Strategizing Digital Transformations: Sensing Threats and Opportunities with the Digital Disruption Analysis

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Abstract: Managers need to navigate the increasing complexity of their business environments due to emerging technological developments and digital disruption. Strategic threats and opportunities to their business must constantly be assessed, but organizations often lack the time and resources to develop a structured approach. With the Digital Disruption Analysis, Voß et al. (2020) published a systematic methodology to assess emerging innovations and to derive digital transformation strategies. In this paper, the Digital Disruption Analysis is tested with technology foresight experts of an established enterprise in the energy sector and improved in an iterative approach. In an initial application, opportunities for improvement are identified through participatory observation and direct feedback. Then, the Digital Disruption Analysis is revised and applied again in the same company to assess the improvements, using the same evaluation method and an additional qualitative questionnaire. The main adaptations of the Digital Disruption Analysis are the integration of a weak signal analysis based on a data and text mining approach to identify relevant emerging innovations, the integration of a multidimensional digital disruption scoring model, and a new Trajectory Mapping approach. The experts note improved applicability and overall enhanced functionality of the revised Digital Disruption Analysis. Our findings contribute to future research on applicable management tools for digital transformations and serve as a foundation for understanding the nature of digital disruptions and how they can be identified and monitored.

Keywords: Digital Disruption; Digital Transformation; Technology Foresight; Business Environment Analysis; Weak Signal Analysis

1. Introduction

Over the past decade, digital technologies have led to far-reaching changes in business environments of companies. They lead to changes in customer requirements, the way business is conducted, competition and interaction between businesses (Osmundsen et al. 2018). Digital technologies foster new ways of collaborating, organizing resources, designing products, matching complex demand and supply, and developing new standards and solutions (Markus and Loebbecke 2013). In this context, the term digital disruption has gained attention in research and practice. Digital disruption is a rapid, technology-induced, and difficult-to-anticipate market change process that overwhelms leading companies to adapt to the new environment (Skog 2018). It requires strategic and operational transformation in incumbent companies (Hanelt et al. 2021; Vial 2019; Skog 2018). Technology foresight, the continuous monitoring and evaluation of technological trends, reduces the risk of being surprised by such threats. In addition, opportunities are identified to transform business, thus progressing the digital transformation, and generating a competitive advantage (Reger 2006). Technology adoptions are determined by high-level decision makers. In the process, some companies have leveraged the evolution of digital technologies to achieve a dominant position in the market, while others have been unable to select and adopt them efficiently (Klos and Spieth 2020). Consequently, in a fast-paced environment where managers are confronted with a flood of information from different sources, it is even more important to develop decision-making routines to cope with the complex reality (Rauch et al. 2016).

Therefore, we identify a need for a practical approach for facilitating technology foresight activities in incumbent companies. We aim to contribute to meeting this need by developing a Digital Disruption Analysis (DDA) methodology. We thereby apply the Design Science Research Method Process Model by Peffers et. al. (2014). In a previous published article, Voß et al. (2020) presented the results of the first design phase. We derived relevant requirements on a DDA in incumbent companies, especially SMEs, from literature. Then, we conducted a systematic literature review identifying methods that can be used to manage digital technologies and their trajectories. Subsequently, relevant methods were selected and linked that meet the derived requirements according to the authors. The resulting DDA was structured into two subsections *business environment analysis* and *organizational impact analysis*, and three subordinate functional areas *information generation, information*

processing, and *information derivation*. Having the literature based DDA designed, the first iteration phase including the steps of demonstration and evaluation will be completed in this paper. This article is structured as follows. The methodological approach of this paper is described in section 2. The results of the empirical validation phase are presented in section 3. The resulting adaptations of the DDA are presented in section 4. In section 5, we discuss the adapted DDA. Lastly, we close the paper with a conclusion and summarize limitations and elaborate directions for future research in section 6.

2. Research Method

With this paper, we present the results from a process iteration including the demonstration, evaluation and a second design phases according to the Design Science Research Method by Peffers et al. (2014). Thus, the following empirical study investigates the extent to which the theoretical DDA, our created artefact from the first design phase (Voß et al., 2020), can be used as an instrument for the structured analysis of disruptive digital innovations in business practice. For this reason, the DDA was initially conducted as an online workshop series involving three technology foresight experts, including a digital in-house consultant, an innovation manager, and a business analyst in a large European energy company. The participants are qualified by several years of practical experience in the field of technology foresight and are part of a cross-organizational tech- and trend-scouting team that develops new methods for business environment analysis.

