown hours of the hosts $H = \{h_1, \ldots, h_m\}$ during a time span T.
- Let $D_{i,y}$: be the required resource for $v_i \in V$ from resource type $y \in R$
- Let $C_{j,y}$: be the total capacity of $h_j \in H$ of the resource type $y \in R$

It is desired to allocate this set of VMs V on the hosts dynamically, in which the total shutdown hours of all servers over a time interval T is to be maximized as shown in equation 1. Those are to reduce total energy consumption taking into consideration the corresponding SLAs requirements and conditions.

$$Maximize\ total\ shutdown\ hours = \sum_{x=1}^{m} s_x : subject\ to\ (2) \qquad (1)$$

$$\forall\, y \in \{r_1, \ldots, r_o\} : \sum_{i=1}^{n} D_{i,y} < \sum_{j=1}^{m} C_{j,y} \qquad (2)$$

3.3 System description and specifications

The IT landscape of the considered system consists of eight homogeneous servers, which host five different types of virtualized system deployed in 290 VMs as presented in Table 1. The considered system provide SAP system access as a service for high educational institutions with different characteristics. In addition, they provide desktop access for research purposes. The main memory capacity of each server is 500 GB. Nevertheless, the bottleneck in the system is believed to be the main memory, since a fixed allocation of the main memory is maintained during the deployment of the VMs. In addition, the monitoring information, which has been extracted from the system, showed that the generated CPU workload by the VMs is relatively low. We described the online hours of the different VMs based on expert's interviews using mathematical distributions. For instance, a researcher works roughly 40 hours a week with an average of 8 hours a day. In addition, the periods, in which the VMs are active, are mostly during the day.

Table 1. The specifications of the deployed virtual machines in the considered IT landscape.

Virtual machine Type	*Main memory*	*Quantity*	*Online time distribution*	*Offline time distribution*
Research assistant VMs	4	30	Triangular (1, 6, 3)	Triangular (22, 30, 24)
Researcher VMs	8	30	Triangular (6, 14, 8)	Triangular (14, 18, 16)
SAP system access 1	10	90	Triangular (2, 8, 5)	Triangular (16, 22, 19)
SAP system access 2	12	40	Triangular (2, 8, 5)	Triangular (16, 22, 19)
SAP system access 3	14	100	Triangular (2, 8, 5)	Triangular (16, 22, 19)

3.4 Conceptual representation of the simulation model

The evaluation process of new or existed load distribution strategies is normally conducted in an emulated environment of the real system. Those to avoid instability and other implications (e.g. network traffic) in the real system during operational time by using new distribution strategy, which might cause violations in the SLA [20]. For instance, simulation is a very powerful technique, which is widely used to investigate different aspects of IT system landscapes [26] and might be combined with various optimization strategies [27]. Recently, many new simulation packages have been developed to model and investigate cloud computing environments [28].

In Figure 1, the conceptual representation of the simulation model is presented, which is derived from the basis of the previously discussed closed class interactive workload queuing network, to model IT system landscape. An initial number of virtual machines is created in the closed queuing network. Different types of VMs can be taken

into consideration. Those VMs must be dynamically allocated during the operational time to *n* number of active servers. According to this concept, the virtual machines do not leave the system. Instead, the virtual machines have two main states in the system, an active state, when the VMs are online, and a passive state, when the VMs are offline. The passive state is known in the original model as the thinking time. During the thinking time, the user does not generate any workload in the system, which corresponds to the concept of offline hours by a VM. In the next section, will discuss the implementation of the simulation model demonstrate the obtained computational results.

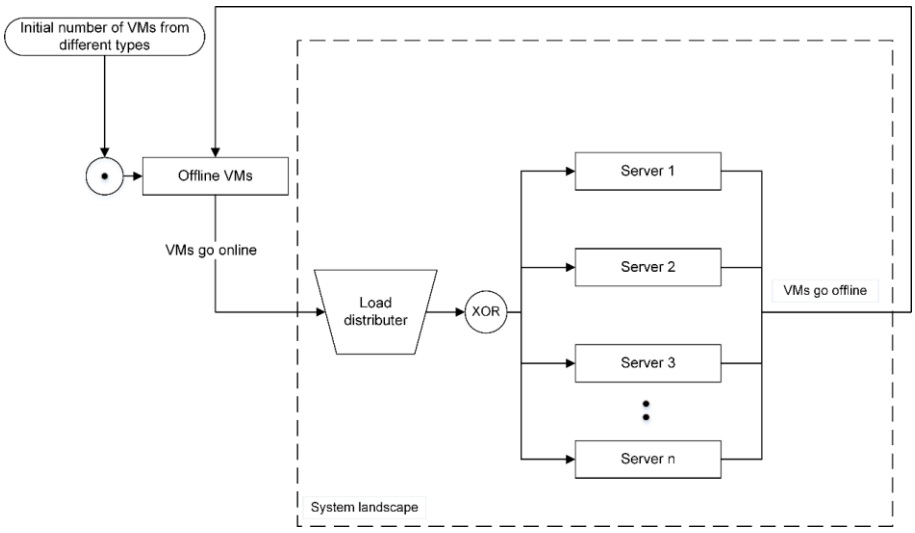

Figure 1: Conceptual representation of the simulation model based on the closed class interactive workload queuing network for IT landscape.

4 Implementation and computational results

Since new load distribution strategies are not supposed to be, without previous evaluation, directly used during the operational time, a prototypical implementation of the presented concept has been developed in the form of a simulation study. The IT landscape of the considered system and its specification have been mapped to the simulation model. The simulation model has been built in ExtendSim simulation package. Discrete event simulation approach has been adapted to build the simulation model. We evaluated two different scenarios using different load distribution strategies to identify the most suitable strategy for reducing energy power consumption.

4.1 The evaluated load distribution algorithms

We evaluated load balancing and load concentration algorithms on the modeled system with the given specifications. A control policy based on lower- and upper-threshold is

designed to conduct live migrations on the virtual machines. A 25 % local lower threshold on the physical hosts has been evaluated to initiate migrations in the system. Moreover, the control policy is executed whenever a virtual machine goes offline to decided whether to trigger a live migration or not. The migration policy is conducted only to switch off an active server if this desired migrated load can be hosted on the other active servers in the system. However, a 20 % global upper threshold of the RAM capacity is evaluated to automatically scale up the system capacity through activating hibernated physical servers.

The load concentration algorithm

Since the bottleneck of the system, described in the use case, is the main memory, the algorithm is designed to allocate VMs based on the main memory utilization of the servers. The load concentration algorithm is based on the best-fit decreasing algorithm, which has been modified to allocate the VMs based the main memory. Moreover, the algorithm maintains a list of the available capacity of all active servers sorted in an increasing order. It is a very straightforward algorithm, which concentrates the load on the currently most loaded server. This is to reduce the number of initiated migration policies since the least loaded server maintains its status and does not receive any new VMs if not needed.

The load balancing algorithm

The load balancing algorithm is similarly designed to the load concertation one. It is also based on the best-fit decreasing algorithm, which has been modified to allocate VMs based on the main memory utilization of the servers. However, this algorithm maintains a list of the available capacity of all servers sorted in decreasing order. The algorithm aims to sustain a balance in the workload between servers by allocating VMs to the least loaded server, which is the first server in the list. The migration policy of this strategy is based on the threshold principle.

4.2 Evaluation and computational results

The demonstrated distributions in Table 1, has been used to model the processes of the virtual machines in the system. Two algorithms are tested in combination with migration and control policies. Eight servers have been taken into consideration with 500 GB main memory capacity for each. The simulation has been set to consider a time interval of 120 hours, which correspond to five days. For each simulated scenario, 200 replications are recorded to ensure the quality of the obtained results and eliminate the byes from the system. The average total shutdown hours of all servers, the average number of initiated migration policies and the average of the total migrated VMs have been closely observed over the conducted simulation runs. A 95 % confidence interval has been applied on all observed measurements to observe the possible deviation and

obtain the margin error. The computational results of the evaluated scenarios are presented in Figure 2.

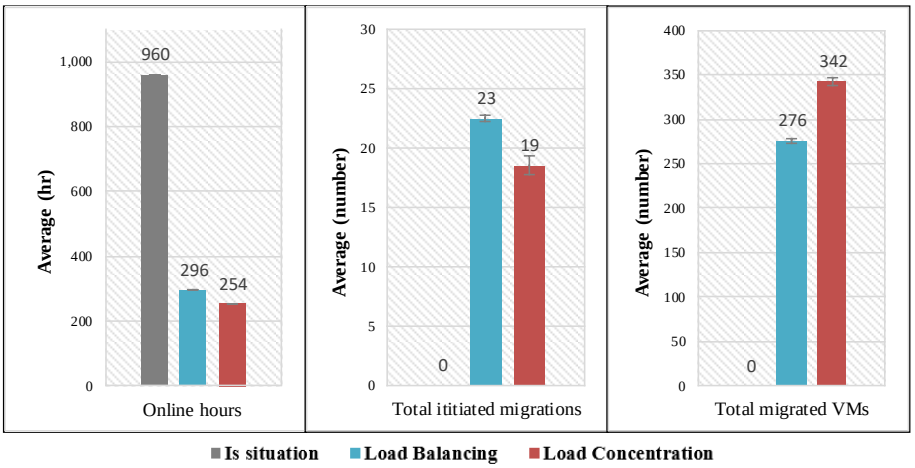

Figure 2: The computational results of the simulation model.

With a simple calculation, the total possible online hours of all servers over the simulation time is equal to the number of servers multiplied by the number of simulated hours of five days, which is 960 online hours. Both load distribution strategies manage the load of the described system using roughly between 25% and 30 % of the total available online hours of all servers. The load concentration strategy outperforms the load balancing one in terms of maximizing the total shutdown hours. However, the load balancing algorithm reports a significant outperformance in terms of the number of migrated VMs during the considered time span. Although as expected, the number of initiated migration policies by the load concentration algorithm is slightly smaller, the number of migrated VMs is considerably higher than the one, reported by the load balancing algorithm.

5 Conclusion and future work

The analysis showed that the load concentration algorithm performs the best to reduce the energy consumption of the considered IT landscape. Nevertheless, we recommend applying load balancing algorithm with a global lower threshold to maximize total shutdown hours since this algorithm maintains a higher stability in the system in terms of the number of migrated virtual machines. Nowadays, a considerable proportion of cloud customers are small or middle size companies, which outsource their entire IT requirements based on the concept of cloud computing. Those, reflect a high potential in managing their system efficiently by an IT service provider through seizing the advantage of their predicted generated load behavior. Future works might spot a light on a hybrid load distribution strategy for managing IT system landscapes. Moreover,

investigating a large-scale use case, in which several independent closed IT system landscapes are taken into consideration, would generates a federated or autonomic management of load distribution strategies in data centers. Let us assume that a definite number of closed classes can be indicated in a data center. Accordingly, we can classify them into classes and separate their load distribution algorithms. In other words, the load distribution strategies can be implemented and offered as a service to manage the workload of a data center to satisfy various SLAs requirements. Based on the requirements of various systems, a distribution algorithm with the required allocation dimension (e.g. RAM, CPU or a combination) might be used to manage their generated workload in the data center. This federation of managing the data center might allow IT service providers to manage the load distribution more efficiently, by seizing the advantage of separating unpredicted workload system (e.g. web application of online shop) from the predicted ones. In addition, solving smaller independent sub-problems and managing resource allocation in data centers based on autonomic strategy might contribute in gaining major advantages over highly generic solution for a sustainable IT resources management.

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Contrasting Brand Community Support for Sustainable Smartphone Practices of Charging and Managing Battery Power

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Abstract. Charging and managing the battery power of smartphones has energy impacts on a global scale. In studies of social practices the immediate material arrangement, i.e. the smartphone product design, itself has received less attention. Human-battery interaction and its link to a specific design becomes crucial in the light of technology brands' sustainability marketing. For some time, closed product designs in smartphones fabricated a link between battery life and the life span of the smartphone. In order to adjust daily habits towards conservation of battery life people need to be engaged. The aim of this paper is to give insights into which engagements peer-to-peer problem solving communities transport with regard to battery practices. Battery narratives reported by online brand community members were investigated through netnographic procedures. The results of the descriptive inference indicate that sustainability-oriented interactions in brand communities vary. The engagements towards energy saving are more wide spread in closed product design contexts than in the design for repair context.

Keywords: Online community, Sufficiency, Sustainability Marketing, human-battery interaction.

1 Introduction

Considering a rising global population and limited natural resources, sustainability and the reduction of energy consumption presents an important challenge. The relationship between smartphone use and the environment, as mediated by consumption practices benefits from different perspectives. Sustainability marketing research is well known for its focus on consumer attitudes towards the environment [1]. This research community has struggled with a long-standing gap between reported consumer intention and action [2]. On the one hand, consumers begin to adopt sustainability-oriented smartphone brands, but on the other hand, the readiness to forsake convenience of use is limited. Hence, solutions directed at reducing energy consumption have to take consumer practices and the engagements underlying their actions into account. From this, companies who wish to understand this market may derive important implications.

The positive impacts of information and communication technologies (ICT) like smartphones have on our *digital life* include dematerialization, online delivery, greater

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energy efficiency in production, and social impacts, such as eased connectivity [3, 4]. However, one cannot neglect the negative impacts of the production and consumption of ICTs, such as emissions into the air, water, and soil; the consumption of valuable metals; and the increasing consumption of primary energy [5, 6] during production. The energy consumption of smartphones during use has naturally energy impacts on a global scale. In order to power the estimated 5.34 billion phones in operation in 2010, a 3.15 GW wind power capacity would need to run for one whole year to provide the global consumption of 6-8 TWh [7]. In addition to the globally rising CO-2 emissions of mobile communications, results from a field trial display that during the charging process of mobile phones half of the energy taken from the electronic grid is lost on average [7]. Hence, smartphone use has considerable potential for saving energy.

Gradually, sustainability marketing research takes into account the increasing use of smartphones [8]. In debates about pathways towards more sustainable markets, voluntary agreements among brands are usually juxtaposed to regulatory measures as a means to reduce the energy requirements of ICTs [7, 9]. The emerging perspective of ethical branding, which intends to increase the share of sustainability-oriented products [10], is valuable, but remains restricted to the acquisition of goods. Research most often investigates consumers' propensity to acquire sustainability-oriented goods, but with regard to smartphones, this allows little insights into use practices that affect battery life.

Studies on human-battery interaction that control for smartphone product design have relied on survey methods to discern the environmental attitudes [11] and the collection of battery information through apps [12]. These studies promise reliable insights with regard to the actual energy consumption of smartphones. However, these perspectives are not able to account for smartphone use practices that consist of *social* action. Socio-cultural aspects of consumer culture may explain why consumers act in a certain way [13].

The cultural dynamics associated with symbolic brand meaning offer opportunities to *energize* sustainability-oriented battery power management further. The goal of this research is to make sense of the engagements that drive consumers' battery management practices. It therewith complements studies that take into account usage of the devices after purchase [14].

This study extends earlier perspectives on battery practices to take into account the *situatedness* of social interactions [15] in the specific setting of online brand communities. Online communities have been proposed as fora that spread signifying practices and sustainability-oriented engagements [13].

Brands, by themselves are symbols that marketing practices advance in a multitude of ways to make consumers care for their product in the first place. Sustainability marketing supports consumer education in favor of sustainable practices [16], with online communities presenting a suitable context for such interactions [17]. This paper furthers the sustainability marketing research agenda to answer the question: Which engagements go together with practices of charging and managing battery power in different brand communities?

As of now, few studies on technology use consider energy consumption in smartphones as discrete bundles of practices and material arrangements. In the

following section, the social practice theory approach to energy consumption is laid out. In the section on empirical research, the article tackles the procedures of data acquisition and analysis. The findings section presents instances of *doing* sustainability-oriented smartphone consumption. Here, sustainability is defined narrowly as practices that save energy. In the outlook section, wider implications for fostering transformation towards sustainable smartphone practices are considered.

2 Conceptual Framework

There is an astonishing literature within environmental informatics research that provides instruments, helping to reduce resource consumption [18, 19]. One instance is the concept of smart consumption feedback, which intends to drive change of user consumption patterns [20, 21]. Empirical research that tracks the longevity of such interventions is critical of longer-term effects [22]. The bottom line of interventions directed at energy consumption is that users have to be engaged to change their routines. Social media communities have been optimistically considered a force for social good, because they facilitate interaction and potentially leverage commitment towards resource conservation [17].

Social Theory

In earlier energy research the praxeological concepts of Schatzki [23] and Reckwitz [24] were well received. Social practice approaches to consumption promise to provide an improved grasp of barriers and enablers of sustainable smartphone practices. Energy consumption practices are highly integrated with technological systems [22, 25]. Smartphone product design is increasingly accommodating to circular economy perspectives [26], providing consumers with a choice of either an open or a closed design. These material arrangements exert affordances for sustainability-oriented smartphone use. Battery practices are a distinct practice field that allows an exploration of the engagements that participants direct towards specific smartphone use practices.

For an empirical practice study of smartphones 'the functions of items within repertoires of practices are the primary data for an analysis of consumption' [27]. Four elements that hold practices together are used to explore battery practices as they are enacted online: (1) know-how and embodied habits, (2) institutionalized knowledge and explicit rules, (3) engagements and (4) technologies.

In order for a transformation of practices to take hold [27] people need to be engaged. Practice fields are contexts that carry meanings and ways to relate to material arrangements. For example, work practices may require users always to maintain a fully charged smartphone battery. Such on-site [22] practice fields are extended to online contexts which are by themselves practice fields [28]. For human-battery interaction this means that social interaction in online communities may exert engagements with regard to smartphone practices, given that users see an immediate social use for their participation [29].

Engagements within Peer-to-Peer Problem-Solving Communities

The practice element of engagements orients locally situated conventions within practices towards higher ends. Exactly, what constitutes this higher end depends on a of range factors and may entail both individualistic and collectivistic objectives. Peer-to-peer problem-solving (P3)-communities may be considered as contexts in which situated conventions are formed. The display of proven rules of smartphone practice online gives rise to groups of activities that form projects, understood as combinations of tasks [30]. Often these interactions are intended to inspire others to adjust their embodied habits regarding their use of technology. In order to grasp the inspiration that underlies technology use a praxeological approach is of great use. An empirical design therefore uses hermeneutic interpretation to infer the engagement elements of a practice through careful scrutiny of the interactions between participants and the meanings they attach to their actions [31]

3 Empirical Research

This netnographic research investigates the practices of consumption communities through using publicly available online information about interactions as data [32, 33]. Since the research question relates to social practices, data are conceived of as '"products of participants" social performing [sic!] with others or in relation to others. This way, such data can be seen as expressions of social action' [31]. Two online P3 communities were selected, which are also smartphone brand communities. The first community is hosted by the brand, Fairphone, while the iPhone community is not supported by the brand Apple.

Data collection

On a descriptive level, the two communities differed significantly in the period between mid-2014 and end of 2015. The Fairphone community had 2812 active users and 21.511 posts in this period, while the iPhone community had only 1464 active users and 13.234 posts. This can be explained by the simple fact that data of the iPhone community is provided by a German website, which thus has a smaller target audience.

Consequently, the Fairphone community produced more posts on an average day with 62.4 (SD = 40.8) than the iPhone community with 38.4 (SD = 42) posts. This also goes in line with the average answers per post. Specifically, the Fairphone community answered threads with 29 posts on average (SD = 62.1) and the iPhone community with 14 posts on average (SD = 66.9).

Considering the average number of posts produced by one user, a striking difference between the two communities may be observed. The smaller iPhone community has more average posts per user with 9 (SD = 27.3) in a day than the bigger Fairphone community with 7.6 (SD = 37.3).

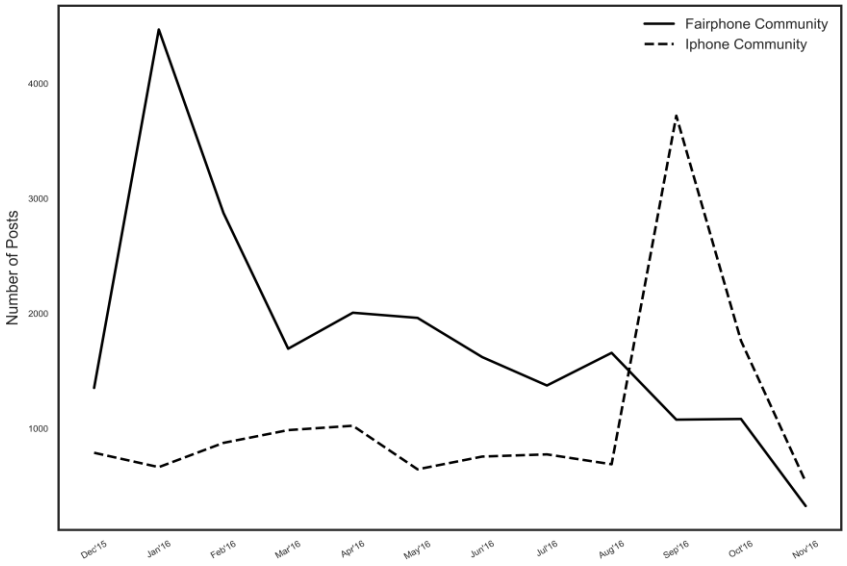

Figure 1. Total post counts for Fairphone and iPhone communities over time

Additionally, the average user lifespan of 45.8 days (SD = 80.6) for the Fairphone community and 61.1 days (SD = 98.6) for the iPhone community shows similar patterns. These statistics indicate that even though the iPhone community is smaller in number than the Fairphone community, its average user is more active for a longer time.

However, it is crucial to note that there is no such thing as the average user, neither in the Fairphone nor in the iPhone community. In both cases, nearly half of the community consists of users who are only active for a single day (Fairphone community with 49.8% and iPhone community with 45.1%). However, as these single day users are evenly represented in both communities, the above observations still hold.

Another observation is that even though both communities have roughly the same percentage of single day users, the number of single day users, who provide multiple posts, are higher in the iPhone community than in the Fairphone community. In fact, 40.6% of users in the Fairphone community and 28.7% in the iPhone community have only a single post.

Considering the user activity across the whole year, two peaks, one for each community, stand out (Figure 1). These peaks can be explained by the release of the new Fairphone2 on December 21th and the release of the iPhone7 on September 16th, respectively. Furthermore, activity in these P3-communities displays receptiveness for marketing practices.

Netnographic research with an interdisciplinary focus on social practices in consumers' everyday serves the purpose of identifying elements holding practices together such as engagements or meanings as well as user know-how and procedures. In other words, data on smartphone practices is used to answer the question 'which engagements seem to go together with which procedures?' [34].

The coding procedures were carried out with the support of computer-assisted qualitative data analysis software MaxQDA12. The archived online postings about battery management cover the period between mid-2014 and end of 2015 for the Fairphone community. For the iPhone community it was possible to cover a much longer period, spanning from 2010 to 2015. The descriptive inference covers one product generation for Fairphone and several product generations for the iPhone. This broad data base fulfills the objective of this study to increase the amount of observed social practices within the two online communities, a common step in qualitative research involving a small amount of cases [35]. This serves to improve confidence in understanding the prevailing engagements within the two communities.

To explore the structures of engagement visible in user procedures, all the threads in the data were screened for the terms 'battery', 'energy', and ‘power’ and the respective German expressions for the terms. The data for the transnational English-language Fairphone community returned 1.171 hits related to these search terms within the period observed of approximately 18 months. By comparison, the data on the German-language iPhone community returned 510 hits, but for a much longer period of approximately 60 months (see figure 2). Considering the total hits in the Fairphone community, many reported functional defects with the battery of the first generation Fairphone, which explains the great amount of posts. The further analysis excluded obvious battery defects, because they did not relate to routine user procedures of handling the smartphone battery.

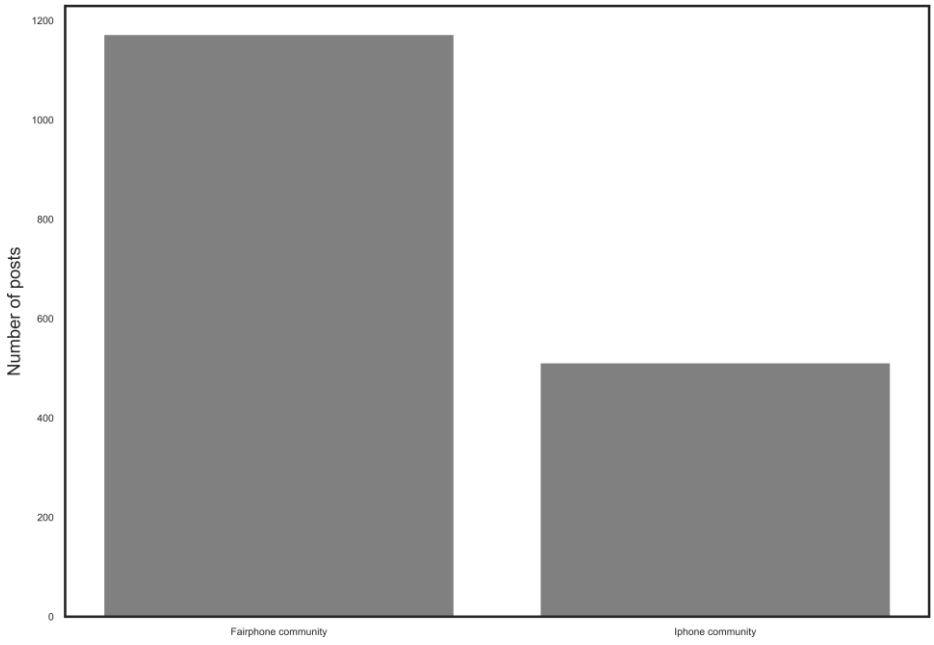

Figure 2. Total battery-related posts for Fairphone and iPhone communities over time

The matches and related discussion threads were exported to a calculation sheet. Practices of charging and managing battery power were subjected to manual within-code coding [36] for selected categories to grasp emerging engagements tied towards battery procedures.

Sufficiently detailed postings were coded with three types of battery practices. The procedures and engagements consisted of [14]: (1) procedures devoted to actions that do not save any energy, but improve the deficiency through drawing on new or additional energy sources to ensure the functionality of the smartphone; (2) procedures that enhance energy efficiency; (3) procedures that display curtailment measures to save energy. The inquiry focused on the question, whether reflexivity, which is located at the level of engagements, becomes enacted within procedures of battery power management, to form end-task-action combinations [30]. Procedures that carry sustainability-oriented engagements were marked either with (2) or (3). Accordingly, in battery use procedures marked with (1), no sustainability-oriented engagements were discerned.

4 Findings

Growing data traffic routed through smartphones and the adoption of applications relying on the internet make practices directed at managing battery power increasingly important [14]. Many other practices are co-dependent upon the mobile device, which in earlier studies on mobile communities was put in a nutshell as 'no juice, no use' [37].

The distribution of different types of battery practices reveals an interesting pattern. As depicted in Table 1, 70% of iPhone community users carry out sustainability-oriented smartphone battery practices in contrast to 46% of Fairphone community users. In interpreting these results, caution is required and the material arrangements of the two research contexts must be taken into account. Only use practices involving the first generation device Fairphone 1 formed part of the Fairphone community sample. For the iPhone community, the base was a much broader, including several generations of iPhone devices, which were available on the market between 2010 and 2015, as well as used products. The Fairphone is a very young brand, and more basic users are active in the community, overall the amount of expert users is smaller. By comparison, in the iPhone community, more time elapsed during which knowledge about battery practices could be accumulated.

Table 1. Distribution of engagements across battery practices

	Fairphone	*iPhone*
Battery Practices	N=102	N=296
Engagements		
Enhance energy efficiency	28 (27%)	125 (42%)
Curtailment	19 (19%)	82 (28%)
Do not save energy	55 (54%)	89 (30%)

Users of iPhones share more advice on how to enhance energy efficiency. Here the material condition of the iPhone with its non-removable batteries exerts an effect. For the Fairphone, which adheres to a design philosophy that allows opening and self-repair, practices of enhancing energy efficiency are less of an issue.

Procedures that don't save any energy

The documentation of adjustments, even if the procedures presented do not save any energy at all, but serve to keep the functionality of the device intact, are typical of grooming practices which participants offer as how-to-consume manuals. Users get creative in this regard and there are sometimes also myths surrounding these measures: '*Especially lately I notice how my battery gets warm while I use it so I turn it off and take the battery out for a couple minutes*' (posting). Often it is impossible to tell, whether such measures have an actual effect.

Curtailment measures

The curtailment measures that manage battery power are ways of relinquishing some of the many features of smartphones. In areas where the expansion of Wi-Fi-infrastructure meets with a growing multi-functionality of smartphones, curtailment measures become unattractive, given that in many social settings, participation in social media is a *must-have*, sometimes leading to addiction [38].

In managing battery power, the focus of participants' commitment is directed at several sites of the social. The acquisition of spare batteries clearly champions the everyday activity in which the smartphone is involved. The curtailment that is involved in doing without the smartphone for some time, places the focus on the coherence of sustainable smartphone practices. Here sufficiency becomes palpable.

Procedures that enhance energy efficiency

Some features of smartphones enable a monitoring of energy use and therefore support practices of charging and managing battery power that enhance energy efficiency. '*My Fairphone currently tells me, that 74% of battery usage was for the display*' (posting).

Users also exchange information about additional battery apps to track their energy consumption. Sometimes users join the forum, when they are unskilled in handling their battery, for example if it drains faster than expected. There are often constellations of hardware/software/usage which defy energy saving. This becomes crucial if users have to forego the functionality of their device.

If techniques of energy efficiency are in concern, aspects of software have to be taken into account. *'Push notifications (Facebook, Gmail etc.) that are on continuously drain the battery'* (posting).

The use practices of 'grooming' and 'customizing' refer to documenting innovative on-site practices, which are formalized through their very explication [39]. Expert users, who are in possession of greater competence, display a greater degree of commitment to the objective of *doing* sustainability-oriented smartphone consumption.

These users present further performances of engaging in a mission for more sustainability, therewith putting forth techniques that enhance energy efficiency.

The descriptive inference about types of battery practices has displayed the range of different smartphone battery practices. Although the engagements leading to curtailment measures with regard to battery power featured evocative quotes from the Fairphone community, these practices are less common than in the iPhone community. This might well be associated with the open design, as many users, who frequently travel, acquired spare batteries. Since curtailment measures may be associated with the sustainability-oriented norm of sufficiency, it comes as a surprise that iPhone users more frequently share advice about curtailment measures with regard to battery power procedures.

The Fairphone brand story advocates social sustainability and fair working conditions during the production of smartphones. Through acquisition of the device, users in the community have expressed commitment towards sustainability-oriented engagements. These engagements do not necessarily translate into sustainability-oriented smartphone usage after acquisition. Saving energy is not part of the brand story and is apparently not on the radar of many users. With regard to battery practices, iPhone users are displaying a greater commitment towards sustainability-orientated engagements that translate into specific practices of charging and managing battery power. The functionality of the smartphone is of even greater importance when users are away from convenient ICT infrastructures or electricity [40].

5 Outlook

Engagements have been found to spark consumers' actions and to cause changes within existing practices [22]. Consumers suggest idiosyncratic adjustments to smartphone battery practices online. The insights for potential sustainable product innovations concern not only specific functions, which diffuse rapidly in this market. Based on the objectives of the study, the following insights were generated: the engagements that are tied to battery practices within the observed brand communities differ considerably. However, the marked prevalence of procedures directed at saving energy, stems from product design, rather than a general propensity towards sustainability within a brand community. On the one hand, almost half of the end-task-action combinations in the iPhone community were oriented towards saving energy. On the other hand, around half of the end-task-action combinations in the Fairphone community are not concerned with saving energy at all. This snapshot of the Fairphone community indicates a turning away from energy consumption practices directed at sufficiency. Both energy efficiency and curtailment practices would benefit from the provision of information on how to improve the management of battery power. Power management of future smartphones could improve usability and incorporate manufacturer information [14].

In a broader perspective, a non-removable not working battery usually leads users to discard their phones. The product design of the Fairphone prioritizes longer usage of the entire device against a reduction of smartphone energy consumption. There remains considerable potential for brands to support transformations towards sustainable

consumption practices by ensuring that, if new practices are adopted within communities, they are maintained [41]. Given the sustainability challenges that the smartphone market faces, the desire of consumers for more ethical alternatives is unlikely to be short lived.

This study had the following limitations. First, the paper reported on only two different online communities. To learn more about the conventions specific to the on-site contexts of the everyday, such as the use of ICTs in mobility cultures, future research should study the practices of further communities. Second, the number and type of observations were limited to online data, indicating that consumers express their narratives in public [42] and refer to on-site practices. Third, in this research, the period between the actual documentation of user comments online, interpretive analysis and discussion through a netnographic summary spanned approximately 24 months, which might count as a limitation when the constantly evolving functionality of smartphone batteries is considered.

This article focused on the use of a specific technology in everyday practice. It would be interesting to compare the constitutive context of P3 communities across settings of multiple brands and to determine the level of preparedness of users to practice more sustainable ways of consuming smartphones. Future research could also examine the role that moderators in online environments can play to foster sustainable practices.

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Informationssysteme und Innovationsstrukturen in der Finanzwirtschaft

Teilkonferenzleitung

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Einfluss der vertraglichen Zielgestaltung auf den wahrgenommenen Outsourcing-Erfolg
Eine explorative Analyse im deutschen Bankensektor

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Abstract. Die Auslagerung von IT-Dienstleistungen gehört im kompetitiven deutschen Bankensektor zu einem etablierten Mittel des strategischen Managements. Die bestehende Literatur fokussiert vor allem auf die Erfolgsfaktoren. Der Outsourcing-Vertrag wurde zwar als wichtiger Faktor einer erfolgreichen Auslagerung identifiziert, diesbezügliche Forschung, die den Vertrag in den Mittelpunkt stellt, ist jedoch rar.

Die vorliegende Arbeit untersucht explorativ den Zusammenhang zwischen der vertraglichen Ausgestaltung der Outsourcing-Ziele und dem wahrgenommenen Erfolg der Maßnahme am Beispiel von fünf deutschen Banken. Dazu wurde ein Rahmenwerk zur Abbildung der Ziele in vertraglichen Regelungen entwickelt, die realen Outsourcing-Verträge der teilnehmenden Banken analysiert und die Ergebnisse im Anschluss in Interviews mit Experten, die mit den Auslagerungsprojekten vertraut sind, reflektiert.

Die Ergebnisse haben gezeigt, dass die untersuchten Banken ihre Ziele nicht vollständig erreicht haben. Es konnten Rückschlüsse über ausgewählte vertragliche Mechanismen gezogen werden und deren Einfluss auf den wahrgenommenen Projekterfolg. Insbesondere Regelungen, die im Vorfeld Unsicherheiten abbauen, sind dabei von großer Wirkung.

Keywords: Outsourcing, Finanzdienstleistungssektor, Vertragsgestaltung.

1 Einleitung

Outsourcing bezeichnet im Bankwesen die „Wahrnehmung von Aktivitäten und Prozessen im Zusammenhang mit der Durchführung von Bankgeschäften, Finanzdienstleistungen oder sonstigen institutstypischen Dienstleistungen, die ansonsten vom Institut selbst erbracht würden." [1]. Diese eng ausgelegte Definition steht im Einklang mit anderen Formulierungen, wie sie bspw. Dibbern et al. [2] ausführlich diskutiert haben. Im Kern geht es darum, dass ein Institut Teile seiner Aufgaben durch einen Dritten erledigen lässt. Diese Praxis bildet mittlerweile einen festen Bestandteil des Management-Instrumentariums und folgt einem Trend, der seit Jahren stetig an Bedeutung gewinnt und dessen Ende nicht absehbar ist [3]. Hauptgrund

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für die Anwendung von Auslagerungsmaßnahmen ist die ungebrochene Wettbewerbsintensität, welche zu einem ständigen Innovations- und Kostendruck führt [3, 4]. Outsourcing wird dabei als probates Mittel gesehen, die Wertschöpfungskette neu zu gestalten, um diesem steigenden Druck standhalten zu können [5].

Das Outsourcing Phänomen wurde in der Forschung im Verlauf der letzten drei Jahrzehnte von verschiedensten Seiten beleuchtet [2, 6, 7]. Als ein sehr wichtiger Faktor einer erfolgreichen Auslagerung wurde dabei der Vertrag zwischen Service Provider und Bank identifiziert [8-12]. In der vorliegenden Literatur wurde das Konstrukt des „Vertrags" bislang überwiegend modelltheoretisch als Steuerungsinstrument der Outsourcing-Beziehung diskutiert [11]. Unglücklicherweise entzieht sich die Untersuchung real geschlossener Verträge weitgehend der wissenschaftlichen Forschung, da diese Dokumente strenger Vertraulichkeit unterliegen. Die Autoren dieser Arbeit waren in der Lage, unter Wahrung strengster Vertraulichkeit, fünf reale Verträge analysieren zu dürfen, und mit den verantwortlichen Personen Experteninterviews zu führen. Dabei wurde untersucht, wie die Ziele, die die Bank mit dem Outsourcing verbindet, im Vertrag umgesetzt wurden und *welchen Einfluss die Vertragsgestaltung auf den wahrgenommenen Erfolg der Auslagerungsmaßnahme hat.*

Um diese forschungsleitenden Fragen beantworten zu können, wurde zunächst ein theoretischer Grundrahmen als Basis für die empirische Studie geschaffen. Dieser beinhaltet den aktuellen Forschungsstand, gibt einen Überblick über die grundlegenden Forschungsbereiche des Outsourcings und ermittelt die Ziele, die deutsche Banken mit der Auslagerung verfolgen. Ein wesentlicher Bestandteil der theoretischen Basis stellt die Analyse der Vertragsgestaltung im Allgemeinen dar. Auf diesen Inhalten basierend, wurde eine empirische Studie durchgeführt, die sich aus der Analyse der Verträge und komplementären Interviews mit Experten der jeweiligen Banken zusammensetzt.

Aufgrund der geringen Fallzahl, ist diese Studie als explorativ einzustufen. Sie hat somit das forschungsmethodische Ziel einen Rahmen zu schaffen, der von nachfolgenden Wissenschaftlern als Grundlage für Vertragsanalysen mit breiterer Datenbasis verwendet werden kann.

2 Stand der Forschung

Die Forschung im Themenfeld Outsourcing ist mittlerweile sehr weit fortgeschritten [3]. Sie umfasst bspw. den Auswahlprozess, die Ergebnisse der Auslagerung und die Betrachtung kritischer Erfolgsfaktoren. Für die Betrachtung des Vertrages sind insbesondere die Analyse der Outsourcing-Beziehung sowie Forschungen zum Vertrag per se relevant.

2.1 Die Outsourcing-Beziehung

Dieser Forschungsstrang analysiert, wie die Beziehung zwischen den beteiligten Parteien ex ante aufgebaut, strukturiert und während der Auslagerung gesteuert werden kann. Die Beziehung zwischen den Vertragsparteien stellt einen bedeutenden Faktor für den Erfolg der Auslagerung dar [13-21]. Die Untersuchungen von Barthélemy [16], in welcher 50 Outsourcing-Beziehungen untersucht wurden, zeigen beispielsweise, dass

sowohl vertragliche, als auch relationale Faktoren (z.B. Vertrauen und Kommunikation) Schlüssel zu einer erfolgreichen Auslagerungsbeziehung sind. Daher ist ein umfassendes Verständnis der beiderseitig bindenden Vertragsgestaltung notwendig, um die langfristig angelegte Beziehung positiv zu formen [22]. In der Literatur wird durchgehend postuliert, dass die Outsourcing-Beziehung einen wichtigen Erfolgsfaktor darstellt, und die Vertragsgestaltung einen großen Einfluss hat, da sie der Grundstein für den Aufbau und die Steuerung einer langfristig erfolgreichen Beziehung ist [8-10]. Aufgrund der attestierten hohen Bedeutung des Vertrages bei gleichzeitig ausgesprochen schwieriger empirischer Datenerhebung ist den Autoren keine Publikation bekannt, die die theoretisch erarbeiteten Erkenntnisse mit empirisch erhobenen, realen Verträgen abgleicht. Zahlreiche Autoren postulieren daher, dass weitergehende Untersuchungen der Vertragsgestaltung notwendig sind [22-24].

2.2 Der Outsourcing-Vertrag

Der Vertrag ist Gegenstand verschiedener Forschungsarbeiten, die sich entweder mit dem Vertrag im Allgemeinen oder mit einzelnen abstrakten/ konzeptionellen Klauseln auseinandergesetzt haben [11, 13, 18, 20, 24-28]. Im Zuge der Forschung am konkreten Objekt mit präskriptivem Charakter hat Gellings [29] in ihrer Studie die Merkmale eines erfolgreichen Vertrags erarbeitet. Weitere Untersuchungen befassen sich mit vertraglichen Mechanismen (Vereinbarungen, Bestimmungen oder Klauseln im Vertrag) z.B. im Kontext der Minimierung von Risiken [30]. Demnach können vertragliche Mechanismen wie Anreizsysteme das Risiko eines Qualitätsverlustes minimieren [30] oder Wiederverhandlungsoptionen die Flexibilität erhöhen [26]. Die Studie von Barthélemy [31] zeigt, dass das Ausarbeiten eines „schlechten“ Vertrags zu einer der „sieben Todsünden“ im Outsourcing zählt und erklärt dass ein „guter“ Vertrag u.a. präzise, vollständig und flexibel gestaltet sein sollte. Saunders et al. [9] unterstreichen die Bedeutung des Vertrages, da er die Möglichkeit bietet, ein Machtgleichgewicht zwischen Auftraggeber und Auftragnehmer herzustellen. Chen et al. [23] untersuchten Aufbau und Gestaltung von 112 Verträgen und identifizierten u.a. Audit-Rechte als ein wichtigen Vertragsbestandteil. Die genannten Autoren sehen unisono weiteren Forschungsbedarf bzgl. der Identifikation vertraglicher Mechanismen, welche den Erfolg einer Auslagerung positiv beeinflussen können.

Zusammenfassend kann festgehalten werden, Dass die Outsourcing-Beziehung als besonders wichtig eingestuft wird und der Vertrag dafür ein steuerndes Instrument ist. Letzterer ist jedoch in der Forschung noch nicht hinreichend untersucht, insbesondere nicht an real existierenden Beispielen.

3 Methodik der empirischen Untersuchung

In dieser Arbeit wird zunächst eine qualitative Inhaltsanalyse der vorliegenden Verträge vorgenommen und im Anschluss daran Interviews mit den verantwortlichen Experten geführt.

3.1 Fallstudiendesign

Es wurde ein multiple-case Design nach Yin [32] gewählt, da die Analyse mehrerer gleichartiger Fälle Erkenntnisse über Ähnlichkeiten und Unterschiede im Vergleich zur Einzelfallbetrachtung ermöglicht. Es standen fünf Verträge aus dem IT-Outsourcing deutscher Banken zur Verfügung. Die untersuchten Banken haben eine teilweise oder komplette Auslagerung von IT-Leistungen über einen definierten Zeitraum an einen Service Provider vorgenommen. Die untersuchten Verträge wurden geschlossen, um (a) vormals intern erbrachte IT-Funktionen erstmalig auszulagern, oder (b) einen Providerwechsel zu vollziehen.

