

2 Essay I: Survival in the digital age – a framework for formulating a Digital Transformation Strategy in SME

Johannes Trenkle
Technical University of Munich
TUM School of Management
j.trenkle@tum.de

Abstract essay I

Many digitally successful companies have established a dedicated digital transformation strategy. A small and medium-sized enterprise (SME) perspective on this topic remains unclear. I fill this research gap with a qualitative research approach. Main findings include a set of 14 strategic questions along four summarizing categories – use of technologies, changes in value creation, organizational changes, and financial aspects. Three out of these four categories hold true in SME environments as they are valid in large corporation settings. I recommend establishing the term “organizational changes” instead of “structural changes” in order to increase fit to the mindset of SME owners. Answer options enrich these strategic questions, based on the experience of successful examples from the field. I identify differences between SME and large corporations in the areas of value creation, organizational changes and financial aspects. This paper elaborates theory on digital transformation strategy, contributing to understand management behavior and decision levels in an economic environment, where the adaptation of digital technologies has become an imperative.

Keywords: digital transformation, digital transformation strategy, SME, case research.

Status: Published¹⁰

10 Essay is published: Trenkle, Johannes (2019). Survival in the digital age – A framework for formulating a Digital Transformation Strategy in SME. *Proceedings of the 19th International Conference on Electronic Business* (pp. 428–442). ICEB, Newcastle upon Tyne, UK, December 8–12.

2.1 Introduction

This study combines the view of SME with existing literature about frameworks to develop digital transformation strategies. I contrast new, cross-sector findings from SME knowledge to previous, single industrial, large company contexts and answer the question: *How does a cross-sector SME context influence core elements of a digital transformation strategy?* Academic groundwork (e.g.: Matt, Hess and Benlian, 2015) has identified core areas affected by digital transformation on a strategic level. By analyzing the digital transformation of selected SME from various industries I show to what extent the same strategic categories are at the center of the digital transformation in SME as it is the case in large companies.

In private as well as in business environments, modes and habits of communication, information, research, as well as simple and sophisticated working processes almost naturally involve the use of hardware and software. There is no doubt that companies must react to the modifications the progress of technologies is causing in society and in their business environments. Technological advancements require existing companies to act in two directions: to adapt their business models, but also to rethink their entire industries (see e.g.: Lucas et al. 2013). *Digital transformation* focuses on change aspects in ways of working, roles, and business offering caused by the adoption of digital technologies in an organization, or in the operations environment of the organization, in order to assure sustainable value creation (Gimpel & Röglinger, 2015).

The academic groundwork of this paper is given by the digital transformation framework of Matt et al. (2015), who developed a generic conceptual model along guiding categories to formulate a digital transformation strategy: *Use of technologies, changes in value creation, structural changes, and financial aspects*. The representative contextual power of these four dimensions was proven for diversified, large scale companies (Hess et al., 2016; Wiesböck et al., 2017). My project eliminates industry specificity by taking a view on digital transformation across sectors.

In order to ensure competitiveness by leveraging digital technologies, SME must gear up for digital transformation. SME show a range of differentiating organizational criteria that make them merit separate consideration (see e.g.: Carney, 2005). Some outstanding aspects include: (1) *Leadership*: outstanding influence of the company owner on management decisions. (2) *Organization*: owner-manager-centered hierarchical design, role-accumulation, tight personal interconnections across staff. (3) *Production process design*: low degrees of work-sharing, universal machinery, strong de-

pendence on small numbers of basic innovations and low economies of scale. (4) *Sales*: lot-size-one, high degree of customization, limited regional and/or highly specialized segment. (5) *R&D*: no institutionalized R&D department, short-range, highly intuitive R&D activities, limited financial resources, short time budgets from invention to monetization. Around 3.5 million companies in Germany are SME, representing 99.4 % of all companies in Germany (see e.g. European Commission, 2015). Together they account for ~2,200 EURbn in annual turnover, representing a share of 34.1 % of all companies' value added. They employ more than 15.5 million people, providing a job to 52.7 % of the German nation's employment. They all face the challenge to find a successful way of handling the progress of digital technology usage. Based on the large number of SME in Germany, I expect recurring challenges at firms with comparable size, and from comparable industries, giving knowledge about cross-sector digital transformation mechanisms a sizeable audience also from the practitioner community.

From the author's knowledge, digital transformation strategies in SME remain unaddressed in literature. This study fills this gap by relying on a multiple case research design, applied to seven family owned SME from different sectors. All of them are considered typical SME, who have successfully mastered steps towards digital transformation and therefore are rich in information. By conducting open, semi-structured interviews with the seven company owners and members of the management, I provide deep insights. I triangulated the interview data by additional data sources like company websites, social media channels, books written by the company owners, press articles, and financial data. Thereby, this paper elaborates the digital transformation framework of Matt et al. (2015) towards an applicability in situations, where SME owners, independent of their profession, define a digital transformation strategy for their firm.

I find a set of 14 guiding questions a SME owner -independent from sector or industry- can follow in order to define an individual digital transformation strategy along an empirically derived path. Answer options, based on experience of successful examples from the field, enrich these strategic questions. These findings provide a twofold value-added: elaborate the scholar research on digital transformation as well as bridging the gap to practical, all-day business challenges.

2.2 Background

2.2.1 Digital transformation as a key management challenge

The ongoing advancement of digital technologies provides an unquantifiable number of challenges for businesses of all sizes. It is a sort of “mission impossible” to find a C-level representative from large, publicly listed multinationals, who has not publicly committed to the necessity of a “digital change”. Digitization, digitalization and digital transformation have become omnipresent catchwords, often lacking clarity. Scholar literature has tried to ascribe these phrases a unique definition. *Digitization* defines the (pure) technical process of converting analog information into a digital format (see e.g.: Negroponte, 1995). By bringing all types of information down to the lowest common factor, i.e. binary digits, digitization dematerializes information and decouples information from physical carriers and storage, transmission, and processing equipment. This development, in connection with multiple users’ wish to benefit from the negotiation and arrangement of the meaning of the bits, set the basis for a need in interoperable standards and common definitions of application and service interfaces (Tilson et al., 2010). Therefore, the term *Digitalization* comprises the manifold sociotechnical phenomena and processes of adopting and using these technologies in broader individual, organizational, and societal contexts. Matt et al. (2015) argue that the ubiquity of information technology pushes companies to explore new digital technologies and to exploit their benefits, which involves transformations of key business operations and affects products, processes, organizational structures and management concepts. In order to realize manifold potential benefits like increases in sales or productivity, innovations in value creation, and novel forms of interaction with customers, companies have to open themselves to change, within their own structures as well as beyond their borders (Matt et al., 2015).