Using three exemplary innovations of H2 networks, low-code/no-code platforms and electromobility, the DDA was used to assess the risks and opportunities of disruption. However, the main objective of the workshops was not to accurately predict disruption potential. Rather, the participants were meant to get a feeling for the logical arrangement and design of the DDA process phases and methods to uncover potential complications in the application. Therefore, the results on the disruption potential of the innovations are not a part of this paper. The workshop results were evaluated by participative observation and direct feedback, using the agile tool of the Starfish Method, as an alternative form of lessons learned according to Grundner (2021), at the end of each workshop day.

The application of the DDA resulted in several suggestions made by the experts. In section 3, we compare the most important points of criticisms with the context- and application-related requirements for a DDA defined by Voß et al. (2020). Based on the given feedback, the requirements are evaluated in terms of their degree of fulfilment, using a four-point value scale, ranging from: *[1] The requirement is fulfilled: The underlying processes and methods do not need to be modified to [4] The requirement is not fulfilled: The underlying processes and methods must be modified completely*, as shown in Table 1 in section 5. This procedure shows which components of the DDA require adaptation or further development, carried out in section 4.

Similar to the first demonstration, we conducted an online workshop series to test the enhanced DDA, under section 5. The evaluation was carried out in February 2022, spread over three workshop days. Two participants from the expert team for tech- and trend-scouting, two participants from the corporate foresight unit and four participants from the IT Strategy and Architecture department of the European energy company took part in the workshops. Feedback on the DDA was gathered on each workshop day using the proven Starfish Method and a questionnaire, which was used to determine the degree of fulfilment of the context- and application-related requirements. In line with the first application, the participants went through the DDA process phases using an exemplary digital innovation, the Internet of Things, which was identified using the analysis presented in section 4.1.

3. Fulfilment of the requirements by applying the DDA in business practice

To comprehensively search the business environment for disruptive innovations, Voß et al. (2020) define a set of contextual- and application-related requirements for a DDA. These are derived from the characteristics of a disruption, such as technological progress in combination with social drivers and the archetypical constraints of SMEs, i.e., lack of resources (Kugler and Anrich 2018) and the lack of digitalization know-how and business development experience (Demary, Engels and Röhl 2016). Based on the first-time application of the DDA in corporate practice, the context- and application-related requirements were assessed according to their degree of fulfilment, as shown in Table 1 in section 5.

3.1 Fulfilment of context-related requirements

For a company, disruption brings risks, but also opportunities (Christensen et al. 2018). Therefore, the DDA must promote the exploration of *new opportunities for digital transformation*. First, this requires a suitable *scanning approach* to identify new types of digital innovations in the corporate environment. From the experts' point of view, this is contradicted by the fact that the information generation phase has been insufficiently implemented in the DDA so far. It is not specified how relevant information can be collected and combined in a meaningful way. Therefore, the *scanning approach* was rated as [4] not fulfilled. Second, *the exploration of new opportunities for digital transformation* requires the identification of suitable interventions and thus a *solution orientation* (Baumfeld et al. 2014). By using a value proposition canvas, basic ideas for a digital transformation project can be developed, but the experts criticized that no concrete strategic recommendations can be derived from the SWOT-Canvas introduced by Voß et al. (2020), which compares the opportunities and risks of digital innovations for the own company. It remains unclear how the results of the DDA should be dealt with from a management perspective. For this reason, the *solution orientation* is rated as [3] mainly not fulfilled and consequently *the exploration of new opportunities for digital transformation* is also rated as [3] mainly not fulfilled due to the sum of criticism.