Für jede Fallstudie wurde mindestens ein Experte, der das Auslagerungsprojekt der Bank persönlich betreut hat, über die Vertragsinhalte befragt. Die strukturierten Interviews dauerten jeweils ca. 90 Minuten und wurden persönlich oder telefonisch durchgeführt. Im Vorfeld wurde sichergestellt, dass die Interview-Partner die Gestaltung der Vertragsinhalte bewerten können und auch -durch Ihrer langjährige Rolle als Key-Account-Betreuer- den Erfolg der Auslagerung aus Sicht der Bank zuverlässig einschätzen können. **Tabelle 1** gibt einen Überblick über die fünf Cases.

Tabelle 1: Demografie der Studien und Ziele der Vorhaben

Fallstudie	Anzahl Mitarbeiter	Kontext	IT Outsourcing- Ziele (priorisiert)
Bank 1	< 2.500 Mitarbeiter	Providerwechsel	1. Qualitätsverbesserungen, Erhöhung der IT Sicherheit 2. Zugang zu besserem Know-how 3. Kostenreduktion
Bank 2	> 10.000 Mitarbeiter	Erstmalige Auslagerung	1. Zugang zu Innovationen/besseren Technologien, Nutzung von Synergien durch Zusammenarbeit mit Service Provider 2. Qualität mindestens auf dem aktuellen Niveau halten 3. Erhöhung der Kostentransparenz und -kontrolle, Kostenreduktion
Bank 3	< 2.500 Mitarbeiter	Providerwechsel	1. Qualitätsverbesserungen, Zugriff auf bessere Ressourcen, Steigerung der Flexibilität 2. Zugriff auf Innovationen, um IT Sicherheit zu erhöhen 3. Kostenvorteile durch Providerwechsel
Bank 4	> 10.000 Mitarbeiter	Erstmalige Auslagerung	1. Kostenreduktion
Bank 5	< 500 Mitarbeiter	Erstmalige Auslagerung	1. Zugriff auf bessere Ressourcen, Erhöhung der Flexibilität 2. IT Sicherheit und Compliance erhöhen 3. Erhöhung der Kostentransparenz und –kontrolle, Kostenreduktion

3.2 Datenerhebung: Inhaltliche Vertragsanalyse

Basierend auf den vorgenannten Informationen zur Zielsetzung wurden die folgenden Zielmechanismen für das weitere Vorgehen kondensiert: Kosten, Qualität, Flexibilität, Innovationen und IT Sicherheit und Compliance. Im Weiteren wurden die Verträge auf

die Abbildung dieser Mechanismen hin überprüft. In **Tabelle 2** sind die maßgeblichen Zielmechanismen und ihre jeweiligen Detailmechanismen beschrieben, wie sie in den vorliegenden Verträgen identifiziert werden konnten.

Tabelle 2: Untersuchungsrahmen der inhaltlichen Vertragsanalyse

	Mechanismus	Vertragliche Fixierung
Kosten	Vergütungsstruktur	Abrechnung nach tatsächlichem Verbrauch (Preismodell); Vergütungsstruktur vorteilhaftig für beide Parteien; Kosten transparent nachvollziehbar; welche Preismodelle (z.B. variabler Kostenansatz oder Fixpreise).
	Preisanpassung (Benchmarking)	Periodischer Preisvergleich zum Markt vorgesehen (Benchmarking); fixierte Option, die Preise auf Basis von Benchmark-Ergebnissen anzupassen.
	Preisanpassung (Volumen)	Preisanpassung bei Überschreitung einer definierten Leistungsmenge.
	vereinbarte Kostensenkungsziele	Vereinbarung, innerhalb eines definierten Zeitraumes die Kosten um einen definierten Prozentsatz zu senken.
	Anreizsysteme für Kostenoptimierung	Regelung, den Dienstleister zu motivieren, Kosteneinsparungspotenziale aufzuzeigen und zu realisieren (z.B. in Form einer Gewinnbeteiligung (Profit- oder Gain-Sharing).
Qualität	Bonus-/Malus-System	Bonus-/Malus-System, gekoppelt an definierte Service Level Agreements (SLA).
	SLAs	Vollständig und eindeutig beschriebene SLAs.
	SLA Messungen	Festlegung, in welcher Form und welchen Intervallen SLAs gemessen werden.
	SLA Reporting	Festlegung, in welcher Form und welchen Intervallen SLAs berichtet werden.
	SLA Monitoring	Festlegung, in welcher Form und welchen Intervallen SLAs kontrolliert werden.
	Eskalationsprozess	Prozess, bei Nichteinhaltung vereinbarter Leistungen oder bei Konflikten
	Kontinuierlicher Verbesserungsprozess	Dedizierter Prozess zur permanenten Qualitätsverbesserung und Durchführung von Optimierungsmaßnahmen.
	Nutzung von Standards	Vereinbarung standardisierter Frameworks z.B. ITIL oder COBIT, um Qualitätsstandards zu gewährleisten.
Flexibilität	Vertragsänderung	Einzelne Vertragsteile können bei Bedarf angepasst werden.
	Vorzeitige Kündigungsrecht	Möglichkeit einer vorzeitigen Vertragskündigung (Termination for Convenience).
	Änderungsprozess	Definierter Prozess, mit welchem Veränderungen implementiert werden.
	Exit-Management	Mitwirkungspflichten des Auftragnehmers im Falle einer Vertragsbeendigung sind definiert.
	Vertragsverlängerungsoption	Es existiert die Möglichkeit den Vertrag zu verlängern, und es gibt Vereinbarungen über die Konditionen.
	Governance-Strukturen	Es gibt eine vereinbarte Governance-Struktur, die verantwortlich für die Umsetzung und Steuerung von Änderungen ist.
Innovationen	Anreizsysteme für innovative Lösungen	Es gibt spezielle Anreizsysteme für Innovationsprojekte z.B. Profit-/Gain-Sharing.
	Produktivitätssteigerung	Es wurde eine definierte Produktivitätssteigerung (z.B. Verbesserung der Produktivität um 5 Prozent p.a.) vereinbart.
	Governance-Strukturen (Innovationskomitee)	Es gibt eine dedizierte Governance-Struktur, die verantwortlich für die Entwicklung und Umsetzung von Innovationen ist.
IT Sicherheit und Compliance	Audit-Rechte	Es gibt Vereinbarungen für die Durchführung von Audits.
	Regulatorische Änderungen	Es gibt Vereinbarungen zu Vertragsanpassung bei regulatorischen Änderungen.
	Datenschutz und -sicherheit	Es existieren Klauseln zu Datenschutzbestimmungen und Datensicherheit.
	Int. Kontrollsystem (IKS)	Es gibt ein IKS für Risikosteuerung und -controlling .
	Notfallkonzept (BCM und Tests)	Es existiert ein Notfallkonzept/Business Continuity Management um die operative Geschäftstätigkeit im Notfall zu gewährleisten (inkl. Testzyklen).
	Einhaltung von Sicherheitsstandards	Es existieren Vereinbarungen, die die Einhaltung definierter Sicherheitsstandards (z.B. BSI-Standards) gewährleisten.
	Dokumentation	Es gibt Vereinbarungen zur Dokumentation für Prüfungszwecke.
	Haftungsklauseln	Beschreibt, in welchem Verhältnis zum Gesamtvolumen des Vertrags der Dienstleister bei fahrlässigem oder vorsätzlichen Handeln haftet.

4 Datenanalyse

Das o.g. Rahmenwerk dient als Grundlage der strukturierten Experteninterviews. Die Interviews geben Auskunft über die Ziele der Banken im Zusammenhang mit der Auslagerungsmaßnahme und den (subjektiven) Erfolg dieser Maßnahme aus Sicht der Bank. **Tabelle 3** zeigt einen zusammenfassenden Überblick über den wahrgenommenen Erfolg der Outsourcing-Projekte aus Sicht der Bank.

Tabelle 3: Übersicht über den wahrgenommenen Erfolg der Auslagerungen

	Bank 1	Bank 2	Bank 3	Bank 4	Bank 5
Zielerreichung	Nicht erreicht	Teilweise	Teilweise	Nicht erreicht	Teilweise
Zufriedenheit Auslagerung insgesamt	Sehr unzufrieden	Zufrieden	Zufrieden	Wenig Zufrieden	Wenig Zufrieden

4.1 Ergebnisse der Experteninterviews

In den Experteninterviews wurden die Ansprechpartner strukturiert zu den fünf übergeordneten Zielkategorien der Banken befragt. Sie wurden um eine Einschätzung der jeweiligen Zielerreichung gebeten und wurden motiviert, die Sachverhalte umfänglich zu erläutern.

Bzgl. der **Kostenziele** konnte ein deutlicher Zusammenhang zwischen der Gestaltung der Vergütungsstruktur und dem wahrgenommenen Erfolg einer Auslagerungsbeziehung hergestellt werden. Konnte der Provider mit der Auslagerung keinen Gewinn erzielen, führte dies zu einer weniger erfolgreichen Auslagerungsbeziehung. Ferner kann gesagt werden, dass Handlungsbedarf im Bereich der Transparenz der Kostenaufstellung besteht. Auf breiter Basis berichteten die Experten von der Unzufriedenheit der Banken mit nicht nachvollziehbarer Darstellung der verrechneten Kosten. Insbesondere wird die Möglichkeit vermisst, auf die Kostenpositionen Einfluss zu nehmen.

Daher ist bereits in der Vertragsgestaltung darauf zu achten, ein Preismodell zu wählen, dass die Möglichkeit bietet auf das Ziel „Kostenreduktion“ zu wirken. Dafür eignen sich besonders verbrauchsorientierte Modelle mit niederstufigen Schwellwerten. Eine Cost-Plus-Methode ist laut den Aussagen der Experten weniger geeignet, denn dieses Modell bietet dem Provider zu wenig Anreiz selbständig Kosten zu optimieren. Eine Preisneuverhandlungsoption auf Basis von Benchmarking-Ergebnissen empfiehlt sich bei längeren Vertragslaufzeiten, um die Preise auf ihre Angemessenheit zu überprüfen. Preisneuverhandlungsoptionen auf Basis von Volumenänderungen in der Vertragsgestaltung zu berücksichtigen ist empfehlenswert, wenn die Banken ein dauerhaftes Wachstum anstreben. Bei eher schwankenden Volumina ist es sinnvoller, eine Mengenstaffelung zu vereinbaren. Die Gestaltung von Anreizsystemen wie z.B. Gain-Sharing, hat sich vor allem bei Verträgen, bei denen die Parteien gemeinsam in neue Technologien investieren, als zielführend herausgestellt. Hier besteht das Potenzial bei langen Laufzeiten, Kosten zu reduzieren. Damit das Modell in der Auslagerungsbeziehung tatsächlich angewendet werden kann, sollte die Mechanik zur Feststellung der Erfolgsbeteiligung explizit im Vertrag geregelt sein.

Banken, die ihre **Qualitätsziele** mittels expliziter SLAs mit eindeutigen Leistungsanforderungen formuliert haben, zeigten erfolgreichere Auslagerungen. Insbesondere wurden in diesen Verträgen die Messverfahren und Messpunkte für die jeweiligen Service Levels klar festgelegt. Für das Monitoring der Leistungserbringung hat es sich als sinnvoll erwiesen, ein Service Level-Management einzurichten.

Bereits während der Vertragsgestaltung sollte eine Steuerungseinheit (sog. Retained Organisation) etabliert werden, die regelmäßig die Einhaltung der SLAs überwacht und kontrolliert. Die Vereinbarung dieser Funktion erleichtert die Institutionalisierung nach Vertragsschluss und stellt sicher, dass sich beide Parteien im Vorfeld hinreichend mit der Thematik beschäftigt haben.

Einige Interviewpartner wiesen darauf hin, dass es zielführend sei, mindestens ein Malus-System zu vereinbaren (4 der 5 Banken), wobei wichtig ist, das System nicht zu komplex zu konstruieren. Wünschenswert wäre ein Bonus/Malus-System (in nur einer Bank im Einsatz), welches den Dienstleister stärker motiviert. Zwischen der Implementierung solcher Systeme und dem Erfolg der Auslagerung konnte kein klarer Zusammenhang etabliert werden.

Die Untersuchung hat gezeigt, dass dem Eskalationsprozess eine hohe Bedeutung bei der Zielerreichung zukommt. Er bietet den Parteien regelmäßig die Möglichkeit, strukturiert Probleme zu diskutieren. Bei der Gestaltung des Prozesses, haben die Vertragspartner mehrere Eskalationsstufen definiert, um auf verschiedenen Ebenen mit Fach-und Führungspersonal kommunizieren zu können. Besonders geeignet erscheint dabei die Option über einen sogenannten “Fast-Track“ den Eskalationsprozess zu beschleunigen. Es empfiehlt sich weiterhin, bei der Vertragsgestaltung internationale Standards wie ITIL und COBIT zu verwenden. Es hat sich bewährt, Prozesse wie z.B. das Service Level-Management gemäß ITIL oder auf Basis von COBIT einzurichten.

Um **Flexibilitätsziele** zu erreichen, sollte ein standardisierter Änderungsprozess im Vertrag fixiert werden. Die Parteien sollten gemeinsam definieren, welche Änderungen im Rahmen der Leistungserbringung mit dem Vertrag abgegolten sind (z.B. technische Änderungen, regulatorische Änderungen) und wie Änderungen vergütet werden. Die Experten bewerten diese Maßnahme zur Reduktion von Unsicherheit als maßgeblich für die Vertrauensbildung und damit als wichtig für den Outsourcing-Erfolg.

Es empfiehlt sich außerdem, eine vorzeitige Kündigungsmöglichkeit zu vereinbaren wie bspw. ein Sonderkündigungsrecht, welches ab dem zweiten Vertragsjahr angewendet werden kann. Eine sogenannte „Termination for Convenience“-Klausel erlaubt es der Bank jederzeit ohne Angabe von Gründen zu kündigen (gegen eine im Vorfeld vereinbarte Ausgleichszahlung). Zusätzlich sollte eine Verlängerungsoption des Vertrags von mindestens zwei bis fünf Jahren vereinbart werden, um der Bank genügend Flexibilität zu bieten die Auslagerung weiterzuführen.

Bei der Vertragsgestaltung zum Exit-Management sollte insbesondere darauf geachtet werden, die Unterstützungsleistungen sehr umfassend im Vertrag zu beschreiben. Dazu gehören Inhalte wie Nutzungsrechte, Wissenstransfer, Schulungen des Personals, Überleitungskonzepte, etc. Es empfiehlt sich zusätzlich festzulegen, welche Unterstützungsleistungen kostenfrei oder auch kostenpflichtig im Rahmen der Überleitung durch den Service Provider erbracht werden sollen.

Vorteilhaft ist es, eine Governance-Struktur zu etablieren, die für Koordination und Umsetzung von Änderungsbedarfen zuständig ist. Dafür sollten im Vertrag sowohl auf der operativen, als auch auf der strategischen Ebene Prozesse und Verantwortliche bestimmt werden. Auf der operativen Ebene ist das Gremium für die Umsetzung von operativen Änderungen verantwortlich, auf der strategischen Ebene wird darüber entschieden, welche Änderungen erforderlich sind, um die Geschäftsziele zu erreichen.

Für das Erreichen der **Innovationsziele** empfehlen die Experten unisono ein Anreizmodell z.B. Gain-Sharing. Dieses scheint am besten geeignet, um den Provider zu motivieren, innovative Lösungen voranzutreiben. Bei der Vertragsgestaltung sollte beachtet werden, dass eindeutig festgelegt wird, wie die Parteien den Gewinn (Gain) aufgrund der Verbesserung z.B. durch den Einsatz einer neuen Technologie bewerten und aufteilen. Weiterhin ist es sinnvoll, Verantwortlichkeiten für Innovationen in Form einer Governance-Struktur zu vereinbaren.

Insgesamt ergeben die Expertengespräche in dieser Kategorie ein uneinheitliches Bild. Dies kann zum einen darauf zurückgeführt werden, dass der Begriff „Innovation“ sehr unterschiedlich besetzt ist und in der Praxis breit interpretiert und angewendet wird. Es zeigte sich in den Interviews vielfach, dass die Zufriedenheit dort am Größten ist, wo die Ambivalenzen am geringsten sind. Zum anderen kann die Begründung aber auch in der vergleichsweise kurzen Laufzeit der Verträge zum Zeitpunkt des Interviews liegen. Üblicherweise wird das Hauptaugenmerk zunächst auf die Transition und einen stabilen Betrieb gelegt und erst später auf Innovationen.

In der Kategorie **IT Sicherheit und Compliance** müssen Banken die regulatorischen Vorgaben für Auslagerungen konsequent umsetzen. Dazu gehören insbesondere die Vereinbarung von Audit-Rechten, Datenschutz und -sicherheit, die Errichtung eines internen Kontrollsystems sowie eines Notfallkonzepts.

Es hat sich als erfolgreich erwiesen in der Vertragsgestaltung auf internationale Standards wie ITIL oder COBIT bzw. die Standards des BSI IT-Grundschutzes zurückzugreifen. Zusätzlich muss der Vertrag umfassende Inhalte zum Umfang und den expliziten Leistungspflichten des Providers für eine ordnungsgemäße Dokumentation beinhalten. Dazu gehört die Vereinbarung, dass der Provider jegliche Information für die Prüfung sowie den Wissenstransfer in einem Betriebshandbuch dokumentiert und stets aktuell hält. Es empfiehlt sich zudem, bei der Gestaltung der Haftungsbestimmungen nach Vorsatz, einfacher und grober Fahrlässigkeit zu differenzieren, sowie bei den Haftungsbeschränkungen die Haftungssumme im Verhältnis zur Gesamtvergütung zu vereinbaren.

Diese Zielkategorie stellt sich als „Hygienefaktor“ dar. Es konnte kein systematischer Zusammenhang zwischen Formulierungen in den Verträgen und den Aussagen der Experten zur Zufriedenheit der Banken hergestellt werden. Da die regulatorischen Anforderungen an alle Banken gleich sind, ist davon auszugehen, dass die Beurteilung und Abarbeitung dieser Sachverhalte nicht spezifisch auf die einzelne Auslagerungsmaßnahme wirkt.

Unter Berücksichtigung der Erkenntnisse aus den Experteninterviews wurden in einem Folgeschritt die Verträge anhand des Rahmenwerks analysiert und die Wirksamkeit der jeweiligen Detailmechanismen für die gesetzten Ziele der Auslagerungsmaßnahme evaluiert.

4.2 Ergebnisse der Vertragsanalyse

Kostenreduktion, Erhöhung der Kostenkontrolle und -transparenz wurden von den untersuchten Banken eher als sekundäres Ziel der Auslagerung gewertet. Einzig Bank 4 hat dies als primäres Ziel verfolgt. Die Vertragsanalyse ergab, dass die Banken die Kostenkontrolle und –transparenz mittels der vertraglichen Mechanismen nicht im erwarteten Umfang realisieren konnten. Desgleichen konnten die erwarteten Kostenreduktionen nicht wie erhofft erzielt werden. Es muss allerdings angemerkt werden, dass Kostenreduzierungen erst nach einer gewissen Laufzeit der Auslagerung (Amortisationszeit) möglich sind, und sich die hier untersuchten Auslagerungen weniger als zwei Jahre im Regelbetrieb befinden. Es ist daher möglich, dass Kostensenkungsziele im weiteren Verlauf des Projekts erzielt werden können.

Die Verbesserung der **Leistungsqualität** wurde von den untersuchten Banken häufig als einer der Haupttreiber der Outsourcing-Entscheidung identifiziert. Die Ergebnisse der Vertragsanalyse zeigen, dass die Institute dieses Ziel weitestgehend in ihren Verträgen berücksichtigt haben. Doch nur eine von fünf Banken konnte durch die Auslagerung die Leistungsqualitäten hinsichtlich der Serviceerbringung verbessern. Bei der Mehrheit der Institute werden die vereinbarten Leistungen zwar erbracht, die Qualität ist jedoch nicht immer zufriedenstellend, geschweige denn besser, als zuvor.

Das Ziel **Flexibilität** spiegelt sich bei den untersuchten Banken auch in den Verträgen wider. Diese beinhaltenen Mechanismen, die eindeutig geeignet sind, um auf besondere Anforderungen der Geschäftsstrategie reagieren zu können. Insgesamt ermöglichen die gegebenen Änderungsmodalitäten allen Banken flexibel auf Leistungsänderungen zu reagieren. Die Ergebnisse zeigen, dass das Flexibilitätsziel in den untersuchten Outsourcing-Verträgen gut berücksichtigt wird.

Der **Zugang zu Innovationen** wurde in der durchgeführten Studie nur durch zwei Banken als ein wichtiges Ziel ihres Auslagerungsvorhabens angegeben und die Ergebnisse zeigen, dass die Institute ihre Innovationsziele nicht im erwarteten Umfang erreichen konnten. Da in der Auslagerungspraxis zunächst operative Ziele wie der Aufbau eines stabilen IT-Betriebs vorrangig sind, rückt der Fokus Innovationen zunächst einmal in den Hintergrund bei „jungen“ Auslagerungsprojekten.

IT Sicherheit und Compliance spielen aufgrund aufsichtsrechtlicher Anforderungen eine wichtige Rolle bei Outsourcing-Vorhaben im Bankwesen. Die BaFin konkretisiert diese in ihren *Mindestanforderungen an das Risikomanagement (BA)* [1]. Die Untersuchung hat gezeigt, dass diese Vorgaben umfänglich im Vertrag beschrieben und in der Auslagerungspraxis umgesetzt werden. Das Ziel der Erhöhung von IT Sicherheit und Compliance konnte von der Mehrheit der Banken erreicht werden.

5 Grenzen der Studie und weiterer Forschungsbedarf

Die Analyse von realen existierenden Outsourcing-Verträgen ist ein ausgesprochen schwieriges Unterfangen. Aufgrund der strengen Vertraulichkeit legen Unternehmen diese üblicherweise nicht offen. Diesem Sachverhalt ist geschuldet, dass die Datengrundlage dieser Studie überschaubar ist, bei der Interpretation der Ergebnisse muss berücksichtigt werden, dass nur fünf Banken Ihre Verträge zur Verfügung gestellt

haben. Auch die Anzahl der Experten, die für Interviews zur Verfügung standen, war begrenzt. Es wäre wünschenswert, pro Fall mit einer größeren Gruppe zu sprechen. Somit muss noch einmal deutlich darauf hingewiesen werden, dass diese Forschung als explorativ einzustufen ist, auch wenn die Untersuchung der Verträge in einer stark quantitativ orientierten Darstellung erfolgt ist.

Bezüglich der analysierten Verträge ist anzumerken, dass diese zum Zeitpunkt der Erhebung allesamt eine Laufzeit von weniger als zwei Jahren hatten. Dies war notwendig, um genügend Experten zu finden, die in die ursprüngliche Vertragsgestaltung involviert und somit entsprechend auskunftsfähig waren. Dies hat zur Folge, dass Sachverhalte, die langfristiger Natur sind und sich erst im Lauf der Zeit entwickeln, ggf. nicht adäquat berücksichtigt werden konnten.

Zukünftige Forschung sollte nicht nur die genannten Limitationen überwinden, sondern insbesondere die vertragliche Komponente einer Auslagerungsmaßnahme longitudinal begleiten, d.h. neben der ursprünglichen Gestaltung des Vertrages auch allfällige Änderungen und ggf. Erneuerungen des Vertrages betrachten und den Erfolg im Zeitablauf des Projektes erheben.

6 Implikationen für Theorie und Praxis

Aus theoretischer Sicht konnte durch diese Studie gezeigt werden -wenn auch in explorativer Form-, dass ein grundsätzlicher Zusammenhang zwischen der Gestaltung des Vertrages und der Zufriedenheit mit der Auslagerungsmaßnahme besteht. Der formelle Charakter der Beziehung nimmt somit deutlichen Einfluss auf die informelle Gestaltung und insbesondere die subjektive Zufriedenheit. Sicherlich ist hier weiterer Forschungsbedarf vorhanden, aber eine Tendenz zeichnet sich deutlich ab.

Für die Praxis ergeben sich die in Abschnitt 4.1 skizzierten Empfehlungen für erfolgreiche Outsourcing-Vorhaben. Es zeigt sich, dass eine gute Vorbereitung der Auslagerungsmaßnahme maßgeblich für den Erfolg des Projektes ist. So haben sich beispielsweise detailliert ausgearbeitete SLAs als besonders wichtig erwiesen. Durch die umfassende Beschäftigung im Vorfeld konnten viele Probleme a priori vermieden werden. Dies wurde von den Experten mehrfach und mit Nachdruck bestätigt.

7 Schlussbetrachtung

Die vorliegende Arbeit untersucht explorativ, in wie weit die Abbildung von Zielen einer Auslagerung im Vertragswerk den wahrgenommenen Erfolg einer Auslagerungsmaßnahme beeinflussen kann. Auch wenn aufgrund der geringen Fallzahlen keine generalisierbaren Aussagen getroffen werden können, so zeigten sich doch interessante Anhaltspunkte. Entlang der Zielkategorien: Reduktion der **Kosten**, Erhöhung der Kostenkontrolle und -Transparenz, Steigerung der **Qualität,** Erhöhung der **Flexibilität**, Zugang zu **Innovationen** und Erhöhung der **IT Sicherheit und Compliance** wurden ein Rahmenwerk geschaffen, wie diese Ziele vertraglich umgesetzt werden und beurteilt werden können. In Experteninterviews wurden die Auslagerungen von IT-

Dienstleistungen von fünf deutschen Banken untersucht, sowie die Verträge und begleitendes Material ausgewertet.

Aus den Ergebnissen dieses explorativen Vorgehens lässt sich ableiten, dass die vertragliche Ausgestaltung der Ziele einen merklichen Einfluss auf den wahrgenommenen Erfolg der Auslagerung hat. Insbesondere Maßnahmen, die der Reduktion von Unsicherheiten dienen und die dazu anhalten, den Sachverhalt der Auslagerung im Vorfeld komplett zu durchdenken, scheinen gut geeignet, die Zufriedenheit mit der Auslagerungsmaßnahme zu erhöhen.

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Towards a Reference Compliance Organization in the Financial Sector

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Abstract. After the global financial crisis ten years ago, European directives in the financial sector demanded from financial organizations fast and complex adaptation regarding their organizational structure and compliance-related internal processes. Since then, these organizations primarily implemented isolated solutions to comply with the plethora of regulatory requirements. Still, no holistic approach is provided by neither research nor practice. In this paper we represent a reference model that uses enterprise architecture management (EAM) concepts to develop a reference compliance organization (R-CO) in a design science research approach. We contribute to practice by providing an approach for holistic regulatory compliance management. Further, we provide insights to reference model research by utilizing methods to the EAM domain.

Keywords: Reference Compliance Organization, Reference Enterprise Architecture, Regulatory Compliance Management, Compliance Management

1 Introduction

After the global financial crisis in 2007 the G20 nations agreed to reform the global financial markets. Five years later the Financial Times described the reactions to this agreement in the financial sector as a 'tsunami' of regulations [1]. Regulators of the European Union responded to G20's agreements by a plethora of regulations addressing financial institutions. This included European Directives like Capital Requirements Directive IV (CRD IV), European Market Infrastructure Regulation (EMIR), Markets Abuse Directive II (MAD II), Markets in Financial Instruments Directive II (MiFID II) or the Fourth EU Directive for preventing Money Laundering IV. The latter, for instance, dictates what financial institutions are obliged to do in order to combat money launderers in their customer bases, by addressing means like hazard analysis, customer identification, further customer due diligences, prevention mechanisms and reporting duties [2].

Due to the increased number of regulations on national, European and international level especially for the financial sector, banks and other financial organizations are forced to implement a coherent Governance, Risk and Compliance (GRC) program [3]. Racz et al. define GRC as "*integrated, holistic approach […] ensuring that an organization acts ethically correct and in accordance with its risk appetite, internal*

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policies and external regulations through the alignment of strategy, processes, technology and people […]" [4]. The compliance function of an organization herein has the objective to identify relevant regulatory requirements and to facilitate adherence to these obligations [5]. This is done by regulatory compliance management (RCM). Kharbili defines RCM as "…*the problem of ensuring that enterprises (data, processes, organization, etc.) are structured and behave in accordance with the regulations that apply, i.e., with the guidelines specified in the regulations*" [6].

Research and practitioners agree that financial organizations currently do not approach RCM issues in a holistic manner and rather implement isolated compliance solutions due to the plethora of short-term implementation deadlines [7, 8]. Such compliance solutions typically consist of organizational structures and processes supported by information systems and IT-based instruments [8]. A potential way for moving towards more integrated or holistic compliance solutions is to provide a reference model for the financial industry as a normative guide. Experiences from other industrial areas show that reference models can provide an accepted guideline which also helps in adaptation to future regulation changes.

Research results reported in this paper originate from a project sponsored by 9 member organizations of BITKOM, the German digital industry association, with the objective to develop such a reference model. The ambition is not to start "top-down" from existing regulations and their "translation" into actable compliance solutions but to analyze established practices in financial institutions and a "bottom-up" distillation of a reference from these practices. Such a "bottom-up" approach leads to numerous challenges including the method for developing the reference organization, the kind and quantity of financial institutions to include, the approach for capturing relevant practices, how to document the actual reference, etc. In this paper, the focus is on the motivation for the reference model, the process of development and the structure and evaluation of the first version. In the application domain, the reference is considered as reference compliance organization (R-CO); technically this has to be a reference enterprise architecture because business, application, information and technology architecture have to be tackled including their inter-dependencies (see section 4.2).

The paper is structured as follows: Section 2 describes the research design which is based on the design science paradigm. Section 3 report on a literature study about challenges in financial service compliance. Section 4 discusses the R-CO's overall approach, its current structure and the development process applied. Section 5 summarizes the work and gives an outlook on future research.

2 Research Design

The main objective of this research is to design a reference model for IT-based compliance in financial industries that supports organizational and technological implementation of regulatory compliance and fulfils industry needs. The objective was decomposed into research questions (RQ) as a means to structure and guide the research activities required:

- RQ1. What are the current problems in regulatory compliance for institutions in financial industries and the requirements to a potentially solution? (Section 3)
- RQ2. Which methods are available for reference modelling? (Section 4.1)
- RQ3. How should a stable and standardized R-CO be shaped? (Section 4.2)
- RQ4. What benefits and drawbacks are to the R.CO? (Section 5)

The research work addressing the above RQ is structured in terms of the design science research (DSR) methodology proposed by [9] since it aims at designing a complex new artefact (i.e. the R-CO) and at acquiring new knowledge (e.g. discovering established practices in financial industries as a basis for such a reference architecture, demonstrating the use of the architecture to assess its strengths and limitations). Peffers et al. propose a process for DSR projects consisting of five activities which in our research work were performed as follows:

The first activity is *problem identification and motivation.* We performed a literature study to investigate the existing body of knowledge in the field of compliance in financial industries (see section 3). The results of this study indicated the need for a reference compliance organization spanning organizational and technological aspects, such as a reference enterprise architecture (REA). The business relevance was confirmed in the interview study performed as part of identifying objectives (activity 2) and designing the R-CO (activity 3). Activity 2 is to *define the objectives for a solution.* Objectives for the design of the R-CO originated in our case from using two instruments: focus group and interview study. Our research was funded by a group of 9 companies organized in a committee of the German IT-association BITKOM. The companies' representatives are experienced in the field of IT-based compliance and contributed objectives of the solution which were captured in a focus group-like setting (not discussed in this paper for brevity reasons). The interview study consisted so far of 71 phone interviews (each interview between 60 and 110 minutes) with compliance officers and other experts of financial institutions about their practices and their view on missing elements in IT-based compliance. The "missing elements" are input to the objectives; practices are a basis for activity 3 of the DSR process, the *design and development* of the actual artefact (see Section 4.2).

The fourth activity is *demonstration* that the artifact actually solves the problem. We performed expert interviews with consultants from enterprises providing IT-based compliance solutions (see Section 5). Activity 5, *evaluation*, has the intention to observe and measure how well the artifact supports the solution to the given problem. This is an ongoing activity in our project which includes validation workshops with the industrial partners funding the project and with financial institutions interested in applying the R-CO. This activity is only partly covered in Section 5.

3 Challenges in Financial Service Compliance

As stated in section 1, GRC and RCM in particular should aim to comply with complex regulatory obligations from a holistic perspective. Volonino et al. highlight that holistic compliance has to be considered enterprise-wide and, in contrast to simply complying to certain rules, it is about developing an integrated approach by identifying

both all relevant organizational elements and the relationships among them [10]. In reality financial institutions tend to implement insulated compliance solutions due to short-term deadlines set by regulators [7]. The question arises, how the above stated holistic and enterprise-wide RCM can be realized. In the context of the Sarbanes-Oxley-Act Wagner and Dittmar observed that a thorough implementation of RCM achieved side-benefits like process standardization or consolidation [11]. Further, Gozman and Currie understand a mature GRC as a new value-adding capability since it can be offered to third parties as a consulting service [7]. In the following we discuss IS research in compliance management in and beyond the financial domain. Based on this, we then motivate the need for our R-CO for financial organizations.

3.1 IS Research in Regulatory Compliance Domain

There exist numerous systematic literature reviews and meta-analyses in this field. Akhigbe et al. conduct a meta-analysis on the results of fourteen literature reviews, that focus on RCM of business processes [12]. As a result, they require future IS research to focus on real-life regulatory compliance scenarios and compliance enactment tasks (i.e. mechanisms to dynamically react to violation occurrences to re-establish compliance). Cleven and Winter focus on a broader and more aggregated perspective by including articles beyond business process management. Using the concept of EAM for their theoretical framework, they map the identified articles to the several EA layers [8]. Their work reveals that there exists no holistic approach covering all EA layers. Abdullah et al. identify gaps between industry challenges and research solutions in RCM by dint of expert interviews and a literature review [3]. They derive the need for benchmark studies, reference models and knowledge of appropriate IT support.

One topic of interest of IS research in RCM is compliance modeling, where legal requirements are identified [6]. Boella et al. understand methods from the discipline of requirements engineering as appropriate in this field. They think research lacks mechanisms for understanding legal reasoning and demand a dialogue among legal and industry experts [13]. Further, Ghanavati et al. provide a method that enables the extraction of legal requirements from regulations and articulates them in a "Legal GRL" (goal-oriented requirements engineering language), which can be used for compliant software development [14].

There are also contributions that focus on the regulatory impact on organizational and operational structures. Boella et al. identify the need to map legal interpretations with business rules and processes and introduce a web-based knowledge management system called Eunomos [15]. On Eunomos, legal researchers and practitioners map different interpretations to processes and rules. The authors define a procedure for financial institutes to use it and provide an example with the MiFID directive. Kahrbili introduces a conceptual framework for RCM in the domain of business process management [6]. Becker et al. discuss how reference model methods can be used by financial organizations to meet prior defined legal requirements [16]. Still, they only provide a methodical sketch for the compliance reporting domain. Timm et al. go one step further and develop a reference process model for customer identification in the context of anti-money laundering directives [17]. The reference model defines essential

steps a financial organization should perform in order to be compliant with current laws and also states the process data necessary to do so. The authors focus on internal behavior of organization in RCM, but since using an deductive approach their reference model is based on statements from legal texts or literature and may differ from actual real-life behavior of organizations as demanded by [12]. Another reference model is presented by Schlosser et al. [18]. Their functional reference model for business rules management can be used for better Business-IT alignment by defining requirements for rule-based IS solution in the regulatory context. On a more global perspective Foorthuis and Bos provide a strategical framework for implementing compliance means in an organization [19]. Unfortunately, the high-level approach lacks concrete means of implementations. Further, Gozman and Currie emphasize the importance of means like early engagements between software vendors and compliance managers or holistic data management [20]. By Conducting a long-term study with several financial institutions they derive eight IS capabilities they identified to be necessary to implement a holistic GRC initiative [7]. Their capability framework agrees with the holistic approach for RCM. Likewise, it emphasizes the vital role of information technology (IT) in the context of RCM.

3.2 Need for a Reference Compliance Organization in the Financial Domain

This section motivates the need for a reference compliance organization, which we provide with this work. We extract some requirements for IS research discipline in the RCM domain from the earlier discussed literature reviews: *(i) to consider more real-life scenarios and actual organizational behavior in a regulatory environment* (see [3, 12]), *(ii) the need for reference models* (see [8, 12]), (iii) *a more holistic approach for RCM realization* (see [8]) and (iv) *more transparency on sufficient IT support in RCM scenarios* (see [3]).

In order to meet these requirements, we suggest a reference compliance organization model (R-CO). As the financial industry is the most regulated industry (see [3]), we apply the R-CO for this sector. By developing a reference model based on organizational knowledge in the financial compliance domain we address requirements (i) and (ii). Thereby we rather focus on how financial organizations can comply to their regulative environment than solely taking legal texts as a knowledge fundament. According to Thomas, we understand a reference model as a model that can be reused for the construction of another model by a certain group of reference model users [21]. Abdullah et al. state, that reference models in RCM "*significantly lessen the cost of compliance management in organizations*" [3]. Reference Models can be composed of different model structures [22]. From the work of Cleven and Winter we can draw the conclusion that EAM is an appropriate means to develop a holistic approach [8]. Thus, the R-CO will be based on EA model structures. In general, EAM aims to maintain flexibility, cost efficiency and transparency within an enterprise and addresses effective and efficient Business-IT-alignment [23]. An EA model provides a holistic view on an organization capturing business related elements, information structures as well as the IT landscape and the relations among these concepts [24]. Thus, applying EAM concepts to the R-CO aims to address the requirements (iii) and (iv) stated above. It

also captures the different dimensions of Gozman and Currie's IS capabilities, e.g. the alignment among business, regulation and IT, data management, IT sourcing management [7], which are in line with EAM's objectives [23, 24].

Since research frequently asks for a holistic approach to RCM, we want to clarify that we interpret the holism from two perspectives in the context of financial RCM. From the first perspective, we propose a R-CO that holistically captures all relevant aspects of the financial organization affected by regulation. This is the point where we apply EAM to consider elements of strategy, business behavior, information and application landscape. From the second perspective, we see requirements towards the R-CO to capture the whole regulatory context that is relevant for the defined user group of the financial industry. By capturing both perspectives we think financial organizations can successfully implement RCM since it allows them to evolve from a state of isolated implementation of single regulations to a more stable state, where RCM is realized as an integrated discipline and can efficiently and effectively react in dynamic regulatory environment. While our aim is to capture both perspectives of holism in the R-CO, this work presents the R-CO with an extract from the regulatory landscape, i.e. focuses on the first perspectives.

4 Reference Compliance Organization

This section presents the current version of the R-CO by discussing its structure and explains it by concentrating on a certain segment of the model (section 4.2). In order to provide a better understanding of the development process of the R-CO, we put our work into the context of reference modeling methods we applied (section 4.1).

4.1 Reference Model Development of the R-CO

From a user-oriented perspective, Thomas understands a reference model as a model used to support the construction of another model [21]. In general, reference models are information models developed for a certain problem in a certain application domain. The purpose of their development is to be reused in a concrete application case in the addressed domain. The reuse of a reference model is intended to increase both efficiency and effectivity of an enterprise's information systems and their change management [25]. This argues in line with our intention to develop a reference model (i.e. the R-CO) for the financial industry, where we address the problem that financial institutes implement isolated solutions to comply with complex and short-term regulations (see section 3). We intend the R-CO to be reused by these organizations in order to implement a holistic RCM approach while reducing costs of its realization.

The life cycle of reference models can be distinguished between the phase of construction and the phase of application [22]. Schütte defines a cyclic procedure model for reference model construction [26], which comprises of the phases problem definition, model frame construction, model structure construction, model completion and application. Research discusses two generic strategies for reference model construction. While the deductive reference modeling derives reference models from

generally accepted knowledge, the inductive approach abstracts from individual models to agree on a common understanding within the reference model [27]. Recently, IS research shows growing interest towards inductive methods as they tend to have a higher degree of detail and seem to be more accepted when it comes to reference model application [28]. Fettke provides a procedure model for inductive development, where he addresses collection, pre-processing and the reference abstraction of individual models [27].

This work focuses on the construction phase of the R-CO and the model itself. The R-CO was defined to develop a stable and standardized reference model, that represents how financial organizations should implement a holistic RCM. As discussed in section 3.2 the model follows the structure of EA models. Therefore, we followed the widely-accepted EAM framework TOGAF, which differentiate between business, data, application layers [29]. For the actual modeling we use ArchiMate in version 3.0 since it is developed for TOGAF [30]. The R-CO model structure is defined by the following aspects: regulatory matter, EA layer and ArchiMate viewpoints therein while several levels of detail are provided. The structure is presented in the next section 4.2.

For the development of the R-CO we used both deductive and inductive strategies for knowledge elicitation. The foundation for this approach is based on a method for reference enterprise architecture development [31]. First, we deductively constructed a model frame for the R-CO by consulting domain-related literature and legislative texts, and conducted expert interviews with the project's IS vendors. This resulted in an initial R-CO, which contained an overview on (i) the general organizational structure of a compliance department within a financial organization, (ii) general compliance functions within this compliance department and (iii) relevant regulative topics in financial services. This built the fundament for the phase of inductive reference model development. Overall we collected qualitative data from 32 German financial organizations regarding their realization of selected regulative topic using structured phone interviews. So far, the R-CO covers (a) money laundering prevention, (b) identification of new costumers (mainly referenced as know your customer – KYC) and (c) fraud prevention. Thus, we conducted three cycles for inductive reference model development so far – one for each of (a), (b) and (c). The phone interviews and simultaneously transcribed in an online survey tool. This data was then modeled using the ArchiMate language, whereby each interview resulted in an individual model. Each individual model followed the same predefined modeling guidelines and structure by dint of prior defined ArchiMate viewpoints. From base of individual models, we derived a reference model using the minimal cost of change approach developed by Ardalani et al. [32], which we applied to EA model structures [33].

4.2 The Reference Compliance Organization Model (R-CO)

The R-CO's underlying framework is "The Open Group Architecture Framework" (TOGAF) since it is widely accepted amongst practitioners and researchers. It is thoroughly documented in [29] and comes with a detailed modeling language

specification ArchiMate (currently in version 3.0[1]) [30]. TOGAF constitutes of the business layer, data layer, application layer and technology layer. For each layer, ArchiMate defines elements and specifies relations among them. Further, the language introduces the concept of architecture viewpoints, which are projections of the EA model, each considering a certain purpose by addressing different stakeholders' interests [24]. We excluded the technology layer since it focuses on services such as processing or communication required to run applications in the application layer [30] and, thus, we deem it as too dependent on the organization at hand.