Digital transformation therefore emphasizes the change aspect, i.e. the managed adaptation, focusing on changes in ways of working, roles, and business offering caused by the adoption of digital technologies in an organization or in the operation environment of the organization in order to assure sustainable value creation (Gimpel & Röglinger, 2015). Riasanow et al. (2018), p. 13, define digital transformation “as probabilistic organizational change philosophy where digital technologies are used to fundamentally transform an organization’s business model and value network”. It is about managing internal efficiency, external opportunities, and addi-

tionally disruptive change (Parviainen, Tihinen, Kääriäinen, & Teppola, 2017). It touches a company holistically, including external partners along its supply chain (Bowersox, Closs, & Drayer, 2005), comprising the “use of new digital technologies to enable major business improvements (such as enhancing customer experience, streamlining operations or creating new business models)” (Fitzgerald et al. 2013, p. 2).

Several experts consider the impact of digitalization similar to the impact of the industrial revolution. Downes & Nunes (2013) describe how entire business models can be reshaped or replaced by what they call “big-bang disruption”. Traditional industries or business models like e.g. video gaming, stock exchanges, analogue photography, portable navigation tools, physical book sellers, or physical newspapers can suffer substantial losses of significance or become obsolete, as new incumbents use digital opportunities on supply (company) and demand (user) sides. E.g. Lucas et al. (2013) show that the impact of technological advancements requires existing companies not only to adapt, but to rethink entire industries.

2.2.2 Importance of and core elements constituting a digital transformation strategy

Via digital transformation, companies target to compete better by using digital innovations (Main et al., 2018). In order to stay competitive, companies must actively manage challenges arising from a deep penetration of technology in their entire business- and operating models. Though the imperative to act is well accepted in general, the execution of digital transformation yields many obstacles. Henriette, Feki and Boughzala (2015) argue that a digital transformation project involves the implementation of digital capabilities to support business model transformations. They call for collaboration and interaction throughout a company's whole organization, across operational processes, resources, internal and external users, and by this causing major change in employees' habits and ways of working. An explicitly formulated strategy for implementing digital technologies is essential in order to realize the full benefits from digitalization. Less digitally mature organizations tend to focus on individual technologies to solve lone standing problems, whereas elaborate digital strategies guide successful business transformation in most digitally mature organizations (Kane et al., 2015).

Earlier research focuses on IT-strategy, that must be aligned, but subordinate to the business strategy (see e.g. Henderson & Venkatraman, 1993;

Hirschheim & Sabherwal, 2001), even in an SME context (Hussin et al., 2002). However, researchers recently claimed for a new type of digital business strategy, nevertheless struggling how to get there. Bharadwaj et al. (2013) call for an evolution from IT-strategy into a digital business strategy, comprising IT-strategy and business strategy into an overarching phenomenon, which is defined as an organizational strategy formulated and executed by leveraging digital resources to create differential value (Bharadwaj et al. 2013, p. 472). Others demand for a standalone digital-edge strategy, taking into account the specific nature of SMAC technologies, incorporating digital and physical resources, and concentrating on specific business outcomes rather than grand strategies (McDonald, 2012). Both viewpoints agree urging for an integrated view on business and technology in the light of digital transformation, but they remain unclear about how to incorporate actions on the actual transformation steps. Furthermore, as it has been shown that not all digitalization that is possible is desirable, e.g. due to negative effects of transparency towards competitors (Grover & Kohli, 2013), companies need to consider an individual optimum of digital infusion to their business strategy.

Scholars have identified necessary strategic actions in digital transformation, thereby laying the ground to develop industry specific frameworks for the configuration of a digital transformation strategy. A case of a digital business strategy for online music content providers fosters the call for an integrated view on business and technology on a company strategy level (Oestreicher-Singer & Zalmanson, 2013). Further case study-based articles discuss guidelines for digital business strategies and organizational implications with a special focus on publishing and newspaper industry (see e.g.: Øiestad & Bugge 2014). Results indicate the necessity to entrench elements of exploitation and exploration into a company's digital transformation strategy, next to necessary innovation capacity and capabilities like resources, processes, and values. An imperative to include inter- and intra-company organizational change aspects in a digital transformation strategy can be derived from a case study from the retail industry (Hansen & Sia, 2015). An example from a toy producer lists distinctive characteristics of business strategy and business model, an enterprise platform, necessary mindset, corporate IT, and workplace environment necessary in order to create digital leadership (El Sawy et al., 2016).

The digital transformation framework by Matt et al. (2015) represents a clear step towards a holistic approach for the construction of a digital transformation strategy. It claims that every digital transformation endeavor should be structured along four, well aligned key dimensions (Matt et

al. 2015, p. 340–341): 1) *Use of technologies*: a company's strategic position and future ambition towards new technologies, as well as its ability to exploit them. 2) *Changes in value creation*: the influence of digital transformation on the way, a firm aims to add and create value. 3) *Structural changes*: modifications in a company's operations, i.e. structures, processes, and skill set. 4) *Financial aspects*: deliver transparency about the urgency to act in the face of declining margins in a firm's core business, and about a firm's financial scope to invest in a digital transformation endeavor. These four dimensions have been explored by scholars, taking a case based view on diversified media companies (Hess et al., 2016) and medium to large scale insurance companies (Wiesböck et al., 2017). While in both studies, the strategic configuration especially of the “use of technologies”, “structural changes”, and “financial aspects” dimensions show potential for generalization, the designs of the “changes in value creation” dimension – not surprisingly – does not allow for any transfer of conclusions across sectors. Furthermore, small companies and their specific attributes are excluded from any investigation so far.