The Five Forces Model turned out to be an effective tool for identifying the different driving forces that emerge from an innovation and change the industry structure. However, the model does not give any indication of the extent to which the company is at risk of becoming disrupted. It was therefore recommended to illustrate the impact of an innovation on an appropriate scale. Disruption must also be analyzed in its *causes*. While the macro- and microeconomic drivers in the emergence of a digital technology become visible by combining the PESTEL Analysis and the Five Forces Model, drivers that might be characteristic for the emergence of digital disruptions are not considered. The DDA does not offer any guidelines on how digital disruptions in particular should be identified. The expert team fundamentally questioned whether a phenomenon such as disruptive innovations, with its highly controversial theoretical basis, can be analyzed at all. The *cause orientation* is therefore just considered as [2] mainly fulfilled because *the identification of risks from digital disruptions* is limited and must therefore be considered [3] mainly not fulfilled. However, considering the suggestions for improvement, the investigation area is considered to be [2] mainly fulfilled at the *macro- and microeconomic level*.

To monitor macroeconomic changes, the DDA introduces the Technology Map. Based on the results of the PESTEL Analysis, the Technology Map compares the technological maturity of an innovation with its social acceptance. Significant problems were caused by summarizing the information obtained in the PESTEL Analysis under the dimension of social acceptance, as suggested by Voß et al. (2020). The current DDA does not provide a methodical procedure, which results in the assessment being subjective. The graphical presentation of the Technology Map, on the other hand, was highlighted as very helpful. Apart from this problem, the *monitoring approach* can therefore be considered as [2] mainly fulfilled.

It is necessary to introduce a suitable system that brings together all the objective information obtained in the preceding process phases. *Trajectory Mapping* was rated [4] not fulfilled and therefore cannot fulfil the requirement of *future orientation,* [4] not fulfilled. This leads us to one of the most important criticisms of the DDA, its *system orientation*. Even though the methodology is highly *system-oriented*, a major weakness of the DDA is the insufficient integration of the DDA process phases and methods. The observation was repeatedly made that interim results of one process phase could not be transferred to the following one. Therefore, previously gained information was lost at these breaking points. This problem was attributed to the lack of scales and KPIs, which is why the *system orientation* is rated [2] mainly fulfilled.

3.2 Fulfilment of application-related requirements

It can be noted that the DDA is generally *resource-efficient* in its use. However, the identification of numerous innovations and their subsequent assessment require a considerable amount of time and resources. A preselection of relevant technologies is hence required. Additionally, integrating data-driven approaches in the DDA, can drastically reduce the required resources. Against this background, the requirement must be regarded as [2] mainly fulfilled.

The practical testing of the DDA, on the other hand, has shown that after a brief introduction to the topic of disruptive innovations and the methods used, the practical application of the DDA does not require any *deep methodological know-how*. Consequently, this requirement can be considered as [1] fulfilled. Furthermore, it can be stated that the DDA is universally applicable and therefore *adaptable to individual organizational*

contexts. But problems can arise when integrating the DDA into already existing tech- and trend-scouting processes. Therefore, the requirement is rated as [2] mainly fulfilled. The workshops have shown that the DDA is suitable for an *iterative application*. This might only be limited by a high resource demand. Nevertheless, this requirement can be assessed as [1] fulfilled.

From the perspective of the workshop participants, there are no barriers in linking the DDA with the *internal business analysis*. This is countered by the fact that the insights gained in the DDA are difficult to transfer into a direct strategic recommendation. For this reason, the requirement is considered [2] mainly fulfilled. Same applies to the *development of a transformation strategy;* [2] mainly fulfilled. Using a value proposition canvas, initial approaches of a potential *business model innovation* can be developed. However, the identification of environmental changes and disruption potentials is not synonymous with the development of disruptive ideas and business models, whereby complementary methods would have to be integrated into the DDA. The requirement is therefore [2] mainly fulfilled.

4. Adaptations to the Digital Disruption Analysis

The adapted methodology is illustrated in the figure below. As outlined in the application the DDA is embedded into a digital transformation process. It serves as a linkage between the creation of strategic awareness, and the definition of a digital transformation roadmap. Embodying a digital maturity model could be helpful to identify a first list of focal technologies for further investigation, while also supporting a shared understanding of the internal digital capabilities and implementation gaps. This means that, in our view, technology adoption and creating organizational change are most relevant when, on the one hand, there is a low level of technology adoption, and on the other hand, this technology can cause significant disruption to the business. The DDA is designed to derive digitalization opportunities and threats and hence is a suitable starting point to define measures of digital transformation. These measures can be detailed in a subsequent implementation plan, using project management tools.