The R-CO is structured as follows. Currently, the model is stored in a single repository, which holds all elements of the respective model layers and their interrelations. The R-CO mainly contains knowledge of involved business roles (e.g. compliance officer), business functions and processes (e.g. customer identification), compliance-related data objects (e.g. documents for proof of identity) or supporting compliance software solutions (e.g. transaction monitoring system) (see [30]). We use viewpoints to define projections on this model repository to address certain concerns regarding compliance issues, e.g. overview of responsibilities in the Anti-Money Laundering (AML) program (see [24]). Therefore, we defined the R-CO structure by using standard ArchiMate viewpoints. The R-CO structure is visualized in Figure 1. Each rectangle represents a certain model view, which addresses a certain concern of the R-CO. For example, the view "compliance organization" shows relevant business roles in a compliance department of a financial organization and their interrelations. Vertically read Figure 1 illustrates the different TOGAF layers. Horizontally read it shows the several regulatory domains like AML or fraud prevention. Some viewpoints address concerns related to a single TOGAF layer, while some reveal interrelations among two layers. For instance, "AML data usage" presents what tasks in AML should use what data for its realization. Further, "AML Application Usage" identifies information systems supporting certain task of the business layer. Further, the R-CO uses integrated (left side) and regulation-specific views (middle and right side). While integrated views (e.g. "compliance function overview") capture information across all compliance domains, regulation-specific views (e.g. "Anti-Money Laundering Process") consider aspects directly related to certain compliance domains. For reasons of clarity Figure 1 does not show the different levels of detail the R-CO incorporates. As an example, views in the business and data layer have up to three different layers of detail so far.

In Figure 2 one view is shown in more detail. It is a regulation-specific view focusing on business layer concerns. It illustrates how a financial organization should conduct know your customer (KYC) principles, which are required by the 4th EU Directive for Money-Laundering Prevention. In the center of the view necessary steps for KYC are grouped into the phases *customer identification*, *risk classification* and *due diligence*. It is documented that there exist different types of events that trigger the customer identification process (left side, e.g. a new client applies). In short, after identifying required documents regarding the organization and involved deputies in the first phase, the client is categorized into the pre-defined risk systems, on which it is determined

[1] http://pubs.opengroup.org/architecture/archimate3-doc/toc.html

whether normal, simplified or enhanced due diligence is triggered. On the top and bottom of the view, responsible business roles are defined, e.g. respective account manager is hold responsible for all activities of the financial organization.

So far, the R-CO holds organizational knowledge regarding the regulatory domains AML, KYC and Fraud Prevention in the context of the financial industry. Next to process-related knowledge it also shows, what information a financial organization has to gather and how this can be supported by certain information systems. Further, the R-CO forms a basis for a holistic RCM, since the integrated views reveal, for instance, what different regulatory domain may process the same data.

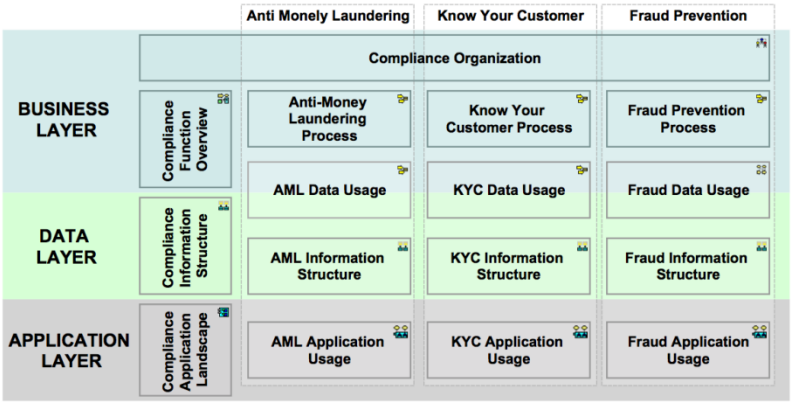

Figure 1. Overview of the R-CO Model Structure

5 Artefact Demonstration

In the demonstration and evaluation steps of the DSR process by Peffers the artefact at hand is put into practice in order to reveal its flaws or to enhance its usability to users from the problem domain [9]. So far, the R-CO run through one evaluation loop. Therefore, several experts from the financial service compliance domain were consulted during the development of the R-CO. The experts were consultants from IS vendors of financial compliance software solutions and IT consultancies and had multiple years of experience in the RCM domain in the financial sector. They were involved both during the R-CO development and after the finalization of the R-CO's first version. During the development stage they were regularly consulted to validate the initial R-CO, its structure and the three questionnaires for the interviews with the financial interviews, which we conducted in the domains of AML, KYC and Fraud Prevention. After the results of this interviews were processed into the preliminary R-CO, we conducted in summary eight validation workshops with respectively one or two of the experts. These workshops took each one day, where we went through all models to discuss the plausibility of each element and relationships. With these insights we adjusted the models to the current version of the R-CO. In these validation workshops it turned out to be very useful to directly work within the modeling environment, so that

we've been able to directly change or annotate the model views. In a next step we intend to apply the current R-CO in a bank in order to further increase its maturity and gain insights in the application process of the R-CO.

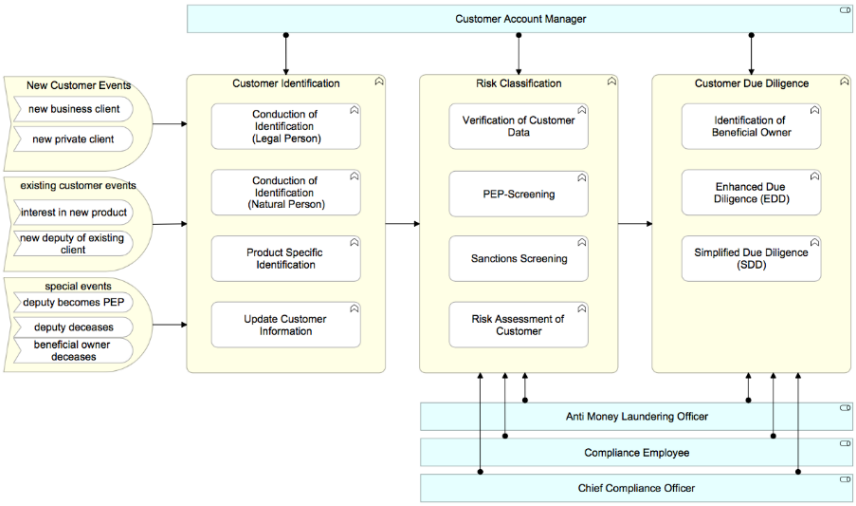

Figure 2. R-CO View: Know Your Customer Process (2nd Level of Detail)

6 Summary and Future Work

Financial organizations face the complex task to implement a stable and holistic regulatory compliance management program in order to comply with a dynamic regulatory environment [3, 5, 20]. We address the need of organizations to overcome current isolated solutions by presenting a reference compliance organization (R-CO), which we develop in the context of an industry project. We provide insight in the development process of the R-CO and presents its current structure and content. The results were validated by dint of several workshops and interviews with domain experts from IS vendors and IT consultancies. Nevertheless, the R-CO has its limitations. At the moment, it only addresses an extract of the regulatory landscape, that is anti-money laundering, know your customer principles and fraud prevention. Further, while its business and data layer were evaluated to have a solid depth, we aim to further investigate the application layer of the R-CO. Future research will further focus on the application phase of the R-CO. We therefore intend to investigate configurational aspects (currently the R-CO can be configured by organizational type) and different maturity levels of the R-CO (Does the bank at hand only want to meet regulatory requirements or implement best practices?). At the moment we are preparing to conduct workshops with concrete financial institutes, where we further validate and apply our reference model.

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Make or Break: Business Model Determinants of FinTech Venture Success

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Abstract. In recent years, the phenomenon of rapidly proliferating FinTech companies along diverse segments of the financial services value chain has attracted considerable interest in academic research and practice. So far, various factors of FinTech venture success have been explored, but there is little empirical insight through the lens of business model theory. To close this gap, we build on a FinTech business model taxonomy and examine 221 FinTech companies in order to statistically infer crucial business model determinants responsible for FinTech venture success. Our findings show that the business model component "Product/Service Offering" is the most important determinant for the success of a FinTech venture.

Keywords: FinTech, Business Model, Venture Success, Taxonomy

1 Introduction

The global digital revolution has led to fundamental changes in the financial services sector. The development of new information technologies (IT) enables increasingly technology-savvy customers to access classic services and products offered by incumbent banks in a faster, customer-friendly, and more efficient manner. The emergence of financial technology companies, commonly known as FinTech companies, is the trigger for this new era of fast-growing digital financial products and alternative financial services markets. These FinTech companies, as defined by [1], are "companies that operate at the intersection of (i) financial products and services and (ii) IT, they are usually (iii) relatively new companies (often startups) with (iv) their own innovative product or service offerings."

Although the term FinTech has turned into a mainstream benchmark for innovation in the financial sector, the digitalization of the financial services as we know it today is fundamentally the result of an ongoing process of digital transformation that has taken place throughout the last century. As identified by [2], the overarching conception of financial technology began to emerge in the 1990s through a phased transition from analog to digital financial services. This was made possible by the introduction of

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diverse technological developments such as the onset of the use of the Internet for online banking in the mid-1990s and the development of smartphone technology together with complex application programming interfaces. These innovations provided the basis for the globalization of financial services and further integration of information and communication technologies (ICT) into the financial sector [2], [3].

Yet, despite that the assimilation of cutting-edge technologies into the financial industry has been a constant catalyzer for the evolution and development of financial services and products, the term FinTech mainly began to earn notoriety in recent years when the regulatory reaction to the financial crisis of 2008 held back the technology integration capability of the financial sector [4]. So far, the size, scope, influence and high barriers to market entry ensured the prevalence of the traditional business models of incumbent banks and insurance companies. But, the rapid rise of FinTech companies along diverse segments of the financial services value chain has made evident that these market entrants possess the disruptive potential to overcome these barriers.

However, whereas the innovation in ICT is one of the fundamental pillars for the emergence of the FinTech phenomenon [2], it is also true that the revolutionary digital technologies brought into play by FinTech companies are only profitable to the extent that they can be made marketable through a suitable business model [5]. Consequently, the venture success and initial survival of FinTechs is largely build upon the ability of FinTech entrepreneurs to describe their business logic, value network, and position of the company in the financial industry value system to investors [6]. They also need to prove how the introduction of a new technology not only creates and captures new value but also generates economic return [7]. Only then, investors can differentiate FinTech companies in accordance with their business model and identify inherent key value drivers of FinTech business models like profitability and growth prospects [8], [9]. Considering the outlined aspects and the fact that three out of ten FinTech ventures fail [10], this paper addresses the following research question: *Which components of a FinTech company's business model have the highest impact on venture success?*

2 Theoretical Background

2.1 Business Model Theory

In the last two decades, the interest on the business model concept has been growing at pace with the increasing role of entrepreneurship and innovation as drivers of economic growth [5]. However, despite of the popularity of the term and the growing scientific research on business models, there is still no common definition of what a business model is and how it is composed. Notwithstanding this lack of consensus, over the past 15 years, diverse research papers, such as [9–12], have aimed to provide a common interpretation and conceptualization of the business model term. This is attempted either through the development of ontologies or by combining different descriptions and constituent elements in order to generate a collective business model framework consistent with the state of the art of the scientific literature. Following this approach, a comprehensive study performed by [11] analyzed 1,253 articles published in

management journals between the years 1975 and 2009. The study synthesized the business model concept as "a new unit of analysis, offering a systemic perspective on how to 'do business,' encompassing boundary-spanning activities (performed by a focal firm or other), and focusing on value creation as well as on value capture." This definition has been used in the academic literature mainly with the purpose to analyze 1) the application of e-business and IT in organizations, 2) strategic management mechanisms to achieve value creation and competitive advantages, and 3) innovation and technology management issues, such as the process of converting innovations in ICT into economic value. Given the scope and timeframe of the analysis, the former business model definition provides a representative characterization of the business model concept during the onset of the digitalization of traditional financial services, denominated as FinTech 2.0 [2]. Still, as documented by [6], due to the lack of a proper definition of the business model concept, there is also no universal consensus about the components that a business model encompasses. In order to close this research gap, [9] developed a hierarchical taxonomy of the business model concept aiming to identify the main business model dimensions and their respective elements. They managed to delineate the ontological structure of the business model concept taking into consideration its interconnection with information systems (IS), business processes, and strategy research. In this way, [9] identified "Value Proposition," "Value Architecture," "Value Network," and "Value Finance" as the four fundamental components of the business model concept. The former conceptualization of the business model definition and the identification of its fundamental components provide an aggregated research perspective on business models from multiple fields.

According to [13], three main research streams can be identified throughout the evolution of the research on business models performed in the fields of strategic and innovation management, entrepreneurship, marketing, and IS. As identified by [14–16], the first stream of business model literature emerged in the 1990s and was triggered by the revolution in ICT caused by the arrival of the Internet and the reduction in transaction processing costs. The main focus of this research stream lies on the exploration of the impact of new technologies, i.e. the Internet and the World Wide Web at that time, on the traditional business models, and the emerging electronic business models [17]. The second stream of literature takes a conceptual step forward by evaluating the intrinsic capability of the business model framework. This allows for a consolidation of new digital technologies within the entire value creation process and value networks with customers, suppliers, and other business partners of an organization to create value through digital business models [14]. Thus, as stated by [18], value can be generated from innovation in the form of 1) new products that increase customer value through better problem-solving, performance, customization, accessibility, ease of use, etc., 2) new methods of production that contribute to reduce costs or risks, 3) new distribution channels and customer interfaces to deliver the company's value proposition, 4) new markets and customer segments, 5) new revenue mechanisms, or 6) new disruptive business models. The latter embodies the focus of the third stream of literature on business model research, which examines "the role of ICT as the driver of a new wave of industrialization" [19], where ICT-enabled business models fundamentally transform the value creation process and disrupt the value

system of an industry [13]. According to [20], the business model components that will be restructured by digital business model innovations are mainly those related to the customer value proposition, the methods of production, and the revenue mechanisms.

2.2 FinTech Business Model Taxonomy

In the context of FinTechs, disruptive business models are developed around a novel technology and a customer-centric perspective. This allows FinTechs to unlock new markets and customer interactions, to introduce different mechanisms for revenue generation, and to implement novel approaches for producing customer-centric products and services. The latter enables FinTechs to engage in co-creation of value with their customers, in such a way that both the supply and the demand-side can contribute to the development of resources and activity-based competitive advantages [11]. However, the scientific literature has not yet agreed on a universal definition of the term FinTech due to the varying business strategy alignments, product and service portfolios, and digitally-induced business models framing the concept.

To structure and better relate existent business models in the FinTech domain, [1] develop a taxonomy of FinTech business models by following the methodology for taxonomy development by [21]. This taxonomy builds on a) theoretical foundations of the business model concept and b) data from Crunchbase, a database aggregating information regarding innovative companies, e.g. investors, funding, and incubators [22]. [1] suggest six dimensions of FinTech business models in line with the identified components of [6], [11], and [18]. Using the Crunchbase attribute tag "FinTech" to extract relevant companies, mutually exclusive and collectively exhaustive characteristics related to these dimensions were identified (Table 1).

Table 1. Taxonomy dimensions and their respective characteristics [1]

Dimension	*Characteristics*
Dominant Technology Component	Blockchain, Digital Platform, Decision Support System, Database, Marketplace, Transaction Processing System
Value Proposition	Automation, Collaboration, Customization, Insight, Matching/ Intermediation, Monetary, Financial Risk, Transparency, Unification/Consolidation, Security, Convenience/Usability
Delivery Channel	API, App, Physical, WWW, WWW + App, Instant Message
Customers	B2B, B2C, B2B + B2C
Revenue Stream	Kickback, Pay Per Use, Revenue Share, Sales, Subscription, Unknown, Free, Hybrid
Product/Service Offering	Information Aggregation, Brokerage, Currency Exchange, Current Account, Device, Financial Education, Financing, Investments, Payment Service, Personal Assistant, Lending/Credit, Fraud Prevention, User Identification

Furthermore, in order to validate the robustness of the conducted taxonomy of FinTech companies, [1] examined representative firm archetypes in the FinTech sector. By using

the firm tags of the database Crunchbase (e.g. business sector and technology) and a multiscale bootstrap resampling approach, they constructed a cluster dendrogram and were able to identify ten clusters of FinTech business model archetypes. Namely, (1) "Cryptocurrency"; (2) "Payment Service"; (3) "Financial Markets Intermediary"; (4) "Information Aggregator"; (5) "Information Extractor"; (6) "Insourcer of Sub-Processes"; (7) "Lending Community"; (8) "Alternative Trading Venue" (9) "Robo Advisor" and (10) "Co-Creator of Financial Analysis." In order to distinguish determinant factors for potential success or failure of FinTech companies, we build upon this taxonomy and connect the related archetypes to our findings.

2.3 FinTech and Venture Success

According to [12], the survival and success of for-profit organizations is directly associated to their capacity to both create and capture value. Therefore, in line with this logic, each component of a business model provides a fundamental insight of the constituent elements required for the company innovation, short-term survival, and long-term success. As stated by [23] a successful venture must guarantee market performance results such as sales volume and growth, a competitive market share, as well as a strong market position. Otherwise, in agreement with the definition of business failure of [24], in the event of the inability of the company to fulfill its responsibilities towards its stakeholders, the business venture can be regarded as failed.

Hence, the business model concept constitutes a major instrument to generate crucial knowledge for the identification of the factors (i.e. business model dimensions, characteristics or components) that are relevant for the success and development of the FinTech ventures. Nevertheless, as identified in the meta-analysis of the literature on FinTechs performed by [25], the limited existing academic literature on critical success factors for FinTechs is mainly focused on the determinants of success for the adoption and performance of the dominant IT artifact driving the business models [26], among which studies on the determinants of success for peer-to-peer digital platforms take an important position [27–29]. Furthermore, studies like [30] have identified different aspects such as entrepreneur quality, policy regulations, product demand, and capital as the key determining factors for the development of the FinTech industry in diverse European countries.

In addition, given the still incipient academic literature on FinTech success [25], a further insight into the elements required for the potential success and survival of FinTech ventures can also be gained through the consideration of academic literature in the field of entrepreneurship. Studies like [31] have identified that high-tech ventures are likely to be more successful if they implement product customization strategies to target existing markets, rather than addressing new markets. Furthermore, [31] identified that the initial success of high-tech ventures is mostly determined by factors like the entrepreneurial quality (i.e. technological expertise, leadership, business skills, capacity to assess and respond to risk, and market knowledge) as well as resource and product-based factors like the product market fit and the market acceptance. Likewise, factors like the access to capital have been conjectured to play a role in the prospect of success of business ventures considering that: 1) new technology-based firms are

generally capital-intensive and in danger of being undercapitalized [32]; 2) new ventures often have to survive an initial growth phase without profits and depend on their financial resources to continue their operations [33]; 3) as in the case of ICT companies, FinTech ventures also rely on innovation in order to gain a competitive advantage over incumbent financial services firms. Therefore, it can be inferred that the financial resources obtained through funding will increase the chances of the FinTech ventures to expand their capabilities and further invest in research and development in order to enhance their value proposition [34].

Following a one-dimensional resource-based view, we utilize total funding as an indicator for potential FinTech venture success in line with a voluntarist approach to entrepreneurial failure of [35]. Consequently, this choice corresponds to the causal assumption that the successful development of a FinTech venture is determined, to a large extent, by its resource base [36] and the existence of established funding relationships [37]. Building on the aforementioned theoretical background where we identify a lack of research on venture success for FinTech companies that specifically addresses the business model concept, we conduct an empirical analysis using a FinTech-specific dataset.

3 Empirical Study on FinTech Venture Success

3.1 Description of the Used Datasets

The primary data used in this research is based on the dataset utilized in the taxonomy development of [1]. The core aspects of this dataset are 1) the manual review process through which companies incorrectly identified as FinTech were removed and 2) the assignment of characteristics depending on the judgement of the researchers. Every company is assigned to the most fitting characteristic for each of the six dimensions of the FinTech business model taxonomy. Additionally, using the Crunchbase API [22], we gather a dataset of complementary information on FinTech companies where the contained information does not exceed the timeframe (as of June 2016) of the original taxonomy dataset. It provides a variety of details including funding rounds, investors, acquisitions, and IPOs. For the following analysis, data about the country of operation, number of employees, current mode of operation (operating, closed, acquired, and IPO), funding rounds, time since first funding, and total funding denominated in USD is the most relevant. Restricted by the amount of companies for which funding data is available, a dataset of 400 companies is generated. To allow for an automated analysis of the taxonomy dataset through regression analysis, it is necessary to further clean and standardize the available data. Since the information required for our analytical purposes is not available for every company, a subset of companies is chosen for which the described data is available. This results in a final data set of 221 companies, of which more than 50 % are based in the US.

3.2 Analysis

In order to ensure the validity of the following analysis that addresses the underlying research question**,** we determine to which degree the dimensions of the business model taxonomy are dependent. This does not only have the potential to provide a first intuition for the underlying data itself, but can also reveal potential pitfalls in the analytical approach (e.g. highly correlated dimensions). Since the taxonomy consists of six nominal variables, each with multiple levels, a sensible approach is the utilization of Cramér's V [38]. This measure describes the degree of dependence between two discrete variables (that have two or more levels) on a standardized scale from zero to one. Albeit some dimension tuples possess a correlation of up to 0.52, for example "Dominant Technology Component" and "Product/Service Offering," the results indicate at most moderate correlations as displayed in Figure 1. In case of highly dependent variables (Cramér's V close to one), it would be necessary to question the carried out coding or even the taxonomy itself.

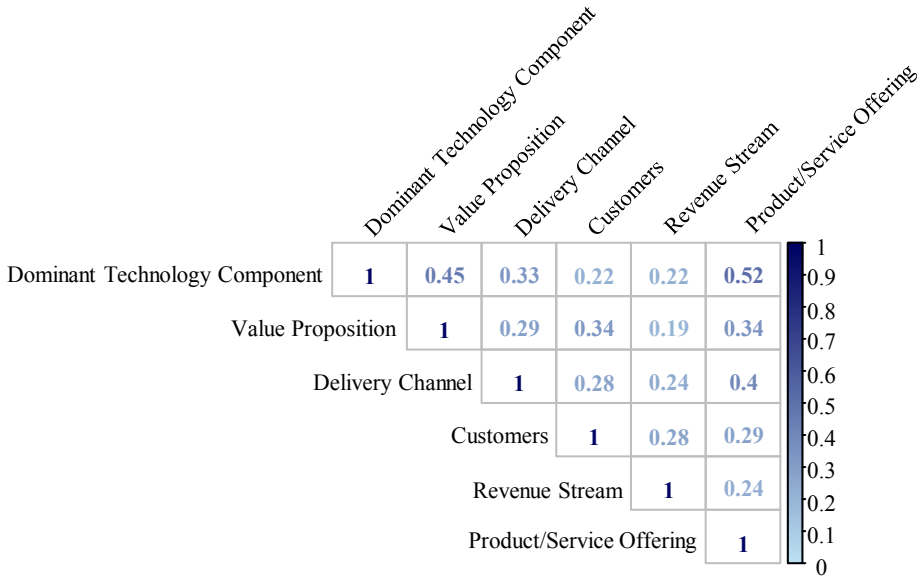

Figure 1. Strength of association between constituent dimensions of the FinTech business model taxonomy indicated by Cramér's V

Equipped with a deeper understanding of the relations between the dimensions, in the next step we use multiple linear regression to uncover which characteristics are significant predictors for FinTech venture success. We operationalize this in the form of the aggregated received funding denominated in USD for every funding round contained in the dataset. For our analysis, we include the six dimensions of the taxonomy, expressed in the form of 45 characteristics, as explanatory variables by using dummy coding [39]. Furthermore, we control for the employee count, the country of operation, the number of funding rounds, and the time since first funding. The total

funding each company received is included as the dependent variable. According to the foregoing, Table 2 gives a brief overview of how many p-values <0.1 were identified per dimension. Naturally, statistical significance alone cannot be used to assess the overall meaning of each dimension, but we include this overview to explain the subset of the analysis presented in more detail in Table 3.

Table 2. Number of significant predictor variables (dummy coded) per taxonomy dimension resulting from the multiple regression analysis

Name	*Significant Variables*	*Total Variables*
Dominant Technology Component	0	5
Value Proposition	0	10
Delivery Channel	0	4
Customers	0	2
Revenue Stream	0	7
Product/Service Offering	3	11

The multiple regression analysis shows significant relationships between characteristics located in the "Product/Service Offering" dimension and the aggregated funding per company. An in-depth view of the regression summary for this specific dimension is provided in Table 3.

Table 3. Excerpt from the multiple regression analysis showing the taxonomy dimension "Product/Service Offering"

Name	*Estimate*	*Std. Error*	*t-value*	*Pr(>|t|)*
Intercept	-22.944	70.575	-0.325	0.746
Product/Service Offering				
Credit Lending	**92.686*** **	27.265	3.399	<0.001
Currency Exchange	18.347	37.167	0.494	0.622
Device	-46.818	103.951	-0.450	0.653
Financial Education	37.666	39.778	0.947	0.345
Financing	**60.204***	33.809	1.781	0.077
Fraud Prevention	42.388	46.656	0.909	0.365
Information Aggregation	**51.982***	27.393	1.898	0.060
Investments	39.830	28.159	2.377	0.019
Payment Services	19.432	28.713	0.677	0.500
Personal Assistant	25.962	29.423	0.882	0.379
User Identification	29.543	51.560	0.573	0.568
Observations				221
R^2				0.702
Adjusted R^2				0.544
Residual Std. Error				48.449
F-Statistics				4.457***
Note:	*: p<0.1; **: p<0.05; ***: p<0.01			

The dimension "Product/Service Offering" contains three significant characteristics. Of particular interest is the characteristic "Credit Lending": A p-value of <0.001 is accompanied by a relatively large coefficient estimate of 92.686. "Financing" and "Information Aggregation" are also statistically significant but exhibit a slightly lower effect size. This finding indicates that specific types of "Product/Service Offerings" receive significantly more funding than others. As a final step, we take a closer look at the mentioned characteristics. To create an intuition for what kind of company belongs to these characteristics, we construct contingency tables and filter for the specific instance of "Product/Service Offering." The characteristics with the highest absolute frequency are displayed in Table 4.

Table 4. Most common taxonomy instances for each of the relevant characteristics (underlined)

Dominant Technology Component	*Value Proposition*	*Delivery Channel*	*Custo-mers*	*Revenue Stream*	*Product/ Service Offering*
Marketplace	Matching/ Intermediation	www	B2C	Unknown	Credit Lending
Marketplace	Matching/ Intermediation	www	B2B	Unknown	Financing
Decision Support System	Insight	App	B2B	Unknown	Information Aggregation

4 Results and Implications

Our empirical results show that the FinTech business model component "Product/Service Offering" plays a significant role in the potential success of a FinTech venture, as addressed in the research question. These findings are in line with the theoretical foundations on success factors for new high-tech ventures and contribute to close the research gap identified in section 2. Studies like [31] have identified that product-specific factors represent crucial determinants of venture success that rely on innovation to generate competitive advantages, as it is also the case for FinTech companies. Relating to Table 4, a connection to the FinTech business model archetypes, given in section 2.2, can be drawn. Naturally, when filtering for single characteristics, patterns similar to the archetypes emerge. However, a distinct assignment to specific archetypes cannot be made. This poses the question whether further insights can be gained by directly relating FinTech venture success to FinTech archetypes. As observed in Table 3, the FinTech companies that are more likely to succeed are those that target existing markets with growth potential like credit markets. The findings provide investors with determinants of the potential success of a FinTech venture that can be used throughout the venture lifecycle. These contribute not only to optimize the early stage FinTech valuation process, but also help to mitigate significant risks inherent to new ventures such as product risk, market risk, implementation risk, and competitive risk [40]. In addition, the correlation analysis, as indicated by Cramèr's V, shows at most moderate correlations between the taxonomy dimensions, which can be seen as a

first evaluation step of the FinTech business model taxonomy by [1]. To the best of our knowledge, this paper is one of the first studies to empirically analyze the business model determinants responsible for FinTech venture success and contributes to increase the existing body of knowledge in FinTech research.

5 Limitations and Future Research

As in any secondary data analysis, this study is restricted by limitations. Since Crunchbase is updated by selected contributors, the data quality varies in terms of completeness and accuracy. In addition, data about the revenue stream is not available in several cases. Therefore, the implications that can be drawn for this specific dimension are limited. For the analyzed dataset, this issue is especially prevalent in the B2B domain (62% "Unknown") compared to the B2C domain (38% "Unknown"). One could hypothesize that contract details are discussed in a bilateral manner between a FinTech company and its client. Thus, companies do not have an incentive to make this data publicly available. However, this presents an interesting research opportunity. A researcher may be able to generate additional insights in this area by interviewing FinTech companies. A course of action to improve the practical usability of the taxonomy is the further refinement and in-depth discussion of the characteristics assignment process to reduce ambiguities and improve consistency. Since FinTechs in different subsectors and funding stages might have different funding requirements, a further subdivision of the dataset might be useful, insofar as there are enough data points. In addition, a time dependent analysis of the funding across the taxonomy characteristics could possibly lead to more detailed insights. As [1] previously pointed out, the dataset used for this analysis presents a strong regional focus, as it is concentrated particularly on FinTech ventures in developed countries. To overcome the aforementioned limitation, future research could reproduce this study using a different dataset containing FinTech ventures belonging to the FinTech 3.5 period as defined by [2]. This approach will contribute to obtain a better understanding of FinTech ventures in emerging markets. As [2] indicate, the private sector is highly interested in new investment opportunities in financial services in emerging markets. A better knowledge about these investment objectives could provide useful decision criteria for new regulations in order to accelerate and support the successful funding and development of FinTech ventures in these countries.

6 Conclusion

Given the growing importance and disruptive force of FinTech ventures, this paper empirically explores the business model determinants of venture success. For that purpose, we relate business model characteristics and FinTech venture success by utilizing a FinTech business model taxonomy that allows for a company classification along six business model dimensions. By analyzing a dataset containing 221 FinTech companies and extracting complementary company details from Crunchbase, we identify the business model component "Product/Service Offering" to be the most

influential determinant of venture success. Through these findings, we contribute to the existent body of research on FinTech ventures by identifying business model components determining the success of a company. On the other hand, potential investors may benefit from our findings when attempting to derive predictors for the future success of companies of interest. Possible avenues for future research are the collection and analysis of additional FinTech specific data and the time-variant analysis of funding across the taxonomy characteristics.

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Internet of Value and Blockchain

Teilkonferenzleitung

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“Social Blockchain”: Improving Situational Awareness for Open Entrepreneurs by Designing a Bitcoin Seismograph

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Abstract. Modern economies and especially open source (OS) communities are fueled by entrepreneurs. Yet, in case of community disruption, entrepreneurs are more affected than larger firms due to lesser resources. Initial point for our research was the Mt.Gox bankruptcy in the Bitcoin community. Based on a qualitative analysis among open entrepreneurs we investigate on situational awareness as an instrument for improving resilience. For this purpose, we propose a tool, the Bitcoin Seismograph, which provides a rapid understanding of changes in the Bitcoin open source system. Its design, launch and evaluation are presented. Our Seismograph correlates discussions from social media platforms and online forums in the Bitcoin community with technical data from the blockchain and business data such as currency statistics. As such, our insights so far contribute to improving situational awareness in open source and blockchain communities.

Keywords: Situational Awareness, Bitcoin, Entrepreneurship, Blockchain, Design Science.

1 Introduction

When Mt.Gox, one of the largest Bitcoin exchange and an entry point for new users of the cryptocurrency, went bankrupt overnight in 2014, the Bitcoin community was thrown into turmoil. As the real reason behind the downfall was unknown (and still is), community members had to make sense based on speculation and uncertain observations. The explanation ranged from hacking, technical problems, unprofessional behavior from the Mt.Gox owners to fraud and customer asset stealing [1]. The bankruptcy of Mt.Gox is understood to be a major shock for the emergent sociotechnical field to date as it made many question the future of Bitcoin and blockchain technology. Since then, this question has never faded away due to recurring criticism [2, 3]. However, a growing number of entrepreneurs have built businesses that rely on the Bitcoin infrastructure. These entrepreneurs have to constantly observe their open source system to anticipate new trends or unwanted developments. As one

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entrepreneurs interviewed in a previous study [4], stated: "*I try to follow the Bitcoin news as closely as my time allows, so if something does come up that we can react as fast as possible and not just learn about it after one or two days."*

As a result, we conclude that situational aware entrepreneurs are more capable to foresee developments in their context and react to them faster in comparison to unaware actors. But this comes at a price. Whereas mature firms typically have more resources to continuously analyze their environment [5], entrepreneurs firms must work with fewer resources [6] for bouncing back. Again, this is expressed in the next statement underlining the cost needed for situational awareness: "*That it requires more attention and more time, because these spaces are just moving so quickly and there were so many new things happening every day, so actually I'd like to dedicate more time to follow news about Bitcoin specific news and I just scan it, because otherwise I couldn't run my business."*

This presents us a practical puzzle as entrepreneurs have to choose between dedicating time and resources observing their OS system to protect their ventures or expanding their businesses to become a mature organization. This organizational problem leads us to ask the following research question: *How can situational awareness of entrepreneurs embedded in an open source context be improved by reducing the required use of resources?*

Our answer to this question lies in a design science based development of an open source tool, the Bitcoin Seismograph. The Seismograph provides overview over a large amount of a variety of available data resources combining and correlating them. It enriches technical/block chain data with data from the business and social realm.

The paper is structured as follows. In the next section, concepts of situational awareness in entrepreneurial OS systems are defined. We describe the context Bitcoin in the third section. Then, our research approach and our research findings are presented. Finally, we discuss our findings, draw limitations and present theoretical as well as practical contribution of this paper.

2 Situational Awareness in Entrepreneurial Open Source Systems

Entrepreneurship is a vivid part of modern economies [7] as a source of new jobs, innovation and new business models [8]. While entrepreneurship is often understood as creation of new businesses [9], we define it more broadly as a venture of "a creative and social/collective organizing process" [10]. Entrepreneurs discover and exploit opportunities in their environment and transform them into business models and processes. This is especially true for open entrepreneurs, who build their businesses entrepreneurship on an open source community [11, 12]. We define open entrepreneurship as discovery and exploitation of business opportunities in an open source context (definition adapted from [13]). Open entrepreneurs benefit from low barriers to entry and exit [14, 15], fast internationalization and access to collectively generated knowledge. Especially, knowledge transferred from the community to the entrepreneur is an essential resource for open entrepreneurship [16, 17] as it will open

paths for new business opportunities or adapting existing business models to new circumstances [18]. Furthermore, knowledge gathered from the open source community supports the alignment of entrepreneur's actions with community developments fostering the entrepreneur's legitimacy [19] and reputation [20]. This gives entrepreneurs the chance to direct and control the open source community [21].

Nevertheless, interweaving into an open source community can be a double-edged sword. Strong reliance on a chosen open source community can also hurt entrepreneurs as unwanted developments in the OS context might damage entrepreneurs' reputation and legitimacy in the non OS environment and limits access to financial, human and social capital as well as public resources from authorities [22–24]. Open entrepreneurs have to balance the goodwill of the OS community in which they primarily operate, with their profitability and long-term success depending on stakeholders outside of the OS community. Thus, an open entrepreneur must gain situational awareness over its open source context to sponsor promising trends, limit the damages of harmful developments or even leave the chosen OS context in case of a cataclysm [25].

Situational awareness can be broadly defined as "knowing what is going on" [26] and includes a state of knowledge as well as "a variety of cognitive processing activities" [27]. In more detail, a fully situational aware actor perceives critical and relevant elements in its environment, interprets and evaluates the elements to achieve a comprehensive understanding of a given situation and can make prediction how a system will behave in the nearer future [26]. To achieve this, data from the environment must be compiled, processed and fused [28] in adaptive and changing systems [29] and under uncertainty [30]. Situational awareness is not an end in itself but a prerequisite for the sense making process [31], because "situation parameters or context of a problem largely determines the ability of individuals to adopt an effective problem-solving strategy" [26]. This means situational awareness is essential during uncertain situations as the "less adequate the sense making process directed at a crisis, the more likely it is that the crisis will get out of control" [32].

3 Context Bitcoin

Bitcoin and blockchains in general have developed into a vivid environment for entrepreneurial activities. Introduced in 2008 by an entity named Satoshi Nakamoto, Bitcoin has established an alternative for exchanging goods, store value and as unit of account lowering transaction costs and allowing new business models or the adoption of existing ones.

Motivated by a rising distrust in the banking industry [33] and a need for frictionless payment systems [34], cryptocurrencies are decentralized digital currency schemes based on peer-to-peer networks and cryptographic tools. Bitcoin as the most prominent example was founded as "an electronic cash system" [35] and quickly after its introduction transformed into an vivid open source system in 2009. Since then, Bitcoin became the most used cryptocurrency today with a market capitalization of around 137 billion USD (11/21/2017) and a price of around 8000 USD per Bitcoin [36].

Bitcoin users, who want to exchange Bitcoin, must implement the Bitcoin protocol to connect to an open peer-to-peer network. All users store a copy of a transaction ledger, the blockchain, permitting participants to verify all publicly available transactions to prevent misuse and fraudulent behavior. This has created a community of active supporters fostering the Bitcoin protocol and network. Embedded into the open source community are also open entrepreneurs offering eCommerce and financial services like Bitcoin exchanges, peer-to-peer Bitcoin lending or selling mining hardware to the community [37].

Since its introduction, Bitcoin is heavily discussed in online forums and social media websites (like Reddit). These platforms are used to announce updates of the Bitcoin protocol, debate developments of Bitcoin or notify each other of new events in the Bitcoin context. As of today, bitcointalk.org as the largest Bitcoin related forum has 1.125.392 members engaged in 761.449 forum threads, whereas the largest Bitcoin subreddit (/r/Bitcoin) exceeds 300.000 subscribers. At the same time, due to the availability to publicly available data from the blockchain, several websites gather statistical data around Bitcoin and present them to users. One of the most prominent websites, blockchain.info, enables users to check currency statistics (e.g. Bitcoin market price), block details (like transactions per block) or mining and network information (e.g. current mining difficulty). Other websites like btcforkmonitor.info focus on detection of blockchain forks or comparing market capitalizations of cryptocurrencies (coinmarketcap.com). Nevertheless, to the best of our knowledge, we have found no tool which combines statistical data and discussion from the Bitcoin community to provide a quicker understanding and explanation of developments in the Bitcoin open source system.

4 Research Methods

We followed the design science paradigm by Hevner et al. [38] to create a "purposeful IT artifact" [38] to address the problem of entrepreneurial situational awareness. To foster relevant and rigorous results, we used the Design Science Research Methodology (DSRM) by Peffers et al. [39]. This widely used methodology in IS research is a "consensus-building approach to produce the design" [39] and describes an iterative process consisting six core activities, described further below.

Problem identification and motivation. We identified our organizational problem in a previous study published in [4]. The problem is described in the introduction.

Define the objectives for a solution. Shortly after the problem identification, we turned to Bitcoin entrepreneurs and asked for further insights into the problem of situational awareness. From ten inquired entrepreneurs, a Bitcoin entrepreneur from Germany agreed to a workshop to gather requirements for the artifact. We conducted the workshop in a four-hour session with five participants at the site of the entrepreneur in October 2015. We conducted open, inductive and iterative coding of the workshop's transcript and triangulated our findings with literature about situational awareness and our knowledge about Bitcoin gathered in previous studies.

Design and development. The tool was designed in two iterations, but due to page restriction only the second iteration is described in this paper. The tool was developed by the authors using agile development methods Weekly sprints were established for coordination of the project supported by cloud based collaboration tools for day-to-day conversations and cooperation.
Demonstration. The tool was made public via a website (http://www.bitcoinseismograph.info/) in August 2017. The URL of the website and the intention of the tool were announced in Bitcoin related online forums and social media platforms to raise interest and direct users to our website. The source code is published as OS project on Github.
Evaluation. The evaluation of the Bitcoin Seismograph is based on two tiers; first, feedback from the Bitcoin OS community through active engagement with the community via social media channels and second, feedback from Bitcoin open entrepreneurs. We conducted a second workshop together with the German entrepreneur who already provided requirements for the artifact. During a two-hour session with five participants (four of them participated in the first workshop), we discussed the current version of the tool, future enhancements and the tool's ability to improve situational awareness of open entrepreneurs. Completed discussion with the community as well as the entrepreneur were saved and coded openly.

5 Improving Situational Awareness via the Bitcoin Seismograph

We turn now to outline the Bitcoin Seismograph. The results of each DSRM activity is described in the corresponding section.

5.1 Defining Objectives of a Solution

Literature about situational awareness describes three major requirements for designing situational awareness tools. Firstly, a tool must capture "status, attributes, and dynamics of relevant elements in the environment" [40] and put them in a second step "in relation to relevant goals and objectives" [40]. Thirdly, a situational awareness tool should have "the ability to predict what those elements will do in the future" [40]. Data collected must be accurate and consistent to avoid misinterpretation [41]. Other authors [42] suggest to store historical data to facilitate pattern recognition and learning.

In addition to requirements described in literature, the Bitcoin entrepreneur named further, context-specific challenges. Bitcoin indicators like Bitcoin price, transaction volumes or current blockchain difficulty have to be collected on a regular basis. These quantitative data should be set into context with current discussion in the OS community supporting the interpretation of indicators' developments. Bitcointalk.org and the Bitcoin subreddit are named as most important platforms for Bitcoin community communications. Due to the high frequency in these message boards, the community contributions should be filtered and pre-analyzed (e.g. via a sentiment analysis) to present only the most relevant to the user. But, the user shall also have the

possibility to go deeper and get a more detailed information about Bitcoin trends. Therefore, it is necessary to switch between community centric and data centric views. Additionally, the interviewees demand a traffic light system to get quick assessment of the situation: *"With these statistics, it is usually the case that everything is normal on 363 days per year and then there are two days something out of the ordinary happens. This makes tired, therefore, if there would be a traffic light with green, yellow and red signals and with a yellow signal you check again, and with a red signal you definitely check again and trigger further actions" (translation by the authors)*.

Warning and alert levels have to be defined for each Bitcoin indicator, for example triggering an alert when group of miners control more than 50% of the network's mining hash rate. The frontend of the situational awareness tool shall have an esthetic and modern look to support user to find relevant information quickly. In addition, an API is for the entrepreneur to be able to integrate certain data into their website.

5.2 Design & Development

We designed and implemented a web service with a website as a visualization frontend. The theoretical and practical objectives are addressed by a series of distinct features, which we describe in the following paragraphs. We detail in which software components these features are realized. Each one of them is also collectively illustrated in the data flow diagram (Figure 1), including its name, technological implementation and individual purpose.

Capture relevant elements in the environment. Through a selection of multiple complementary and redundant sources (e.g. blockchain.info), we gather Bitcoin quantitative technical and business data (Bitcoin indicators) about the Bitcoin price (in euro, dollar and yen), Bitcoin market, blockchain status, network details and mining pools. An integrated data model is defined by merging overlapping data and thus improving data accuracy and consistency. Data is extracted via *API Crawlers* which are realized as one-off Python scripts, which request the data via HTTP, apply necessary transformations and load it into storage (see below). The scripts are executed periodically in a 5 min interval by the *Job Scheduler*. Sources for qualitative data are social media platforms named by the entrepreneur like Reddit and bitcointalk.org. All text is scraped with another set of Python scripts (*Forum Scrapers*) and stored in an Elasticsearch database (*Text Storage*).