Due to their special attributes, a plain analytical transfer of existing knowledge around digital transformation strategies to SME is not permissible.

2.3 Research design, sample, and methods

2.3.1 Research design

I apply a case based research design that “investigates the contemporary phenomenon in depth and within its real-life context” (Yin 2014, p. 16). Units of analysis are digital transformation mechanisms in SME. Within a narrative section, I describe the cases in order to give the audience context, stories and meanings in order to promote understanding of each case's situation. Meanings and patterns are elaborated using an abductive approach.

2.3.2 Sample

I purposefully chose selected examples of SME, who successfully mastered digital transformation. The scope of digital transformation as the investigated phenomenon is not limited. All cases stem from the German skilled craft sector, a unique German phenomenon that is not clearly delimited as

Table 2-1: Overview of cases under analysis

Company (Crafts)	Carpenter	Denturist	Electronics technician	Electronics technician	Joiner	Metal-worker	Tailor
Abbreviation	A	B	C	D	E	F	G
Core business	Wood-work	Dental technology	Industrial-fire prevention technology	Capacitive and optical sensor technology	Wood-work	Metal construction, plastics injection molding	Textiles
Number of staff	~20	~40	~20	~130	~35	~30	~5
Founded	1995	1981	1997	1983	1999	1985	1961
Target market	Germany	Germany	World-wide	World-wide	Europe	Germany	Germany
Principal client relation	B2C	B2C/B2B	B2B	B2B	B2C	B2C/B2B	B2C/B2B
Organizational scope of digital transformation	Processes	Products and processes	Products and processes	Processes	Processes	Processes	Products and processes

a business sector, comprising services and manufacturing goods providers. 98 professions belong to the skilled craft sector, being listed in the German “Trade and Crafts Code”. Based on an evaluation of the employee numbers across the sector I consider craft businesses typical representatives of SME. Together with technological consultants from the chamber of skilled crafts for Munich and Upper Bavaria I selected outstandingly successful examples of digitally transformed SME, who’s actions “permit logical generalization and maximum application of information to other cases [...]” (Patton 1990, p. 182). In order to identify those critical cases, I used different preselection criteria (see e.g.: Miles, Huberman and Saldaña, 2014). The sample SME must have fully or partially transformed their business- and/or operating model. As a basis for judging the relative degree of digital transformation in their respective fields, IT was used (a) for fundamentally altering traditional ways of doing business, or (b) to dramatically change how tasks are carried out and therefore is recognized as being important in enabling the firm to operate (see e.g.: Lucas *et al.*, 2013, p. 372). Sampling continued until no new insights emerged from additional case analysis,

meaning until theoretical saturation was reached. The final sample consisted of seven cases, all located within a radius of 80 kilometers around Munich, Germany. In order to allow for an acceptable degree of generalizability across the SME sector, I chose an industry-spanning approach. Table 2-1 gives an overview of the seven case companies under analysis.

2.3.3 Data sources

Main source of data were semi-structured, open interviews with owner managers of the selected SME. When the owner manager suggested to include additional knowledge carriers (e.g. children working in the company or co-managers), I always agreed. The number of interviews I conducted in each firm ranged from one to three. Overall, I conducted 11 interviews, which is more than in previous studies (Hess et al., 2016; Wiesböck et al., 2017). The interview data was triangulated based on availability by further sources of information, e.g. the firms' websites, brochures, social media activities, books, financial data, or guild information materials. I also asked accompanying junior researchers to write down their impression, providing a common understanding to formulate each company's case report.

2.3.4 Data analysis

The interviews were recorded, transcribed and coded. I applied first cycle coding methods labeling the data blocks (Miles, Huberman and Saldaña, 2014). Then, I adopted second cycle coding methods in order to group and summarize the initially found first cycle codes into "a smaller number of categories, themes, or constructs" (see e.g.: Miles et al. (2014), p. 86). Emerging pattern codes laid the basis for cross-case analysis. From the first case, an initial SME digital transformation framework was developed. Following, I examined successive cases to see whether new patterns found match the findings from previous cases or increase variance (Yin 2014; Miles et al. 2014, p. 103).

In order to ensure a satisfying degree of transferability, case reports provide thick description. Validity and reliability in coding are supported by a three stage process proposed by Campbell et al. (2013), where I as a senior coder at start identified blocks of meaning in the interview transcripts. I gave the so-called unitized data as well as the first version of the codebook to a junior coder in order to redo the coding. After this, we compared our

codes, which resulted in an inter-coder reliability of 0.74 on concept-level, 0.75 on theme-level, and 0.82 on dimension level (Campbell et al., 2013; Miles et al., 2014). After discussing and negotiating the results as well as eliminating ambiguity, inter-coder reliability reached 1.00 on all pattern levels.

2.4 Case descriptions

2.4.1 Carpenter (A)

A is family-owned and was founded in 1995, currently employing ~20 people. The main business is custom-made woodwork. From start, innovative production technologies were a central element in the company founders' investment activities, targeting to simplify processes and reduce production costs. The firm's strategic focus lies on private upmarket customers with a demand for high quality individualization. The automatization of production processes based on cutting-edge numerical control (NC)-machinery, able to fulfil highest requirements in the elaboration of complex geometries, helped to meet increasing customer requirements. For visualizing complex, personalized products, CAD programs are in use throughout the sales process. Considering its location in the countryside, the firm in recent years strengthened its capabilities around online customer interaction by combining a website, built according to customer feedback, with a structured online marketing approach.

CAD usage and the frictionless integration of automated production via computerized NC machines led to successful positioning in high quality, high margin sector. Being among the firsts to use these techniques in classical woodwork gave the company a competitive advantage. Highly elaborate, digital sketches including inherent NC-production-programs represent a marketable product on their own, creating an additional field of revenue. Due to the high degree of automation, the company realized efficiency gains, based on reductions in waste, increased quality, and the ability to employ lower skilled people in production. To replace mailings and newspaper advertisements, a new website was launched in 2015, which is constantly updated based on customer feedback. In parallel, A started to make use of search engine optimization (SEO) and search engine marketing (SEM). Whereas sales and customer base are increasing, the marketing budget was reduced by 80 %.