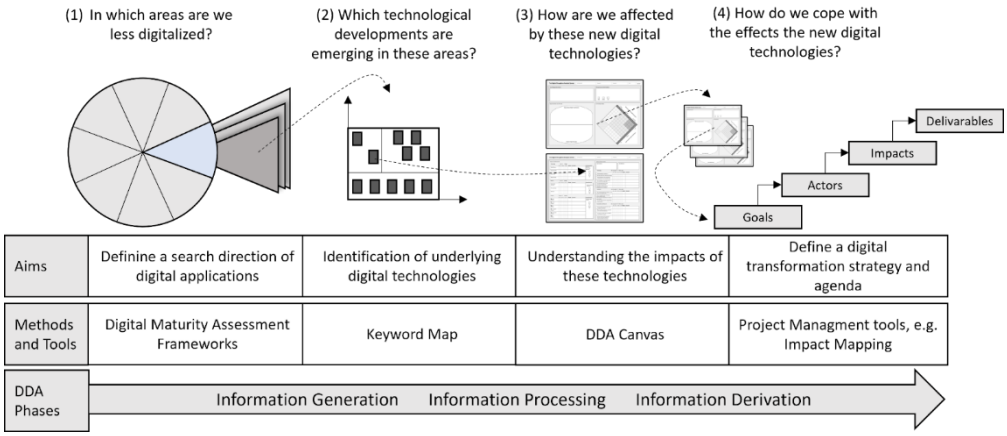

Figure 1: Digital Disruption Analysis in a Digital Transformation Process

4.1 Information Generation

For more guidance in the information generation phase, we include a structured process to identify emerging and potentially disruptive technologies for further analysis. This aligns to the demand of reducing the effort of technology identification. A digital maturity model may provide guidance for a first search direction for relevant digital technology application areas (Osorio et al. 2021). This can be combined with data mining, for a more refined technology identification. As data mining can be automated, it is characterized by a better efficiency compared to qualitative data assessments (Gibson et al. 2018). Integrating a data mining-based approach of technology scanning could help to identify weak signals of emerging trends in digital technology domains of low maturity. Following Yoon (2012), a keyword analysis of literature is incorporated to identify early-stage technological advancements. A suitable approach to detect such signals has been developed by Griol-Barres et al. (2020) and leads to a visualized Keyword Map that assigns keywords on two dimensions, the average frequency and the weighted growth rate of keywords in the literature. The later dimension gives more weight to recent publications. The keywords are clustered by predefining median value boundaries for the two dimensions (Lee and Park 2018). The resulting Keyword Map is depictured below. Strong and weak signals are both further investigated to select the sample for the subsequent information processing phase of the DDA. This

selection process can be supported by further qualitative assessment as proposed in the former version of the DDA, such as expert interviews and lead user or supplier analyses.

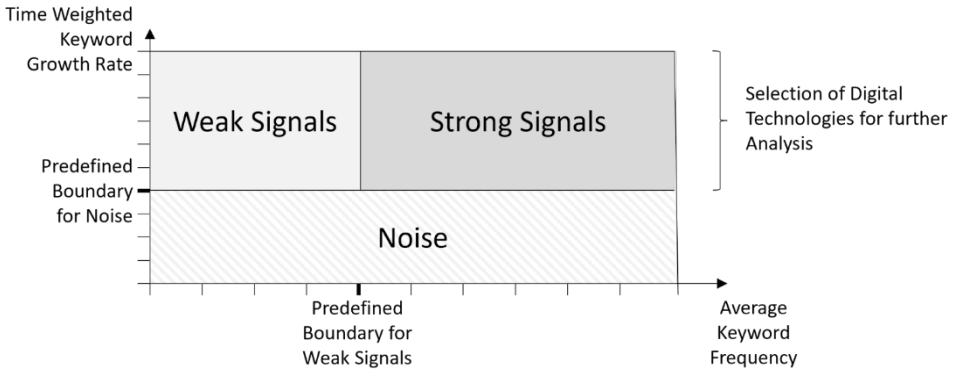

Figure 2: Signal Clustering with the Keyword Map

4.2 Information Processing

In the macro- and microenvironment analysis quantitative questionnaire-based assessments are implemented to calculate disruption index values. First, the macroenvironment is assessed in three main categories: *Technology, Market* and *Context*. In addition, three related conditional factors for digital disruption are introduced.