Putting elements in relation to objectives. Improving situational awareness resource-efficiently, we query and compose quantitative data and qualitative data by analyzing and filtering them in the *Analysis Backend*. For Reddit we use the native ranking system to show the ten most relevant threads. Since the forum threads work fundamentally different, we filter out every thread older than 3 days and show ten with the most views as a rough depiction of an active forum discussion. Additionally, we provide a sentiment analysis of the initial thread post by utilizing the Python library TextBlob with its default model. The sentiment analysis supports detection of atmosphere in the Bitcoin community. In our *Frontend*, we integrate and correlate Bitcoin indicators with analyzed threads from current community discussions for a quick overview. The key indicators are displayed as a structured number dashboard with appropriate sections,

labels, optionally information source, and applicable units. Current discussions are placed next to the dashboard. The sentiment is indicated by a green (positive) or red (negative) background of the thread display. For a further drill down, the user can click on the threads for a detail view and switch between a community- and indicator-centric view.

Display warning levels. As a main objective, we provide warning and alert levels for most of the Bitcoin indicators, which are following a traffic light scheme. In case pre-defined thresholds are exceeded, the indicators are displayed in yellow (warning) or red (alert). Once any indicator is yellow or red, the header color of the *Frontend* changes to yellow or red to make users aware of the overall status of the Bitcoin OS system.

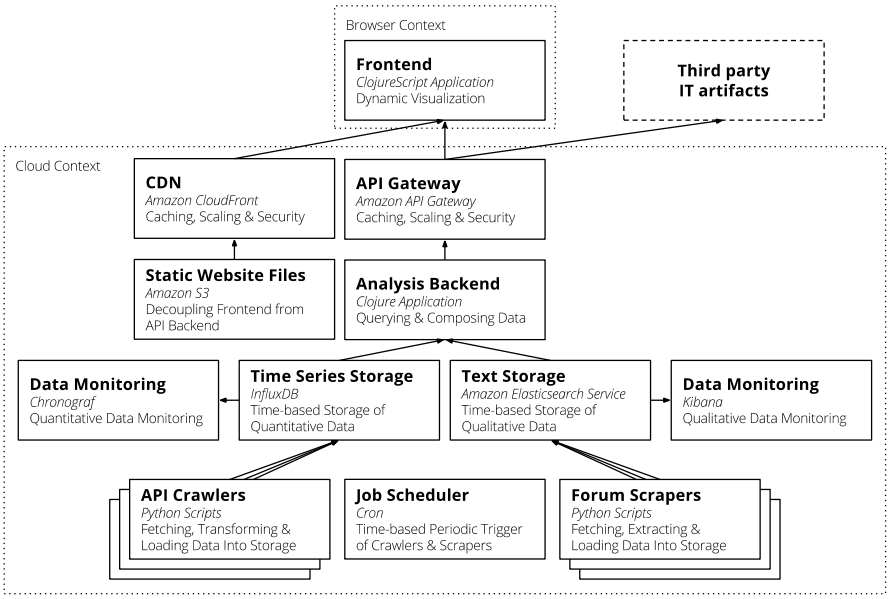

Figure 1: Data Flow Diagram of the Bitcoin Seismograph

Store and provide historical data. We store every data point in the *Time Series Storage* InfluxDB decoupling collecting data and delivering data to the *Frontend*. The database allows us to query data by time range and to generate additional Bitcoin indicators based on history of the underlying value (e.g. price volatility and change), which are also shown in the dashboard. For displaying historical data, we provide a second interface component in the *Frontend*: an interactive timeline chart, which can display all dashboard indicators mapped out over the past 30 days with an aggregated granularity of 12 hours. Then applicable community discussions are displayed below the timeline chart, for selectable timeline points in the past.

Predict future outcome of elements. Trend analysis of gathered indicators (e.g. price) are helpful to predict future developments in Bitcoin. We showcase this by offering a linear regression and displaying the percentage increase of the expected next value (with 12 hours granularity).

Provide an API. The web service can be also accessed directly via HTTP and JSON in a documented (Swagger) and standardized manner. Tool users can access available information directly and integrate them into their tools and processes.

5.3 Demonstration

Since launch of the Bitcoin Seismograph (August 1) until end of August, 4480 service requests (excluding bots and search engine robots) were handled by our CDN. Most user originated from the United States of America (34.2%), followed by Germany (28%) and Russian Federation (4.2%). In total, users from 49 different countries accessed the tool. At the time of writing, most visitors per day were counted on the 31st of August (809 service requests), shortly after a heated discussion about the tool started on bitcointalk.org. At the moment, the website is called 170 times per day on average.

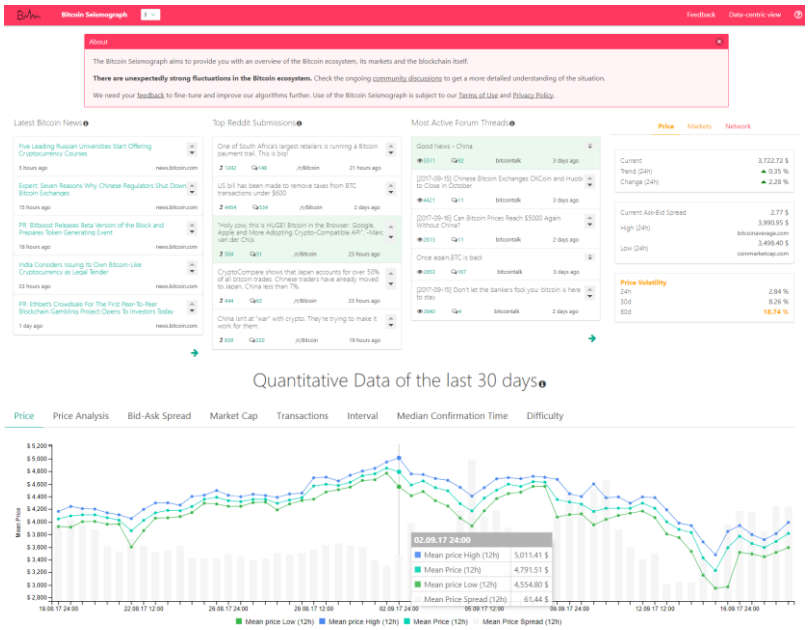

Figure 2: Screenshot of Bitcoin Seismograph illustrating Bitcoin Price Drop

Shortly after tool launch, Bitcoin came under heavy pressure due to new restriction on Bitcoin trading introduced by Chinese legislators [43]. Two major Chinese based Bitcoin exchanges, BTCC and ViaBTC, are forced to close their exchanges, other Chinese exchanges are expected to follow. As a consequence, the Bitcoin price dropped from an all-time high of $5,013 on September 2 to $2,951 on September 15 returning to around 4000 USD per Bitcoin on September 18. This turbulences in the Bitcoin market were fully captured by the Bitcoin Seismograph, the alert status was triggered informing users about the price fluctuations and correlating discussions (see Figure 2).

5.4 Evaluation

The Bitcoin Seismograph receives generally positive review from the Bitcoin OS community supporting the idea of the tool and the combination of quantitative and qualitative data. The claim, that the Bitcoin Seismograph is helpful to understand movements in the Bitcoin ecosystem and captures crisis and unforeseen developments, is supported by feedback received from users and OS community members. Criticism aims at misleading warning and alert level descriptions and the tool's emphasis on price volatility. As a response, we changed the descriptions to make them more comprehensible, improved user guidance for stronger attentiveness of the community-centric view as well as raised the volatility warning and alert levels to reduce sensitivity of the indicator.

The Bitcoin entrepreneur evaluating our tool also supports the hypothesis, that the Seismograph will improve situational awareness during unforeseen events and will save time and resources to understand developments. One participant answers to the question of intention to use in general: *"But, I would use something like that [Bitcoin Seismograph], because it is also great to have community and quantitative data at a glance" (translation by the authors).* Especially the history graph is praised for the possibility to investigate previous events with correlating social, technical and business data at that period of time. To the entrepreneur's knowledge, no other Bitcoin analysis tool offers this potential making the Bitcoin Seismograph also interesting for blockchain researchers and journalists. Similar to comments from the Bitcoin community, the pre-defined threshold values of warning and alert levels are named as the important point of criticism. These values for each Bitcoin indicator shall be customizable based on users' needs. In addition, the workshop participants ask for future inclusion of more technical and business data, like blockchain fork detection and analysis of Bitcoin financial instruments (e.g. futures). As a conclusion, it can be stated, that the Bitcoin Seismograph is seen as a helpful tool to solve the organizational problem, but needs a higher adaptability to meet the different information requirements of diverse Bitcoin open entrepreneurs.

6 Conclusion and Limitations

The overall contribution of this design science research project is an open source IT artifact under the guidance of the DSRM [39]. The Seismograph addresses the need to observe a fast-moving open source environment to detect trends or unwanted events with only limited resources at hand. So far, no research has covered this subject yet. The resulting artifact thus addresses this need with the implementation of objectives triangulated from research literature and practical observations. To the best of our knowledge, no similar tool is available in the Bitcoin. The demonstration of the artifact shows interest and the intention to use of the open source community and entrepreneurs. An unexpected Bitcoin price drop and its impact was captured by the artifact underlining the tool's usefulness. The evaluation in a real-life setting indicates that the Bitcoin Seismograph is effective to gain situational awareness resource-efficiently, both for community members as well as open entrepreneurs. Especially, the historical

display of quantitative and qualitative data is seen helpful to understand previous events and facilitates organizational learning and preparation for future events. Admittedly, situational awareness can be further enhanced, if Seismograph users are able to change warning and alert levels to their individual needs. Although this is anticipated in the tool's architecture, the implementation remains to be done in the following development iterations.

We believe that our findings have implications for situational awareness and blockchain research: 1) highlighting the dynamics between correlated social, technical and business data to observe developments in Bitcoin; 2) showing how open Bitcoin entrepreneurs can be situational aware with only limited resources; and 3) demonstrating how design science based artifacts can improve situational awareness. The practical implications of this research are twofold. Firstly, Bitcoin entrepreneurs can use the developed tool to get a faster understanding of a given situation in Bitcoin without time-consuming checking statistics and Bitcoin related communication channels on manifold websites at the same time. Secondly, due to the Seismograph's open source character, open entrepreneurs and other Bitcoin community members can check and change the implementation to their specific needs. This is especially important for the heterogeneous group of open entrepreneurs as they have different triggers and interest based on their business models, ideologies and resources at hand. It is therefore a starting point for future refinement of the IT artifact.

There are some limitations of the research. The Bitcoin Seismograph only covers publicly available information. Data originated from internal entrepreneurial processes can also provide helpful insights to understand current developments. Nevertheless, the inclusion of such data is possible in future, entrepreneur-specific versions due to the adaptability of the tool's architecture. Also, this research focusses on Bitcoin only. Other promising blockchain based projects like Ethereum are not covered by the tool, but might have also effects on the success of Bitcoin. Data from non-blockchain based system interfering with Bitcoin are also not included into the tool. Thirdly, the designed artifact is yet to be tested in an entrepreneur or system threatening situation. But, tool's behavior during the demonstration phase suggests, that the Seismograph can support entrepreneurs during devastating events. Fourthly, the Bitcoin Seismograph has only limited capabilities to predict crisis beforehand due to limited data and valid prediction methods. As it serves as a crisis detection tool in today's version, future tool enhancements should focus on crisis prediction. Finally, the Bitcoin specific definition of objectives and the evaluation rest upon the experiences of one Bitcoin entrepreneur. Future iterations of the DSRM will focus to include more entrepreneurs to get a more complete picture of their needs and triggers to be situational aware in Bitcoin. In summary, despite current missing adaptability for diverse needs of open entrepreneurs, the Bitcoin Seismograph improves efficient situational awareness of entrepreneurs and other OS community members by correlating social, technical and business data from the Bitcoin open source system. Consequently, it underlines that the Bitcoin context although it is evidently based on blockchain technology, is also highly depending on social behavior, letting the Bitcoin context converge to a "social blockchain".

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Ein problemzentrierter Blick auf Blockchain-Anwendungsfälle

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Abstract. Die Studie bedient sich eines Literature Reviews zur Analyse von Anwendungsfällen der Blockchain-Technologie (BCT). Diese Anwendungsfälle werden zu Klassen zusammengefasst und abgeleitet, welche Businessprobleme den Klassen zugrunde liegen. Diese Probleme werden wiederum in Gruppen geordnet und den Elementen von Transaktionen zugeordnet. So wird der durch BCT adressierte Problemraum aus Businesssicht dimensioniert und sprachlich erfassbar. Mittels dieser zweistufigen Klassifikation wird eine Übersetzungshilfe entwickelt, welche vor allem Entscheidungsträgern das Erfassen der Problemlösefähigkeit der BCT ermöglicht und das Übertragen dieser Erkenntnisse auf eigene Businessmodelle erleichtert.

Keywords: Blockchaintechnologie, Literature Review, Problemklassifikation

1 Einleitung

Die BCT[1] ist ein vielbeachtetes und von vielen Entscheidungsträgern für wichtig befundenes Element der digitalen Transformation [3]. So rief die EU-Kommission 2017 ein Projekt ins Leben, um die transformative Wirkung von Blockchain (BC) auf den Industriesektor zu erforschen [4].

Zugleich scheint bisher nur rudimentär durchdrungen, welche Probleme BCT aus Businesssicht adressiert [3]. In welchen Businessmodellen kann BCT wie eingesetzt werden? Wie können mittels BCT neue Businessmodelle entwickelt werden, welchen Mehrwert bietet sie [5,6]? Der hier gewählte Ansatz trägt zur Beantwortung dieser Fragen bei, indem BC-Anwendungsfälle und dadurch adressierte Probleme zwecks Übertragung auf andere Fälle abstrahiert werden. Es werden bereits Taxonomien zur Unterscheidung von BCs vorgeschlagen. Diese Ansätze klassifizieren jedoch kaum die mit ihnen verbundenen Businessprobleme, sondern Technologiebündel (vgl. z.B. Einteilungen in BC-Archetypen [7]; bzgl. BC-Merkmale [8] oder eine Checkliste zur

[1] Auf kryptographischen Regeln basierendes Transaktionsregister, das in einem dezentralen Netz von Computern abgelegt ist, wobei eine Transaktion vom Netzwerk validiert wird [1]. Für technische Erläuterungen am Beispiel der Bitcoin-Technologie vgl. [2].

BC-Typ-Auswahl [9]). Ein vom Businessproblem ausgehendes und zur Technologie hinführendes Verständnis streben diese Beiträge nicht an.

In dieser Arbeit werden auf Basis eines Literature Reviews (LR) BC-Anwendungsfälle, die ähnliche Probleme lösen, zu Klassen zusammengefasst und es wird klassenspezifisch analysiert, welche Probleme der BC-Einsatz jeweils lösen soll. Diese Probleme werden wiederrum zu Klassen verdichtet, um aufbauend hierauf die Rolle und die Relevanz der Elemente einer Transaktion je Klasse zu untersuchen. So kann Technologiezentrierung reduziert und der BC-Einsatz aus Blickrichtung der zu lösenden Businessprobleme motiviert werden. Ziel ist es folglich, eine Übersetzungshilfe vom Problem zur Technologie zu entwickeln.

Die Arbeit ist wie folgt gegliedert. An die Beschreibung des methodischen Vorgehens schließt ein zweigeteilter Ergebnisteil. Zunächst werden die identifizierten und klassifizierten Anwendungsfälle sowie die hierbei durch die BCT zu lösenden Probleme aufgezeigt. In Teil zwei werden Elemente einer Transaktion beschrieben, bevor die identifizierten Probleme geordnet, klassifiziert und den Transaktionselementen zugeordnet werden. Die Arbeit schließt mit einer Zusammenfassung samt Ausblick.

2 Methodisches Vorgehen

Die Identifikation der BC Use Cases wird auf Basis eines LR erschlossen (vgl. [10]), um die adressierten Probleme zu abstrahieren und letztlich Dimensionen des von BCT adressierten Problemraums zu erkennen. Diese induktive, von bekannten Problemlösungen ausgehende Vorgehensweise wird gewählt, um auf ‚verborgene' Problemdimensionen zu schließen [11,12].

BC-Anwendungsfälle sind nicht nur in wissenschaftlicher Literatur, sondern ebenso in Whitepapern (z.B. [13]), Ideenskizzen von Startups (z.B. [14]) oder Videos[2] erfasst, weshalb die Literatursuche breit zu organisieren ist. Potentiell erfolgreiche Konzepte sollten zusätzlich häufiger zu finden sein und junge mediale Spuren aufweisen (Aktualität der Ideen), was die Beschränkung der Suche auf 2015 bis 2017 erklärt. Der LR erfolgt gem. Cooper „pivotal" [15]. Die identifizierten Use Cases signalisieren Problemlösungen, deren Probleme klassifiziert und abstrahiert werden. Die für die Literatursuche zentralen Konzeptbegriffe (vgl. [16]) wurden per Pilotsuche evaluiert [17] und auf zwei besonders relevante Literale eingegrenzt: (1) „Blockchain Use Cases" und (2) „Blockchain Implementation". Als Suchplattform wird „Google Scholar" gewählt, um die angesprochene Breite zu erreichen.

Diese Überlegungen führen zu folgendem Vorgehen:

1) Suchliterale: „Blockchain Use Cases" und „Blockchain Implementation";
2) Suchplattform: Google Scholar;
3) Suchzeitraum: 2015 – 2017;
4) Forschungsökonomie: Ergebnisbeschränkung auf erste je 50 Publikationen;
5) Elimination Duplikate (Verbleib: 83 Publikationen);

[2] z.B. https://youtu.be/ZggkzPJ5Yt4

6) Selektion nach Verfügbarkeit (Verbleib: 77 Publikationen);
7) Elimination thematisch irrelevanter Publikationen (Verbleib: 48 Publikationen);

Die verbleibenden 48 Publikationen (Stand 23.03.2017) finden Eingang in die Analyse.

3 Ergebnisse

Erstes Ergebnis ist eine Use Case-Klassifikation und eine Beschreibung der Probleme, die durch BCT-Anwendung in der jeweiligen Use Case-Klasse adressiert werden (Abschnitt 3.1). Zweites Ergebnis ist eine Beschreibung und Abstraktion der identifizierten Probleme in Business-bezogene Problemdimensionen. Hierdurch wird das Verständnis der Businessrelevanz gefördert und es entsteht eine Übersetzungsfunktion, um Entscheidungsträgern das Reflektieren der BCT in ‚ihrer Sprache' zu ermöglichen.

3.1 Erfasste Use Cases und darin adressierte Probleme

Die untersuchten Use Cases und deren Zuordnung zu Use Case-Klassen sind in **Abbildung 1** aufgelistet. Dabei wird jede Klasse um eine Kurzbeschreibung, was BCT für die Use Cases ermöglicht, um eine die Use Case-Klasse erfassende und den zugehörigen Business Case umschreibende Namensgebung und die adressierten, im Business Case auftretenden Probleme ergänzt. Es gibt Publikationen, die mehr als einen Anwendungsfall beschreiben, weshalb Doppelnennungen möglich sind.

Insgesamt sind sieben Use Case-Klassen identifiziert. (1) *Bezahlung* durch Transaktion von ‚Währungs'-Tokens. (2) *Individuelle Informationsverwaltung*, mittels derer Informationen aggregiert, gespeichert und durch den Besitzer verwaltet werden und der die BC als Verzeichnis dient. (3) *Transaktionshistorie* mit Informationen über Objekte oder deren Referenzen, etwa bzgl. Existenz, Eigentum oder Transaktionsdatum. (4) *Kommunikation*, bei welcher Inhalte dezentral verwaltet werden, was Datenschutz befördert und die Macht des ‚Kommunikationsintermediärs' beschränkt. (5) *Ergebnisbasierte, automatisierte Transaktionen*, die Ereignissen folgend als Smart Contracts durch die BC abgewickelt werden. (6) *Transaktionsmediär*, zur Vermittlung von Partnern, der Erfassung, Überwachung und Abwicklung von Vereinbarungen sowie möglicher Schlichtung bei Rückabwicklungen. (7) *Communitymanager*, bei welchem Algorithmen die Koordination gleichgestellter Akteure so regeln, dass Kooperationsregeln erfasst, aber nur gemeinschaftlich geändert werden können.

Die Use Case-Klassen weisen bzgl. des abgebildeten Szenarios und tlw. hinsichtlich der technischen Umsetzung unterschiedliche Komplexitäten auf. Betrachtet man die Klassen *Bezahlung* und *Transaktionshistorie*, so ist festzustellen, dass eher granulare Services vorliegen, die relativ einfach umsetzbar sind. Bereits die *Individuelle Informationsverwaltung* gestaltet sich komplexer, da hierbei oftmals ganz individuelle Zugriffsrechte auf komplexe Informationsobjekte sowohl ermöglicht als auch entzogen werden sollen. Die Klassen *Ergebnisbasierte, automatisierte Transaktionen* und *Transaktionsmediär* sind noch anspruchsvoller, da hier komplexe Verhaltensweisen

abgebildet und automatisiert werden. *Comunitymanager* ist die Klasse mit den komplexesten Szenarien, da hier die Governance kompletter Organisationsformen algorithmisch abzubilden ist. Mit steigendem Komplexitätsgrad ist es möglich, granulare Services einzubetten. So kann bei komplexeren Use Case-Klassen das Bezahlen ebenso wie die Transaktionshistorie eine Rolle spielen.

Use Cases	Beschreibung, was BCT ermöglicht	Name	Probleme, die abgemindert werden sollen
Kreditkartenzahlungen [18–23] Staatliche Kryptowährung [18,24,25] Staatliche Zahlungen, z.B. Sozialhilfe [18,26,27] Token als Währung, z.B. Airline Meilen, Festivalcoin [18] Micropayments, z.B. Trinkgeld [19,28–31]	Tokens als Währung und Transaktions-austauschinstrument	Bezahlung	(1) Gebühren für Finanztransaktionen (FT) (2) Dauer von FT (Echtzeittransfer) (3) Regulierung durch Regierung/EZB (4) Intermediär nötig, der FT nachweist (Wann? Wie viel? Wohin?) (5) Authentifizierung bei digitalen FT
Behördliche Dokumente verwalten [18,22,26] Dig. Wahlen (Stimmtransfer) [18,29,32–34] Fallsammlung für Streitschlichtung [18] Gesundheitsdaten-Mgmt. [13,18,26,35,36] Medizinische Datenbanken [18,27] Authentifizierung [18,29,37–39] Programm-Code-Tracking [18,40]	Informationen basierend auf BCT aggregiert, gespeichert, verwaltet; als Verzeichnis dieser Informationen; Informationsbesitzer verwaltet Informationen und Zugriffsrechte	Individuelle Infor-mationsverwaltung	(6) Existenz-/Inhaltsnachweis von Information (7) Interaktionshemmnisse zw. Organisationen (Schnittstellen, fragmentierte Datenhaltung) (8) Zeitverluste durch Interaktionshemmnisse (9) Authentifizierung bei digitaler Interaktion (10) Verfügungsverlust transaktionierter Daten, z.B. Einwohnermeldeamt
Eigentumsrechteverwaltung, z.B. Immobilien, Geistiges Eigentum [18,29,41,42] Proof-of-Existence, z.B. Testament, Organspende [18,27,29,41] Inhalts-/Herkunftsnachweis in Supply Chains [20,22,33,43,44] Integrität von Bildern/Videos, z.B. Versicherungsbeweis [45] Echtheit von Abschlüssen [46]	Informationen über Objekte bzw. deren Referenzen in BC festgehalten, z.B. bzgl. Existenz, Eigentum, Zeitpunkt der Transaktion	Transaktionshistorie	(11) Nachweis von Zeitpunkt/Inhalt/Umfang einer Objektexistenz (12) Fälschung durch einen Partner (13) Koordination bei Nachweis (viele Beteiligte) (14) Nachweiszeit (Beteiligte/Verfahren) (15) Nachweiskosten (Personal/Verfahren)
Social Media [18,47] Sprach-/Voice-Chat [18]	Dezentral verwaltete Inhalte ermöglichen Datenschutz und eliminieren Einfluss von Mittelsmännern	Kommuni-kation	(16) Intermediär als Servicevoraussetzung (17) Macht des Intermediär (18) Datenweitergabe ohne Selbstbestimmtheit (19) Kontrolle von Datenschutzregeln/-gesetzen
Automatisierte Infrastrukturressourcenverteilung, z.B. Verkehrsnetz [18,48] Automatisierter Zugriff auf physische Objekte, z.B. Smart Locks [31,49,50] Automatisierte Vertragsausführung [23, 24,31,33,42,51] Eigentumsrechtsübertragung [18,42] Wetten [18,52] Interaktion und Geschäftsabwicklung zw. Maschinen [31,46,49,50] Clearing und Settlement [52–54]	Bei Auftreten eines Ereignisses wird Aktion gem. Smart Contract automatisch ausgeführt	Ereignisbasierte, automatisierte Transaktionen	(20) Nachweis über Aktionsauslöser (21) Sicherstellen von Vereinbarungen automatisierter Prozesse (22) Interaktionshemmnisse von Geräten/Perso-nen in automatisierten Prozessen (23) Zeitverlust durch begrenzte Automatisierung (24) Personalkosten (25) Authentifizierung von Maschinen/Personen (26) Keine automatisierte Reaktion auf Auslöser
Teilen von Ressourcen, z.B. CPU [18] Data Storage and Sharing [18,55,56] Kreditvergabe [18,27,51,54] Fondmarkt [57] Crowdfunding [18] Vermarktung persönlicher Daten [27,30,58–60] Vermietung, z.B. Carsharing [18] Publikationen [18] Marktplatz im Energiesektor [30,40] Spenden [18]	Vermittlung von (Vertrags-) partnern; festhalten, überwachen, abwickeln von Vereinbarungen; ggf. Schlichtung bei Transaktionsrückabwicklung	Transaktionsmediär	(27) Vereinbarungsnachweis (Willens-erklärung/Bedingungen) (28) Betrug/Vertragsbruch (29) Partnerfindung/-vermittlung (30) Zeitverluste durch Anbietervergleiche (31) Gebühren für Intermediäre/Plattform (32) Abhängigkeit von Anbietern
Algorithmikbasierende Organisations-Governance, z.B. DAO [18,31,42,61] Kollaborative Prozesse, z.B. Status, Audi-tierung, Datenablage [22,27,43,47] Ranking von „Politik-Bürgern“ (Liquid Democracy) [18] P2P Domain Name System (DNS) lookup tables [14,18,42,46,62] Zusammenschluss von Maschinen (Robotic Swarm Systems) [63]	Koordination von gleichgestellten Akteuren; Kooperationsregeln der Zusammenarbeit nur gemeinschaftlich änderbar; Kollaborationsmonitoring möglich	Communitymanager	(33) Rechenschaftsnachweis ggü. Akteuren (34) Einhaltung vereinbarter Regeln (35) Koordination bei Vielfalt an Akteuren (36) Zeitverluste durch Koordination (37) Gleichberechtigung der Akteure unmöglich (38) Vertrauen in Governance-Verantwortliche (39) Fehlende Schnittstellen zum Austausch (40) Regulierung/Zensur durch Regierungen

Abbildung 1. Identifizierte Use Cases und durch diese adressierte Probleme

Die Klassifikation der Anwendungsfälle ermöglicht es Entscheidungsträgern zu prüfen, ob strukturgleiche Anforderungen im eigenen Business Model vorliegen. Ist dies der Fall, kann die BCT als potentielle Technologie für den eigenen Anwendungsfall ins Auge gefasst werden. Zusätzlich bildet **Abbildung 1** (Spalte 4) die in den jeweiligen Use Case-Klassen adressierten Probleme ab, welche durch BCT abgemildert oder gelöst werden sollen. Die Probleme sind nummeriert, um im nachfolgenden Abschnitt den Bezug zwischen **Abbildung 1** und **Abbildung 3** herstellen zu können.

3.2 Problemdimensionen und betroffene Transaktionselemente

Nachdem basierend auf den Use Cases Probleme identifiziert wurden (**Abbildung 1**, Spalte 4), die durch BCT überwunden werden sollen, werden diese Probleme in diesem Abschnitt in Business-bezogene Problemdimensionen zusammengefasst und den Elementen einer Transaktion zugeordnet.

BCT dient als Transaktionsspeicher, dies wird durch die Use Cases deutlich. So können Token im Sinne einer Währung transaktioniert werden. Informationen können zu verschiedenen Zwecken (Verwaltung, Kommunikation, Kollaboration) Gegenstand einer BC-Transaktion sein. Auch die Klassen Transaktionshistorie, Automatisierung von Transaktionen oder Transaktionsmediär fokussieren die Transaktionsabwicklung.

Eine Transaktion ist die Übertragung von Gütern oder Forderungen zwischen Entitäten [64]. Bei der BCT ist das Gut zunächst ein Informationsgut, welches jedoch als Recht über andere Güter und Dienstleistungen stellvertretend fungieren kann.

Transaktionen können durch die vier Elemente Entitäten, Gut, Vereinbarung und Austausch charakterisiert werden [64,65] (Abbildung 2). Dabei sind Entitäten am Austauschprozess beteiligt, Gut ist das auszutauschende Objekt, Vereinbarung fixiert Austauschregeln und Austausch selbst beschreibt den Übertragungsprozess zum Vollzug. Nachfolgend wird die Frage beantwortet, bei welchem durch BCT adressierten Problem (**Abbildung 1**, Spalte 4) welches Transaktionselement betroffen bzw. Auslöser des Problems ist.

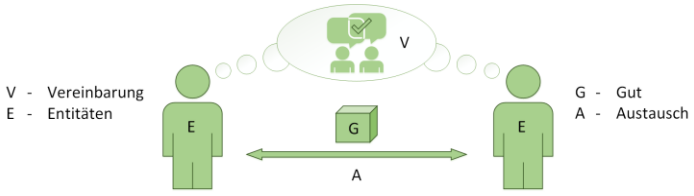

Abbildung 2. Elemente einer Transaktion

Die identifizierten Probleme referenziert Spalte 1 in **Abbildung 3** mittels Nummern aus **Abbildung 1**. Die Probleme sind nunmehr so geordnet, dass bzgl. der betroffenen Businessprobleme als gleichartig anzusehende Probleme zusammengefasst und unter Angabe einer Kurzbeschreibung (Spalte 2) als Dimension klassifiziert sind. Spalte 3 zeigt die für das zu lösende Problem verantwortlichen Transaktionselemente.

Es gibt Problemdimensionen, die vorrangig einem und solche, die mehreren Elementen zugeordnet sind. In Klammern stehen Elemente, die eine sekundäre Rolle

spielen. Die Zuordnung bezieht sich dabei auf augenscheinliche Zusammenhänge. Durch neue, noch unbekannte Use Cases kann sich diese Zuordnung ändern. Darüber hinaus ist es möglich, durch empirisch unwahrscheinliche Argumentationen Fälle herbeizuführen, in denen andere Transaktionselemente ursächlich für die Probleme sind. Die Idee der hier vorgenommenen Zuordnung liegt jedoch in der besseren Kommunikationsfähigkeit aus Sicht der Businessprobleme, die durch die Klassifikation der Probleme und die Zuordnung zu den entsprechenden Interaktionselementen sicher gegeben ist.

Durch Use Cases adressierte Probleme	**Kurzbeschreibung der Problemdimension**	**Betroffene Transaktions-elemente**			
		A	**G**	**E**	**V**
(4), (16)	Intermediär ist Voraussetzung			X	
(32)	Partner ist Voraussetzung			X	
(17)	Macht der Intermediäre			X	
(37)	Macht der Partner			X	
(5), (9), (25)	Erschwerte digitale Authentifizierung			X	
(7), (22), (39)	Kein bzw. erschwerter Daten-/ Informationsaustausch	X			
(10), (18)	Verlust von Selbstbestimmtheit/ Verfügung (entweder technisch hervorgerufen oder durch Machtstellung des Partners gegeben)		X	(X)	
(21), (19), (38)	Abwägung zwischen teurer Kontrolle oder risikobehaftetem Vertrauen			(X)	X
(12), (28), (34)	Fälschung/Betrug		X	(X)	X
(6), (11), (20), (27), (33)	Fehlende Nachweise in Transaktionen	X			X
(26)	Automatisierung	X			(X)
(2), (8), (14), (30), (23), (36)	Zeitaufwändige Interaktion/Zeitverluste	X		(X)	
(1), (15), (24), (31)	Gebühren	X		X	
(13), (29), (35)	Viele Personen/Parteien koordinieren	X		X	(X)
(3), (40)	Möglicher Machtmissbrauch staatl. Organe	X	X	X	X

Abbildung 3. Problemdimensionen und diese verursachende Transaktionselemente

Sind die Entitäten Voraussetzung des Zustandekommens der Transaktion (im Sinne von Partner/Intermediäre finden/identifizieren) oder ist deren Machtstellung ein Problem, dann sind nur die Entitäten als Transaktionselemente betroffen. Gleiches gilt, wenn die Authentifizierung ein Problem der Transaktion darstellt.

Kein bzw. erschwerter Daten-/Informationsaustausch ist ein Problem des Austauschs, hervorgerufen durch Hemmnisse wie fehlende Schnittstellen oder dispergierte Daten.

Der Verfügungsverlust über Informationen und damit einhergehende Einschränkungen digitaler Selbstbestimmtheit ist ein Problem des Guts (Information). Durch die Eigenschaften von Informationen (z.B. schnell und kostengünstig replizier-, tausch- und teilbar; nicht verbrauchbar [66]) kann Information in unzähligen Kopien bei Partnern existieren, ohne dass dies der Information angesehen werden kann. Andererseits würde Informationsweitergabe u.U. nicht als problematisch angesehen

werden, falls gegenseitiges Vertrauen der Entitäten, die Information nur wie vereinbart und vorgesehen zu verwenden, existiert und auch nicht beschädigt wird. Somit sind die Entitäten sekundärer Auslöser des Problems und deshalb eingeklammert.

Kontrolle oder Vertrauen beziehen sich auf das Einhalten von Vereinbarungen. Kennt man seine Partner und haben sich diese sich in vorangegangenen Transaktionen als vertrauenswürdig erwiesen, kann häufig auf Kontrolle verzichtet werden (z.B. Supply-Chains und Lieferanten). Sind die Partner unbekannt, ist Kontrolle eher notwendig. Insofern wird das Problem mittelbar durch die Entitäten verursacht. Grundsätzlich besteht das Problem aber, weil das Einhalten der Verträge bzw. Vereinbarungen nicht garantiert werden kann, was durch Smart Contracts in BCs jedoch in vielen Fällen möglich ist.

Fälschung bezieht sich auf das Gut, Betrug auf die Vereinbarungen. Die Argumentation erfolgt analog zur Betrachtung von Kontrolle vs. Vertrauen, da es bei Kontrolle gerade darum geht, sich vor Fälschung oder Betrug zu schützen.

Bei der Problematik des fehlenden Nachweises sind die Vereinbarung (Willenserklärungen, Vertragsinhalte) und der Austausch (Zeitpunkt einer Existenz, Rechenschaft ggü. Kollaborationspartnern) betroffen, da es diese Elemente nachzuweisen gilt. Das Gut ist durch diese Dimension nicht betroffen, da durch die BCT keine Änderung bzw. Beeinflussung am Gut vorgenommen wird. Die Technologie kann Einfluss auf die Übertragung des Guts sowie auf die Vereinbarung über die Transaktion haben.

Automatisierung ist zum einen ein Problem der Infrastruktur, über die Austausch stattfindet. Zum anderen kann die Automatisierung der geschlossenen Vereinbarung selbst ein sekundäres Problem darstellen, wenn in dieser das auslösende Ereignis einer Transaktion (z.B. eingehende Zahlung) festgehalten ist.

Transferzeiten, Interaktionshemmnisse oder begrenzte Automatisierung sind durch den Austausch bedingte Gründe für den Zeitaufwand von Transaktionen. Begrenzte Automatisierung führt weiterhin zu manuellen, zeitintensiven Handlungen durch die Entitäten. Diese sind jedoch im Austausch begründet. Kostengründe unterliegen einerseits dem Austausch selbst (Plattform, Austauschgebühren) und andererseits den Kosten für Personal, ob durch Partner oder Intermediäre verursacht.

Das Problem der Koordination ist keinem Transaktionselement per se zuzuordnen. Z.B. können Entitäten ursächlich sein, wenn Anzahl und Heterogenität der Absichten Koordination sehr aufwändig gestaltet (vgl. Ideen zur DAO [61]). Auch der Austausch kann Quelle des Problems sein, bspw. beim Finden von Transaktionspartnern (Vermittlung). Die Vereinbarungen werden zum Problem, wenn viele Sonderrechte und –rollen die Entitäten grundsätzlich nur schwer koordinierbar machen.

Der mögliche Machtmissbrauch staatl. Organe kann bezogen auf Vereinbarungen bereits bei der Gesetzgebung stattfinden. Gesetze und Regelungen wirken aber auch auf den Austausch, da dieser innerhalb eines Ordnungsrahmens stattfindet. Es gibt auch klare Regeln, welche Güter nicht getauscht werden dürfen, die nicht immer gesellschaftlicher Konsens sind (vgl. regulierte Märkte). Entitäten sind vor allem dann betroffen, wenn staatliche Regelungen auf bestimmte Gruppen Bezug nehmen.

Als Ergebnis liegen Problemklassen und deren Interaktion mit Transaktions-elementen vor, die in vielen Geschäftsmodellen eine Rolle spielen. Bei der Analyse der

Geschäftsmodelle besteht nun die Möglichkeit, vergleichbare Probleme zu identifizieren (weil sie sprachlich erfasst sind) und hierdurch gleichzeitig einen Hinweis zu erhalten, dass BCT ein möglicher Technologiekandidat zum Lösen der Probleme ist. Dies führt zur angestrebten Business-Technologie Übersetzungshilfe.

4 Zusammenfassung und Ausblick

Ziel der Studie ist die Entwicklung einer Übersetzungshilfe, anhand derer erkannt werden kann, welche Businessprobleme BCT adressiert. So wird mittels Sprache die vorherrschende Technologiezentrierung im Bereich BC reduziert und auf diese Weise ein Rahmen geschaffen, der Entscheidungsträger bei der Identifikation von Problemen unterstützt, für welche BCT eine Lösungsoption darstellt. Obwohl das Ergebnis induktiv – d.h. von den Use Cases her entwickelt und aus Gründen der Intersubjektivität auch so dargestellt wurde, ist es vom Ende her zu lesen. Das bedeutet, es ist z.B. im Geschäftsmodell nunmehr eher möglich zu erkennen, dass Probleme bei gewissen Transaktionselementen vorliegen, die auf dispergierte Informationen zurückzuführen sind. Über **Abbildung 3** wird ein Bezug zu einer passenden Problemklasse ermöglicht, um über die Probleme auf Use Cases zu schließen, die wiederum als Inspiration des Technologieeinsatzes dienen können.

Der Beitrag hat, wie jede Forschung, Limitationen. Zunächst ist der LR aufgrund der potentiellen Menge an Use Cases nicht umfassend, was bei einem induktiven Ansatz dazu führen kann, dass Anwendungsklassen aber auch Problemklassen nicht erfasst sind. Insofern ist dieser Ansatz als zu erweiterndes Angebot zu verstehen.

Limitation und Inhalt möglicher zukünftiger Forschung ist die empirische Evaluation des Ansatzes durch Konfrontation von Entscheidungsträgern mit selbigem. Dabei sollten Gedanken und Erkenntnisse erfasst werden, die der Ansatz auslöst. In diesem Zuge gilt es auch zu untersuchen, worin weitere Probleme beim Verständnis der BCT für die Technologieadoption liegen, sodass die Technologie oder aber auch das Ökosystem der Technologie weiterentwickelt werden kann.

Eine Weiterentwicklung des Ansatzes besteht z.B. darin, im nächsten Schritt von den Businessproblemen auszugehen und Technologiekonfigurationen, die als Lösungsartefakte in Frage kommen, mit diesen Problemen zu verbinden. So kann der vorgelegte Ansatz mit einem sich auf die Technologie konzentrierenden Archetypenansatz (vgl. z.B. [7]), verbunden werden.

5 Würdigung

Wir möchten uns ganz besonders bei Wolf Wenger und Philipp Giese für die konstruktive Kritik bedanken.

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Energiemarkt mit Blockchain-Technologie: Ein Marktmodell unter Berücksichtigung bestehender Netzkomponenten und Marktakteure

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Abstract. Die Energiebranche befindet sich in einem signifikanten Veränderungsprozess. Angesichts des starken Wachstums dezentraler Energieressourcen experimentieren Regierungen, Versorger und weitere Stakeholder mit neuen Lösungen um Effizienz des Elektrizitätsnetzes zu optimieren und einen fortschreitenden Kapazitätsausbau erneuerbarer Energien zu ermöglichen. Nach Jahren, in denen die Energiewende vorrangig mit dem Aufbau erneuerbarer Energie assoziiert wurde, rücken zunehmend systemische Fragen in den Vordergrund, insbesondere zur Integration neuer Marktakteure. Die bestehenden Geschäftsmodelle unterliegen einem grundlegenden Wandlungsprozess, jedoch lassen aktuelle Forschungsarbeiten bestehende Netzkomponenten und Marktakteure unbetrachtet. Die breite Einsatzfähigkeit dieser Ansätze bleibt daher fraglich. Dieser Beitragpräsentiert eine Machbarkeitsstudie eines dezentralen Energiemarktes unter Berücksichtigung des State of the Art des Energieversorgungsnetzes.

Keywords: Blockchain, Energiemarkt, Netzkomponenten, Ethereum

1 Einleitung

Große Veränderungen auf dem Energiemarkt, politische Vorgaben und Ziele im Hinblick auf die Energiewende sowie neue, teilweise bereits ausgereifte Energietechnik führen zu einem Umschwung in der Energiewirtschaft. Die Akteure am Energiemarkt stehen vor der Herausforderung, sich auf die wandelnden dezentralen Erzeugerstrukturen einzustellen und Auswirkungen auf den Energiemarkt der Zukunft abzuschätzen [1]. Die Dezentralisierung des Energiemarktes von wenigen großen Stromerzeugern zu vielen kleinen- und mittelgroßen Erzeugern erfordert eine datenbasierte Umstrukturierung des Energiemanagements. Dies bietet eine Chance durch neue Informations- und Kommunikationstechnologien (IKT) effizientere Steuermechanismen zu etablieren und neue Geschäftsmodelle zu erschließen. Die Einführung intelligenter Stromzähler (Smart Meter) wird als Schlüsselfaktor für die Digitalisierung in der Energiewirtschaft angesehen und bietet durch die Lieferung von Echtzeitdaten eine Grundlage für datenbasierte Technologien und Mehrwertdienste. Der heutige Energiehandel erfolgt über

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diverse Wertschöpfungsstufen, bei denen der Endkunde einen Energieversorger beauftragt, der wiederum verschiedene Dienstleister (z. B. Makler, Broker) beauftragt, Energie an der Strombörse (z. B. EEX) zu erwerben. Durch den Einsatz der Blockchain-Technologie als Energiehandelsplattform wird ein direkter Energiehandel zwischen den Energiekonsumenten und -produzenten ohne zusätzliche Intermediäre ermöglicht. Eine Disintermediation ist die direkte Folge.