2.4.2 Denturist (B)

The owner manager founded company B in 1981. With a yearly turnover of ~1.5 EURmn, the company employs ~25 people by manufacturing dental prostheses. It combines traditional dental with digital technologies. The company started digital transformation in 2002, when the owner bought the first automated milling machines for dentures. Then, as now, competing companies still traditionally produce dentures with a lot of manual effort. In order to achieve highest accuracy, the company since a decade relies on natural tooth recording using intraoral 3D-scanners, a *modus operandi* still ahead of industry standard. Based on digital scanning and modeling, the move to automate production appeared logical. Recently, the company digitally addressed office support processes and invested in digital proposal generation, order management and e-invoicing. Digital transformation is driven by the owner manager's fascination with the opportunities that digital technology offers across the entire value chain. He constantly observes the market for innovations around his core business, but also strives to leverage his company's capabilities and capacities even beyond.

The firm sees digital technologies as enabler of business goals and to remain one of the leading dental technology laboratories. Throughout its existence, the company was able to enhance its client base constantly by offering high quality dentures at lower cost in a shorter range of time. B's owner has developed several innovative production techniques, incorporating 3D-printing, and milling. This enabled the firm to work with non-standard materials and enabled additional products like drilling templates for dentists. B, based on own patents, sells self-developed techniques to other companies worldwide. The deep penetration of digital technologies in the value chain allowed to increase quality, reduce costs by almost eliminating defective goods, and speed up production processes.

2.4.3 Electronics technician (C)

C is specialized on automated firefighting solutions for industrial machinery. Founded in 1997, today it employs ~20 people in Germany and ~10 in China to serve worldwide clients. Products are customized to client needs and offered including installation and maintenance, being constructed for spatial limited areas in machines. Digital transformation was a reaction to fast corporate growth and incorporated organizational challenges. C's in-

dustrial customers requested firefighting devices to be implemented in automated production lines already in planning and construction phases. Therefore, the company developed necessary digital interfaces. Resulting remote maintenance services are now offered additionally to the regular service portfolio. All customer communication is enabled digitally incl. electronic billing. C owns a data base covering all historical installations. Thereby, physical maintenance works at clients' sights, causing costly production outages, can be planned with a high degree of precision, including necessary parts and actions. This led to quality and efficiency improvements of products and services. At the time of this study, the firm is in the latest development stages of a completely new product family, based on the digitalization of industrial fire prevention.

The newly innovated, digitally enriched product will set a new industry standard regarding reaction times and integration in digital machinery environments. The company expects to benefit from tighter strategic alliances with its current as well as new customers. Also, C is increasing its efficiency due to comprehensive reduction in manual office work as well as digital tool usage in preparation of assembly and installation processes. Employees, based on the cloud database, digital part lists and office workflow management, can use travelling times more effectively. While in earlier years billing took several months, as technicians are on assembly for several weeks in a row, billing is now executed within days.

2.4.4 Electronics technician (D)

D is a world market leading producer of sensors for various fields of applications. Based in Munich, it owns branch offices in China and the USA. Core products are capacitive level sensors and optical sensors, which the company develops and produces tailor-made for its B2B client base. The firm, founded in 1983, is family-owned with ~120 employees. Due to its core product focus on sensor technology and constant R&D activities, working with digital technologies always was part of D's DNA. Customers request the firm to stay at the edge of digital developments with respect to products and processes. On the product side, the firm engages in the internet of things (IoT), developing sensors, which can communicate among each other as well as among a network of machines. On the process side, D has introduced a new enterprise resource planning (ERP) system with a customer interface, so that customers can place their orders directly within the company's order management system. Feedback from customers is giv-

en via a one-click feedback system, thereby creating an early warning system for potential process threats. Being in a knowledge driven industry led D to implement a comprehensive, yet easy to use, social-media-like internal communication platform and included knowledge management system. An automated database using text blocks was introduced in order to avoid extensive editorial work when creating user and production manuals. As the company is active globally, social business networks play a major role to communicate with partners and customers.

High customer centricity involving digital technologies has led the firm to conquer a niche market and to develop its unique selling proposition. The ERP-integrated order management helped to reduce office work and to avoid recurring mistakes due to manual data handling. Automated billing will be the next step to realize an order execution without manual interference. In order to tighten customer relationships, D is participating in the creation of a platform based B2B web shop, incorporating partner companies and allowing business customers to order integrated solutions online.

2.4.5 Joiner (E)

E's owner started the joinery with three employees in 1999. Today the firm employs ~30 people. It remains family-owned and serves the European market, focusing on production and distribution of woodwork with linoleum surfaces. At the time the owner started E, market situation was difficult caused by high competition. In wish for flexibility in personal life and less market pressure, the owner decided to leverage technological options he had in his manufacturing site, specializing his product portfolio on tables with linoleum surfaces. Based on first market success of the product, customer demand, and opportunities of e-commerce, the company opened its first web shop in 2005. Since then, E strives to use innovative technology to distribute products in a convenient, customer-centered manner, e.g. via an online 3D-configurator and integrated live chat function for direct customer interaction. Relying on online sales as single distribution channel included investments in SEO and SEM. In order to streamline the order execution process, E introduced a product-data management tool, which interconnects order entry, production terminals and customer communication.

The interplay of a highly specialized product portfolio, automated cutting, milling and finishing machines in production, and online sales, led

the company to conquer a niche market. The company's expertise regarding user experience and technological capabilities around its web shop provide competitive advantage. The high degree of automation throughout the production processes yields efficiency gains. By avoiding manually caused information gaps as well as defects, customer rejects and waste were minimized. The employment of lower skilled people in production led to decreasing labor costs.