The *Technology* category relates to the capabilities of the innovation. The first evaluation relates to the capability of digital solutions to *simplify* complex processes (Guo et al. 2019; Urbinati 2018). Therefore, it is assessed whether it leads to a reduction of complexity when applied or rather increases it. Secondly, the emergence of disruption depends on the capability to substitute existing technologies and achieve a monopolization (Schuessler and Nagy 2014). A high rating of the *substitutability* dimension corresponds with this capability, while a low level means that the digital technology itself can easily be substituted by alternative solutions. Then the *integrability* of the innovation is assessed based on its ease of adoption. The evaluation is positively influenced if the technology relates to well-established infrastructures and is characterized by low-cost development and application (Govindarajan and Kopalle 2006; Rafii and Kampas 2002). Finally, the technology *maturity* level is assessed as a driver of disruption (Lyu et al. 2021). Yet, an imminent disruption requires a sufficient degree of maturity, which is also included as a conditional factor in the evaluation.

The *Market* category consists of three assessments. First the *mainstream market potential* is assessed. This refers to the categories of Habtay (2012) of technology- and market-driven innovations. Technology-driven innovations have longer development times and tend to penetrate niche markets first before entering mainstream markets and hence require more time for diffusion. Market-driven innovations, such as the creation of new value propositions, are often designed for mainstream market diffusion and thus have a higher chance of disruption. However, a potential niche market is a prerequisite for an innovation to develop any potential disruption. This is considered by integrating *pioneer market adoption* as a conditional factor. Another driver of disruption is the ability of a technology to support customers, specifically by creating new values, or reducing cost and efforts (Lyu et al. 2021; Klenner et al. 2013). This is assessed in the subdimensions Customer value. Finally, the potential *diffusion* of the innovation is evaluated. This sub-category relates to two major aspects of digital technologies, the exploitation of network effects and the decreasing marginal costs for diffusion (Guo et al. 2019; Koch and Windsperger 2017). A high level in this dimension corresponds to active network effects and low-cost diffusion, while a low level describes barriers due to these effects in already established alternative products and business models.

In the *Context* category, a PESTEL Analysis remains a part of the DDA. The five dimensions are assessed individually to describe factors that promote or inhibit digital disruption. The *political* context refers to the government's willingness to promote the technology. It can also be a barrier to innovation if the government seeks to preserve old economic structures from disruption (Urbinati et al. 2018). The *economic* dimension refers to the general business environment, such as the availability of necessary competencies, the propensity to adopt the innovation on the market, or cost-related drivers and constraints. The *social* dimension focuses on the

general acceptance of the technology in society. The *technology* dimension takes the existing macroeconomic technology-related infrastructure into account. The *ecological* dimension reflects on the importance of sustainable digital solutions and resources as adoption factor that might accelerate or inhibit digital disruption. Finally, the *legal* dimension assesses the legal conditions for innovation and the associated facilitation of technology diffusion. *Lawfulness* of the innovation is also a pre-requirement for disruptions and is thus also added as a conditional factor.

The subsequent micro-environment analysis shifts the focus to the impact of a digital innovation on the individual company and its readiness to cope with it. The Five Forces Analysis is maintained but detailed by concrete evaluation items and more disruption specific questions, as shown in figure 5 Also, the value proposition of the technology remains part of the DDA analysis.

Finally, the technologies are mapped on a diagram that illustrates the degree of disruptive potential and the magnitude of disruption. Individual assessments can be weighted by the company to emphasize the most relevant aspects of the technology. Finally, the Disruption Map aggregates the results by indexing the macro- and microenvironment analysis by summing up the weighted items and indexing them on the 10-point scales. For the analysis of future developments, both assessments can be repeated, focusing on the expected differences and then visualized on the Disruption Map as illustrated below. This substitutes the Trajectory Mapping of the former DDA to anticipate future-oriented developments.