Politisch fokussieren auf internationaler Ebene das Kyoto-Protokoll sowie das Pariser Klimaabkommen die Reduktion von schädlichen Emission und wirken somit als Treiber für die Energiewende [2], [3]. Auf nationaler Ebene legt das Erneuerbare-Energien-Gesetz (EEG) einen richtungsweisenden Rahmen, der zu einer Umstrukturierung des Energiemarktes führt [4]. Neben politischen Regularien sowie dem gesellschaftlichen Drang nach „sauberem Strom“ tritt auch der ökonomische Aspekt stärker in den Vordergrund. Durch effizientere und kostengünstigere Technologien regenerativer Energieanlagen werden finanzielle Anreize geschaffen, in erneuerbare Energien zu investieren oder eigenständig als Marktakteur teilzunehmen.

Das heutige, auf fossil-nuklearer Erzeugung basierende Energiesystem ist ein Auslaufmodell und die Entwicklung des Energiemarktes im Bereich erneuerbarer Energie schreitet rasant voran [5]. In den vergangenen 15 Jahren hat sich der Anteil an erneuerbaren Energien bereits verfünffacht und liegt in Deutschland bei über 30% des gesamten Bruttostromverbrauchs [6].

Die Dezentralisierung des Energiemarktes von wenigen großen Stromerzeugern zu vielen kleinen- und mittelgroßen Erzeugern verlangt nach einer Umstrukturierung des Energiemanagements. Dies bietet eine Chance durch neue Informations- und Kommunikationstechnologien (IKT) effizientere Steuermechanismen und neue Geschäftsmodelle zu etablieren [7]. Die Einführung intelligenter Stromzähler (Smart Meter) wird als entscheidendes Kriterium für die Digitalisierung in der Energiewirtschaft angesehen und bietet durch die Lieferung von Echtzeitdaten eine Grundlage für zahlreiche darauf aufbauende Technologien [8-12].

In dem vorliegenden Paper wird erläutert, wie ein Blockchain-Ansatz im dezentralen Energiemarkt eingesetzt werden kann. Der Fokus liegt dabei auf realistischen Marktszenarien, indem aktuelle Marktakteure wie Energieversorger und Netzbetreiber berücksichtigt werden. Nachdem in Kapitel 2 die Ausgangssituation vorgestellt wurde, wird in Kapitel 3 das entwickelte Marktmodell des prognosebasierten Energiehandels erläutert. Dabei werden sowohl Aspekte des Energiemarktes als auch des Energienetzes berücksichtigt. In Kapitel 4 wird die prototypische Umsetzung beschrieben. Schließlich wird die vorliegende Arbeit mit einem Fazit sowie einem Ausblick geschlossen.

2 Ausgangssituation

Der in der Einleitung dargestellte Rahmen wirft relevante Fragestellungen auf und bietet den Forschungskontext zur Umsetzung verschiedener Szenarien auf Grundlage einer Blockchain-Anwendung. Die Verwendung der Blockchain-Technologie stößt im Finanzsektor bereits auf großes Interesse und auch im Energiesektor ergeben sich Potentiale und Einsatzmöglichkeiten [13].

Durch die fortschreitende Entwicklung dezentraler Erzeugerstrukturen und den Einsatz digitaler Messtechnik, ergeben sich für den Energiemarkt Chancen hinsichtlich der

Entwicklung neuer Geschäftsmodelle. Eine Anpassung an die sich ändernden Umweltbedingungen ist netz- und marktseitig zwingend erforderlich, da elektrische Energie aus regenerativen Energiequellen nicht nach Bedarf gesteuert werden kann. Die zuvor nach Bedarf regelbaren konventionellen bspw. Kohle- oder Gaskraftwerke bieten die Möglichkeit, planbar Energie zu erzeugen und je nach Netzauslastung steuernd eingreifen zu können.

Erneuerbare Energien werden in Deutschland durch die EEG-Umlage weiter gefördert, sodass erneuerbare Energieanlagen weiter ausgebaut werden und die Herausforderungen in der Planungsunsicherheit sowie die Einhaltung der Netzstabilität in Zukunft weiter zunehmen werden [4]. Die Planungsunsicherheit ist auf die erhöhte Anzahl dezentraler Erzeuger zurückzuführen. Die unbekannte Menge an Strom, die in das Netz eingespeist wird, erschwert die Erhaltung der Netzstabilität. Dem Endverbraucher wird kaum die Möglichkeit gegeben, auf die Volatilität erneuerbarer Energien zu reagieren. Durch über Monate und Jahre statisch festgesetzte Preise ist es nicht möglich die Netzauslastung an dynamisch schwankende Energieerzeugung anzupassen. Die sich ändernden Angebots- und Nachfragemengen an elektrischer Energie werden im Energiemarkt demnach unzureichend an die Endverbraucher herangetragen. Dieses Informationsdefizit gilt es zu beseitigen.

Das heutige Energiesystem ist auf zentrale Erzeugungsanlagen ausgerichtet und wird, abgesehen von Großverbrauchern (>100.000 kwh/a) mithilfe von Standardlastprofilen gesteuert. Standardlastprofile sind standardisierte Prognosen über den zukünftigen Lastgang eines Energieverbrauchers [18]. Die prognostizierte Energie wird am Terminmarkt bereits Wochen oder Jahre im Voraus gehandelt. Dazu werden feste Verträge mit Energielieferanten bzw. Aggregatoren vereinbart, die den Energiehandel übernehmen. An Energiebörsen kann weiterhin anhand von Verbrauchsprognosen auf dem Spotmarkt ein Tag sowie auf einem Intraday-Markt bis zu 45 Minuten vor der Energiebereitstellung gehandelt werden [19]. Erneuerbare Energien können auf dem Spotmarkt am vorherigen Tag prognostiziert und entsprechend gehandelt werden.

Der Wandel zu einem dezentralen Energiemarkt bietet Potential für eine Umsetzung durch Blockchain-Technologie, da diese Technologie dezentrale Strukturen und transaktionsbasierte Erlösmodelle abbilden kann. Zahlreiche Start-Ups befassen sich daher mit der Entwicklung von Geschäftsmodellen im Energiesektor in Verbindung mit Blockchain-Technologien [13]. Das *Brooklyn Microgrid* ist ein Beispiel für die isolierte Umsetzung einer Peer-to-Peer Handelsplattform mit dezentral erzeugtem Strom. Das *PowerLedger-Projekt* verfolgt den Vertrieb und die Dokumentation von erneuerbaren Energien in einem offenen Stromnetz [14]. Die Analyse bestehender Projekte in Forschung und Industrie ergab jedoch die Notwendigkeit der Berücksichtigung sowohl der Netzkomponenten, als auch aktueller Marktakteure [15].

Dezentrale Erzeugerstrukturen führen im Rahmen der Energiewende zu neuen Anforderungen und erfordern Anpassungen des markt- und netzseitigen Energiesystems. Fehlende Informationen über exakt prognostizierte Lasten und Energieerzeugung erschweren die Einhaltung der Netzstabilität. Der Blockchain wird Lösungspotential hinsichtlich der neuen Anforderungen im Energiemarkt prophezeit. Die vorliegende Arbeit untersucht folglich, ob dezentraler Energiehandel mithilfe einer Blockchain-Implementierung realisiert werden kann. Dabei steht die Frage im Mittelpunkt, ob die markt- und

netzseitigen Komponenten des Energiemarktes innerhalb einer Blockchain-Anwendung berücksichtigt werden können. Zur Untersuchung der Frage wurde zunächst ein theoretisches Marktmodell entwickelt. Anschließend wurde die technische Machbarkeit auf IKT-Ebene anhand eines Prototyps evaluiert.

3 Prognosebasierter, direkter Energiehandel

Dezentrale Erzeugungsstrukturen führen im Rahmen der Energiewende zu einer Umstrukturierung der Wertschöpfungskette. Die klassischen Marktakteure, insbesondere der Energieversorger, weichen den dezentralen Kleinerzeugern. Gleichzeitig können prognosebasierte Energiehandelsszenarien Indikatoren für die zukünftige Entwicklung des Energiemarktes darstellen. In diesem Abschnitt werden zunächst die Akteure vorgestellt sowie die Relevanz von individuellen Lastprognosen beschrieben. Anschließend wird ein hierauf basierendes Marktmodell vorgestellt. Bisherige blockchainbasierte Energiehandelsansätze betrachten den Energieversorger und Netzbetreiber (sowie deren Wertschöpfung) als Marktakteure bisher nicht.

3.1 Akteure

Die heutige Energiehandelssystematik erfolgt über diverse Intermediäre, bei denen der Endkunde einen Energielieferanten beauftragt, der wiederum verschiedene Dienstleister (z. B. Makler, Broker) beauftragt, Energie an der Strombörse zu erwerben. Durch den Einsatz einer Blockchain als dezentrale Energiehandelsplattform wird direkter Energiehandel zwischen Energiekonsumenten und -produzenten ermöglicht, da die Bilanzierung und Abrechnung der Transaktionen automatisiert werden können und durch dezentrale Sicherheitsmechanismen (insbesondere Proof of Work) auf einen klassischen vertriebsseitigen Energieversorger, der die jährliche Abrechnung für Energiekunden durchführt, verzichtet werden kann [13]. Im Folgenden werden die Marktakteure vorgestellt, die im Marktmodell berücksichtigt werden.

Energiekonsument: Der Marktakteur *Energiekonsument* entnimmt elektrische Energie aus dem Stromnetz. Durch entsprechende Verbrauchsquellen stellt der Energiekonsument eine Netzlast dar. Beispiele für diesen Marktakteur sind private Haushalte, Unternehmen, Energiespeicher oder E-Tankstellen.

Energieproduzent: Der Marktakteur *Energieproduzent* speist Strom in das Netz ein. Mittels Stromerzeugungsanlagen wie Windkraft-, Photovoltaikanlagen oder Biomassekraftwerken produziert der Energieproduzent elektrische Energie, um diese an Energiekonsumenten verkaufen zu können.

Prosumer: Der Marktakteur *Prosumer* ist sowohl Energiekonsument als auch Energieproduzent, der bspw. durch Solaranlagen auf Firmengebäuden oder Privathaushalten elektrische Energie in das Stromnetz einspeist.

Netzbetreiber: Unter dem Marktakteur *Netzbetreiber* werden die bestehenden Akteure Übertragungsnetzbetreiber und Verteilnetzbetreiber zusammengefasst. Der Netzbetreiber stellt mit dem Stromnetz die Infrastruktur bereit und ist zuständig für Frequenzstabilität, Spannungsstabilität und Versorgungszuverlässigkeit.

Versicherer: Der Marktakteur *Versicherer* tritt nach Bedarf als Energiekonsument oder Energieproduzent auf, um ein Gleichgewicht zwischen Einspeisungen und Entnahmen zu gewährleisten. Dieser muss flexible Reserven (Regelleistung, Sekundärleistung, Minutenreserve, etc.) elektrischer Energie vorhalten und auch als Netzlast (Energiekonsument) agieren können. Der Versicherer tritt nur im unperfekten Markt (Angebot und Nachfrage gleichen sich nicht exakt aus) auf, um Abweichungen der Prognosen oder unausgeglichenem Handel entgegenzuwirken.

3.2 Notwendigkeit von Energieverbrauchs- und Erzeugungsprognosen

Der heutige Energiemarkt basiert auf der Nutzung von aggregierten Standardlastprofilen für Privathaushalte. Sämtliche Verbraucher, die weniger als 100.000 kwh/a Strom verbrauchen, werden mittels dieser aggregierten Profile zusammengefasst [18]. Aus dieser Aggregation resultiert eine Planungsunsicherheit bezüglich der Netzauslastung und des Börsenhandels für Energieunternehmen. Höhere Planungssicherheit lässt sich nur durch eine feinere Granularität der Datengrundlage über den Konsum bzw. die Produktion der Energie erzielen. Infolge der fortschreitenden Verbreitung digitaler Stromzähler können detaillierte Verbrauchs- und Produktionsdaten einzelner Haushalte in Echtzeit erhoben werden. Mithilfe von Machine Learning-Ansätzen (v.a. Regressionsanalysen) lassen sich anhand dieser Datengrundlage individuelle Lastprofile für einzelne Haushalte und Unternehmen erstellen [16].

Das nachfolgend erläuterte Marktmodell setzt das Vorliegen von individuellen Lastprofilen voraus. Dies ist notwendig, da Strom basierend auf Verbrauchs- und Erzeugungsprognosen einzelner Marktakteure gehandelt wird. Neben höherer Planungssicherheit des Netzbetreibers können individuelle Lastprofile gehandelt werden. Das heißt, dass zu Konsum-Lastprofilen Produktionsprofile erworben werden können. Innerhalb dezentraler Erzeugerstrukturen können so einzelne Konsumenten und Erzeuger zusammengebracht werden und direkt untereinander handeln. Exakte Prognosen setzen hochwertige Datenbestände voraus. Aktuelle Forschungen zeigen, dass hinreichend granulare Datenbestände mit digitalen Stromzählern gewonnen werden können, digitale Zähler teilweise jedoch noch fehlerhafte Werte liefern [17]. Aus feingranularen, qualitativ hochwertigen Prognosen folgen für die Anwender niedrige Pönalzahlungen und für den Netzbetreiber eine effizientere Netzplanung, da die erforderliche Ausgleichsenergie minimiert wird. Ausgleichsenergie oder Regelenergie wird dann produziert, wenn weniger Strom verbraucht, als prognostiziert wurde [18]. Im Energiesektor wird ein Lastprofil eines Tages in 96 Gültigkeitszeiträumen à 15 Minuten unterteilt. Diese Zeitreihe bildet die Grundlage des blockchainbasierten Ansatzes. Die einzelnen 15-Minuten-Intervalle werden nachfolgend als *Pakete* bezeichnet und enthalten neben einer fortlaufenden Nummer für den jeweiligen Zeitpunkt (0-95) auch die Menge an Strom, die in diesem Zeitraum verbraucht, produziert, aber auch prognostiziert wurde, sowie die scharfe Zuordnung des jeweiligen Marktakteures. Beispielsweise entspricht das Paket mit der Nummer 0 dem Zeitraum 00:00-00:15 Uhr. Innerhalb des Marktmodells sind drei Gruppierungen der Prognosen relevant: der jeweilige Energieverbrauch, die Energieproduktion und die zugrundliegende Netzauslastung.

Durch die Berücksichtigung der Netzauslastung in diesem Energiehandelsmodell werden Steuerungsmechanismen erzielt, die zur Vermeidung von möglichen Engpässen beitragen. Der Netzbetreiber veröffentlicht hierbei täglich die Auslastung der jeweiligen Trasse und kann unterschiedliche Preise für die Netznutzung bestimmen. Bei hoher Netzauslastung folgt ein dementsprechend höheres Netzentgelt. Ebenso können bspw. negative Netzkosten bei niedriger Netzauslastung veranlasst werden. Der Netzbetreiber „entlohnt" den Konsumenten de facto für das Einschalten von elektronischen Geräten. Durch den Handelsmechanismus kann der Stromverkehr passiv kontrolliert werden, da neben dem Strompreis auch der Netzpreis Berücksichtigung findet.

3.3 Marktmodell des dezentralen, direkten Energiehandels

Neben der erläuterten Notwendigkeit von Prognosen sind sogenannte Pönalen von besonderer Relevanz. Pönalen sind Vertragsstrafen und wirken sich in diesem Modell durch Gebühren für falsch prognostizierte Verbrauchs- und Produktionsmengen aus. Der Energiehandel erfolgt *ex ante* und wird täglich abgerechnet. So wird eine feingranulare Strompreiskontrolle und hohe Transparenz erzielt. Der Ablauf des Handelsprozesses wird in Abbildung 1 dargestellt. Dabei werden die Aktionen der einzelnen Akteure auf einer Zeitachse abgebildet. Dieser Abschnitt befasst sich zunächst ausschließlich mit der marktseitigen Konzeption. Die technische Umsetzung wird in Kapitel 4 erläutert.

Wie in Abbildung 1 dargestellt, unterteilt sich der prognosebasierte Energiehandel in drei logisch voneinander abgegrenzte Phasen. Die Phase *Prognose veröffentlichen* repräsentiert das Handelsfenster, welches vor dem Handelstag stattfindet. Hier werden Netzbetreiber, Konsumenten und Produzenten aktiv und veröffentlichen ihre Prognosen über Verbrauch und Produktion für die 96 Viertelstundenintervalle (insgesamt 24 Stunden). Der Zeitpunkt *t* bis *t+1* beinhaltet die Erfassung der *Realdaten*. Hierbei wird über den digitalen Stromzähler die Menge an produziertem und konsumiertem Strom über eine Schnittstelle ausgelesen und in der Blockchain dokumentiert. Abschließend findet die Phase der *Abrechnung* statt. Diese Phase beginnt nach der Erfassung des 96. Strompaketes (23:45 – 00:00). Abschließend wird die Bilanzierung der Realwerte und der prognostizierten Werte durchgeführt.

Die Prognosen der jeweiligen Akteure werden in sogenannte Smart Contracts geschrieben. Dies sind kleine Programme, die eigenständig auf Programmierlogik basierende Transaktionen auf Blockchains durchführen können. Der Netzbetreiber veröffentlicht eine Prognose über die Netzauslastung des Handelstages. Das Netz wird hierbei in verschiedene Regionen (Minigrids) unterteilt. Die Prognose beinhaltet die Angabe des jeweiligen Minigrids und eine Angabe zur Netzauslastung des jeweiligen Zeitpunktes. Der Produzent veröffentlicht ebenfalls die prognostizierte Energieproduktion des Handelstages. Der Produzent definiert zudem die Höhe des Kaufpreises der produzierten Energie. Das Netz wird hierbei in verschiedene Regionen (Minigrids) unterteilt. Die Prognose beinhaltet die Angabe des jeweiligen Minigrids und eine Angabe zur Netzauslastung des jeweiligen Zeitpunktes. Der Produzent veröffentlicht ebenfalls die prognostizierte Energieproduktion des Handelstages. Der Konsument definiert seine Handelsstrategie und veröffentlicht seinen Strombedarf für den kommenden Handelstag in der Blockchain. Der implementierte Handelsmechanismus stellt sicher, dass der Bedarf gedeckt wird. Dabei werden Präferenzen des Konsumenten (Einschränkungen

wie z.B. Preis oder Herkunft) berücksichtigt. Der Einkaufspreis setzt sich aus dem Verkaufspreis der Produzenten und der konsumentenspezifischen Netzkosten zusammen. Der Handel kann also zwischen einem Konsumenten und mehreren Produzenten stattfinden (1:n-Beziehung). So wird sichergestellt, dass der Bedarf auch durch verschiedene Produzenten parallel gedeckt werden kann. Um finanzielle Sicherheit zu gewährleisten, bezahlt der Konsument den benötigten Strom unmittelbar mit der zugehörigen Währung des verwendeten Blockchain-Ökosystems, im vorliegenden Beitrag wurde *Ethereum* eingesetzt, da Ethereum zum Zeitpunkt der Entwicklung des Prototyps, dass am weitesten entwickelte Blockchain-Ökosystem mit Unterstützung intelligenter Verträge (Smart Contracts) war.

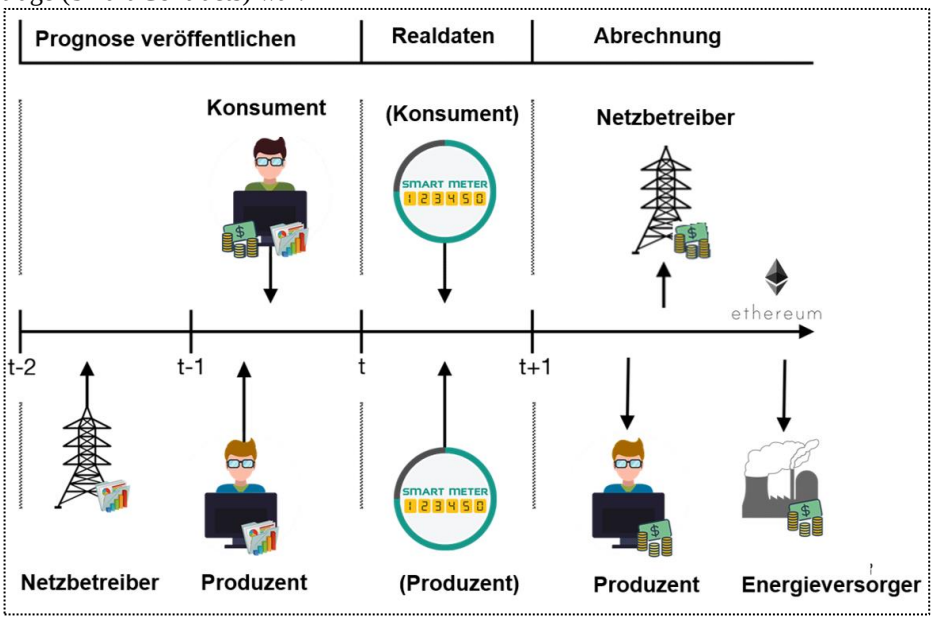

Abbildung 1: Prognosebasierter Energiehandel

Während der Phase *Realdaten* werden durch den digitalen Stromzähler die Daten über Produktion bzw. Verbrauch erhoben. Durch eine optische Schnittstelle werden diese ausgelesen und der Blockchain-Anwendung zur Verfügung gestellt. Nach dem letzten Zeitfenster (oder der Auslieferung des letzten Pakets) werden diese in der Blockchain dokumentiert, sodass die Abrechnung mithilfe eines Soll-Ist-Vergleichs (Bilanzierung) realisiert wird. Die Abrechnung wird vom Smart Contract nach Erfassung der Realdaten implementiert. Ergeben sich Differenzen, so kommt es zu Pönalzahlungen. Die Höhe der jeweiligen Zahlungen ist ein Marktmechanismus und kann an dieser Stelle noch nicht abgeschätzt werden. Ebenso wird durch den Smart Contract der Netzbetreiber gemäß seiner Leistung entlohnt. Die Besonderheit des Marktmodells stellt die Position des Energieversorgers als *Versicherer* dar. Eine exakte Übereinstimmung der Prognose und der Realdaten ist unmöglich zu erzielen, daher müssen Differenzen ausgeglichen werden. Weiterhin ist eine Umstellung zu einem Peer-to-Peer Handelsmarkt ein langfristiger Prozess und dementsprechend weiterhin auf den Energieversorger an-

gewiesen. Eine kurzfristige Umstellung erscheint aufgrund der aktuellen Marktdurchdringung der Energieversorger als sehr unrealistisch. Die Steuerungseffekte, die durch dieses Marktdesign erzielt werden, beziehen sich auf die Entlastung des Netzbetreibers durch die Minimierung von Netzengpässen. Ebenso werden durch die Angabe der Regionen der Akteure lange Transportstrecken vermieden, da diese mit hohen Netzkosten bepreist werden. Außerdem kann das Verbrauchsverhalten der Konsumenten beeinflusst werden, da eine Einhaltung der Prognose von wirtschaftlichem Interesse ist, weil Pönalzahlungen vermieden werden können.

4 Prototypische Implementierung

Die Möglichkeit, das dargestellte Marktmodell in der Blockchain abbilden zu können, ist für die irreversible Sicherung der dem Energiehandel zugrundeliegenden Daten (Prognosen, tatsächliche Verbrauchs/Erzeugungsdaten, Preise) essentiell. Für die prototypische Umsetzung wurde eine Ethereum-Blockchain verwendet. Diese basiert auf der zweiten Generation der Blockchain-Technologie, die neben reinen Währungstransaktionen auch das Bereitstellen von dezentralen Applikationen (Smart Contracts) ermöglicht [13].

Hardware: Um Energiehandel mit mehreren Marktakteuren über die Blockchain realitätsnah zu simulieren wurde als Test- und Entwicklungsumgebung auf fünf Raspberry Pi Einplatinencomputern (Pi) der dritten Modellreihe zurückgegriffen. Diese verfügen über ausreichend Rechen- und Speicherkapazität sowie notwendiger Schnittstellen für die prototypische Anwendung. Durch die geringen Kosten und gute Verfügbarkeit der Hardware ist zudem eine einfache Reproduktion der Ergebnisse sichergestellt. Die Pis wurden in einem abgeschlossen, gemeinsamen Netzwerk als eigenständige Topologie konfiguriert, um die Kommunikation zwischen den einzelnen Geräten zu ermöglichen.

Software: Als Grundlage für die Softwarearchitektur kommen ausschließlich kostenfreie, frei verfügbare Komponenten zum Einsatz. So wird als Betriebssystem auf den einzelnen Pis raspbian verwendet. Zusätzlich wurde ganglia zur zentralen Überwachung wichtiger Systemparameter wie CPU-, RAM- und Netzwerkauslastung eingesetzt. Im Rahmen der Anwendungsentwicklung unter den fünf Pis wurde eine private Blockchain mit Hilfe des Parity-Ethereum-Clients aufgesetzt. Durch die Verwendung einer privaten Blockchain wurde die Grundlage für die Entwicklungsumgebung geschaffen, die im Vergleich zu einer öffentlichen Blockchain keine realen Kosten für Transaktionen verursacht. Ein Pi samt Parity-Client stellt hierbei eine sog. Node dar, sichert stetig eine Kopie der gesamten privaten Blockchain und ermöglicht die Interaktion mit dieser. Die prototypische Anwendung selbst (siehe Abbildung 2) wurde unter NodeJS realisiert.

Die prototypische Applikation lässt sich in zwei Teile unterteilen: Einer clientseitigen NodeJS-Anwendung, die auf den Pis installiert ist und einem Smart Contract, der in der Blockchain hinterlegt ist und somit gemeinsam von allen Teilnehmern genutzt wird. Dabei ermöglicht die clientseitig ausgeführte Applikation unterschiedliche Konfigurationen um die Handlungen eines Käufers, Verkäufers oder Netzbetreibers simulieren zu können. Das Architekturmodell ist in Abbildung 2 dargestellt.

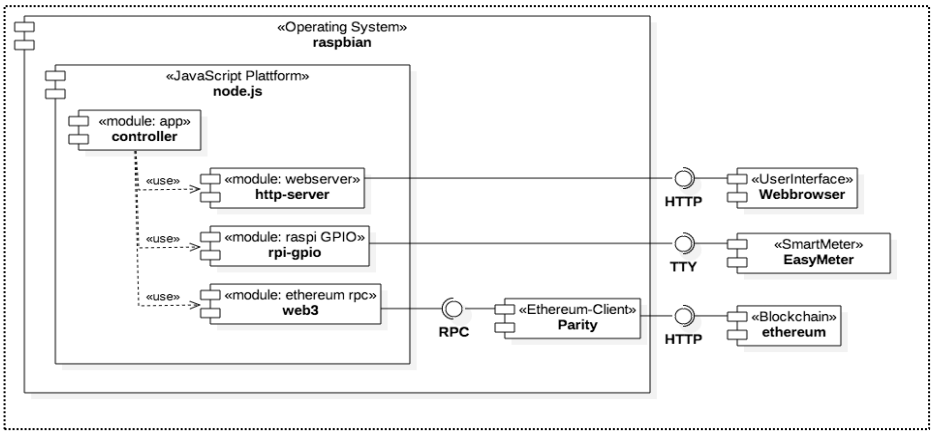

Abbildung 2: Architekturmodelle / Komponentendiagramm der Anwendung

Der Controller dient als Steuereinheit der einzelnen Module. Seine Aufgabe ist es, Daten automatisiert zu verarbeiten und so – je nach Anwendungsszenario – bspw. Prognosen in die Blockchain zu schreiben, automatisch eine Liste von präferierten Verkäufern zu erstellen um anschließend die notwendigen Transaktionen zu tätigen. Je nach Konfiguration kann er als Käufer, Verkäufer, Prosumer oder Netzbetreiber agieren. Der Energiehandel und die Interaktion mit der Blockchain wird also autonom, gemäß parametrisierter Constraints, durchgeführt.

Die Bereitstellung eines Webservice über das Standardmodul http-server ermöglicht dem Anwender mit dem Webbrowser auf die Applikation zuzugreifen. Über eine grafische Oberfläche werden alle relevanten Informationen wie Verbrauchs-, Produktions- und Handelsdaten angezeigt. Ferner lässt sich die Applikation über das Webinterface parametrisieren, um etwa Einschränkungen oder Prognosezahlen zum Energiehandel zu pflegen und so selbst aktiv in den Energiehandel einzugreifen. Über das Modul rpi-gpio wird auf die serielle Schnittstelle des Pi zugegriffen und so aktuelle Verbrauchs- und Erzeugungswerte vom Smart Meter in digitalisierter Form zur Verfügung gestellt. Diese werden in Folge automatisiert in die Blockchain geschrieben bzw. auf dem Web-Interface angezeigt.

Die Verbindung zur Blockchain wird über das Modul web3 realisiert – es kommuniziert über eine standardisierte JSON-RPC-Schnittstelle mit dem Parity-Client. Hierdurch ist es möglich, auch andere Ethereum-Clients als Parity anzubinden. Durch den modularen Aufbau der gesamten Applikation könnte an dieser Stelle auch ein Modul zum Zugriff auf andere/zukünftige Blockchain-Implementierungen eingesetzt werden.

Der in der Blockchain gespeicherte Smart Contract muss in der von Ethereum eigens entwickelten Sprache Solidity implementiert werden. Er umfasst alle für die prototypische Anwendung notwendigen Funktionen um die Daten, die von allen Teilnehmern des Marktes benötigt werden, zu verwalten. Der Smart Contract dient zusätzlich auch als Treuhänder – sämtliche Zahlungen werden zunächst hier hinterlegt und erst im Zuge der Abrechnung an die entsprechenden Parteien freigegeben.

Der Ablauf des Erstellens eines Inserates auf der Blockchain ist wie folgt. So werden dem Smart Contract Daten zur eindeutigen Identifizierung des jeweiligen Verkäufers, der prognostizierten Menge und Preises pro Watt/h übermittelt. Zusätzlich wird

der 15-minütige Zeitraum, in dem die angegebene Menge produziert werden soll über das Tripel *VerkäuferID, Produktionsmenge und Viertelstundenwert* definiert und im dreidimensionalen Array hinterlegt. Entsprechende Funktionen sind auch für das Hinterlegen der Netzkosten, das Handeln und das Abrufen der genannten Daten implementiert. Ferner wurden Fallback-Mechanismen für den Fall der Abweichung von Prognose und Ist-Wert implementiert.

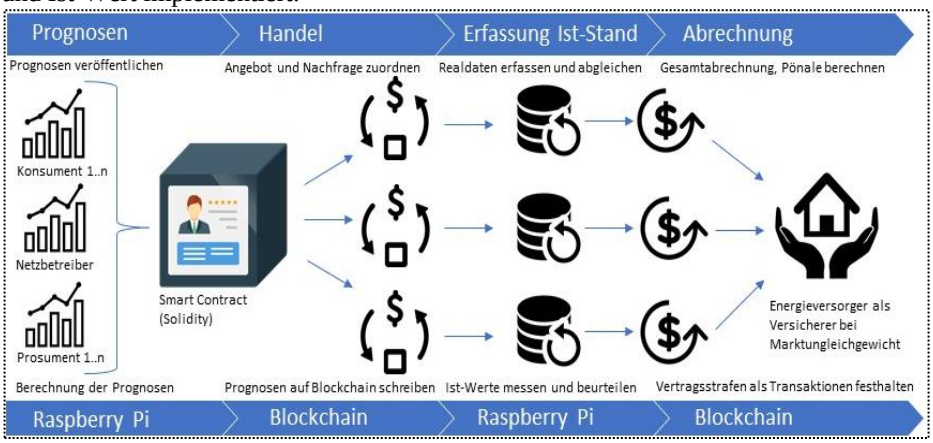

Abbildung 3: Phasen, Prozess und beteiligte Hardware eines Handelstages, die Berechnungsgrundlage für Prognosen liefert der Smart Meter (hier nicht mitmodelliert)

Eine bedeutende Einschränkung bei der Implementierung mittels Solidity ist, dass ausschließlich primitive Datentypen beim Aufruf von Funktionen im Smart Contract verwendet werden können. So muss ein Anbieter zum Abspeichern der Prognosen für einen Tag im dargestellten Fall 96 rechen-, zeit- und kostenintensive Transaktionen durchführen (um 96 Integer-Werte abzulegen). Gleiches gilt für die Käufer-Seite: Es ist nicht möglich, eine Liste oder ein Array aller Anbieter zu einem definierten Zeitraum (Tag/Paketnummer) abzufragen. Auf Clientseite muss hierzu erst über alle Transaktionen der Blockchain iteriert werden. In Solidity gibt es zwar sog. *Events*, die aufgerufen werden können, sobald eine bestimmte Funktion in einem Smart Contract ausgeführt wird. Auch lässt sich mit einer gefilterten Abfrage aller Events zur Funktion Ergebnismenge einschränken. Die genannten Vorgehensweisen stellen aber im Vergleich zur Arbeitsweise herkömmlicher Datenbanken allenfalls *Workarounds* dar. Es lässt sich somit feststellen, dass Möglichkeiten zur effizienten Datenverarbeitung in Solidity faktisch nicht gegeben sind. Der Prototyp zeigte somit eindeutig Performanzprobleme bei Hochskalierung der Teilnehmer. Folglich müssen Teile der Anwendung (insbesondere Zuordnung von Angebot und Nachfrage stellen ein sehr aufwändiges kombinatorisches Problem dar) künftig aus dem hier vorliegenden Prototyp ausgelagert werden.

5 Fazit und Ausblick

Im Rahmen des vorliegenden Papers wurde ein dezentrales Marktmodell sowie eine prototypische Machbarkeitsstudie auf Basis einer Blockchain-Anwendung vorgestellt. Dezentraler Energiehandel kann mithilfe einer Blockchain-Implementierung realisiert

werden. Ebenso konnte die marktseitige Komponente durch den Handel zwischen Energieproduzenten und Energiekonsumenten abgebildet werden und die netzseitige Komponente durch Einbindung der Prognosen der Netzauslastung betrachtet werden.

Das Marktmodell basiert auf kurzfristigen Verbrauchs- und Konsumprognosen und ist bewusst an den bestehenden Energiemarkt angelehnt, da beide Energiesysteme mittelfristig parallel existieren müssen. Daher baut der dezentrale Energiehandel auf bestehenden Strukturen auf und einer Koexistenz mit dem derzeit praktizierten State of the Art steht grundsätzlich nichts im Wege. Aus diesem Modell erschließt sich jedoch der Wandel des klassischen Intermediäres vom Energieversorger zum Versicherer. Konsumenten, Produzenten und Prosumer nehmen aktiv am Energiehandel teil, ohne den klassischen Energieversorger damit zu beauftragen. Angebot und Nachfrage werden stark liberalisiert und deutlich transparenter, als im aktuellen Energiesystem.

Dezentraler Energiehandel über die Blockchain führt zu verschiedenen Vorteilen, so entstehen Steuerungseffekte durch die Berücksichtigung der Netzkosten während des Energiehandels. Hierbei kann das Konsumverhalten durch Preismechanismen beeinflusst werden. Das vorgestellte Marktdesign kann dazu beitragen, dass sich Konsumenten verstärkt netzdienlich verhalten. Die beschriebene Systemarchitektur ermöglicht zudem einen hohen Automatisierungsgrad, da der Energiehandel durch die individuell konfigurierbare Applikation abgewickelt wird, ohne dass tiefgreifende Eingriffe des Anwenders erforderlich werden. Weiterhin hat die Verwendung eines Blockchain-Ansatzes den positiven Effekt, dass Transaktionen prinzipbedingt manipulationssicher dokumentiert werden und gleichzeitig jederzeit transparent und nachprüfbar bleiben.

Durch die anschließende Konzeption und Anwendungsentwicklung wurden wertvolle Erkenntnisse gewonnen, die zum vorgestellten Energiehandelssystem führten. Die grundsätzliche Umsetzbarkeit auf IKT-Ebene wurde dabei gezeigt. Jedoch wurde festgestellt, dass ausschließlich auf Blockchain basierende Ansätze aus Performanzgründen in dieser Form zum jetzigen Zeitpunkt nicht in der Breite eingesetzt werden können. Dies liegt insbesondere an der Ineffizienz der Verifikationsprozesse (Proof of Work) und der Sicherheitsmechanismen der Blockchain-Datenstruktur, bei der Daten, seien dies nun Prognosen oder monetäre Transaktionen, lediglich immer nur an das Ende angehängt werden können (append only). Auch zeigte sich, dass die Möglichkeiten zur Datenverarbeitung stark limitiert bleiben. Somit ist es sehr unwahrscheinlich, dass Anwendungen, die ausschließlich auf Blockchain zur Datenhaltung und -verarbeitung basieren, den dezentralen Energiemarkt beflügeln werden. Vielmehr wird eine weitere Verarbeitungsschicht implementiert werden müssen, die die individuellen Prognosen miteinander verknüpft, also die Rolle eines Brokers einnimmt. Als Alternative kommen natürlich auch Weiterentwicklungen im Bereich der Blockchain-Technologie infrage, bei der die Datenverarbeitungsgeschwindigkeit und die Verifikationsmechanismen deutlich effizienter gestaltet werden müssen.

Um das tatsächliche Potential abschließend beurteilen zu können, muss die Blockchain-Technologie einen ausreichenden Reifegrad erlangen. Des Weiteren müssen wichtige Kriterien wie die Skalierbarkeit sowie weiterführende Sicherheitsaspekte hinsichtlich der Software als auch der Hardware erforscht werden. Hierbei sind u.a. Maßnahmen festzulegen, wie bei einem Hardwareausfall oder bei Verlust des Blockchain-Nutzerkontos (privater Schlüssel, öffentlicher Schlüssel) verfahren wird. Darüber hinaus sind viele (datenschutz-)rechtliche Fragen ungelöst, die insbesondere durch die ab 2018 geltende EU-Datenschutzgrundverordnung [20] nochmals verschärft werden.

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IT-Beratung im Wandel: Daten, Digitalisierung und Geschäftsmodelle

Teilkonferenzleitung

Thomas Deelmann
Paul Drews

Consulting Business Models in the Digital Era

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Abstract. Consulting research and consulting practice needs to think beyond digitalization. Consulting business models for a digital ecosystem are requested but can rarely be found in the relevant literature and the market. Coping with legacy systems and shifting historical strategy decisions is still on the agenda of many consulting projects. This paper aims to deliver a scientific building block to the consulting business by exploring the consulting processes and methods in the digitalized age. Based on semi-structured interviews with different kinds of consulting firms, a multiple case study has been designed. As our research shows, Digital Transformation has a substantial impact on consulting research and consulting in practice. Both have to be reconsidered in the digital context, for instance concerning business models, science and data-driven methods or rapid prototyping. The authors aim – practically - to deliver a Business Model Canvas for future consulting and to create an explanatory model for the information system-centric perspective on business model research.

Keywords: Digital Transformation, Consulting Research, Business Model Innovation

1 Introduction

Digital Transformation (DT) has a tremendous impact on almost all areas of society, personal life, and business. Consulting Research, which intends to provide both scientific and practical perspectives to the consulting industry [20], represents an IS-research stream, which is affected by DT in different ways (see section 2.1). In parallel, enterprises face a sharp digital shift and claim (at least more and more) IT not only as a corporate function but as a core driver for innovation. We assume here that the same concept applies for consulting companies; thus, innovation and strategy consulting will go stronger hand in hand with IT focused consulting [15].

These initial aspects define the frame of our research. More precisely, we want to answer the following research questions: Which key-drivers for DT exist within consulting companies in general? In a digitalized world, how could a business model for an IT and innovation focused consulting company look like?

To answer these questions, we structured the paper as follows. First, we want to create a theoretical background based on brief introductions to the different aspects of

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the given phenomenon. Next, we describe our data gathering method. We will interpret this data, using a qualitative research database for our coding. As a main practical outcome, a Business Model Canvas (BMC) will be provided, as well as two artefacts for a more scientific audience, interested in the data utilization. Finally, we sum up our results and criticize our work as a baseline for future research projects.

2 Connecting the Dots: Background and Related Research

2.1 Consulting Research – Context and Scientific Classification

Like all organizations and companies, consulting firms are facing rapid and constant changes in their clients' demands. As the authors have shown in a previous publication [14], DT has not only had a huge impact on the primary sector (e.g. 'Industry 4.0') but also on consulting services.

Following the definition of Nissen, consulting research represents, on the one hand, a profound academic understanding of a phenomenon in the consulting context, and on the other, a research-driven design or enhancement of consulting services [20]. This not only means an ongoing development of the consulting as such, especially regarding technical trends and collaboration models [5] but also a role shift, as a new and extensive technical knowledge and a wide strategic scope might be required at the same time [15]. More precisely, consulting increasingly tends to become information processing. Almost all kind of consultants (change consultants, IT consultants, management consultants, etc.) are facing a technology- and information-centered focus of their action fields. Whereas business models and the responsibilities of consulting companies have been strictly separated in the past, today's consulting projects cannot be divided into the classical slices anymore [21].

2.2 IS-Driven Business Model Innovation

Understanding and creating Business Model Innovation (BMI) is a dominant and continuous field of research for IS and business management researchers. According to Hanelt, IS has three roles in the field of BMI: '(1) IS as a BMI enabler, (2) IS as a BMI capability, and (3) IS as a frame of reference for BMIs' [10].

We will utilize the BMC by [22] as a 'holistic structuring tool in the process of BMI' [29]. The canvas offers a grid of key resources which a company can transform into values. The value propositions give us a more flexible view of business models, compared with classical business plans, which tend to be too finance-oriented and leave the big picture of the business model out of scope.

In this paper, we have also included Porter's Value Chain method as one of the major perspectives into the core activities of a company. It is nothing but a high-level aggregation of all processes and functions of a company [26]. Porter showed all primary

elements of a business, from purchase to sales, as well as all supporting functions, like HR, and so forth. We intend to understand the activities of our case study partners – which are consulting companies – with regards to the Value Chain segments they treat during their consulting activities. Through this, we want to investigate whether the consulting projects in our sample fit to all parts of clients' firms or if there are still blind spots. The combination of the BMC and the Value Chain of Porter is new, as far as our knowledge goes.

2.3 Digital Transformation as Enabler for New Business Models

DT was – due to our research – initially defined by Zhu as 'technology-enabled innovations' [31] within an enterprise. With the growing research on DT initiatives, the understanding of the scope, chances, and implications of DT matured. [18] put it upside down and showed how a 'business-driven IT transformation' could look like. This brings us closer to the point of today's understanding and definition. DT is rather about redefining business models and creating disruptive innovations than creating incremental innovation steps [9]. Even new thoughts have been developed about leadership in the digitalized age [3], including new models of participation, company culture, and workflows. Therefore, it is crucial to understand the process-layer of what today's IS literature includes in DT: '(understand and reflect on the) assumptions that shape an organization's IS leadership practices' [11]. This is exactly what defines the major strengths of our discipline, as we can see in the latest publications [25].