2.4.6 Metalworker (F)

With ~30 employees, F, since 1985, is focused on the individual development and production of special purpose tools via metal and mold construction. Furthermore, it produces specialized parts for bicycles and bicycle trailers, and engages in plastic injection molding.

F's owner and management ascribe digital technologies a support function. In order to reduce the workload of office employees, e.g. taking calls by customers regarding orders and special requests, the company created its own web shop. As demand for plastic injection molding and customer requirements in this area have increased over the last years, the firm in this business field applies material handling via robots as well as digitally supported production planning.

The establishment of the web shop enabled higher sales as well as increased efficiency regarding office work. The automated production processes in plastic injection molding leveraged productivity, whereas product quality became better and output has increased.

2.4.7 Tailor (G)

G was founded in 1961. Being originally a toll manufacturer for leather goods, the present owner, the founder's son, created his own collection of traditional costumes and fashion. With currently ~5 employees, the company produces traditional dresses, high quality clothing for motor cyclists, and technologically enriched special clothing. Motivation for first steps of digital transformation came from customer requests 10–15 years ago. Out of a scientific project, the company was asked to combine textiles with sensors in order to document motions of the wearer. This newly gained knowledge today is used to enlarge G's product portfolio. The firm develops and distributes functional work fashion incl. sensors, e.g. to measure

vital signs and environment data. As a basis for all products, the company relies on customer satisfaction and good quality. Defects are repaired in-house in order to gain knowledge and to improve new products. Due to concerns around quality and theft of intellectual property, the company only makes little use of digital technologies in production. Only standard sewing patterns are digitally exchanged with outsourcing partners, all critical expertise is kept in-house.

Proficiency in digital technology handling enabled G a position as preferred partner of various institutions and business partners, incl. universities, scientific institutes, and large corporations, when it comes to digitally enriched clothing and wearables. In order to gain financial and structural headroom for further R&D and product innovations, the company currently separates its wearable solutions business from the core business, traditional and biker clothing. Vision thereby is to improve the life of customers along their daily routines by a useful combination of digital technology and elaborate artisanship. Nevertheless, by exploiting light templates in combination with laser cutting, G was able to leverage quality and profitability of traditional products as well.,

2.5 *Guidelines for formulating an SME's digital transformation strategy*

The following section unfolds a decision framework in the form of strategic questions, each enriched by answer options company owners can choose from in order to structure individual digital transformation journeys. The basic structure was provided by the four dimensions of the Digital Transformation Framework (Hess et al., 2016). Summarizing tables of all dimensions can be found in the appendix to this paper, 2–1 to 2–5.

2.5.1 Use of technologies dimension

The adoption of information technology across the company depends on the importance the owner ascribes to their usage. A general level of ambition lays ground for the intensity of technological penetration throughout the firm.

Question 1: How significant is your firm's IT to achieve strategic goals? The importance firm owners ascribe to the strategic necessity of adopting digital technologies shows great variation across the various companies. Opportunities as well as strategic imperatives dictated by clients are seen from

different perspectives. Some firm owners consider IT to be an enabler of strategic goals. By actively absorbing digital technologies, they see new business opportunities arising. Being an enabler urges a firm to constantly observe the digital future and screen the market for technological advancements, e.g. in collaboration with scientific institutions. In contrast, other firm owners ascribe IT a support function to reach their strategic goals. In this latter case, digital technologies drive market developments, urging companies to adopt to a changing environment in order to stay competitive. Firms with a supporter lens screen the technological landscape for sources of improving their operations or aligning their processes with clients' value chains.

Question 2: How ambitious is your firm's approach to new digital technologies? In SME, technological ambition of the company owner is crucial for organization's openness towards digital advancements. Thereby, individual ambition is independent from the strategic role of IT as labeled in question 1, as personal experiences of the company owner, existing capabilities among the company's employees or among firms' networks, the financial situation of the company, or the risk-taking appetite as well as some inventive genius are more decisive factors. While cautious company owners may in general trust on well-established technologies with a proven record of accomplishment and reliability, more curious and entrepreneurial minds might strive to dive deeply into new technological developments. Those firms who are at the forefront of innovating new technologies are labeled innovators. They search for cutting-edge technology, regarding their products and services as well as with a view on their operations. Companies, who are not engaged in this fundamental style of research but see opportunities from being the first ones to apply new sorts of technologies to their individual field of business, are named early adopters. They actively screen the market for recent developments, in their own field as well as in other sectors, and try to exploit them as early as possible in their own field. The most conservative firms, called followers, rely on well-established solutions, which have already been applied in similar environments and to similar challenges. Motives of the firms' own accord mainly arise from the wish of leveraging efficiency across processes; external triggers are mainly customer requirements.

2.5.2 Changes in value creation dimension

Defining the model of value creation is the most severe task for the owner of a company. As digital technologies have proven to revolutionize competitive landscapes within a few years, a digital transformation strategy must target the mode of generating revenue, sources of efficiency, and the constitution of a firms' value network.

Question 3: How can your firm digitally leverage sales? The ubiquity of the internet accompanied by IoT technologies are changing purchase and sales processes in both B2B as well as B2C relationships. It is an important task to define the role of digital channels in market positioning. Firms need to define how digital their interface to customers and their interaction to potential buyers should be, a crucial point in an SME environment where often there is no sales team, but instead company owners and their office support staff do sales. The cases imply that online presentation of products and services on the company's website or via social media channels is an imperative, independent from the target customer base. B2C as well as B2B focused companies all try to be present online at least with a website, but also using private and business social media sites. The same holds true for product sale via web shops. The decision for direct online sales is more dependent on the type of products offered, market dynamics and current and future customer habits than on the target customer base. Sophisticated online responsiveness labeled as the ability to enter in a mutual dialogue with the customer, using the website or social platforms as a trigger, is mainly deployed by B2C focused firms. This is also the case for the engagement in SEO and SEM. Both are only practiced by selected case companies after thorough investigation of the impact of their marketing budget allocation.