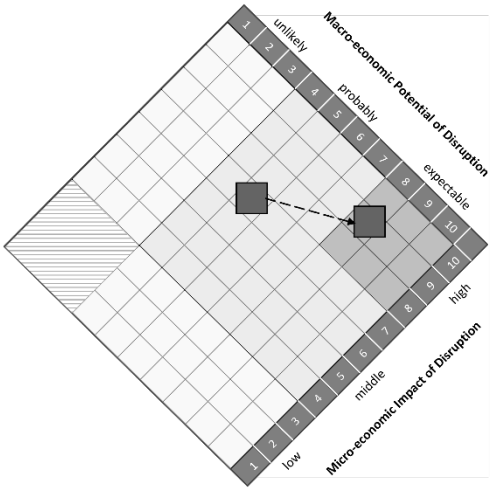

Figure 3: Monitoring Digital Technologies with the Disruption Map

4.3 Information Derivation

The information derivation phase is adapted in less intensity and still includes the exploration of opportunities and threats. It serves as an aggregation of all reflections from the information processing phase. In addition, three kinds of measures are categorized for more guidance. These strategic responses are called *Watch, Think* and *Act* (Dörge and Wirth 2021). For low disruption potential or estimated small effects on the company, the technology should be monitored to react if changes may occur. Responses under the Think category are characterized by further investigations to estimate the necessity to fent off threats or to exploit digital transformation opportunities. This is relevant when macro-perspective disruption is probable or there is a mid-level impact due to the concerning digital innovation. It requires measures of the Act category if digital disruption is imminent and vastly affects the individual business situation. Then immediate strategic action is required.

4.4 Introducing the Digital Disruption Analysis Canvas

The figures below show a two-page canvas, which can be used as a template in corporate practice to carry out the analysis. The first page summarizes key findings of the DDA. The opportunities of digital transformation and threats of digital disruption are explored as well as interventions. Also, the Disruption Map is illustrated on this page to visualize the macroeconomic potential of disruption and the micro-economic impact.

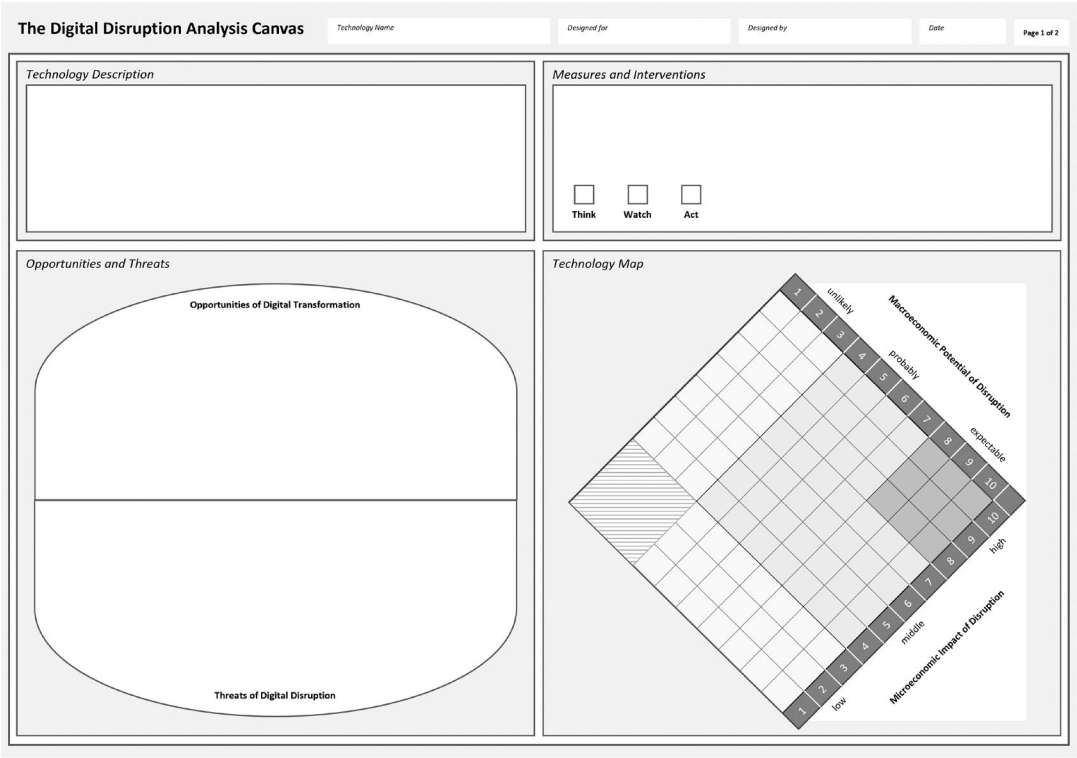

Figure 4: The Digital Disruption Analysis Canvas (Page 1)