As we discovered earlier in our literature review paper, companies across all branches struggle to realize the strategic relevance of combining business-, IT- and data-driven thinking [14]. This affects the consulting business in different ways:

DT of the consulting business. Virtual or virtualized consulting services, sequences, modules or processes are still in their early stage, but are visible on the horizon of research on the consulting business [28] and consulting practitioners. The latter can be exemplified by new, digital, and participative forms of consulting contracting platforms like newcoventure.com or comatch.com. Both platforms go beyond freelancer-project platforms and create their business models alongside the value chain of consulting, e.g., as a partner of well-matured consulting firms to bridge the bottlenecks in their capacity with pre-tested consultants.

DT of the consultant. New skills and methods, as described in [19] and, e.g., agile methods, coding skills, etc. are required in the Digitalized age. Within the broad variety of role models in the consulting field [24], DT initiatives and Digitalized consulting processes ask for a new generation of consultants. The IS literature body has been discussing the skill portfolio of (IT) consultants for a couple of years [8]. Job vacancy analytics is still a common and impactful practice in consulting research [2].

DT as a (consulting) service. 'Under-one-roof' consulting, aiming at an agile, digitalized and data-driven clients' company in future. Those consultants treat the entire

scope, including change of the clients' business model, technical implementation and cultural change. At the same time, other consulting companies will try to continue a single-function scope [15].

In the following section 3, we will build our research method upon this literature background and the previous research questions.

3 Multiple Case Study Research Approach

3.1 Research Design and Data Gathering

Our research questions try to enlighten the 'how' aspects of a phenomenon in a business context. To understand the organizational frame and business environment, the case study method has been well established in IS for many years [1]. To strengthen the chain of evidence in the study, a multiple case study setting has been selected [30]. We relied on semi-structured interviews to strengthen the chain of evidence. They allow in-depth exploration and are considered as vital instrument of case research [30]. In addition to the interviews, we took field notes [23] and coded them within the qualitative research database software MAXQDA.

The process of data gathering was following these steps: selection of interview partners, interview design and structuring, piloting, interview preparation (for each partner), execution of the talk, and coding of field notes and transcripts. For the selection of possible interview partners, the authors executed a member-search for the queries {'big data', 'digital transformation'} to get the first list of potential experts on the social network platforms Xing and LinkedIn. Further, the authors invited experts, who have spent at least two years or more in the field of DT, via a direct message. We focused on interview partners, who played an active role in Dt projects. Nine out of 57 contacts were open to be interviewed on the given topic. Each interview took between 40 and 100 minutes. To maximize the outcome of each interview, the authors prepared themselves thoroughly in advance. By using the created contact database, some basic company and interviewee information were collected. It could be enriched with public information about each interviewee's social business network profile. Additional field research improved the author's knowledge about the interviewees and companies. In most cases, the interviewees asked for some information in advance and welcomed the prepared interview structure and guidelines.

The talks were conducted via Skype, or telephone in some cases. In other cases, a personal meeting was possible. All interviews were recorded for further transcription process and stored digitally as raw data with field notes in MAXQDA. Thus, the final data set of each case contains contact database information, interview recordings, and field notes.

3.2 Data Analysis

We created a data analysis strategy to follow a standardized approach while handling the case material. First, the transcript and all field notes were uploaded to the case database to start with a first classification and coding phase. During this phase, we generated high-level coding clusters onto all materials [6], for instance, group clusters of strategy- or IT-focused consulting approaches, and different consulting models and approaches. This phase was followed by a more elaborate sequence of coding tactics. Finally, the cross-case analysis, e.g. or pair building, took place [7].

To strengthen the study's validity and reliability, we followed the three principles of data collection recommended by [30]. These are 1) the use of multiple sources of evidence, 2) creation of a case study database, 3) securing and maintaining a chain of evidence. According to the first recommendation and to increase the robustness of our results through triangulation of sources [13, 30], we selected case partners with diverse perspectives. By following Yin's second recommendation, we built a database in MAXQDA to manage audio, text, and meta-data.

4 Results

4.1 Within-Case Analysis

For multiple case studies, it became a good practice in IS research to sum up a research twofold: A within-case analysis and a cross-case analysis [4, 7, 17]. The upcoming section provides a brief introduction to each case interview and the context of its scope in the consulting project.

Table 1. Anonymized case write-ups and selected key statements.

#	*Write-Up / Introduction*	*Key takeaway*
1	Advises enterprises on DT. To handle this, they rely internally on generalists, who can not only steer the projects on a high-level basis but also bring along field experiences.	'If he (the project lead) is a generalist, he can get relatively quickly into the topic, create the concept and get somebody via his/her network.'
2	In-house consulting unit for Big Data. An expert group of business consultants, data scientists, and architects analyzes the potential big data projects, develops predictive or prescriptive models, and implements them into the corporate IT, regardless of which part of the value chain the question arises.	'When processing Big Data applications, we use an approach that originates from the CRISP-DM method. (…) It essentially describes an iterative approach model, extremely agile, from business understanding, data understanding, data preparation, modeling, and evaluation.'

#	*Write-Up / Introduction*	*Key takeaway*
3	One of the so-called big four leading consulting companies in the world; tackles DT from a general approach.	'Although companies might do the same, they can't do it anymore in the same way'
4	Freelance consultant. Advices clients regarding DT and project incident management independently. Consulting skills and processes must include classic and agile project management (like scrum), as well as software Kanban, lean start-up, and especially, the idea of the minimal viable product.	'My hypothesis is that those projects do not fail because the project content is technically too complicated but because of the project organization. That is, the structure of the project, as well as its processes, is designed in a very complex manner.'
5	Consulting start-up and a hybrid of consulting and software services, looking at other software engineers' output with big data technologies and – in this way – digitalizing the coding, debugging, and code optimization process.	'The machine tells you what the problems are and, partly, also which solutions are available. These information are transferred to our consultants.'
6	As one of the trendiest apps for finding meaningful and well-matching presents in the German market, it is a completely digitalized and algorithm-driven (i.e., automated) company, well experienced in cooperation with consulting partners.	'Digital is the new normal.' '(…) multidisciplinary teams are the most successful ones.'
7	Technology plays a major role regarding hard- and software, facing a new trend regarding the business counterpart at the client's side.	'He (the business consultant) actually brings all the competences together: He implements the statistical models into the systems, but he can (also mentally) transfer from business to IT, because in the end, the whole is still IT-driven'
8	Focusing on strategy, technology, and outsourcing services, this consulting company represents a technology-oriented consulting firm. The big data business unit belongs to the technology consulting part. IT consultants faced a shift to the role of change agents over the last years, even if many elements have always been a part of it.	'(…) it is actually a threefold specialist role, which is then rather a generalist. (…) I do play the roles of the project leader, the architect, or the consultant in the projects. In this respect, it is more generalistic. But I believe that to be able to drive this triple course, the computer science study was essential.'
9	Historically, this consulting firm is a classical IT consulting company with different services, such as system development and integration, big data, training, and many more aspects of DT. Nowadays, innovation and trend topics are covered with internal resources.	'The classical strategy consultants either have to orientate themselves more technologically (…) or classical IT consultants get involved in strategy consulting aspects'

4.2 Cross-Case Analysis

Next, we intend to create a combined view of the cases presented in the previous section. For this, we will first classify the Value Chain – equivalent of every consulting firm's project focus. Second, we cluster the interview answers in the logic of the BMC. Finally, this section ends up with a belief-outcome-model of the subject.

Value Chain Perspective. Porter's Value Chain provides an aggregate picture of all processes and functions in a company, from purchase to sales, including all supporting activities in a firm. A major step in the analysis is matching the elements in the value chain that the interviewed companies are or were working on. Besides, the authors brought the value chain aspect of the case partners together with the consulting typology. We offer a two-dimensional view into our data, based on a classification of our case partners. Table 2 shows, on the one hand, that four of our interview partners focus entirely on all functions of their clients. On the other hand, we find a wide spread of (maybe) specialized or focused consulting activities. We will discuss and interpret this spread in the next section. Obviously, human resources have been an untreated environment for our interview partners so far. In total, we can sum up that the – as Porter defines it – primary activities of a company are a much more integral part of the interviewed consulting firms compared with the supporting functions.

Table 2. Value Chain matches in the coding structure.

	Primary Activities					Support Activities				
	Entire Value Chain	Inbound Logistics	Operations	Outbound Logistics	Marketing and Sales	Services	Procurement	Firm Infrastructure	Human Resources	Technology
Strategy	3				1	2	1	1		
Organization Development	1	1		1	1	1				
IT (-oriented)	1	1	2	1	3	1				3

Business Model Canvas. Next, we used the BMC to cluster our codings in a way which can deliver clear impulses for consulting firms. Figure 1 follows the original grid view of the BMC and summarizes our derived business model impacts.

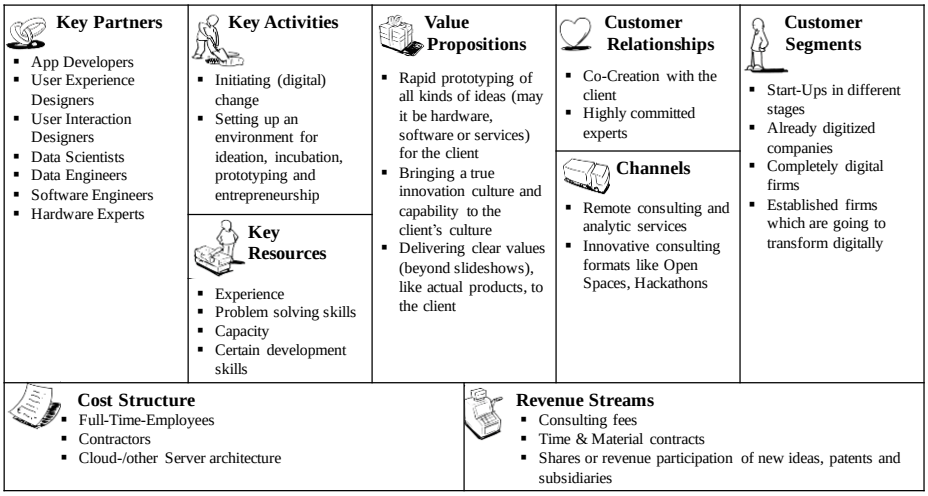

Figure 1. Business Model Canvas for Digitalized consulting firms.

Customer segments. We see possible new customer segments for consulting firms. At the end of the scale, there are established corporates with a strong need for digitalization support. Important here is, that the historical customer differs from today's customer, for instance, because of the user-chooser-aspect in the context of big data systems (Case 7). At the other end, there are digital business models in the recently founded start-up companies, which have other demands than aspects of digitalization (Case 6: 'Digital is the new normal').

Customer relationship management. New relationships between client and consultants will come up. Especially in the era of Web 2.0 and the forthcoming co-creation of products, brands and services are an important example of modern creation processes [16]. Further, highly committed and experience-driven experts will form future relationships in this context, as Roßmann in case 8 points out: 'We recognize that you don't get accepted by the client when you are just certified, but you can't say I did this in a couple of projects in different roles.' Of course, experience is also today a fundamental factor for the qualification of consultants. What the authors see and mean as a significant differentiation here is the fact that those new businesses we are discussing in this context might lack already experienced experts. In contrast, this offers new business opportunities for founders who move on after an exit.

Channels: On- and off-site consulting activities – like remote work for preparation and research on the one hand, and sessions physically taking place at the clients' facilities on the other – are not new concepts. Both will change. Consultants might cooperate with external or internal experts for complex technical solutions or rapid prototyping, for instance, as also suggested by [29]. As case 3 underlines, the scope of consulting companies correlates with the maturity level of the market. The vertical range of manufacturing might differ from consulting firm to consulting firm but it will definitely

include digital solutions and services [15]. Another aspect is the kind of format that consultants offer to their clients: Old-fashioned workshops and impulse speeches will disappear. New, innovative, and meaningful – as case 1 underlines, 'a whole bandwidth' – formats have to deliver clear results [3].

Value propositions. The differentiator that a more successful consulting company offers will primarily need added value beyond strategic recommendations, i.e. the ability to break strategic scopes down to a technical level in the customer context of their consultants, as mentioned in Case 9: '(…) we have to consider more, what digitalization does mean for corporate strategy'. The Lean Start Up method and thereof the Minimal Viable Product by [27] might be techniques that will become important for this purpose, as Case 4 points out: 'those (methods) must be available and connected to each other'. Another aspect is that those deliverables have to be co-created with the client. Lastly, rapid and early prototyping capabilities will matter for consulting companies (again Case 9: '(…) less optimizer, but more involved into the innovation process') as well to make a difference: Concepts need to be prototyped and iterated with customers in high frequency. What is needed here is an in-house full-stack development team in consulting companies [12].

Key activities. The mentioned value propositions go hand in hand with the needed key activities for consulting firms. On a high-level basis, they will still be eager to facilitate change – as especially seen in Case 4, 'therefore we cooperate with organizational psychologists' and in [15]. However, in detail, this means creating a true and honest environment for corporate entrepreneurship and ideation, again Case 4: '(…) I have to deliver my product very fast and therefor I need to know how to test (…)'.

Key resources and key partners. We put both categories together because we still see a lot of room for decision-making here for the consulting companies. Nevertheless, the core of what has to be delivered remains the same. Prototyping and implementation of – at least partly – digital ideas require development skills of different kinds, as mentioned in Case 9: 'The (consulting) teams won't get necessarily bigger but the skill-set will change'. It could be app development, algorithm optimization for (big) data problems, backend and cloud challenges, summarized by a take-away from Case 6: '(…) multidisciplinary teams are the most successful ones'. In many situations, consulting teams might consist of network partners, to cover the skill spread, as seen in Case 1 for instance. We see the majority of problems affecting this.

Cost structure. Besides today's major investments in terms of employees, consulting companies face the need for stronger contractor/freelancer network, as Case 1 pointed out: '(…) do the concept and get the expert via your network'. Additionally, the technical infrastructure to develop and deploy the above-mentioned value propositions has to be installed and maintained, as Case 8 made clear: '(…) I got internal budget (…) and run our own server-cluster'.

Revenue streams. Due to sensitivity, we regret to have no case-base information regarding current consulting fee models. Nevertheless, with new methods and business opportunities, new payment models for consultants might also come up. As coders already manage it today, consultants, by generating new ideas and by founding new companies with the client, could become shareholders of those ideas. This would also encourage the shift from traditionally higher paid strategy-consultants, compared to IT-driven consultants [21] and be a logical step, as future consultants treat both strategic and IT/data-related questions.

Explanatory Model. So far, this paper presented visible changes in the consulting organizations. With an belief-action-outcome framework (BAO) based on [17], we want to summarize our codings with respect to the underlying roots of that change. The model shows the (macro) beliefs, which we tagged within the interviews, leading to (micro) beliefs within the organization. The actions describe management approaches and operational steps, which have been clustered here as main action steps of DT. Finally, externally visible artefacts form the Digitalized outcome on a macro-level.

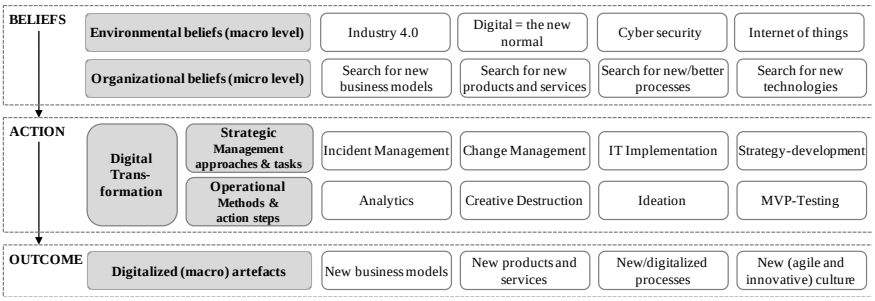

Figure 2. Explanatory model of Digital Transformation.

5 Discussion and Conclusion

5.1 Scientific and Managerial Implications

Our paper should enhance the ongoing academic discussion about the scope, possibilities, and future research of digitalization within consulting. We created three artefacts: First, a process-oriented view onto today's digital transformation projects based on Porter's value chain. Second, a belief-outcome-model of consulting initiatives in the digital era and third, a BMC with important aspects for state of the art consulting toolboxes.

The findings of our paper have a number of important implications for future consulting practice: New working methods, like agile project management, rapid prototyping and so forth are becoming a building block of consultants' work. This will affect the scope of projects (end-to-end), skills of the consultants (or the team setup) and the cost-revenue-structure of the project controlling.

5.2 Conclusion, Limitations and Outlook

Consulting research and practice transforms in many consulting fields to a digital innovation business, as – truly not all, but many – startups and business enhancements are based on digital solutions. Consulting researchers might offer more tools and frameworks for practical toolboxes, as shown in our BMC, to tackle this development.

Like every research, our paper was limited by different factors which might be tackled in our and others future research: As many agencies and innovation labs are creating digital products for enterprises today, these suppliers should be included in such a case study in future. Further, the companies we selected were based in Europe only. A global perspective onto the phenomena would be recommendable for a future setup.

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Digitalisierung im Spiegel der Diskussion etablierter Managementberatungen

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Die mit der Digitalisierung einhergehenden Herausforderungen für Unternehmen sind unübersichtlich, komplex und mit viel Unsicherheit verbunden. Es ist daher nicht verwunderlich, dass Führungskräfte zunehmend Orientierung in der Beratungspraxis suchen. Diese muss sich in Folge auf ein gänzlich neues Feld einrichten und als „Sinnstifter der Digitalisierung" agieren. Im vorliegenden Artikel wird der Diskurs ausgewählter Unternehmensberatungen zum Thema der Digitalisierung systematisch aufgearbeitet. Mittels Inhaltsanalyse werden die wichtigsten Themenfelder sowie die Positionierungen der jeweiligen Beratungen innerhalb der Diskussion identifiziert. Die erlangten Erkenntnisse dürften gleichermaßen für Praktiker und Akademiker interessant sein.

Schlagwörter: Digitalisierung, Digital Business, Digitale Transformation, Digitaler Wandel, Digitale Beratung

1 Digitalisierung als zentrale Herausforderung des Managements

Die digitale Revolution ist in vollem Gange. Der ubiquitäre Einsatz digitaler Technologien, also solcher, die Informations-, Datenverarbeitungs-, Konnektivitäts- und Kommunikationstechnologien vereinen [1], transformiert Gesellschafts- und Wirtschaftsstrukturen maßgeblich und löst einen Umbruch in nahezu allen Lebensbereichen aus. Charakterisiert durch allgegenwärtige Konnektivität, Informationsreichtum und die Auflösung von Raum und Zeit, verändern sich im digitalen Zeitalter nicht nur bestehende gesellschaftliche und wirtschaftliche Praktiken, sondern unser Denken generell. Am Beispiel des Smartphones, insbesondere des iPhones, wird dies schnell ersichtlich: Nicht nur hat das Aufkommen des iPhones die Art der Kommunikation, der Datenverarbeitung und den Ablauf von Geschäftsroutinen verändert, sondern vielmehr einen Standard dafür gesetzt, was heute unter einem Mobiltelefon verstanden wird.

Diese Umwälzungen gehen mit einer bislang ungeahnten Geschwindigkeit und Komplexität einher und stellen vielfältige Ansprüche an die Führungsebene etablierter Unternehmen. Denn diese muss *gleichzeitig* auf veränderte Anforderungen von Kunden reagieren, die in zunehmenden Maße technologieaffin sind und eine entsprechende

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„digital customer experience“ erwarten, digitale Schnittstellen zu einem stetig wachsendem Netzwerk an Zulieferern managen, neue Bedürfnisse von Mitarbeitern wie „bring your own device“ berücksichtigen, digitalisierte Produkte und Dienstleistungen – bis hin zum gänzlich digitalen Geschäftsmodell - entwickeln und bislang unbekannte Herausforderer (z.B. Start-Ups oder digitale Giganten wie Google, Amazon oder Facebook) in einer veränderten Branchenstruktur antizipieren. KREUTZER ET. AL sprechen in diesem Zusammenhang von einem digitalen Darwinismus, in dem langfristig nur solche Unternehmen überleben, die ihr Geschäft optimal an die Gegebenheiten der digitalen Welt anpassen und sich folglich zu einem „digital business“ transformieren [2]. Es ist daher nicht verwunderlich, dass eine Vielzahl von Führungskräften unter erheblichem Erwartungsdruck stehen und nach Orientierungshilfen in Wissenschaft und Praxis suchen [3]. Leider bietet die gegenwärtige akademische Forschung dabei nur bedingt Hilfestellung. Es existieren zwar erste Forschungsarbeiten zum Management der digitalen Transformation [3–5], zur Weiterentwicklung von Geschäftsmodellen [6, 7] oder zur Relevanz digitaler Innovationen [8, 9]. Die Forschung in diesen Bereichen steckt jedoch noch in den Kinderschuhen und bietet bislang kaum konkrete, praktisch relevante Handlungsanweisungen und wenig Empirie. Zudem ist bislang ungeklärt, was grundsätzlich unter dem Begriff des „digital business“ verstanden werden soll bzw. unter welchen Umständen ein Geschäft als ein solches bezeichnet werden kann.

In ihrer Unsicherheit wenden sich Unternehmen deshalb zunehmend an Unternehmensberatungen, die sich in Folge auf ein völlig neues Feld einstellen müssen. Erschwerend kommt hinzu, dass die relevanten Themen innerhalb dieser Domäne nicht vom Top-Management an die Beratungen herangetragen werden, sondern Berater als „Sinnstifter“ agieren und zunächst relevante Themenfelder identifizieren müssen. Um diese Herausforderungen zu adressieren, organisieren sich Beratungen mehr und mehr in eigens dafür eingerichteten Digitalisierungseinheiten (bspw. Digital McKinsey, PwC Digital Services, BCG Digital Ventures), die unter dem Schlagwort „digital business“ regelmäßig Artikel zur Gestaltung des digitalen Wandels in Unternehmen publizieren. Ziel der vorliegenden Arbeit ist daher die Aufarbeitung dieses Diskurses, um nachvollziehen zu können, wie Unternehmensberater sich dem Thema Digitalisierung nähern und welche Zugänge sie sich zum Feld verschaffen.

2 Methodisches Vorgehen

Zur Beantwortung der Forschungsfrage kommt die Methode der empirischen Inhaltsanalyse zum Einsatz. FRÜH definiert die Inhaltsanalyse als „empirische Methode zur systematischen, intersubjektiv nachvollziehbaren Beschreibung inhaltlicher und formaler Merkmale von Mitteilungen [10]“. Diese Methode erlaubt es daher, mittels objektiver und systematischer Identifizierung der Elemente der untersuchten Bedeutungsträger, verallgemeinerbare Schlussfolgerungen zu ziehen, die über das einzelne Analyseobjekt hinausgehen. Beschränkt ist die Inhaltsanalyse dabei auf Semantik und Syntax der Elemente – Aufgabe ist also nicht, latente Intentionen, die im Inhalt verborgen sind herauszustellen, sondern den manifesten Inhalt von Mitteilungen

zu erfassen [11]. Sie ist folglich dazu geeignet, den Diskurs über aufkommende Phänomene durch die Identifikation der gefundenen Elemente so zu strukturieren, dass ein genaueres Verständnis über den Erkenntnisgegenstand selbst generiert werden kann. Ein weiterer Grund, der zur Wahl dieser Methode beigetragen hat, liegt in ihrem non-reaktiven Erhebungsverfahren: Im Gegensatz zu anderen empirischen Forschungsmethoden, wie beispielsweise dem Interview, ist die Wahrscheinlichkeit einer Verzerrung der sozialen Wirklichkeit geringer, da Zeichenfolgen erst nach der Textproduktion und unabhängig von ihrer konnotativ-semantischen Bedeutung analysiert werden.

Zur Durchführung einer Inhaltanalyse existiert ein reichhaltiges Literaturangebot, wobei sich der konkret vorgeschlagene Ablauf nur geringfügig unterscheidet. Die Arbeit orieniert sich an den Richtlinien von BRYMAN & BELL, die ihren Ansatz explizit in einen betriebswirtschaftlichen Kontext setzen [12]. Den Autoren zufolge besteht eine empirische Inhaltsanalyse aus drei sequentiell aufeinanderfolgenden Arbeitsphasen: Festlegung der zu analysierenden Texte (Sampling), Bestimmung der Zähleinheit und schließlich der Verschlüsselung des Textes, wozu zunächst ein Kategorienschema entwickelt werden muss. Im Folgenden werden die einzelnen Phasen näher erläutert.

2.1 Sampling

Im Rahmen des Samplings wird der zu analysierende Inhalt und dessen Umfang festgelegt. Neben der Klasse des zu untersuchenden Inhalts (das können z.B. Zeitungsartikel, Filme, Bilder etc. sein) müssen also auch Größe bzw. Anzahl spezifiziert werden. Wie bereits einleitend erläutert, konzentriert sich diese Arbeit auf Artikel von Managementberatungen, die sich der Thematik des „digital business“ annehmen.

Der Sampling-Prozess unterteilt sich sodann in vier Schritte. Um einen Überblick über die prominentesten Perspektiven der Beratungspraxis zu erhalten, wurde in einem ersten Schritt ein Ranking der Managementberatungen nach deren Reputation gebildet. Datengrundlage hierzu ist das amerikanische Vault.com-Ranking, welches regelmäßig Ranglisten über Unternehmen in verschiedensten Branchen erstellt, die u.a in der New York Times, dem Wall Street Journal, Forbes etc. veröffentlich werden [13]. Abbildung 1 spiegelt das Ranking wider (Stand Februar 2017) und ist repräsentativ für die Regionen Nordamerika, Europa und Asien[1]. In einem nächsten Schritt sollen diejenigen Beratungen identifiziert werden, die sich intensiv mit der Thematik des digitalen Geschäfts befassen. Hierzu wurde zusätzlich zur Suchfunktion auf den globalen Websites der Beratungen auch Googles „Site-Search“ herangezogen. Zur Abdeckung sämtlicher Wortkombinationen (inkl. des Plurals) wurde der Suchbegriff „digital business*“ verwendet. Dabei wurden zunächst nur offizielle, englischsprachige Unternehmensartikel („white paper“) berücksichtigt, die den Suchbegriff in Titel oder Untertitel beinhalten. Werbematerialien, sowie Pressemitteilungen, Interviews,

[1] Trotz genereller Limitationen von Rankings in Bezug auf Erhebungs- und Auswertungsverfahren, bietet das Vault.com-Ranking ein hilfreiches Instrumentarium zur Identifikation etablierter Managementberatungen.

Broschüren und Präsentationen wurden wegen ihrer hohen Spezifität nicht berücksichtigt. Ebenso wenig relevant waren Artikel, die sich auf eine bestimmte Organisation (z.B. „Global Center for Digital Business Transformation“) oder eine spezifische Veranstaltung (z.B. „Digital Business Forum“) bezogen. Unter Anwendung dieser Such- und Gütekriterien konnten die gefundenen Artikel sechs Unternehmensberatungen zugeordnet werden, die sich intensiv mit der Thematik des „digital business“ befassen. Diese Beratungen wurden in einem letzten Schritt genauer unter die Lupe genommen: zusätzlich zu den bereits identifizierten Artikeln wurde das Sample für die ausgewählten Beratungen um solche Artikel erweitert, die den Suchbegriff in Zusammenfassung, Vorwort oder Einleitung erwähnen. Insgesamt ergab sich somit ein Sample von 73 Publikationen, die zwischen 2010 und 2017 veröffentlicht wurden.

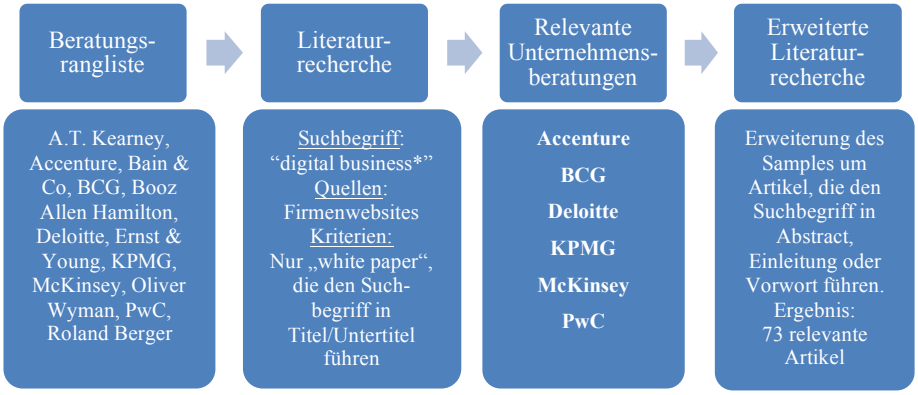

Abbildung 1. Schritte des Samplingverfahrens

2.2 Bestimmung der Zähleinheit

Nachdem der Literaturkorpus festgelegt wurde, ist es in der Inhaltsanalyse notwendig, die Zähleinheiten zu bestimmen. KROMREY, ROOSE & STRÜBING definieren die Zähleinheit als den „Merkmalsträger, an dem untersucht wird, welche Ausprägungen (Unterkategorien) der zu erhebenden Merkmale (Kategorien) vorliegen“ [14]. Im Rahmen von Textanalysen schlagen die genannten Autoren unterschiedlichste Zähleinheiten vor. Diese können z.B. Wortbestandteile, Schlagzeilen, Fremdwörter oder Textabschnitte umfassen. Ziel unserer Arbeit ist zu verstehen, welche Themenfelder unter dem Schlagwort „digital business“ in der Praxis adressiert werden. Unsere Zähleinheiten sind daher Textabschnitte, die sich auf abgrenzbare Themen innerhalb des Praxisdiskurses beschränken lassen.

2.3 Verschlüsselung (Coding)

Sind Literaturkorpus und Zähleinheiten festgelegt, besteht die zentrale Herausforderung der letzten Phase einer Inhaltsanalyse in der Kategorienbildung. Ziel hierbei ist die Bildung eines Schemas, das die Zuordnung sämtlicher Zähleinheiten zu

einer eindeutigen Kategorie zulässt [10]. Grundlegend kann zwischen einer deduktiven und induktiven Vorgehensweise unterschieden werden. Beim deduktiven Ansatz wird das Kategorienschema *vor* der Analyse des Datenmaterials aufgestellt und definiert. Dieses Verfahren eignet sich besonders dann, wenn bereits ein umfangreiches theoretisches Vorwissen vorhanden ist [15]. Wie bereits erläutert, liegt eine solche theoretische Basis im Rahmen des hier behandelten Themas jedoch nicht vor. Daher wurde ein induktiver Ansatz gewählt, bei dem die Kategorien direkt aus dem untersuchten Material abgeleitet werden. Zur systematischen Bearbeitung des Samples wurden daher relevante Aussagen innerhalb des Textes identifiziert und Kategorien zugeordnet. Sich aufeinander beziehende oder inhaltsgleiche Aussagen werden dabei zusammengefasst und einer gemeinsamen Kategorie zugeordnet. Beispielsweise sprechen McKinsey und KPMG unter den Begriffen „digital technologies“ und „disruptive technologies“ von identischen Technologien, benennen diese aber uneinheitlich. Relevante Stellen waren solche, die einen direkten betriebswirtschaftlichen Bezug aufwiesen. So war in der ausgewählten Literatur beispielsweise oft von den Umständen des digitalen Zeitalters die Rede, was für unsere Forschungsfrage als nicht relevant erachtet wurde, trägt es doch nicht zum besseren Verständnis des untersuchten Erkenntnisobjektes bei.

Die Kodierung des gesamten Samples resultierte in insgesamt 578 Codes, die 118 Kategorien zugeordnet werden konnten. Zur Rücküberprüfung der entworfenen Struktur wurde mit einem erneuten Materialdurchlauf begonnen. Dabei konnten einige Kategorien in Oberkategorien zusammengefasst und inhaltsgleiche Aussagen vereint werden, sodass letztlich 74 Kategorien verblieben. Um die am meist diskutierten Themenfelder zu ermitteln, wurden die Kategorien in einem letzten Schritt in eine Rangfolge gebracht. Die schlichte Zählung der Erwähnungen führt dabei nicht zwangsläufig zu einem objektiven Ergebnis. So könnte es beispielsweise sein, dass ein Thema sehr häufig innerhalb weniger Artikel erwähnt wird und diesem Thema somit mehr Bedeutung zukommt, als ihm zusteht. Um eine solche Verzerrung zu vermeiden, wurde jeder Kategorie ein Frequenzwert zugeordnet, in dem die Summe der Nennungen mit dem Anteil der Artikel, in denen die Kategorie auftaucht, gewichtet wird. Der Wert ermittelt sich mittels folgender Formel:

$$F = (NA_1 + \ldots + NA_n) * n/GA \quad (1)$$

Dabei repräsentiert die Variable *NAn* die Nennungen pro Artikel, *n* die Anzahl an Artikeln, in denen die Kategorie identifiziert wurde und *GA* entspricht der Gesamtzahl der Artikel im Sample, in unserem Falle also 73. Die so ermittelte Top-10 der meistdiskutierten Themen wird im folgenden Abschnitt dargestellt und näher erläutert.

3 Kernthemen und Positionierung der Beratungen

Mit Blick auf das eingangs erwähnte Ziel der Arbeit ist die Datenauswertung in zwei Teile untergliedert. Mittels Valenzanalyse wurden in einem ersten Schritt die Kernthemen über das gesamte Sample identifiziert. Dabei gehen Valenzanalysen über die bloße Frequenzanalyse hinaus: Es interessiert nicht nur, wie häufig die

Zähleinheiten den Kategorien zugeordnet werden können, sondern auch der stattfindende Diskurs innerhalb der jeweiligen Themenfelder [15]. In einem zweiten Schritt wurde sodann untersucht, in wie fern sich der Zugang zum Feld beratungsspezifisch unterscheidet.

3.1 Zentrale Themenfelder

Die Ergebnisse der Frequenzanalyse - absteigend sortiert entsprechend des Werts der in Kapitel 2.3 genannten Formel - sind in Tabelle 1 dargestellt. Darüber hinaus finden sich dort den Themenfeldern zugeordnete Schlagwörter, die im Diskurs immer wieder aufgekommen sind.

Tabelle 1. Meistdiskutierte Themen im Praxisdiskurs zum "digital business"

Themenfeld: **Digitale …**	*Frequenz*	*Schlagwörter*
Technologien	2267 (69%)	Soziale/ mobile/ analytische/ cloud Technologien, Internet of things …
Sicherheit	388 (12%)	Cybersecurity, Datenschutz, „digital trust"
Geschäftsmodelle	151 (5%)	Mehrseitige Plattformen, disruptive Geschäftsmodelle
Produkte & Dienstleistungen	98 (3%)	Informatisierte Güter
Strategie	88 (3%)	Strategische Digitalisierungsinitiativen, digitale Geschäftsstrategien
Kundenerfahrung	87 (3%)	Digitale Kundenschnittstelle, Omnichannel
Ökosysteme	79 (3%)	Wertschöpfungsnetzwerke
Unternehmenskultur	48 (1%)	Digitales Mindset, Aufbrechen von „Silo-Denken"
Talente und Fähigkeiten	45 (1%)	Digital Natives
Führung	38 (1%)	Chief Digital Officer

Aus den Ergebnissen der Analyse wird deutlich, dass die Diskussion über *digitale Technologien* vorherrscht. Nur 4 der ausgewählten 73 Artikel haben keinen direkten Technologiebezug. Das Ausmaß der Dominanz dieses Themenfelds war überraschend. Im Kern wird dabei vorwiegend über die Potenziale sogenannter „SMAC-Technologien" (Social, Mobile, Analytics, Cloud) gesprochen, wobei den sozialen Technologien am wenigsten, big data und analytischen Technologien hingegen am meisten Beachtung zukommt. Die Beratungen sind sich einig, dass diese Technologien unabdingbare Elemente eines digitalen Geschäfts darstellen. Wichtig sind offensichtlich auch Aspekte der *digitalen Sicherheit*, welche das zweitpopulärste Thema repräsentieren. Folgt man der Argumentation der Beratungen, sehen sich Unternehmen einer zunehmenden Bedrohung durch Cyber-Attacken ausgesetzt, die zwangsläufig mit der Digitalisierung des Geschäfts einhergehen. Grundsätzlich wird in der Diskussion zwischen digitaler Sicherheit und digitalem Vertrauen unterschieden. Während ersteres Konzept auf die technische Sicherheit der Informationsinfrastruktur abzielt, wird letzteres eher im Zusammenhang mit dem Sicherheitsversprechen

gegenüber Kunden in Verbindung gebracht. *Digitale Geschäftsmodelle*, auf Platz drei, sind untrennbar mit dem laufenden Technologiewandel verbunden und stellen aus Sicht der Unternehmensberatungen nicht nur eine Möglichkeit, sondern eine notwendige Bedingung zum Erhalt der Wettbewerbsfähigkeit im digitalen Zeitalter dar. Merkmale digitaler Geschäftsmodelle sind dabei der strikte Kundenfokus, die Nutzung digitaler Kanäle und der zunehmende Nutzen von Daten zur Gestaltung des Geschäftskonzepts. Natürlich spielen dabei auch *digitale Produkte und Dienstleistungen* eine Rolle. Präziser gesagt geht es in der Diskussion vorrangig um die Einbettung digitaler Technologien in „analoge" Produkte und Dienstleistung, wodurch eine völlig neue Architektur entsteht. So können beispielsweise klassische Industrieprodukte mittels Softwareupdates kontinuierlich erweitert und verbessert werden, ohne dass Kunden die komplette Hardware neu erwerben müssen. Die größte Diskrepanz herrscht in der Debatte zu *digitalen Strategien.* Zwar sind sich die Berater einig, dass digitale Strategien essentiell für den langfristigen Erfolg digitaler Geschäfte sind, über Inhalte solcher Strategien wird jedoch kaum geredet. Stattdessen geht es in erster Linie darum, auf welcher Organisationsebene diese Strategieart angesiedelt ist (Gesamtunternehmens-, vs. Geschäftsbereich-, vs. Funktionsebene). Konsens besteht hingegen in der Annahme, dass sich eine digitale Strategie, bzw. das gesamte Geschäftsmodell im digitalen Zeitalter mit einer möglichst umfassenden *digitalen Kundenerfahrung* beschäftigen sollte. Gemeint ist damit die Erreichbarkeit und Präsentation des Geschäftes auf sämtlichen digitalen Kanälen. Ein Hauptgrund für die Wichtigkeit dieses Themenfelds liegt in der Erwartungshaltung der „digital natives". So schreibt beispielsweise Deloitte: "Digital natives not only want, but expect a great experience in the digital channel, whether it's in social media, banking, or shopping" [16]. Im digitalen Zeitalter verändern sich aber nicht nur einzelne Unternehmen, sondern ganze Industrien, Ökosysteme und Wertschöpfungsketten. Unter dem Begriff *"digitale Ökosysteme"* subsumieren die Berater die mit der Digitalisierung verbundene Entwicklungen von klar abzugrenzenden Industrien zu miteinander verwobenen Ökosystemen. Die letzten drei Themenfelder adressieren hauptsächlich die Personaldomäne. Unter einer *digitalen Unternehmenskultur* wird dabei die Anpassung der betrieblichen Normen und Werte an eine zunehmend digitalisierte Welt verstanden. Häufig ist dabei die Rede von einem digitalen Mindset, das charakterisiert wird durch Agilität, Risikobereitschaft, einen positiven Umgang mit Veränderungen und funktionsübergreifenden Denkweisen. Ebenso beitragen zu einer digitalen Unternehmenskultur kann die Entwicklung von *digitalen Talenten und Fähigkeiten*. Eine Vielzahl der untersuchten Artikel erkennt in diesem Zusammenhang an, dass der Mangel von Fähigkeiten im Umgang mit digitalen Technologien eines der größten Hindernisse im Rahmen einer digitalen Transformation darstellt. Die Berater geben daher allerhand Gestaltungshinweise zum „digitalen Talentmanagement". Schließlich wird im Diskurs über die *digitale Führung (digital leadership)* der Frage nachgegangen, wer sich für die Digitalisierung im Unternehmen verantwortlich zeigt. Hier sind sich die Autoren einig, dass ein wesentlicher Erfolgsfaktor eine vom Top-Management vorgelebte digitale Vision sei. Digitalisierung ist Chefsache, so die Beratungsexperten. Da der CEO jedoch aus verschiedensten Gründen nicht immer

optimal geeignet sei, schlagen einige Berater die Schaffung der Rolle eines „Chief Digital Officers“ vor, der die digitale Transformation verantworten soll.

3.2 Zugang der Beratungen

Interessant ist zudem, wie sich die einzelnen Beratungen innerhalb der Diskussion positionieren, bzw. welchen Zugang sie zum Feld wählen. Analog zur Bildung des gesamten Samples wurden mittels der in Kapitel 2 beschriebenen Vorgehensweise die meist diskutierten Themen der jeweiligen Beratungen eruiert und somit Beratungsprofile erstellt. Die Ergebnisse finden sich in Tabelle 2.

Tabelle 2. Beratungsprofile im Hinblick auf die Digitalisierung

Accenture	*BCG*	*Deloitte*
Technologien (59%)	Technologien (48%)	Technologien (73%)
Sicherheit (25%)	Kundenerfahrungen (18%)	Kundenerfahrungen (5%)
Geschäftsmodelle (5%)	Ökosysteme (15%)	Sicherheit (5%)
Prozesse (2%)	Strategie (6%)	Strategie (4%)
Ökosysteme (2%)	Kanäle (4%)	Führung (3%)
Partnerschaften (2%)	Geschäftsmodelle (2%)	Geschäftsmodelle (2%)
Strategie (2%)	Entwicklung (2%)	Talente und Skills (2%)
Kundenerfahrungen (1%)	Produkte & Services (2%)	Trends (2%)
Produkte & Services (1%)	Applikationen (2%)	E-commerce (2%)
Kanäle (1%)	Kommerz (2%)	Kanäle (2%)

KPMG	*McKinsey*	*PWC*
Technologien (40%)	Technologien (58%)	Technologien (53%)
Strategie (22%)	Sicherheit (10%)	Produkte & Services (9%)
Governance (12%)	Agenda (5%)	Ökosysteme (8%)
Talente und Skills (8%)	Strategie (5%)	Unternehmenskultur (8%)
Führung (4%)	Talente und Skills (4%)	Talente & Skills (6%)
Prozesse (4%)	Produkte & Services (4%)	Geschäftsmodelle (5%)
Initiativen (4%)	Unternehmenskultur (4%)	Sicherheit (5%)
Sicherheit (3%)	Infrastruktur (4%)	Kundenerfahrungen (2%)
Kanäle (2%)	Führung (4%)	Lösungen (2%)
Vision (2%)	Geschäftsmodelle (2%)	Blockchain (2%)

Auf den ersten Blick ergibt sich ein größtenteils homogenes Bild. So verschaffen sich ausnahmslos alle Beratungen überwiegend Zugang über die neuen Technologien selbst. Untersucht man den Diskurs jedoch genauer, ergeben sich einige Unterscheidungsmerkmale, die im Folgenden kurz beschrieben werden sollen.