Question 4: How can we adapt our product portfolio? Digitalizing the product portfolio and thereby exploiting opportunities for new sources of revenue creation is a crucial task within a digital transformation strategy. It yields the chance to stay competitive and to differentiate against competitors. Digital technologies can become components of products themselves, but they can also be utilized in the development and production of analogue products to create competitive advantages. Furthermore, the case companies leverage options for individualization and standardization. Digital production techniques and data analytics allow the realization of so far impossible geometries in production, as well as digital simulation and calculation of products and services, and thereby facilitate an offering of client-individual customization via design and functionality. On the other

hand, digitally enriched and data driven production processes reveal the feasibility of using identical parts or materials in situations where customers do not value manually enabled individualization.

Question 5: How can your firm increase the efficiency of its processes? Five out of seven cases under investigation mentioned that usage of digital technologies is mainly seen from a standpoint to increase efficiency throughout process operations. Only companies B and G tended to see digitally enabled product adaptations as their key focus, despite also exploiting digital technologies throughout their operating models. Main source of efficiency improvements across the cases is the substitution of manual production steps by automated production, thereby realizing speed advantages. Nevertheless, superior quality of goods by reducing rejects, trash and processing time is always seen in combination of seeking speed advantages. To realize the full speed and quality potential of digital production facilities, all cases benefit from a major shift in craft process operations. Traditionally, the usual, time consuming mode of operations was to program necessary metrics into every single machine on its own, which is now done centrally and only once. Another source of efficiency is the reduction of average wages in production by employing lower skilled people who need less training and experience for the handling of digital machines in contrast to manual material treatments.

Question 6: How can your firm leverage efficiency across its value network? All company owners see digitally facilitated or enabled vertical and horizontal partnerships along their value chain as a key factor of success in digital transformation. The internet, simplified methods of data processing, and communication via mobile tools make inter-company cooperation more efficient or even possible, as new partners can be identified via internet and social media research. Some cases use outsourcing in production, enabling an efficient allocation of technological production capabilities across the value chain, e.g. a focus on the production of selected goods, preliminary production steps or focus on design and on-site assembly. As conceptualization and realization of website design and updating as well as a firm-tailored IT infrastructure are considered rather complex tasks, all cases outsource website programming and hosting, operational systems programming, and IT services. Companies C and D are connected to their customers via electronic data interchange ("EDI") interfaces, allowing them an automated exchange of product and process data with their customers and contributing to a favorable strategic position, based on tight digital and processual integration. Some innovator companies struggle that key partners do not understand the favorable impact of their products,

processes and services. Therefore, both pursue the technological education of key business partners, aiming for tight interaction and realizing joint digital progress.

Question 7: Where is it an option not to engage in digital transformation? It revealed to be interesting where leaders in digital transformation see potential analogue hideaways in contrast to digital imperatives. Usage of digital communication channels is considered an absolute must. The same holds true for the implementation of digital production technology. However, the company owners admit that not everything that can be handled digitally must be handled digitally. In case of proven economic disadvantages like insufficient quality of automatically vs. manually crafted products, permanent resistance from the staff leading to processual distortion, or a high risk of knowledge theft, some company owners decided to omit digital potentials. Still, almost all company owners state that some persistent advantages they draw from technology usage would not have been possible without failure, so a general “refusal of digital” is not considered a viable decision option. At last, customer requirements may slow down digital transformation as they require paper-based exchange of information.

2.5.3 Organizational changes dimension

Going through a digital transformation requires a company to reconsider its organizational structure. Firms must define responsibilities, decide about the appropriate entity structure, plan on how to realize a necessary employee structure and how to ensure that a required skill set becomes integrated to the firm.

Question 8: Who is in charge of the digital transformation endeavor? A specialty of SME is the centralization of leadership where the company owner mostly plays the strategically decisive role. When it comes to digital transformation, most cases show a joint responsibility of the management team in decision making. In four of the cases, the management team consists only of family members; two cases have a person in charge of the position of technical director, comparable to the role of a chief technology officer. In all cases with a team approach, the mode of operation is that one dedicated member of the team is responsible for making suggestions towards technological improvements, but final decision and execution are taken care of as a team.

Question 9: Do you plan to integrate new operations into existing structures or to create separate entities? In the execution of digital transformation, some

company owners reach a seminal moment, where they ask themselves about the strategic relationship between their traditional and their future business models. Across the case companies there where two decisive factors that bring along the strategic question of how to arrange the future company structure. At first it can occur that new business operations require technologically skilled employees like engineers or IT specialists, who tend to earn a lot more compared to previous employees. At second, necessary investments tend to raise considerations around financial resources and the incorporated risk profile of the company.

Question 10: What types of operational changes do you expect? Being able to react and adapt requires a clear understanding of expected changes that digital transformation will cause across own as well as contiguous industries. The most important area of change is seen in the improvement of business processes, where incremental developments in the future are expected at an even more intense level than today. Mainly affected are production and office related areas, where e.g. the use of workflow management systems, product data management systems as well the integration of NC programming and production still yield a lot of headroom for improvement regarding usability and customizability to individual requirements of businesses. Along come expectations around a new set of required skills based on digital technologies. In all areas of the firms, employees will need at least a basic understanding of digital tools. A third aspect of expected change concerns products and services. The firms agree that classical craft products will remain also in a digitalized world, but clients' expectations regarding quality, design, and delivery times will increase due to the exploding number of design and functional options, logistics, and digital production techniques. Besides, digitally enriched products are expected to see considerable market growth.

Question 11: How can your firm realize a target employee structure? As most of the case companies expect a changing skill set among their staff, the acquisition of necessary competencies is seen of major importance. All firms agree that two modes must go together. On the one hand, the companies must develop their existing staff by fostering general willingness to develop additional knowledge. On the other hand, all companies agree on the long-term necessity of attracting young employees, so called digital natives, to push digital transformation. Thereby the formal qualification, e.g. in a certain skilled craft, steps back against the digital affinity and knowledge of digital tools of applicants. Hereby, all cases see a positive side effect of being a digital leader. Whereas many companies generally complain about

the scarcity in skilled workforce, the companies under investigation consider their reputation as a clear advantage in this war for talent.