The second page of the DDA canvas consists of the macro- and microenvironment analysis questionnaires and the exploration of gain creators and pain relievers of the digital technology.

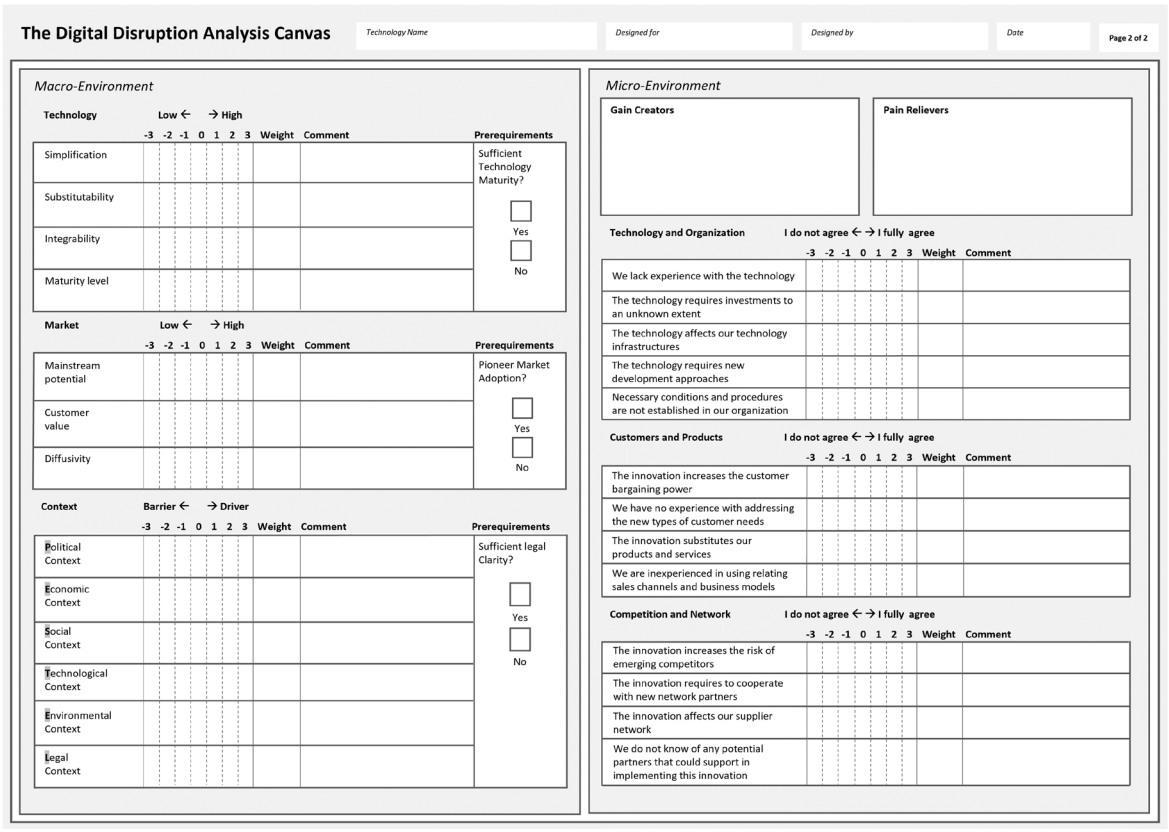

Figure 5: The Digital Disruption Analysis Canvas (Page 2)

5. Discussion

With a re-application of the DDA in practice, we assess if the adaptations lead to improved evaluations, as shown in Table 1. Most of the criticisms were not re-claimed in the final feedback rounds.