Accenture: Neben einem starken Technologiefokus besetzt Accenture vorrangig das Feld der digitalen Sicherheit. In insgesamt 75% der untersuchten Artikel werden Sicherheitsthemen zumindest angeschnitten; McKinsey, bei denen digitale Sicherheit ebenso das zweitwichtigste Thema zu sein scheint, kommt im Vergleich nur auf gut 40%. Es ist daher nicht verwunderlich, dass viele von Accentures Top-Themen aus einer Sicherheitsperspektive betrachtet werden. So werden digitale Technologien nicht

nur im Hinblick auf ihre Potenziale, sondern in erster Linie hinsichtlich der inhärenten Sicherheitsrisiken beurteilt [17, 18]. Ein ähnlicher Fokus ist in der Diskussion um digitale Ökosysteme gesetzt, da durch zunehmend verschwimmende Industriegrenzen neue Sicherheitsrisiken innerhalb und außerhalb der ursprünglichen Industriegrenzen entstehen können [19, 20]. Die Positionierung in dieser Domäne ist nicht gänzlich überraschend, da Accenture bekanntermaßen eine stark ausgeprägte IT-Perspektive auf das Geschäft und somit bereits viel Erfahrung im Bereich IT-Sicherheit gesammelt hat.
BCG: Für die Boston Consulting Group stehen neben den Technologien Kunden und Ökosysteme im Vordergrund eines digitalen Geschäfts. Im Rahmen der Schaffung einer digitalen Kundenerfahrung nennt die Beratung insbesondere zwei Hauptaufgabenfelder [21, 22]: Die Erstellung von „customer journey maps“, in denen die Interaktionswege von Kunden mit der digitalen Organisation aufgezeichnet und ausgewertet werden und die Erschaffung eines kanalübergreifenden Omnichannel-Erlebnisses. Daraus wird deutlich, dass sich BCG vorwiegend auf einer Marketingebene positioniert. Interessanterweise spiegelt sich dies auch in der Diskussion zur digitalen Technologiewahl wider. Während die anderen Beratungen überwiegend von SMAC-Technologien sprechen, bezieht BCG darüber hinaus explizit kundenorientierte Technologien wie augmented reality oder biometrische Identifikation in die Diskussion ein [21].
Deloitte: Deloitte hat den mit Abstand stärksten Technologiebezug. In unserem Sample existiert kein Artikel, in dem nicht zumindest von einer der vier SMAC-Technologien die Rede ist. Ein Schwerpunkt liegt hierbei auf den mobilen Technologien, die den Autoren zufolge die digitale Geschäftstransformation treiben und zu nachhaltigen Innovationen beitragen [23]. Es muss jedoch erwähnt werden, dass Deloitte auch Wert auf die strategische Verankerung der digitalen Technologien legt. So geht es nicht um die planlose Implementierung dieser Technologien, sondern um den strategischen Wert den diese schaffen. Beispielsweise schreiben die Berater: „Consistent with our overall findings, the ability to conceptualize how digital technologies can impact the business is a skill lacking in many companies at the early stages of digital maturity [24].”
KPMG: Im Verhältnis zu den anderen Beratungen spielen digitale Technologien für KPMG eine weniger überlagernde Rolle. Insgesamt zielt die Diskussion hauptsächlich auf geschäftsinterne Aspekte ab. Digitale Geschäftsmodelle, Kundenerfahrungen oder Ökosysteme sucht man in den Top 10 der meist diskutierten Themen vergebens. Die Wirtschaftsprüfungsgesellschaft platziert sich so in den Domänen Steuerung und Strategie, u.a. mit Themen im Bereich Compliance und Governance. Letzteres Themenfeld wird nahezu exklusiv von KPGM besetzt. Hier wäre ein Vergleich bislang vorherrschender Verständnisse und Regeln von IT-Governance im Vergleich zur “digitalen Governance” interessant. Zwar nennen die Berater die Notwendigkeit der Anpassung von Governance-Mechanismen im digitalen Zeitalter, gehen dabei aber nicht über die typischen Schemata wie zentralisiert, dezentralisiert, föderal hinaus [25].
McKinsey: Das Profil der Unternehmens- und Strategieberatung McKinsey hat uns zunächst insofern überrascht, als dass Themen der digitalen Sicherheit priorisiert werden. Betrachtet man den Diskurs genauer, löst sich diese Verwirrung jedoch schnell auf. Denn anders als Accenture, die im Rahmen ihrer Sicherheitsthemen eher auf technische Lösungen abzielen, dreht sich die Diskussion bei McKinsey vornehmlich

um Sicherheitsmanagement. So geht es beispielsweise um die Priorisierung beim Schutz kritischer digitaler Vermögenswerte oder um die Frage, wer für die digitale Sicherheit verantwortlich sein sollte [26, 27]. Insgesamt nimmt McKinsey eine organisatorische Perspektive ein und betrachtet innerhalb dieser Domäne die Bereiche digitale Strategien und Agenden, Unternehmenskultur, Führung und digitale Geschäftsmodelle. Dazu passt auch das Konzept der „digitalen Infrastrukturen". Hierunter versteht McKinsey insbesondere die Aufstellung der IT-Organisation als Funktion der zwei Geschwindigkeiten (two-speed IT) [28, 29].

PwC: Anders als die restlichen Unternehmensberatungen positioniert sich PwC weniger über individuelle Themenfelder, sondern eher über einen Fokus auf spezifische Anwendungsbereiche/Branchen. Zum einen trägt die Beratung substanziell zur „Industrie 4.0"-Debatte bei, was auch erklärt, warum im Zuge der Technologiediskussion über die Potentiale von 3D-Druckern, smarten Sensoren oder Mensch-Maschine-Interfaces gesprochen wird [30]. Zum anderen stellen sich die Berater stark in der Finanzindustrie auf: Themen wie digitale Währungen, Blockchain-Technologien oder smarte Verträge nehmen einen hohen Stellenwert ein und motivieren große Teile der Forschung PwCs [31].

4 Fazit

Unsere Forschung zielte darauf ab, ein besseres Verständnis darüber zu bekommen, wie Unternehmensberatungen sich der Digitalisierung nähern. Dazu wurden mittels Inhaltsanalyse die meistdiskutierten Themenfelder ausgewählter Beratungsunternehmen identifiziert und inhaltlich aufgearbeitet, um schließlich individuelle Unternehmensprofile zu erstellen. Es lässt sich festhalten, dass die Diskussion über die Potenziale neuartiger digitaler Technologien (SMAC-Technologien) dominiert. Ein Grund hierfür könnte sein, dass diese Technologien als Treiber der komplexen Digitalisierungsthematik unmittelbar greifbar sind und so als erster Zugang zum Feld fungieren. Es bleibt in dieser Hinsicht abzuwarten, ob nun, da die technologische Seite größtenteils verstanden und abgedeckt wurde, organisatorische, strategische und Sicherheitsthemen an Relevanz gewinnen. Betrachtet man die individuellen Profile der Unternehmensberatungen und blendet die reine Technologiediskussion aus, lassen sich unterschiedliche Positionierungen innerhalb des Diskurses feststellen. Diese sind größtenteils Konform mit der Grundausrichtung der Beratung, überschneiden sich jedoch in ausgewählten Themenfeldern.

Uns ist bewusst, dass die vorliegenden Daten methodischen Limitationen unterliegen. So kann nicht ausgeschlossen werden, dass relevante Beratungen im Rahmen des Samplings durch den ersten Filter gefallen sind, da dieser nur Publikationen berücksichtigt, die den Begriff „digital business" im Titel führen. Auch die grundsätzliche Beschränkung auf Top-Managementberatungen lässt einen „Bias" nicht ausschließen. Es ist daher gut möglich, dass kleinere, auf Digitalisierung spezialisierte Beratungen, interessante Erkenntnisse zur Debatte beitragen könnten, die von uns nicht berücksichtigt wurden.

Dennoch können die in dieser Forschung dargestellten Ergebnisse in zweierlei Hinsicht hilfreich sein. Einerseits erlaubt die Strukturierung des Digitalisierungsdiskurses eine Identifizierung von praktisch relevanten Themenfeldern, an denen sich weitere Forschungsarbeiten orientieren können. So soll sichergestellt werden, dass Forschung sich an real existierenden Problemen ausrichtet. In dieser Hinsicht kann das hier vorliegende Papier als Meta-Artikel betrachtet werden. Für Beratungsunternehmen auf der anderen Seite, könnten insbesondere die abgebildeten Individualprofile aufschlussreich sein. Denn diese bieten Transparenz im Hinblick auf adressierte Themenfelder konkurrierender Unternehmen und deren Positionierung. Informierten Beratern bietet sich somit die Chance, sich so im Markt zu positionieren, dass ein Alleinstellungsmerkmal entsteht.

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Neue Beratungsperspektiven für den Wirtschaftsprüfer: Expertenbefragung zur Automatisierung von Prüfungshandlungen

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Abstract. Die Hauptaufgabe von externen Wirtschaftsprüfungsgesellschaften ist die Prüfung von Jahresabschlüssen nach gesetzlichen Vorgaben. Diese Aufgabe wird zunehmend durch den Einsatz von Informationstechnologie (IT) bestimmt: Auf der einen Seite führen die Generierung von Rechnungslegungsdaten in Echtzeit und die Komplexität digitaler Wertschöpfungsketten zu erhöhten Anforderungen an die Prüfungsbranche. Auf der anderen Seite ergeben sich durch den Einsatz IT-gestützter Prüfungswerkzeuge neue Geschäftsmodelle und spezialisierte Beratungsleistungen. In diesem Zusammenhang wird in der Literatur seit mehr als 30 Jahren die Automatisierung von Prüfungshandlungen diskutiert. Obwohl dazu im Schrifttum bereits Konzepte und Verfahren vorgestellt wurden, fehlen Erkenntnisse, welche allgemeinen Voraussetzungen für die Automatisierung von Prüfungshandlungen erfüllt sein müssen. In dem vorliegenden Artikel werden die Ergebnisse einer empirischen Studie vorgestellt, in der die Digitalisierungs- und Automatisierungsfähigkeit von Prüfungshandlungen anhand semi-strukturierter Experteninterviews erhoben wurden.

Keywords: Wirtschaftsprüfung, Digitalisierung, Automatisierung, Kontinuierliche Prüfung

1 Einleitung

Die zunehmende Digitalisierung betrieblicher Prozesse führt zu einem Paradigmenwechsel in der externen Wirtschaftsprüfung und stellt Wirtschaftsprüfungsgesellschaften (WPG) vor große Herausforderungen [1–4]. Die durchgängige Nutzung von Informationstechnologie (IT) für betriebliche Kernaufgaben, vor allem Enterprise-Ressource-Planning- (ERP) und Buchhaltungssysteme [5], und die Verarbeitung von Daten in Echtzeit [6] erfordern die Weiterentwicklung von Prüfungsansätzen und -handlungen [7]. Gerade kleine und mittlere WPG müssen sich trotz fehlender personeller Kapazitäten, verhältnismäßig geringen Budgets sowie fehlender IT-Infrastrukturen und personellen Ressourcen den Auswirkungen der digitalen Transformation stellen [8]. Allerdings ergeben sich durch die jederzeitige Verfügbarkeit und damit Prüfbarkeit betrieblicher Daten neue Chancen

für die Erfolgsmessung und Beratungstätigkeiten im Bereich der vorausschauenden Prüfung [9–11].

Der flächendeckende Einsatz von Informationssystemen für Rechnungslegungs- und Prüfungsprozesse ermöglicht zunehmend die Digitalisierung und Automatisierung von Prüfungshandlungen. Dies wiederrum ist eine Voraussetzung, um Geschäftsvorfälle unmittelbar nach ihrer Entstehung zu prüfen und Ergebnisse zeitnah zur Verfügung zu stellen [12], [13]. Diese kontinuierliche Prüfung wird seit mehr als 30 Jahren im Schrifttum diskutiert [14–16]. In diesem Zusammenhang wurden zahlreiche generische Konzepte, u. a. [17], [13], [18], und Individuallösungen, u. a. [19–21], entwickelt. Diese konnten jedoch bislang nicht zu Standardwerkzeugen weiterentwickelt werden, da es sehr viele verschiedene Prüfungshandlungen gibt, die in jedem Prüfer-Mandanten-Verhältnis individuell durchgeführt werden [22], [23]. Die Entwicklung von Standardwerkzeugen erfordert die Abstraktion von diesen individuellen Gegebenheiten und die Identifikation von allgemeingültigen Voraussetzungen, anhand der die Automatisierungsfähigkeit von Prüfungshandlungen beurteilt werden kann.

Ziel des vorliegenden Artikels ist es, diesen Forschungsbedarf aufzugreifen und insbesondere die Situation für in Deutschland ansässige kleine und mittlere WPG zu betrachten. Zur Identifikation und Beschreibung der allgemeingültigen Kriterien werden zwei Forschungsfragen (FF) behandelt:

FF1: *Welche Prüfungshandlungen können nach dem gegenwärtigen Stand der Technik unabhängig vom Prüfungsauftrag digitalisiert und automatisiert durchgeführt werden?*

FF2: *Welche allgemeinen Voraussetzungen müssen seitens des Auftraggebers gegeben sein, damit Prüfungshandlungen digitalisiert und automatisiert durchgeführt werden können?*

Zur Beantwortung der Forschungsfragen muss ein Verständnis des Untersuchungsgegenstands in der Praxis gewonnen und das Erfahrungswissen der betroffenen Nutzer, d. h. Wirtschaftsprüfer, berücksichtigt werden. Dazu wurden in semi-strukturierten Interviews Experten über die Automatisierungsfähigkeit von Prüfungshandlungen befragt und wesentliche Erkenntnisse und Voraussetzungen herausgearbeitet. Diese Erkenntnisse können Wissenschaftler dabei unterstützen, die Digitalisierung der Wirtschaftsprüfung oder vergleichbaren Dienstleistungen, z. B. Steuerberatung, untersuchen. Praktiker, wie z. B. Softwareentwickler oder IT-Berater, können die Ergebnisse zur Entwicklung von Standardanwendungen nutzen.

Der Artikel setzt sich wie folgt fort: In Abschnitt 2 wird der Stand der Forschung in Bezug auf empirische Untersuchungen im Umfeld IT-gestützter Prüfungshandlungen aufgezeigt. In Abschnitt 3 werden das angewendete Forschungsvorgehen und das Interviewdesign beschrieben. Der Hauptteil des Artikels umfasst die Resultate der Interviews (Abschnitt 4). Der Artikel schließt mit einem Fazit der gewonnenen Erkenntnisse in Abschnitt 5.

2 Stand der Forschung

Zur Beurteilung des Stands der Forschung werden in diesem Abschnitt die Ergebnisse einer strukturierten Literaturanalyse im Bereich digitaler und kontinuierlicher Prüfungshandlungen, bestehend aus Datenbank- Rückwärts- und Vorwärtssuche [24] aufgenommen und erweitert. Ergebnisse dieser Literaturanalyse wurden zu einem separaten Forschungsbeitrag zusammengefasst und von den Autoren des vorliegenden Artikels veröffentlicht [16]. Dabei wurden neun Artikel identifiziert, bei denen qualitative Untersuchungen, insbesondere in Form von Interviews, durchgeführt wurden. Dieser Literaturbasis wurden im Rahmen der vorliegenden Arbeit vier weitere Artikel, die zwischen 2015 und 2016 veröffentlicht wurden, hinzugefügt. Die Anzahl von 13 Artikeln diente als Auswertungsbasis für diesen Artikel.

Die Analyse des Schrifttums zeigt, dass zur Automatisierung von Prüfungshandlungen insbesondere allgemeine Prüfsoftwareanwendungen (engl. general audit software, GAS), z. B. ACL und Caseware IDEA, verwendet werden. Dabei handelt es sich um Software, die den Import strukturierter Daten und deren anschließende Analyse ermöglicht. Von den 13 identifizierten Artikeln werden in acht Artikeln der Einsatz und die Verbreitung von GAS anhand qualitativer Studien untersucht. Debreceny et al. (2005) führen eine qualitative Studie unter internen und externen Revisoren im Bankensektor in Singapur durch [25]. Dabei werden verschiedene Einsatzmöglichkeiten und Anwendungsaspekte von GAS gezeigt, z. B. der automatisierte Abgleich von Unterschriften im Bankengeschäft. Ein wesentliches Ergebnis dieser Studie ist, dass externe Prüfungsgesellschaften kaum Standardsoftware zur Prüfung nutzen, da sich diese auskunftsgemäß nicht auf die Prüfung von Rechnungslegungsaussagen oder des internen Kontrollsystems anwenden ließen. Auch Omoteso et al. (2010) beschreiben Barrieren für die Verwendung von GAS und der Automatisierung von Prüfungshandlungen [26]. Bei einer Befragung interner und externer Prüfer im Vereinigten Königreich äußerten Experten Bedenken hinsichtlich dem Mangel an Flexibilität, die automatisierte Prüfungshandlungen bedeuten könnten. Darüber hinaus wird die Gefahr gesehen, dass sich Prüfer zu sehr auf die automatisierten Ergebnisse verlassen und weitere, notwendige Prüfungshandlungen vernachlässigen könnten.

Allen Studien bestätigen, dass der Einsatz von IT die Effizienz von Prüfungshandlungen erhöhen kann. Es werden jedoch auch zahlreiche Limitationen genannt: Die Automatisierung von Kontrollen erfordert z. B. die Sicherstellung von Angemessenheit und Wirksamkeit der Kontrollen sowie die Ordnungsmäßigkeit der zugrundeliegenden IT-Infrastruktur. Zudem bedarf Prüfung stets ein Verständnis von potenziellen Risiken und der Aufstellung geeigneter Prüfungspläne, um potenzielle Risiken zu reduzieren [27]. Weitere Voraussetzungen zur Anwendung von GAS sind das technische Grundverständnis und Zugriff auf die relevanten Daten [28].

Auffällig ist, dass bis auf eine Ausnahme, alle betrachteten Artikel ab dem Jahr 2010 veröffentlicht wurden, obwohl die ersten Konzepte zur kontinuierlichen Prüfung bereits 1989 und zum Teil noch früher beschrieben wurden. Ein Grund dafür könnte die mangelnde Bereitschaft zum Aufbau der benötigten Infrastrukturen und damit die geringe Verbreitung in der Praxis sein. Diese Möglichkeit wird durch die Ergebnisse

von Vasarhelyi et al. (2012) gestützt, bei deren Studie die Mehrheit der Befragten angaben, dass deren Bestrebungen zur Umsetzung kontinuierlicher Prüfungsansätze allenfalls im Entstehen begriffen sind („emerging“) [28].

In den betrachteten Studien werden mehrheitlich Beschäftigte der Internen Revision befragt. Sechs Studien aggregieren Antworten von internen und externen Prüfern. Nur eine Studie betrachtet ausschließlich das externe Prüfungswesen [29]. Darüber hinaus berücksichtigen nur vier der betrachteten Studien kleine und mittlere Prüfungsgesellschaften, die es im Vergleich zu großen Gesellschaften schwerer haben, personelle und technische Kapazitäten für automatisierte und kontinuierliche Prüfungshandlungen aufzubauen. Die Studien wurden vorwiegend im anglo-amerikanischen Raum, in Asien und in Nordafrika durchgeführt. Erkenntnisse aus Deutschland und für Länder der kontinentaleuropäischen Rechnungslegung konnten nicht identifiziert werden.

3 Methodisches Vorgehen

Die Wirtschaftsinformatik (WI) als Interdisziplin zwischen den Mutterdisziplinen Betriebswirtschaftslehre und Informatik kann auf zahlreiche Methoden zur Datenerhebung und -auswertung zurückgreifen [30], [31]. Wie in Abschnitt 1 beschrieben, ist das Ziel des vorliegenden Artikels die empirische Erhebung zur Digitalisierungs- und Automatisierungsfähigkeit von Prüfungshandlungen und den sich daraus ergebenden Chancen und Herausforderungen für den Berufsstand der Wirtschaftsprüfer im Mittelstand. Auf dieser Basis sollen die Bedürfnisse der Benutzer, in diesem Fall Wirtschaftsprüfer, in Bezug auf zu entwickelnde IT-Systeme analysiert und intersubjektiv nachvollziehbare Erkenntnisse über Einsatz und Akzeptanz dieser IT-Systeme generiert werden [32]. Folglich orientiert sich die angewendete Forschungsmethode vorrangig an dem behavioristischen Paradigma, gleichwohl die Ergebnisse in zukünftigen Forschungsarbeiten als Grundlage für die Konstruktion nützlicher IT-Artefakte dienen können [33].

Die Datengrundlage dieser Forschungsarbeit sind leitfadengestützte Interviews, bei denen Wirtschaftsprüfer im Sinne des § 1 WPO als Experten befragt wurden und deren schwerpunktmäßige Tätigkeit die Abschlussprüfung von mittelgroßen Gesellschaften im Sinne des § 267 Abs. 2 HGB ist. Für die Studie wurden insgesamt 28 Wirtschaftsprüfer in Niedersachsen angeschrieben, welche in kleinen und mittelgroßen Prüfungsgesellschaften tätig sind. Infolgedessen, haben sich fünf Wirtschaftsprüfer schriftlich oder telefonisch zurückgemeldet und ihre Teilnahme an der Studie zugesagt. Die Befragungen fanden unmittelbar nach der Rückmeldung im Rahmen eines persönlichen Gesprächs in den Geschäftsräumen der Interviewten oder in den Büros der Autoren statt. Die Spezialisierung der Prüfungsgesellschaften liegt vorwiegend in der pflichtmäßigen und freiwilligen Abschlussprüfung von mittelständischen Unternehmen in der Region. Einen detaillierten Überblick hinsichtlich der Studienteilnehmer liefert die **Tabelle 1**.

Die Fragen des Interviews orientierten sich an einem Gesprächsleifaden mit insgesamt zehn Fragen, welche von Themenfeldern und Kategorien aus der Literatur

und aus bereits durchgeführten Interviews abgeleitet wurden [34]. Die Gespräche wurden elektronisch aufgezeichnet und anschließend in einen Text transkribiert. Die transkribierten Texte dienten in der Folge als Analyseeinheit für eine qualitative und zusammenfassende Inhaltsanalyse [35]. Als Analysetechnik wurde dabei die inhaltliche induktive Kategorienbildung gewählt. Diese Vorgehensweise ist eine Form der zusammenfassenden Inhaltsanalyse, welche den Inhalt des Materials durch definierte Abstraktionen abbildet. Das induktive Vorgehen bezieht sich nicht auf bereits formulierte Theorien, sondern die Kategorienbildung findet durch Verallgemeinerungen aus dem vorhandenen Material statt. Das Ziel dieser Vorgehensweise besteht darin, das Forschungsfeld und die weiteren Forschungsprozesse zu strukturieren und zu präzisieren [34].

Tabelle 1. Teilnehmer der Studie

Nr.	*Position*	*Größe der Prüfungsgesellschaft*	*Berufserfahrung*
E1	Geschäftsführer	120 Mitarbeiter / 5 Standorte	24 Jahre
E2	Partner	160 Mitarbeiter / 2 Standorte	3 Jahre
E3	Angestellter WP	100 Mitarbeiter / 3 Standorte	3 Jahre
E4	Partner	50 Mitarbeiter / 3 Standorte	16 Jahre
E5	Geschäftsführer	120 Mitarbeiter / 3 Standorte	43 Jahre

4 Resultate und Analyse

4.1 Automatisierungsfähigkeit wesentlicher Prüfungshandlungen

Eine Abschlussprüfung beginnt für gewöhnlich mit Prüfungshandlungen, welche die *(1) Generierung von Unternehmenskenntnissen* beabsichtigen**.** Ziel ist es, grundlegende Kenntnisse über die Geschäftstätigkeit sowie das wirtschaftliche und rechtliche Umfeld des zu prüfenden Unternehmens zu generieren. Die Automatisierungsfähigkeit der in diesem Zusammenhang stehenden Prüfungshandlungen wurde als gering eingestuft (E1-E4). Der Hintergrund dieser Einschätzung ist, dass eine IT-gestützte Prüfung nicht dazu führen darf, dass die Abschlussprüfung von Personen begleitet und durchgeführt wird, welche sich mit dem zu prüfenden Unternehmen nicht umfassend auseinandergesetzt haben (E1, E2, E4). Auch wenn mittlerweile viele Dokumente mittels Email ausgetauscht werden, welche digital in der Prüfsoftware eingehängt und vermerkt werden, sollte die persönliche Auseinandersetzung mit dem Unternehmen und die Kommunikation mit der Geschäftsführung oder den Mitarbeitern nicht ausbleiben (E1). Eine Aufzeichnung und digitalisierte Auswertung von Gesprächen ist zwar technisch möglich, aber aus rechtlichen Gründen und mangelndem Verständnis nicht darstellbar und würde darüber hinaus das Vertrauen des Mandanten zum Abschlussprüfer nachhaltig schädigen (E1). Eine Digitalisierung und Automatisierung könnte in diesem Zusammenhang gegebenenfalls sogar kontraproduktiv sein (E1, E3).

Bevor die Vor- und Hauptprüfungshandlungen eingeleitet werden, wird erfolgt eine *(2) erste Feststellung der Datenintegrität***.** Insbesondere vor dem Einsatz von IT-gestützter Datenanalysen muss die Zuverlässigkeit, Richtigkeit und Vollständigkeit der zu prüfenden Daten sowie die Funktionsfähigkeit der eingesetzten Systeme festgestellt werden. Andernfalls können die nachfolgenden Prüfungshandlungen nicht zu verlässliche Prüfungsergebnisse führen (E4). Diese Aufgabe kann ebenfalls noch nicht vollständig maschinell durchgeführt werden. Dazu bedarf es oftmals noch prüferisches Ermessen und persönliche Kenntnis der Unternehmen (E2, E4).

Im Rahmen der *(3) Vorprüfungshandlungen* werden weitere Prüfrisiken festgestellt, um in der Folge gezielt Prüfungsobjekte und Hauptprüfungshandlungen zu definieren. Dazu zählt insbesondere die Untersuchung des internen Kontrollsystems (IKS), welches im weitesten Sine auch die Prüfung der Finanzbuchhaltung umfasst. Der Digitalisierungs- und Automatisierungsgrad der IKS-Prüfung ist laut den Experten davon abhängig, inwieweit Informationen hinsichtlich der Erfassung und Kontrolle der tatsächlichen Arbeitsprozesse in der IT des Mandanten digitalisiert verfügbar sind (E2-E5). Unter dieser Voraussetzung könnten beispielsweise in einem Prüfungsschritt gleichzeitig die Umsatzerlöse und die dazugehörigen Rechnungen, Bankauszüge und Lieferscheine geprüft werden und damit wichtige Erkenntnisse hinsichtlich der Funktionsfähigkeit des IKS gewonnen werden (E1-E3). Ebenfalls können durch Process Mining z. B. mittels Logfiles Prozesse wie z. B. das Genehmigungsverfahren beim Einkauf für die Prüfung visualisiert werden (E3). Wesentliche Unregelmäßigkeiten oder Auffälligkeiten sind auf diese Weise identifizierbar und können mit den Aussagen der Geschäftsführung oder den Mitarbeitern abgeglichen werden (E1-E5). Unabhängig von der digitalen Abbildung der Workflows in den Unternehmen können hingegen auffällige Korrekturen oder Differenzen oftmals auch aus der Buchhaltung abgelesen werden (E2). Eine digitalisierte und teilweise automatisierte Vorprüfung des Rechnungswesens ist mittlerweile bei einer großen Anzahl von Prüfungshandlungen gängige Praxis (E1). Dabei eignen sich insbesondere solche Prüfungshandlungen, die auf der Filterung von Auffälligkeiten und Problemfällen in der Finanzbuchhaltung aufbauen (E2-E3). In diesem Zusammenhang wurden als Beispiele die Analyse der Buchungstexte durch Word-Mining, z. B. das Herausfiltern und Überprüfen von Geschäften mit nahestehenden Personen, die Identifikation ungewohnter Buchungssätze und Kontierungen, z. B. das Konto „Wareneinsatz“ hat als Gegenkonto nicht „Lieferant“, Buchungen auf Konten, die nur für automatische Buchungen reserviert sind oder die Prüfung aller Umsätze mit einem Umsatzsteuersatz, der nicht 19% ist (E1-E5). Die Prüfung von Belegen, z. B. die Differenzen von Belegdatum und Buchungsdatum, oder die Saldenbestätigung eignet sich ebenfalls, sofern die Daten entsprechend digital vorhanden sind (E2).

Die Durchführung *(4) analytischer Prüfungshandlungen* erfolgt teilweise schon automatisiert (E1-E3). Ausschlaggebend für diese Einschätzung ist, dass diese Prüfungen zunehmend mittels IT-gestützter Datenanalyse umgesetzt werden. Das trifft beispielsweise bei der Plausibilisierung der Konten „Materialeinsatz“, „Forderungen aus Lieferungen und Leistungen“, „Verbindlichkeiten aus Lieferungen und Leistungen“ und „Forderungen“ zu (E1). Gleiches gilt für innerbetriebliche Zeitvergleiche, z. B. bei den Umsatzerlösen oder dem Rohgewinn, bei denen auffällige

Abweichungen und Unregelmäßigkeiten identifiziert werden (E1-E5). Die Übernahme der Zahlen und Salden aus dem Vorjahr, sowie die Präsentation der absoluten und relativen Abweichungen erfolgt dabei in der Praxis oftmals vollständig automatisiert (E5). Ferner sind dabei in der Prüfsoftware statistische Verfahren hinterlegt, die Sollwerte wie z. B. den erwarteten Umsatzerlös bei einem bestimmten Materialeinsatz angeben. Die Soll-/Ist-Abweichungen sind umso genauer, je detaillierter die Erwartungswerte gebildet werden (E2).

Der Umfang von *(5) Einzelfallprüfungshandlungen* ist grundsätzlich davon abhängig, inwieweit Prüfungshandlungen mittels analytischer Prüfungshandlungen durchgeführt werden können und inwieweit auf diese Weise eine hinreichende Prüfungssicherheit erzielt wird (E1, E2). Diese Prüfungen erfolgen in der Regel bei unternehmensspezifischen oder ermessensbehafteten Sachverhalten und sind daher mit einem hohen manuellen Arbeitsaufwand verbunden (E2, E3). Dazu zählen Prüfobjekte wie der Lagebericht oder der Anhang, welche trotz handelsrechtlicher Mindeststandards bei jedem Unternehmen äußerst individuell strukturiert sind (E1, E3, E5). Bei der Anhangsprüfung werden z. B. die entsprechenden Angabepflichten in der Prüfsoftware zwar vermerkt und die Vermerke erscheinen anschließend in einer Liste. Ein Automatismus ist jedoch nicht erkennbar (E1). Weitere Einzelfallprüfungen sind die Befragung und Bestätigung von Dritten oder die Inaugenscheinnahme von Vermögensgegenständen (E2). Solche Prüfungshandlungen werden beispielsweise bei der Bewertung und Beurteilung von Bauprojekten durchgeführt (E2). Die Drittbestätigung kann in diesem Zusammenhang z. B. eine fünfseitige Rechtsanwaltsbestätigung sein, welche beurteilt, inwieweit bei einem Bauprojekt ein Nachtrag durchsetzbar ist (E2). In solchen Fällen ist die Ermessensfähigkeit und die Unternehmenskenntnis des Abschlussprüfers gefragt, welche eine Maschine noch nicht hinreichend besitzt (E2, E3).

Abschließend werden Prüfungshandlungen zur *(6) Evaluation der Prüfergebnisse* durchgeführt (E3, E5). Die Ermittlungsergebnisse müssen, auch wenn sie automatisch generiert wurden, hinreichend auf Plausibilität untersucht (E5) und vom Abschlussprüfer final beurteilt werden (E3). Selbst im Falle einer hundertprozentigen Automatisierung der Prüfung muss die finale Urteilsbildung vom Prüfer selbst vorgenommen werden. Maschinell erzeugte Ergebnisse dürfen nicht zwangsläufig als gegeben hingenommen werden (E3, E4).

4.2 Wesentliche Voraussetzungen für eine automatisierte Prüfung

Der (*A) lückenlose Datentransfer* zwischen den Systemen des Prüfers und des Mandanten ist eine zentrale Voraussetzung für die Umsetzung der automatisierten Prüfung (E1-E5). Die Herausforderung bei mittelständischen Unternehmen besteht oftmals darin, dass eine Vielzahl von unterschiedlichen ERP-Systemen zum Einsatz kommt, die sich im Hinblick auf Datenstrukturen und Konfigurationen deutlich voneinander unterscheiden (E2, E3). Infolgedessen ist der Datenexport aus den Systemen der Mandanten und der anschließende Datenimport der korrekten Daten in die Prüfsoftware aktuell mit einem erheblichen manuellen Arbeits- und Zeitaufwand verbunden (E1-E3). Dieses Problem wird verstärkt, wenn der Mandant in seinem

System individuelle Veränderungen und Anpassungen vornimmt. Sobald die Daten in die Prüfsoftware importiert sind, ist eine automatisiert durchgeführte Datenanalyse bei vielen Prüffeldern umsetzbar (E1).

Eine weitere Voraussetzung ist die *(B) vollständige Ausschöpfung der vorhandenen IT-Infrastruktur*. Die Anwendung IT-gestützter Prüfungshandlungen scheitert oftmals daran, dass analytische und mathematische Fähigkeiten, sowie informationstechnologische Grundkenntnisse, wie z. B. in der Programmierung von Visual Basic for Applications (VBA), fehlen (E1-E4). Diese Fähigkeiten werden in der Ausbildung zum Wirtschaftsprüfer oder zum Revisionsassistenten nicht hinreichend vermittelt. In der Folge fehlt in der Praxis qualifiziertes Personal, welches die IT-gestützte Prüfungen einrichten und durchführen kann (E1, E3). Hinzu kommt, dass der Berufsstand der Wirtschaftsprüfer durch ein hohes Durchschnittsalter geprägt ist und infolgedessen die Ambitionen für die Anwendung von technischen Erneuerungen teilweise nicht gegeben sind (E3-E4). Daher ist es für den Wirtschaftsprüfer schwierig seine technischen Möglichkeiten vollständig auszuschöpfen und weiterzuentwickeln (E2-E4). Die Hersteller von Prüfsoftware versuchen dieses Problem zwar mit maßgeschneiderten Lösungen entgegenzuwirken, allerdings müssen auch Sachverhalte, welche sich außerhalb des Maßgeschneiderten befinden, von dem Abschlussprüfer berücksichtigt werden können (E1). Der Berufsstand muss daher attraktiver für Fachkräfte mit IT-Kenntnissen werden und sich gleichzeitig für eine Verbesserung der Ausbildung in Hinblick auf IT-Fähigkeiten einsetzen (E1, E3). Auch bei den mittelständischen Unternehmen wird das Potenzial der vorhandenen Systeme nicht vollständig ausgeschöpft (E1-E4). Als Beispiele hierfür wurde dabei der teilweise oder gänzliche Anwendungsverzicht von Werkzeugen wie das Dokumentenmanagementsystemen (DMS), E-Invoicing, Business-Intelligence-Tools oder die digitale Abbildung des IKS genannt (E3).

Die *(C) digitale Verfügbarkeit von Daten* ist eine weitere, wesentliche Voraussetzung für die Realisierung automatisierter Prüfungen (E2, E3). Infolge der oben beschriebenen Probleme Prüfer werden prüfungspflichtige Daten häufig immer noch in Papierform vorgehalten (E2, E3). Es sollte mandantenseitig eine digitalisierte Infrastruktur vorliegen, welche es überhaupt ermöglicht, automatisiert zu prüfen (E2).

Die *(D) Kollaborationsbereitschaft der Unternehmen* mit dem Abschlussprüfer stellt ebenfalls eine zentrale Voraussetzung dar (E2-E4). Für viele Mandanten besteht jedoch nur ein geringer Anreiz, den Abschlussprüfer über das Notwendige hinaus zu unterstützen (E2, E4, E5). Häufig ist für die Unternehmen ein Mehrwert der Abschlussprüfung nicht erkennbar, wodurch nur eine geringe Wertschätzung für die Aufgaben des Wirtschaftsprüfers besteht (E4, E5). Bedauerlicherweise fehlt den Mandanten daher oftmals die Erkenntnis, dass gute Prüfungsergebnisse auch einen Mehrwert für ihr Unternehmen bedeuten können (E1, E4). Daher fehlt die Bereitschaft finanzielle Mittel für eine Verbesserung ihrer IT und der Datenqualität bereitzustellen, sofern diese Investitionen vermeintlich nur dem Abschlussprüfer dienen (E1, E4, E5).

Ferner stellt die vollständige *(E) Verarbeitungsfähigkeit der Prüfergebnisse* eine Voraussetzung dar (E4). Die Abkehr von Stichprobenprüfungen hin zu einer lückenlosen Prüfung aller einem Prüffeld zugehörigen Daten wird durch die automatisierte Prüfung zunehmend möglich (E1-E3). Diese Entwicklung erhöht

einerseits die Prüfsicherheit und die Prüfqualität, andererseits jedoch auch die Quantität der Prüfungsergebnisse (E1, E2). Inflationäre Prüfungsergebnisse bergen jedoch die Gefahr, dass die Ergebnisse nicht mehr angemessen und unternehmensspezifisch beurteilt und verarbeitet werden (E4).

Schlussendlich ist die *(F) Aufnahmefähigkeit komplexer Sachverhalte* ein zentraler Faktor, um den Umfang der Automatisierung von unternehmensspezifischen Prüfungshandlungen zu erhöhen (E2, E3). Aktuell bedarf es oftmals noch einer kritischen Grundmasse von standardisierten Prüfobjekten und dazugehörigem Datenmaterial, damit durch eine Automatisierung im Vergleich zur manuellen Ausführung ein zeitlicher und qualitativer Mehrwert entstehen kann (E1-E5).

Die Abbildung 1 stellt die wesentlichen Ergebnisse der Studie grafisch dar. Um eine bildliche Darstellung des Automatisierungsgrades der genannten Prüfungshandlungen zu ermöglichen, wurden die Aussagen der Experten in eine fünfstufige Skala transferiert. Im gesamten Prozess, als auch in den Teilprozessen ist dabei eine vollständige Automatisierung noch nicht festzustellen. Allerdings konnten auch keine Prüfungshandlungen identifiziert werden, bei denen eine Automatisierung gänzlich ausgeschlossen ist. Die Erfüllung der in den vorstehenden Abschnitten erläuterten Voraussetzungen ist für die Realisierung der automatisierten Prüfung von erheblicher Bedeutung. Die Abbildung zeigt, inwieweit diese Voraussetzung bei den jeweiligen Prüfungshandlungen noch erfüllt werden müssen.

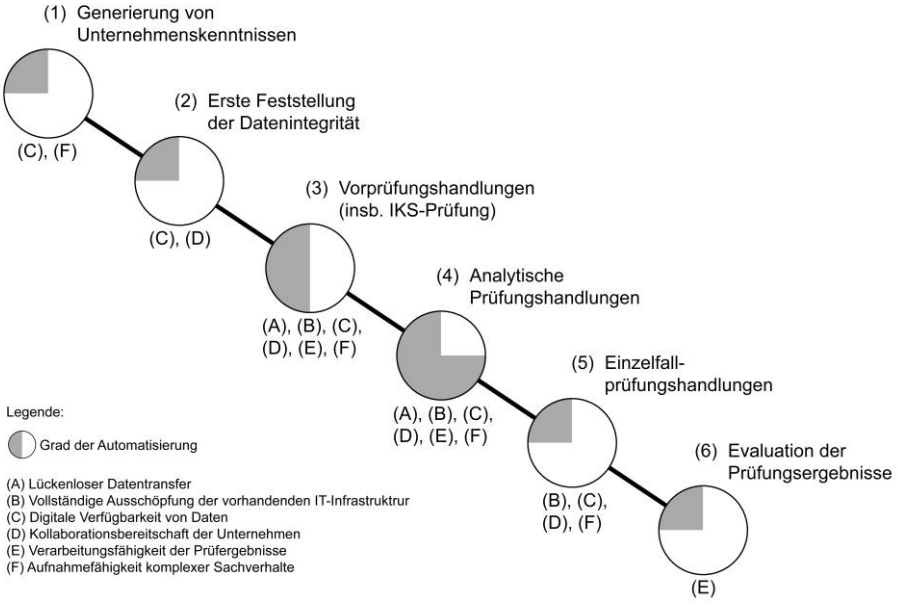

Abbildung 1. Prüfungshandlungen und Automatisierungsfähigkeit

4.3 Automatisierung als Chance für neue Beratungsleistungen

Eine Vielzahl mittelständischer Unternehmen besitzt oftmals keine interne Revision und die Controllingabteilung arbeitet überwiegend projektbezogen (E1, E3, E4). Infolgedessen ist es nicht ungewöhnlich, dass unterjährige Fehlentwicklungen im Rechnungswesen von der Unternehmensführung kurzfristig nicht wahrgenommen werden. Daher kommt es regelmäßig zu einer erstmaligen Aufdeckung dieser Fehlentwicklungen in der Abschlussprüfung, welches für Unternehmen jedoch nur geringfügig weiterbringt (E1). Unterjährige und kontinuierliche Wirtschaftsprüfungsdienstleistungen können gegenwärtig aufgrund ihres hohen Umfangs manueller Arbeiten nicht kosteneffizient umgesetzt werden, da sie den Aufwand der Hauptprüfung noch nicht hinreichend kostenneutral reduzieren (E1-E3). Die Umsetzung automatisierter Prüfungen setzt allerdings Ressourcen für neue Dienstleistungen frei (E1-E5). Mit der kontinuierlichen Prüfung aktueller Daten durch einen Wirtschaftsprüfer können Qualität und Zuverlässigkeit des Rechnungs- und Berichtswesens und damit die Compliance auch bei mittelständischen Unternehmen erheblich erhöht werden (E1-E5). Beratungsdienstleistungen, die die interne Revision und das Controlling durch zeitnahe Analysen und Verifikationen unterstützen, können für die Unternehmen erhebliche Wettbewerbsvorteile schaffen und die eigene Wertschätzung erhöhen (E4, E5). Auf diese Weise kann der Wirtschaftsprüfer seinen Mandanten zeitnah auf Falschdarstellungen und Fehlentwicklungen hinweisen und ihn insbesondere in Krisensituationen frühzeitig unterstützen (E1, E3-E5). Die Unternehmen sind demzufolge vielmehr in der Lage rechtzeitig auf Probleme, negative Entwicklungen oder Auffälligkeiten zu reagieren (E1).

Eine weitere, denkbare Dienstleistung sind zeitnahe Prüfungen und Verifikationen des Berichtswesens von Konzernen (E3). Tochtergesellschaften müssen in der Regel monatlich, quartalsweise oder halbjährlich an ihre Muttergesellschaften berichten. Gerade wenn Mutter- und Tochtergesellschaften in unterschiedlichen Ländern ansässig sind, ist diese Berichterstattung häufig durch qualitative Mängel und Unvollständigkeit gekennzeichnet. Durch die Automatisierung von Prüfungshandlungen und deren Einsatz im Rahmen unterjähriger Abschlüsse könnten Konzerne präzise und tagesaktuelle Kennzahlen über die einzelnen Gesellschaften erhalten (E3).