Question 12: How can you personally acquire necessary competencies and inspiration? The ability to assess technological advancements requires the company owners to be familiar with major technological developments in their fields. All cases show that mastering digital transformation requires both, formal competencies as well as the inspiration to transfer them to their traditional craft business models. Since both go hand in hand, there is no difference between the options where to obtain them. Internally, company owners source their knowledge from regular feedback, given by their staff. External sources for expertise are evaluated by the case companies purposefully on an implicit cost-benefit-basis. All cases consider the chamber of skilled crafts a valuable source of knowledge but vary in the intensity of usage. Some rely on the consulting services of selected experts, whereas others regularly take part in information sessions. Other options to obtain external knowledge and impulse are voluntary, self-organized experience exchange groups, or trade fairs, where company owners search for products and machinery augmenting their sources of value creation, in addition to meeting clients and highlight their own developments. A last option to capture external knowledge are specific vertical networks, including e.g. practitioners from related industries, and scholars from academia.

2.5.4 Financial aspects dimension

Most of digital transformation efforts require significant investments, e.g. in assets, human capital, but also R&D. The case companies ascribe 30–70 % of their total yearly investments to digital technologies. They also agree on an implementation and learning time of at least one year until positive effects from digital transformation components are realized. Therefore, a solid financial structure is critical. At the same time, eroding margins in traditional core business areas may trigger company owners to consider steps towards increasing efficiency or exploiting new revenue sources. To finance all endeavors, different sources of capital are worth evaluating.

Question 13: How strong is the financial pressure on your current core business? If primarily analogue business models continue to deliver sufficient profits, many company owners neglect the necessity for digital transformation. When margins start to plunge, it may be too late. Therefore, company owners should carefully evaluate their whole product portfolio based

on the inherent financial pressure, i.e. the ability to deliver stable or, at best, increasing margins. As soon as they see signs for margin deterioration, action becomes an imperative. For SME, this aspect becomes even more important due to limited economies of scale. Four of the seven case companies see a major threat for themselves as well as other craft businesses, when industrial players enter competition with small-capacity craft businesses, e.g. based on technological advancements that enable lot size one without profit limitations.

Question 14: How will you finance the digital transformation endeavor? Financing digital transformation activities remains a tough question for SME, especially as limited financial resources are one of the key characteristics. In general, due to limited size and recoverable assets, banks remain reluctant when it comes to lend money, especially for digitally ambitious endeavors without proven economics. Still, most cases under investigation see a mix of internal funds from cash flows and loans by their house bank as sufficient. Additional equity financing to fund digital venture ideas is only considered by one firm owner. The rationale is the lack of openness and understanding of his house bank for innovative business ideas, accompanied by own risk considerations to secure the persistence of traditional business. Therefore, the owner sees no alternative than using all financing options possible for gaining headroom for incremental growth, especially private equity in the form of venture capital and crowdfunding. Wherever possible, all companies have already applied for public funds, e.g. economic development programs, subsidized loan programs, or research funds.

2.6 Discussion

Confirmations and differences from existing findings arise on three levels: the *style* in which SME owners tend to think about the development of their business compared to employed managers, relevant *categories* to be covered, and around the *options* company owners can choose from in order to individualize their digital transformation strategies.

SME owners think in a selected *style* about the formulation of their individual digital transformation strategy. This holds true across all categories but becomes obvious when defining aspects of future value creation and organizational aspects. It appears that SME owners tend to define a strategy for their firm highly realization focused. This is indicated by the fact that they ask themselves e.g. “How can my firm digitally leverage sales?” and see the options “Present products on website or in social media”, “Es-

tablish web shop”, “Engage in Search Engine Optimization/Marketing”, and “Communicate with customers online”. They also ask, “How can my firm adapt its product portfolio?”, potentially with “Fully digital products”, “Production techniques/ patent usage”, “Individualization”, and “Standardization”. I find that SME leaders take a multichannel perspective as well as a limited number of potential optimizations in their product offering for granted and set this knowledge in the context of their business. Results from larger corporations tend to be contradictory. While findings from media industry are in line with my results (Hess et al., 2016), findings from insurance industry indicate that the decision options towards a digital sales channel transformation is not predetermined between analog/physical (Wiesböck et al., 2017). Dissociated from any industry specificity, SME leaders seem to sacrifice some degree of freedom in their decision making towards the scope of their digital transformation in order to gain focus on the realization of benefits.

The general architecture of the digital transformation framework (Matt et al., 2015) is corroborated by this study. *Use of technologies*, *changes in value creation*, and *financial aspects* remain top-level strategic dimensions valid for SME. This fortification shows the theoretical suitability of the construct to analyze digital transformation on a common ground. Regarding applications in practice, this finding indicates that practitioners can define digital transformation strategies with at least an acceptable probability to succeed for various companies on the common ground of the proposed categories. Nevertheless, in order to increase fit with the driving thoughts of the owners of the companies under analysis in this study, I suggest to introduce an “organizational changes”-dimension instead of a *structural changes* dimension. In their initial framework, Matt et al. introduced “structural changes” referring to “variations in a firm’s organizational set-up, especially concerning the placement of the new digital activities within the corporate structures” (Matt et al. 2015, p. 341). While I agree on the importance to assign responsibilities, organizational positioning of new activities, focus on operational changes and the development of competencies, I see these aspects in an SME context affecting structural as well as operational aspects. As SME show differential structural characteristics compared to larger corporations, operational and human centric aspects like employee structure or business network of the owner manager gain higher importance compared to formal responsibilities and compared to the integration of new operations in the firms’ structures. The term “organizational changes” incorporates more emphasis on human factors in the concep-

tion of a digital transformation and therefore provides a better representation of the SME context.

Regarding strategic questions and options within the overall four categories of the digital transformation framework, I find three categories to be influenced by the SME environment. Only the *use of technologies* category, defining the importance a company is placing on IT in general, and its technological ambition, proves valid also for the seven SME companies in this study, as it has done for media companies (Hess et al., 2016) and insurance companies (Wiesböck et al., 2017). As this fact confirms the generalizability of the digital transformation framework as a theoretical construct, it points out an essential acknowledgment for the management practice in digital transformation: ascribed significance and ambition by either company owners or managers form the basis of success in digital transformation throughout every business environment.