Table 1: Degree of fulfilment of context- and application-related requirements of the 1st and 2nd iteration

Context-related Requirements		1st Iteration	2nd Iteration	Change
Serving the DDA Target	Exploring new opportunities for digital transformation	[3]	[1]	↗
	Identifying risks of digital disruption	[3]	[2]	↗
Area of Investigation	Macro-environment	[2]	[1]	↗
	Micro-environment	[2]	[2]	→
	Technological trajectories	[4]	[2]	↗
Systemic Approach	System orientation	[2]	[1]	↗
	Cause orientation	[2]	[2]	→
	Solution orientation	[3]	[2]	↗
	Future orientation	[4]	[1]	↗
Data Collection Approach	Scanning	[4]	[2]	↗
	Monitoring	[2]	[2]	→
Application-related Requirements		**1st Iteration**	**2nd Iteration**	**Change**
Suiting to Constraints of SMEs	Not resource demanding	[2]	[2]	→
	Not requiring deep methodological know-how	[1]	[1]	→
Approach	Adaptable to individual SMEs	[2]	[2]	→
	Suitable for iterations	[1]	[1]	→
Digital Transformation Project Integration	Can be integrated into the internal business analysis	[2]	[1]	↗
	Supports transformation strategy development	[2]	[1]	↗
	Stimulates business model innovation	[2]	[1]	↗

In contrast to the first application, the difficulties in interlinking the process phases and methods were no longer observed. This can be explained by the introduction of the quantitative assessment frameworks, now linking the process phases and interim results. However, it was noted that the examination of disruption potential from a macroeconomic perspective is too detailed. Caution was also advised in using absolute numbers in the assessments. While they are helpful for the structured evaluation, they should not become the subject of discussion. While the derivation of direct strategic recommendations was previously very limited, participants highlighted that innovation work can now be given a clear direction by applying the Act, Think and Watch principle. In addition, the new Disruption Map enables the innovation landscape to be viewed from a portfolio perspective and provides a basis for focusing on the most urgent technologies. However, uncertainties were expressed regarding the measurability of disruptive innovations. Nevertheless, according to the experts, being aware of the assumptions of the theory of disruptive innovation gives new directions of creative work in developing business models. In this context, not only including participants from the strategic management level in DDA workshops, but also employees from the operational level, is another valuable impulse from participants. This emphasizes that the strengths of disruption analysis lie in the creative work. To focus resources on this part of the DDA, a more data-driven analysis may be integrated. This corresponds to the experts' assessment that DDA is neither time- nor resource-saving. The only way to save resources, and not at the expense of the quality of the results, is to increase the degree of automation.

The DDA provides SMEs with a set of tools to examine the business environment for digital technologies and their impacts. It may be concluded that the adapted DDA meets the requirements to a high degree. Nevertheless, it remains a question whether the factors introduced in this paper for the ex-ante anticipation are suitable for measuring a phenomenon whose characteristics are still not based on a proven scientific foundation. Analyzing from the perspective of disruptive innovation theory was, however, affirmed by the experts as a clear advantage over other methods. This is largely in line with the view of other researchers such as Kumaraswamy (2018), King and Baatartogtokh (2015) or Hopp (2018).

6. Conclusion

It is a major challenge for established enterprises to recognize the latent impacts of technological advancements and to estimate the strategic implications. With the DDA, Voß et al. (2020) provide decision-makers with a tool to systematically analyze the business environment for digital disruptions. In this study, we were able to identify considerable need for adaptation through the application of the DDA in practice. We propose several changes that, in the view of the technology foresight experts in our study, lead to improved applicability and functionality and overall better requirement fulfilment. The integration of text-mining-based technology identification helps to automate and simplify the scanning phase of the DDA. The scoring model facilitates the assessment and comparison of relevant technological trends as well as the monitoring of developments on the Disruption Map. However, this research is subject to considerable limitations. Due to the single-case approach of our empirical

application and the subjective evaluations by the experts, and the authors' interpretations of the qualitative feedback, future research is needed to further validate the DDA. Another focus topic for future research is the integration of the DDA into the creative process of digitalization strategy development. The DDA can also be further adapted by integrating more data-driven tools to further automate the assessment of technological disruptiveness. However, the disruption theory is still at an early stage and needs to be substantiated for a more accurate ex-ante analysis.

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