5 Fazit und Ausblick

Im Rahmen der Expertenbefragung konnte ein aktueller Stand hinsichtlich des Automatisierungsgrades wesentlicher Prüfungsschritte und den dazugehörigen Prüfungshandlungen festgestellt werden (FF1). Ferner haben sich sechs grundlegende Voraussetzungen ergeben, welche für die Umsetzung von automatisch durchgeführten Prüfungshandlungen von zentraler Bedeutung sind (FF2). Dazu zählt der lückenlose Datentransfer zwischen den Systemen, die vollständige Ausschöpfung der vorhandenen IT-Infrastruktur, die digitale Verfügbarkeit von Daten, die Kollaborationsbereitschaft der Unternehmen, die Verarbeitungsfähigkeit der Prüfergebnisse und die Aufnahmefähigkeit komplexer Sachverhalte. Die Durchführung automatisierter Prüfungshandlungen ist die Grundlage für mehr Prüfungssicherheit, hochwertigere

Prüfungsergebnisse und insbesondere für die Realisierung neuer Beratungsdienstleistungen. Gegenwärtig sind die Ressourcen der Wirtschaftsprüfer aufgrund des hohen manuellen Arbeitsaufwandes noch zu sehr an die Jahresabschlussprüfung gebunden, sodass Kapazitäten für neue Wirtschaftsprüfungsdienstleistungen aktuell noch nicht gegeben sind. Es konnte jedoch erste Hinweise geliefert werden, dass ein Bedarf für kontinuierliche und unterjährige Prüfungsleistungen im Mittelstand besteht und hierdurch erkennbare Mehrwerte entstehen können. Dazu zählt u. a. die Ausweitung und Optimierung der internen Revision, des Controllings oder des Konzernberichtswesens.

In anknüpfenden Forschungsarbeiten werden zunächst die Expertenbefragungen erweitert. Durch die damit beabsichtigte Auflösung des regionalen Bezugs und die Einbeziehung von Experten auf Seite der Mandanten und Prüfsoftwarehersteller soll eine noch stärkere Generalisierbarkeit der Erkenntnisse über Automatisierungsgrade und Voraussetzungen erreicht werden. Auf dieser Grundlage sollen abschließend Hypothesen abgeleitet werden und durch eine quantitative Querschnittsanalyse verifiziert werden.

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A Platform for Data-Driven Self-Consulting to enable Business Transformation and Technology Innovation

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Abstract. Digital transformation has long since become an important topic not only for large companies but also for SMEs. However, it is becoming increasingly difficult to keep track of new technologies, assess their benefits for the company and its business model. Frequently, companies hope for cost reductions and time savings. So why not learn from projects that have already successfully introduced and applied new technologies and come into contact with the companies that carried out that project. The idea is to offer electronic consulting services by means of an information platform at low cost, flexibility and transparency. For this purpose a platform to support companies in their digitalization process is being developed that offers them multiple entry points for business transformation and / or technology innovation, to explore the potentials of new concepts and to find partners to transform their business.

Keywords: business model innovation, e-consulting, value-creation networks

1 Introduction

1.1 Motivation

Companies are currently confronted with the digital transformation [1, 2]. Due to the advent of new technologies, companies are under pressure to make profitable use of them or to promote innovations themselves [3–5]. Unlike the traditional business world which is characterized by stability and lower levels of competition, the arising world of digital business is complex, dynamic and involves higher levels of uncertainty [6]. In order to overcome the challenges of digitalization, business consulting can provide

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assistance. Consulting addresses various aspects such as strategy consulting, organizational consulting, technology or IT consulting. Corresponding projects usually consist of several, technologically different and successive phases, which also offer different levels of support, e.g., planning, concept development, implementation or evaluation. Apart from that, consultants are constantly confronted with different industries and technologies [7, 8]. Therefore, the digitalization heavily affects companies´ business models (BM), which represent the strategy and value creation applied throughout a company [9]. This also explains their relevance for process- or product-specific consulting [10]. In general and especially for BM, there are two innovation directions: market/technology pull and technology push. While technology pull describes the inadequate satisfaction of customer needs, which results in demands for problem-solving, Technology push is initiated by internal or external research aiming at a commercial use of know-how [11]. Especially, small- and medium-sized enterprises (SMEs) are struggling with business transformation and technology innovation, because they are often unaware of the chances and risks and lack the financial, technological and strategic resources to carry out this transformation. Therefore, this paper specifically addresses this customer group.

1.2 Problem Description

As the digitalization makes BM innovation more and more complex, especially SME are facing the challenge of needing many different competencies and resources. This means that no single person in a company or a single consultant can consistently solve the problem [12]. For the consultant, it remains unclear which competencies are needed and who has to be involved, while customers cannot estimate how technologies influence BM aspects or vice versa. Furthermore, it is not easy for companies to find technology or strategy partners or to recognize the benefits of value-creation networks.

1.3 Goal

The goal of this paper is to present a novel design approach for tool-assisted competency and partner search to solve problems of BM innovation. The concept of the electronic provision of consulting services by means of an information platform offers the possibility of providing consulting services at low cost, flexibility and transparency. We also aim to match technologies and BM components to derive recommendations. To analyze the impact of technologies is an important asset for SMEs to decide, whether to pursue a certain innovation strategy.

1.4 Methodology

To develop the online consulting platform, we are following the design science approach [13]. In a first step, the state of the art in BM innovation supports in general and specific tool support was analyzed and research gaps were derived. In order to comply with Design as a Search Process guidelines [13], we follow an iterative development methodology. For the BM aspects in the platform, the building blocks of

the BM Canvas according to Osterwalder et al. [9, 14] are used. To find Industry 4.0 technologies resp. new technologies in general and their influences and connections on BM aspects we used the Plattform Industrie 4.0 [15]. This is exemplary to analyze a coherent field of research in currently emerging technologies. Eventually, a level 1 artifact, a software product, according to Gregor and Hevner [16] is conceived. The remainder of this paper is structured as follows. We review research on BM innovation support and research gaps in section 2. In section 3 usage scenarios that demonstrate the benefits of an online consulting platform are described. The concept and design of the platform are then explained in section 4 before a proof-of-concept itself is presented in section 5. Section 6 concludes the paper and identifies further research and development potentials.

2 Related Work

2.1 Business Model Innovation

Although the term "business model" was already mentioned in contributions around 1957, the concept of BM can be seen as a rather young field of research, which has emerged during the internet boom in the late 1990 [17–20]. Therefore, research and studies on BM innovation have mostly been published since 2000. Wirtz et al. give an overview of existing BM innovation approaches within the literature. These often have a process-related structure [21]. These approaches describe in a general way which phases should be covered at BM innovation. As a basis for optimization, Osterwalder's BM Canvas [9] and the St. Gallener BM Patterns [2] are widely used.

2.2 Existing Tools to Support Business Model Innovation

The first attempts to provide consulting services via an internet-based consulting platform date back to 1996 [7]. Current efforts in the field of eConsulting are shown in prototypes like the ARIS eConsulting Store or the Digital Consulting Platform[1]. These existing tools do not deal specifically with BM innovation through technology and have no value-creation network aspect. The available tools in that field are limited to facilitating the visualization of a business model and provide not more than rudimentary support for calculations (e.g., e3-value editor[2], strategyzer app[3]). An exception is the Business Model Wizard, which is intended to comprise functionality for integrating market data to evaluate a business model and deducing process models [22, 23].

2.3 Research Gaps

In the existing literature there are no comprehensive or detailed classifications of Industrie 4.0 technologies. There are only some publications which identify fields of

[1] https://www.aws-institut.de/digitale-beratung/
[2] https://www.e3value.com
[3] https://strategyzer.com/app

technologies [24, 25].. In addition, the effects of changing a BM aspect on other building blocks are insufficiently investigated. The more data can be analyzed, the better the relationships between technologies and BM elements can be estimated. This way, recommendations regarding technologies and possible implementation partners could be derived. Hence, the need for a digital solution in the area of BM innovation.

3 Usage Scenarios

The usage scenarios describe how customers can use the self-consultancy services of the platform and how they profit from their outcome. Each usage scenario will be described by naming the main actors, the storyline and the success criteria.

1. **Business-Pull / Technology Push:** For inventive companies, it is often not self-evident, which markets can be penetrated and addressed by their technology. Often inventions have been used in a different context as initially intended. The main actor is the company that wants to transform its business and explore new channels and markets for their products or services. The scenario is successful, when appropriate areas of improvement are being identified within the business model.
2. **Business Push / Technology Pull:** Business transformation is usually goal-driven wrt certain business KPIs. Hence, appropriate means have to be found and applied to bring about this change. Technology can be a game-changing catalyst to boost operational performance.

For each of the outcomes, the company may not have the required know-how or operational capacity to implement the changes. Hence, both strategy and technology consulting firms could help them to achieve this goal.

4 Platform Design

According to the usage scenarios, the self-consulting platform consists of a usage layer, that enables users to find consultancy services from multiple entry points and to manage their profile and capabilities. The analytic layer provides intelligent functionalities to explore the knowledge space from multiple angles to support many forms of improvement such as business transformation and technology innovation.

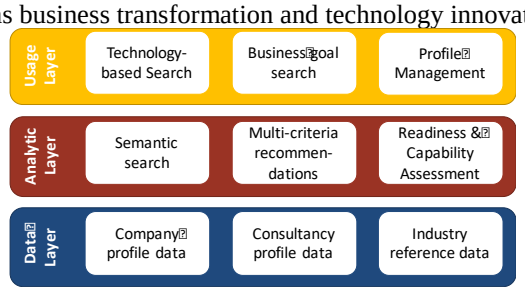

Figure 1. Self-Consultancy Platform Concept

Besides the abovementioned usage scenarios, the company can define its private profile including information about their business model and their technology capabilities. In the analytics layer, semantic search is being used to find business model aspects, technologies and consultancies according to their fit to the search query, in order to discover implicit connections among these concepts that the user is unaware of. The multi-criteria recommendations leverage this knowledge space, industry reference data and usage statistics, to determine the best matches for the respective search query.

5 Prototype Design

In the following a sketch of the system is provided to exemplify its functionality:

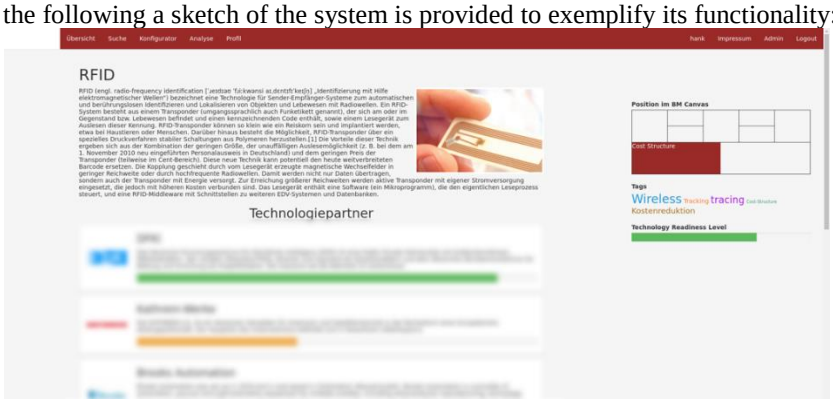

Figure 2. Technology search result “RFID”

The screenshot shows the result of a technology search (UC1) in which a customer wants to explore the possibilities of the specific technology RFID. A basic description of the technology is shown, along with a list of partners that could help the organization with the adoption of the technology. Moreover, a sketch of the Business Model Canvas is being provided, in order to explain how the technology adoption of RFID will affect certain areas of the business model. In that case, it clearly depicts, that improvements of the cost structure could be realized via RFID. Moreover, an assessment of the technology readiness level is given. Overall, it helps the customer to get acquainted with a formerly unknown technology, see its potential business impact and get contacts with consultancy companies that could help him/her to transform his/her business.

For a business-driven search the result would look similar, it would just originate from an improvement area from the building blocks of the business model canvas and would show technology alternatives to implement improvements in that area. The reference data are currently being extracted in a PhD project that analyzes the business model impacts of technologies. As an example, the projects listed at Plattform Industrie 4.0 are used as a starting point to investigate these relationships.

6 Conclusion & Outlook

This paper focused on a platform approach to foster the interconnections among technologies, business model aspects and people. Companies can inform themselves and receive recommendations regarding the technologies to be used as well as possible effects on their business model. If they want to implement their projects, there is the possibility to find and contact project partners on the platform. By describing the individual implementation projects, other companies then receive best practice examples as suggestions for their business ideas.

Some of the platform's contents and functions will be extended. More technologies and relationships with the BM than just from the Industry 4.0 Platform need to be considered. A machine learning approach using the later project data on the platform can prove to be effective. Besides, further approaches other than the BM Canvas could be used for BM design. In addition, a comprehensive analysis functionality for the created BM must be available, e. g. in the areas of financial ratios or marketing strategies. Further collaboration features are planned, including a common workspace for BM or document exchange. These limitations suggest avenues for further research. An interesting question for the future is also how the approach can be transferred to other domains. Moreover, a large-scale evaluation will be carried out.

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Digitale Geschäftsmodelle in der Domäne wissensintensiver Dienstleistungen - Stand der Forschung und Transfer in die Unternehmensberatung

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Abstract. Die Unternehmensberatung ist eine Branche, die sich trotz oder auch gerade wegen ihres Erfolges aktuell mit dem Thema der Digitalisierung konfrontiert sieht. Hierbei entstehen zurzeit sowohl wissenschaftliche Vorgehensmodelle zum Einsatz neuer digitaler Geschäftsmodelle als auch erste Ansätze in der Praxis, welche neue digitale Beratungsangebote direkt am Markt erproben. Ziel ist es, das eher traditionelle "people business" in das Digitale Zeitalter zu führen. Die Herausforderung ist hierbei, neue digitale Potenziale eines komplexen personen- und wissensintensiven Dienstleistungsprozesses zu identifizieren und zu evaluieren. Die Problemstellung ist dabei äquivalent zu artverwandten wissensintensiven Dienstleistungs-segmenten. Ziel der Arbeit ist es daher anhand einer Literaturanalyse digitale Geschäftsmodelle in der wissensintensiven Dienstleistungs-domäne zu identifizieren und ihr Transferpotenzial aufzuzeigen. Verglichen wird dies mit Auszügen aus den bereits adressierten digitalen Geschäftsmodellen in der Domäne der Unternehmensberatung. Es resultieren neue Forschungs- und Themenfelder der Digitalen Transformation in der Unternehmensberatung.

Keywords: Digitalisierung, Unternehmensberatung, Consulting 4.0, wissensintensive Dienstleistungen, Digitale Geschäftsmodelle

1 Motivation und Begrifflichkeiten

Dass die Digitalisierung die Beratungsbranche bereits in den nächsten Jahren grundlegend verändert, davon gehen nach einer aktuellen Umfrage des BDU mehr als 80% der befragten deutschen Berater aus [1]. Dies betrifft sowohl das Portfolio als logische Konsequenz der digitalen Transformation in den Kundenbranchen, aber ebenso die eigenen Prozesse und insbesondere auch die Geschäftsmodelle der Beratung. Auch auf dem internationalen Markt werden in den nächsten Jahren grundlegende und auch disruptive Veränderungen der Geschäftsmodelle erwartet [2].

Dies ist insbesondere für die Unternehmensberatungsforschung von Relevanz, da Beratungen aktuell durch eine Vorreiterrolle nachhaltige Wettbewerbsvorteile erzielen

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können und somit theoretisch fundierte digitale Strategien und Konzepte einen akuten Bedarf darstellen. Zur Bewertung digitaler Geschäftsmodelle in der Beratung werden daher bereits die theoretischen Konzepte und der Einsatz digitaler Geschäftsmodelle in ihrer Gesamtheit erforscht [3]. Zudem werden zahlreiche Ansätze verfolgt, welche neue digitale Beratungsangebote direkt am Markt erproben [4]. Der Einsatz digitaler Technologien zur Innovation des Geschäftsmodells und somit der Prozesse als auch Dienstleistungen sind dabei ein wesentliches aktuelles Potenzial zur Abgrenzung von Mitbewerbern [5].

Hieraus resultieren grundlegende Fragen: Welche digitalen Geschäftsmodelle für die Beratung gibt es? Wie werden neue digitale Geschäftsmodelle entwickelt und welche Möglichkeiten zur Entwicklung gibt es? Sie stellen die offenen Fragen nach dem weiteren Vorgehen dar.

Diese zu beantworten ist grundsätzlich komplex und kann absehbar nicht eindeutig und gleichzeitig vollständig beantwortet werden. Dies liegt daran, dass es sich hierbei zum Teil um Kreativprozesse handelt und eine Gesamtmenge aufgrund der hohen Anzahl an Möglichkeiten nicht bestimmbar ist. Die Beantwortung ist jedoch dennoch von hohem Interesse, da die Entwicklung digitaler Strategien nur hierauf fundieren kann. Eine annähernd vollständige Beantwortung kann somit bereits einen hohen Mehrwert für die Beratungsbranche darstellen. Hierzu gilt es, existierende und neue Ansätze zu verfolgen, wie verschiedene Aspekte der Fragen auch annähernd vollständig beantwortet werden können.

Zunächst ist es hier relevant die Begrifflichkeiten im Kontext näher zu betrachten. Grundsätzlich soll hier die **Unternehmensberatung** (Consulting) als professionelle Dienstleistung verstanden werden, die durch eine oder mehrere, im Allgemeinen fachlich dazu befähigte und von den beratenen Klienten hierarchisch unabhängige Person(en) zeitlich befristet sowie meist gegen Entgelt erbracht wird. Sie hat zum Ziel, betriebswirtschaftliche Probleme des beauftragenden Unternehmens interaktiv mit den Klienten zu definieren, strukturieren und analysieren, sowie Problemlösungen zu erarbeiten und auf Wunsch ihre Umsetzung gemeinsam mit Vertretern des Klienten zu planen und im Unternehmen zu realisieren [6].

Genau wie in anderen Branchen sind **Geschäftsmodelle** in der Beratung eng mit der Unternehmensstrategie verbunden. Sie beschreiben - vor allem textlich auf einer stark aggregierten Ebene - die Geschäftslogik eines Unternehmens durch eine Kombination von aufeinander abgestimmten Angebots-, Markt-, internen und wirtschaftlichen Geschäftsmodellkomponenten auch über die Unternehmensgrenzen hinaus [7]. **Digitale Geschäftsmodelle** sind darauf aufbauend das Resultat der Digitalen Transformation einzelner Geschäftsmodell-Elemente, des gesamten Geschäftsmodells, der Wertschöpfungsketten sowie unterschiedlicher Akteure in einem Wertschöpfungs-netzwerk. Innerhalb der Digitalen Transformation von Geschäftsmodellen werden Enabler bzw. Technologien eingesetzt, die neue Anwendungen bzw. Leistungen erzeugen. Die bewerteten Optionen dienen dazu, neue Prozesse innerhalb des Geschäftsmodells zu initiieren. Sowohl die inkrementelle (geringfügige) als auch die radikale (disruptive) Veränderung eines Geschäftsmodells können vorliegen [8]. Häufig wird dabei davon ausgegangen, dass Geschäftsmodelle, die die Möglichkeiten der Digitalisierung (aus-)nutzen, in ihren Skalierungsgeschwindigkeiten hinsichtlich

ihres Outputs (Gewinn oder Marktabdeckung) – und je nach Produkt – ein überdurchschnittliches, sogar ein überproportionales/exponentielles Wachstum aufweisen – anstelle eines i. d. R. linearen Wachstums [9]. Sowohl für Geschäftsmodelle und infolgedessen auch für digitale Geschäftsmodelle gilt der Anspruch der Übertragbarkeit auch auf andere Branchen und Industrien, was mitunter durch den Abstraktionsgrad begründet ist [7].

Dies hat eine entscheidende Konsequenz für die zuvor gestellten Fragen nach der Entwicklung und Anzahl von digitalen Geschäftsmodellen in der Beratung. Da grundsätzlich digitale Geschäftsmodelle auch aus anderen Bereichen übertragbar sind, ist die Anzahl sowohl durch die existierenden digitalen Geschäftsmodelle in der eigenen Branche, die existierenden in Branchen mit der Möglichkeit zur Übertragbarkeit und durch die potenziell kreativen Neuschöpfungen bestimmt. Hier scheint somit ein passender Ansatzpunkt für eine strukturierte Methode zur Erweiterung der Grundgesamtheit an digitalen Geschäftsmodellen in der Beratung.

Hierzu ist das Feld der Unternehmensberatungsleistung zu abstrahieren. Eine solche Abstraktion stellt die Unternehmensberatung als Teilmenge der wissensintensiven Dienstleistungen dar [10]. **Wissensintensive Dienstleistungen** sind dabei Dienstleistungen, die während der Produktion oder Verarbeitung als essentiellen Bestandteil die Generierung oder Nutzung von neuartigem Wissen umfassen [11]. Diese Dienstleistungen finden sich vor allem in den Branchen Kommunikation, Finanzwesen, Forschung und Beratung, Gesundheitswesen oder Bildung [12]. Nach wissenschaftlicher Annahme benötigen wissensintensive Dienstleistungen übergreifend spezielle Methoden zur Digitalisierung der Geschäftsmodelle [13]. Im Umkehrschluss kann also davon ausgegangen werden, dass resultierende digitale Geschäftsmodelle aus anderen wissensintensiven Dienstleistungsbranchen auch in der Beratung Anwendung finden. Hier setzt diese Arbeit an.

2 Zielsetzung und aufbauende Forschungsfragen

Wie in der Motivation bereits erörtert, besteht ein forschungsseitiges Interesse daran, digitale Geschäftsmodelle in der Beratung zu erfassen. Hierzu ist eine Ausgangsbasis im Ist-Stand der Unternehmensberatungsforschung zu sehen [3, 14–16]. Um eine möglichst vollständige Grundlage für Forschung und Praxis zur Übersicht, Auswahl und Nutzenbeurteilung von digitalen Geschäftsmodellen in der Branche zur Verfügung zu stellen, ist eine Erweiterung dieser Ausgangsbasis sinnvoll. Ein Ansatz zur Erweiterung bietet die Analyse von digitalen Geschäftsmodellen in angrenzenden wissensintensiven Dienstleistungsbranchen. Hierbei ist von einer Übertragbarkeit auf die Beratung auszugehen, da eine Ähnlichkeit in den Unternehmensprozessen durch die Gruppierung in wissensintensive Dienstleistungen per se besteht. Daher werden im Artikel die digitalen Geschäftsmodelle der angrenzenden Bereiche wissensintensiver Dienstleistungen untersucht, Erkenntnisse extrahiert und darauf aufbauend folgende Forschungsfragen adressiert:

- Welche digitalen Geschäftsmodelle in wissensintensiven Domänen außerhalb der etablierten Unternehmensberatungsforschung gibt es bisher und sind diese auf die Beratung übertragbar?
- Ist das Vorgehen bestehend aus Analyse der digitalen Geschäftsmodelle wissensintensiver Dienstleistungen und deren Übertragung auf die Branche der Unternehmensberatung ein auch zukünftig effektives und sinnvolles Instrument zur Erweiterung des Themenfeldes Digitale Geschäftsmodelle in der Beratung?

Um die Fragen zu beantworten, wird in der Arbeit eine Literaturrecherche sowohl in den wissenschaftlichen Arbeiten zu wissensintensiven Dienstleistungen im Allgemeinen und deren konkreten Ausprägungen durchgeführt sowie in der Unternehmensberatungsforschung nach potenziell bestehenden Transfers gesucht. Ziel der Arbeit ist es somit, durch die Literaturrecherche die Grundgesamtheit digitaler Geschäftsmodelle in der Unternehmensberatung zu erweitern, eine fokussierte Betrachtung und Beurteilung spezifischer und neuer digitaler Geschäftsmodelle in der Beratung anzustoßen und die Methodik zur Übertragung digitaler Geschäftsmodelle angrenzender wissensintensiver Dienstleistungsbranchen als Ansatz zu bewerten.

3 Literaturrecherche & Methodik

Die Literaturrecherche wird nach der Methodik von [17] durchgeführt. Ergänzt wird die Methodik durch die Aspekte nach [18]. Zuerst wird der thematische Rahmen der Literaturrecherche definiert, woraus sich primäre Schlagwörter der Suche ableiten. Der thematische Fokus liegt auf den digitalen Geschäftsmodellen der wissensintensiven Dienstleistungen und dessen englischsprachiger Übersetzung. Daraus resultieren die Suchstrings 1 und 2 als primäres Suchfeld. Potenziell erweiterbar wären diese, um konkrete domänenspezifische Suchstrings. Allerdings ergab eine intensive Erstevaluation, dass durch den Domänenfokus, die Anzahl der Literatur stark an Qualität im Verhältnis zum Aufwand bezüglich der Zielsetzung verliert. Es wird sich daher stattdessen zudem dazu entschlossen, zusätzlich das Feld der Unternehmensberatungsforschung auf bereits bestehende Übertragungen aus anderen wissensintensiven Dienstleistungsfeldern zu untersuchen. So entstanden die Suchstrings 3, 4, 5 und 6. Dabei wurden Synonyme und geeignete Schlüsselwörter zur Bildung der Suchstrings ermittelt, welche eine Deckungsgleichheit der Ergebnisse vermeiden. Die zahlreichen Synonyme der Digitalisierung oder auch die Begrifflichkeit der Virtualisierung wurden in einer Erstrecherche durch die Suchstrings 3 und 4 als abgedeckt beurteilt. 5 und 6 stellen einen zusätzlichen fachlichen Fokus auf Themenbereiche dar. Die Suchstrings werden anschließend in ausgewählten Datenbanken genutzt, um Literatur im Themenfeld zu identifizieren.

Die Menge der identifizierten Literatur bildet dabei ein erstes Indiz zur wissenschaftlichen Themenrelevanz sowie zur Beurteilung der Suchstrings und wird daher näher aufgeführt. Die resultierenden sechs Suchstrings lauten:

- ***Suchstring 1:***
  "digital*" AND "business model" AND "knowledge intensive service"

- ***Suchstring 2:***
  "digital*" AND "Geschäftsmodell" AND "wissensintensive" AND "Dienstleistung"
- ***Suchstring 3:***
  (“Digitalisierung” OR “Digitale Transformation”) AND “Unternehmensberatung”
- ***Suchstring 4:***
  (“digitization” OR “digital transformation”) AND “consulting”
- ***Suchstring 5***:
  (“Online-Beratung” OR “E-consulting” OR “self-consulting”) AND “self-service”
- ***Suchstring 6:***
  “Consulting 4.0” OR “Unternehmensberatung 4.0”

Die Recherche beschränkt sich auf die Jahre 2013 bis 2017. Die Restriktion wurde aufgrund begrenzter Ressourcen, Aktualität und anhand der Erscheinung der Publikation von Christensen gesetzt, welche von den Autoren als ein Meilenstein für den erneuten Aufschwung des Forschungsschwerpunktes gesehen wird [2]. Als Basis der Analyse wird eine Auswahl an gängigen Datenbanken mit hoher Abdeckung in der breitflächigen Literatur als auch high ranked Journals genutzt. Die potenzielle Anzahl an relevanten Publikationen wird hierbei auch über den Einbezug von Metasuch-diensten wie Google scholar erreicht, welche mehrere etablierte Wissenschafts-datenbanken wie beispielsweise Springerlink durchsuchen. Hiermit wird gerade auch auf eine Abdeckung der eher praxisnäheren Bücher und Arbeitspapieren abgezielt. Die Durchführung der Recherche fand von August bis September 2017 statt. Die Ergebnisse sind somit beschränkt auf die zu diesem Zeitpunkt aktuelle Literatur. Die Anzahl der Resultate nach Eingabe der Suchstrings findet sich in **Tabelle 1**.

Tabelle 1. Anzahl der Resultate nach Eingabe der Suchstrings in 2013-2017

Datenbank	*science direct*	*ACM Digital*	*ebsco*	*Google scholar*	*Wiley Online*
Suchstring 1	6	0	323	302	13
Suchstring 2	0	0	120	33	0
Suchstring 3	0	1	1952	1370	0
Suchstring 4	206	223	533	347	103
Suchstring 5	0	35	2077	24	0
Suchstring 6	0	0	14	14	3

Die Literatur wird im Anschluss nach konkretem Themenbezug und Qualität beurteilt und eingegrenzt. Zunächst wurde die grobe Tauglichkeit nach dem Titel, Keywords und der schwankend zweizeiligen Vorschau präselektiert. Dabei wurden ca. 80% der Beiträge auf Grund mangelnder thematischer Nähe direkt aussortiert. Die resultierenden 20% wurden daraufhin hinsichtlich deren Abstract näher analysiert.

Die als relevant erachteten Publikationen wurden anschließend nach Branche kategorisiert. Dabei war eine Arbeit relevant, sobald ein digitales Geschäftsmodell identifiziert werden konnte, dieses einen neuartigen Charakter (im Vergleich zum Stand der Beratungsforschung) besaß und von einer Übertragbarkeit auszugehen war. Zudem wurden digitale Geschäftsmodelle, die in die Beratung übertragen wurden, dann

selektiert, wenn sie bislang lediglich ein kleines Anwendungsfeld innerhalb der Beratung finden, aber ein Potenzial für weitere Übertragbarkeit erkennbar ist. Von den 1539 Quellen wurden somit 90% aussortiert. Mit den so erhaltenen 150 Beiträgen wurde eine Rückwärtssuche durchgeführt, um mithilfe der Literaturverzeichnisse der gefundenen Publikationen neue Quellen zum jeweiligen Thema zu finden. Im nächsten Schritt wurde eine Vorwärtssuche durchgeführt, um weitere Quellen zu erhalten. Die Ergebnisse wurden analog zu den vorherigen Schritten analysiert und kategorisiert. Vorwärts und Rückwärtssuche ergaben dabei eine ebenso geringe Quote an neuen Ergebnissen. Konkret wurden 57 ergänzende Quellen identifiziert.

Die identifizierte Literatur (207 Beiträge) wurden näher betrachtet und nach detaillierten Ausprägungen digitaler Geschäftsmodelle im Bereich wissensintensiver Dienstleistungen durchsucht. Hierbei konnte festgestellt werden, dass konkrete Anwendungsbeschreibungen und Praxisbeispiele eine Seltenheit darstellen. Zumeist bleiben die Erläuterungen zu den branchenspezifischen digitalen Geschäftsmodellen auf einem hohen Abstraktionsgrad und werden nicht näher in die konkrete Anwendung gebracht. Erläuterungen zum praktischen Einsatz digitaler Geschäftsmodelle sind auf gängige Beispiele wie Uber, Airbnb oder Rolls Royce beschränkt. Erläuterungen industrienaher Servizifizierung sind als potenzielles digitales Geschäftsmodell im Dienstleistungsbereich prädominant. Beiträge mit neuartigem Geschäftsmodell und Transferpotenzial wurden selektiert. Die Quote betrug daher lediglich 11,4%.
Die 35 als relevant erachteten Publikationen bilden die Grundlage für die Literaturanalyse in Schritt 4.

4 Literaturanalyse

Zunächst wurden aus den 35 Quellen alle digitalen Geschäftsmodelle im Sinne der Definition extrahiert und tabellarisch erfasst. Dabei wurde auch in einzelnen Quellen mehrere Geschäftsmodelle identifiziert. Sie wurden dann dahingehend untersucht, wie sie strukturiert und kompakt für eine Übertragung in Form einer Themenkomplexmatrix zusammengefasst werden können. Sie wurden zunächst nach Branche sortiert. Wie in **Tabelle 2** ersichtlich wird, wurden mit geringer Anpassung die eingangs definierten wissensintensiven Branchen betrachtet. Sie umfassen 24 Quellen. Hierzu zählen Bildungsdienstleistungen, Forschungsdienstleistungen, Gesundheitsdienstleistungen, komplexe Finanzdienste und kreative Dienste. Daneben wurden zwei gesonderte Bereiche eingeführt. Analytische Dienste bezeichnen die wissensintensiven Dienstleistungen der Datenaufbereitung und -analyse. Hierzu zählt beispielsweise die Wettervorhersage als Dienstleistung. Ebenso wurde eine Kategorie branchenneutraler wissensintensiver Dienste eingeführt. Diese umfasst Erkenntnisse auf höherem Abstraktionsgrad aller wissensintensiven digitalen Geschäftsmodelle oder digitalen Geschäftsmodelle der Querschnittsfunktionen in wissensintensiven Dienstleistungsunternehmen.

Die Menge von 11 Arbeiten aus der Beratungsdomäne erlauben, die Aussage, dass bereits Ansätze zur Übertragung von digitalen Geschäftsmodellen aus benachbarten

wissensintensiven Dienstleistungen verfolgt wurden. Diese 11 Arbeiten stellen die unterste Zeile in **Tabelle 2** dar.

Zur Ermittlung der Themenkomplexe, welche die zweite Achse darstellen, wurden Beiträge mit hoher inhaltlicher Ähnlichkeit zusammengefasst. Zur Erläuterung der gewählten Felder werden die Themenkomplexe aus Platzgründen hier beispielhaft jeweils an einer Arbeit erörtert. Die Themenkomplexe sind alphabetisch aufgeführt und wurden retrospektiv aus den 35 Arbeiten abgeleitet. Sie dienen primär der Übersichtlichkeit der Felder und stehen für Sammlungen an neuartigen digitalen Geschäftsmodellen, welche die Autoren nicht in ihrem vollen Potenzial in der Beratungsbranche realisiert sehen.

Tabelle 2. Kategorisierung der Identifizierten Themenkomplexe digitaler Geschäftsmodelle nach wissensintensiver Dienstleistungsbranche

		Themenkomplexe digitaler Geschäftsmodelle							
		Crowd Dienstleistungen	*Datengetriebene Dienste*	*Dienstleistungs-plattformen*	*Kleinteilige Dienstleistungen*	*Problemdatenbanken*	*Self-Services*	*Teil-automatisierung*	*Voll-automatisierung*
Wissensintensive Dienstleistungen	*Analytische Dienstleistungen*		[24], [25], [26], [27]	[25]					[28]
	Bildungsdienste			[22]	[29]				
	Forschungs-dienstleistungen	[19], [30]							
	Gesundheits-dienste		[21], [31]	[21], [23]	[32]	[33]		[32], [33], [34], [35]	
	Komplexe Finanzdienste	[36]	[37]	[36]			[23]		[23], [37]
	Kreative Dienste (Design, Redaktion,…)	[38]			[22]	[39]			
	Branchenneutral	[38]				[40]	[41]	[42], [40]	[43], [42]
	Unternehmens-beratung	[10],[20]		[2], [44]	[45]		[46],[2]	[47],[48], [49]	[4],[2], [47],[16], [48]

Zunächst konnten **Crowd Dienstleistungen** im Bereich der wissensintensiven Dienstleistungen als ein Feld digitaler Geschäftsmodelle identifiziert werden. Hierzu zählen Ansätze, welche die Lösungseffizienz, wissensintensiver Probleme mithilfe eines möglichst großen digitalen Adressatenkreises an potenziellen Problemlösern erhöht. Beispielhaft stehen hierfür Online Communities zur Open Innovation [19]. Hier

werden jegliche F&E-Dienstleistungen die unternehmensintern ineffizient oder nicht lösbar sind, einer anreizgetriebenen Zielgruppe online zur Problemlösung übergeben. In der Beratung selten verbreitet, legen derartige Ansätze bislang einen anderen Fokus. Expertennetzwerke beraten Politiker in strategischen Entscheidungen [20] oder Berater werden mittels Enterprise Social Networks zum Kollektiv [10]. Die Ausgestaltung zur Open oder Crowd Based Beratung für tägliche Beratung unter Nutzung kollektiver Plattformen und Anreizsysteme ist hier der neue Faktor. Frei kombinierte Teams aus Kompetenzträgern lösen dabei tägliche Beratungsprobleme nach Ausschreibung.

Als zweiter Themenkomplex wurden **datengetriebene Dienste** identifiziert. Beispielhaft hierfür stehen Beratungsdienste gekoppelt an Livedaten aus der Gesundheitsbranche, wie zur medizinischen Vorsorge gefährdeter Herzpatienten mittels Onlinedienst, ohne Personal und Aufwand für Kunden [21]. Auf Beratungsunternehmen übertragen, ergibt sich ein Feld der Beratung, in dem Produkte und das Sammeln von Daten weiter in den Mittelpunkt rücken. Beispielsweise ist es denkbar das Beratungen die Position der Datenmittler einnehmen. Neue Modelle wären Unternehmensberatungen als Anbieter freier IoT Plattformen, um sich für die datengetriebenen Beratungsdienste zu positionieren oder Beratungsmodule für Cloudservices als Zukunft des Benchmarking.

Als drittes Feld wurden **Dienstleistungsplattformen** als Kategorie hinzugefügt. Sie umfassen digitale Geschäftsmodelle, welche auf Vermittlungsansätzen zwischen Anfrage und Nachfrage [22] oder online Notfallsofortdiensten [23] basieren. Die digitalen Beratungsplattformen können auch von Modellen der Notfallmedizin lernen. Individualisierung und Dringlichkeit stellen auch Treiber für Kunden in der Beratung dar [5]. Reale 24h/7 Verfügbarkeit in ganzen Beratungsthemen zu gewährleisten, sollte für einen Mediator heute technisch auch für den Long-Tail realisierbar sein.

Vierter Themenkomplex sind die **kleinteiligen Dienste**. Diese entstehen durch die Modularisierung großformatiger Dienstleistungen, welche ohne digitale Technologien auch nicht kompakter abbildbar wären. Beispielsweise werden so Bildungsdienste digitalisiert, welche dann auch kleinteilige Zertifizierung („nano degrees“) in modularen Bausteinen erlauben, anstelle zum Beispiel eines Studiums [29]. Die bereits existente kleinteilige Beratung kann beispielsweise noch von den Denkanstößen der Bildung profitieren. Gerade Konstrukte wie die Zertifizierung, die vorher unteilbar schienen sind doch modularisierbar. Beispielsweise ist die Industriewerksoptimierung mittels Digitalem Zwilling ein Ansatzpunkt. Selbst große Strategieprojekt oder IT-Launches sollten somit Ansatzpunkte für modulare Beratung bieten.

Als fünfter Typ digitaler Geschäftsmodelle wurden **Problemdatenbanken** identifiziert. Gemeint ist damit das strukturierte Wissensmanagement mittels digitaler Technologien. Der Erfahrungswert der Problemdatenbank wird dabei zunehmend zum Core-Asset in Form eines Assistenzsystems, beispielsweise in der medizinischen Diagnose [33] oder dem kreativen Texting [39]. An Stelle der etablierten lösungs-orientierten Webauftritte der Beratung rücken so problemzentrierte Suchdienste in den Mittelpunkt. Als Kunde findet man so die passende Beratung zum aktuellen Problem, was faktisch im B2B Kontext eine der größten Schwierigkeiten des sehr erklärungsintensiven Beratungsvertriebs adressiert.

Sechste Kategorie sind die nicht gänzlich neuen **Self-Services** und den neuartigen Umgang damit. Die grundlegende Idee ist hier die Übertragung der Ausführung wissensintensiver Dienste durch digitale Selbstassistenz an den Dienstleistungsempfänger. Generisch umfasst dies jedoch auch jede durch erfasstes Wissen reproduzierbare Dienstleistung [41], was zur Inspiration anregt. Eine Plattform zur einfachen Konstruktion von Beratungs-Self-Service Apps wäre ein Anlaufpunkt für jeden Beratungsexperten, welcher zum Beispiel mit einer Problemdatenbank stark skaliert. In Kombination mit neuen Feldern entsteht somit wiederum Neues.

Kategorie sieben ist die **Teilautomatisierung**. Jegliche Virtualisierung vor- oder nachgelagerter Prozessschritte einer Dienstleistung oder deren Remoteabwicklung umfasst diesen Teil der digitalen Geschäftsprozesse wissensintensiver Dienstleistungen. Im Fokus steht der Effizienzgewinn, wie beispielsweise im Onlinevertrieb oder der Terminabsprache [42]. Dieser bleibt trotz existierender Ansätze bestehen, da vollintegrierte Plattformen in der Beratung noch nicht realisiert sind. Die letzte Kategorie stellt die **Vollautomatisierung** wissensintensiver Dienste dar. Diese umfasst die Abwicklung von Dienstleistungen über Algorithmen, Logik und teils künstliche Intelligenz ohne menschliches Handeln. Beispielhaft steht hierfür die bereits fortgeschrittene Entwicklung der Roboadvisors in der komplexen Finanzberatung [23].

5 Conclusion

Zusammenfassend konnten die Forschungsfragen vollständig adressiert werden. Mittels der Literaturrecherche wurden sechs Themenkomplexe digitaler Geschäftsmodelle in wissensintensiven Domänen identifiziert. Die Realisierbarkeit des Transfers konnte beispielhaft erörtert und anhand der Literatur, welche Transfers in die Domäne der Beratung bereits ausübte, belegt werden. Das hier angewendete Vorgehen, hat zu realen neuen Ansätzen digitaler Geschäftsmodelle im Bereich der Beratung durch Übertragbarkeit geführt und wird somit auch zukünftig als sinnvolles Instrument beurteilt. In zwei Themenkomplexen gab es bislang keine hier ermittelbaren Forschungsanstrengungen im Bereich der Beratungsforschung, was ebenso wie die Neuausrichtungen der vier anderen Themen klare Forschungspotenziale zeigt.

Kritisch zu limitieren ist die Wahl des Abstraktionsgrades. Ähnlich der Tiefe der Detaillierung von Geschäftsprozessmodellen haben auch Digitale Geschäftsmodelle verschiedene Detaillierungsebenen, teilweise mit direkter Auswirkung auf die instanziierte Übertragbarkeit. Dies ist bei weiteren Arbeiten zu berücksichtigen.

6 Ausblick und Forschungsbedarf

Die Übertragbarkeit digitaler Geschäftsmodelle wissensintensiver Dienstleistungsforschung auf die Beratung ist grundsätzlich ein vielversprechender Ansatz. Hierauf gilt es aufzubauen und Beratungsforschung auch auf diese Resultate zu lenken und noch weiter auszubauen. Die gezielte Auseinandersetzung und detailliertere Recherche in den einzelnen Branchen, d. h. Anpassung der Suchstrings und Ausweitung der Recherche wäre eine Möglichkeit zur Schaffung einer noch größeren Grundmenge an

untersuchbaren Themenkomplexen. Eine nächste Stufe für die Erfassung digitaler Geschäftsmodelle in der Beratung und ihrer Übertragbarkeit, die über die grobe Kategorisierung und Auflistung wie im vorliegenden Beitrag hinausgeht, ist zudem eine wünschenswerte zukünftige Forschung. Die Struktur zur Erfassung digitaler Geschäftsmodelle in der Beratung bezogen auf die wertschöpfenden Bereiche nach Zieldimension (Matrix) und Abstraktionsgrad zu gliedern verspricht einen tieferen Mehrwert. Gerade die Praxis (Start-ups) ist zudem auch im Themenfeld der wissensintensiven Dienstleistungen noch stark voraus, da das Feld für Beratungen teils noch sehr experimentell ist. Es sollte daher aus Perspektive der Forschung ein Ziel sein auch die Praxis der wissensintensiven Dienstleistungen stärker zu evaluieren. Hier sind sowohl empirische Umfragen, offene Onlinerecherchen als auch Expertengespräche erstrebenswerte und zielführende Maßnahmen.

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