The category *changes in value creation* is strongly influenced by the SME setting. I find five strategic questions SME owners ask themselves around the future scope of their value creation metrics. The structure of these questions represents a comprehensive toolbox where digital technologies support the management of SME to strengthen elementary parts of their business model. This comprehensiveness has not been identified within specific industrial, large corporation environments. Digital transformation strategies in the media industry are limited to transformations in sales, product offering, and resulting future main business scope, neglecting an efficiency perspective (Hess et al., 2016). Large insurance franchises cover aspects of operations and efficiency next to sales, product offering and new sources of revenue creation and ask for the future main business scope (Wiesböck et al., 2017). Covering and bundling those same aspects, the SME perspective I present is less differentiated based on its industry-neutrality. New questions from the SME perspective arise in two fields. Firstly, SME owners strive for inter-company efficiency by trying to leverage efficiency across their entire value networks in collaboration with suppliers, partners and clients. Secondly, they urge to become indispensable partners for their clients by getting connected to them via automated interfaces or engage in the technological education of their business partners. Another SME specialty is depicted by the option not to engage in digital transformation.

Having elaborated on the term organizational changes in the contrast to structural changes before, I find SME influence especially on the content level of this category. The owner manager himself together with his management team always takes the responsibility for transformational actions.

There is no C-level structure of responsibilities as seen in large company environments (see e.g. Hess et al., 2016; Singh & Hess, 2017; Wiesböck et al., 2017). SME always take steps of digital transformation based on an integration in existing corporate structures. Only in the case of highly ambitious initiatives, SME consider founding new legal entities. In this perspective as well as in the focus of expected operational changes, there is no difference in the findings on SME compared to larger corporations. Further differences arise from the operationalization of competency building. Large corporations from media and insurance industry take a portfolio management approach towards competency building, incl. takeovers and external sourcing (Hess et al. 2016; Wiesböck et al. 2017). SME focus only on two areas of actions: they develop their existing staff and are eager to attract young, digital affine talent. It is in the particular interest of SME owners to find ways to personally acquire the necessary knowledge about digital technologies. Taking their own responsibility for the firm for granted, they consider proficient knowledge around future developments driving their business as mandatory and evaluate multiple options for knowledge generation. Surprisingly, research on large corporations neglects this aspect.

Finally, this study extends the financial aspects category from the SME perspective. SME owners as well as corporate managers examine the margin development in their core business areas in order to prioritize the necessity of investments in digital technologies. When it comes to financing, SME differentiate more sources of capital in comparison to large corporations, incl. public funds. External equity financing and crowdfunding remain niches, but still observable.

2.7 *Conclusion, Contribution, and Limitations*

This study extends previous work on digital transformation strategies in specific industries, all conducted based on case studies of large corporations, to a cross-sector SME setting. I show that the general categories along which SME and large corporations structure their digital transformation endeavors do not differ widely. “Use of technologies”, “Changes in value creation”, and “Financial aspects” are useful categories to serve companies of all sizes. The SME perspective adds some options on the detailing level. While large companies additionally focus on structural aspects in their digital transformation, I ascribe the term organizational aspects better fit to the conceptual considerations within SME. The absence of hierar-

chy between categories points out complexity and multidimensional nature often ascribed to digital transformation.

For the analysis, I have chosen a clearly defined segment of the German economy, covering about one million SME. Collaboration with technology experts of the chamber of skilled crafts guaranteed access to the firms under analysis, yielding reliable and unbiased data. With the number of seven cases, I more than double the sample size of comparable studies in large corporations. Picking up skepticism about external validity of case-based research in general, seven cases out of one million is far from being representative. This study claims transferability to the context of heterogeneous challenges SME face when dealing with explicit or implicit thoughts of strategy development towards digital transformation. There is a need for more research to ascertain whether the findings of this study can be more broadly generalized. Further investigation should focus on whether the questions found can be confirmed within SME different from the skilled crafts sector, including businesses from other countries.

Focusing on examples of successful digital transformation in SME, the emerging patterns must be interpreted within the limitations of a cross-sectional, exploratory research design, particularly its inability to determine directions of causality. Though I used triangulation to find publicly available evidence for the owner manager statements gathered in interviews, it is not clear e.g., whether process efficiency improvements were intended, or whether they can be ascribed to the inventive genius of an individual in combination with a trial-and-error process. Future research might analyze digital transformation from a longitudinal, process-oriented standpoint or incorporate management control systems research to find out whether success in digital transformation endeavors is controllable. The results of the present study can also serve as a promising point of departure to investigate the mid to long-term (non-)financial benefits from digital transformation. Based on observations during my visits at the companies' facilities I speculate that leaders in terms of technology absorption tend to be successful also in economic terms. Nevertheless, publicly available data was not sufficient to provide any assertion on that topic.

Digital transformation is a long and multilayered development with many outside and inside variables SME owners must consider. The given results aim to support SME owners and managers to motivate themselves and their staff to get inclination and inspiration for a productive way to deal with digital opportunities. By addressing this issue with a structured approach, results shall help to overcome obstacles, avoid mistakes and therefore perpetuate businesses.

2.8 Appendix essay I

Appendix 2-1: Digital transformation strategy – Use of Technologies

Strategic Dimension	Strategic Question	Strategic Option	Description	A	B	C	D	E	F	G	Highlighting Examples
Use of technologies	How significant is your firm's IT to achieving strategic goals?	Enabler	IT is an enabler of strategic goals	x	x		x			x	B: Digital technologies lead to cheaper products at higher quality. D: We always think from the clients' perspective [...] and actively foster their technological advancements
		Supporter	IT is seen as a support function to reach strategic goals	x			x	x	x		A: Digital transformation is mandatory. Without digital processes, we would be out of the market. F: We see digital transformation just as a measure to save costs and lighten our processes
	How ambitious is your firm's approach to new digital technologies?	Innovator	The firm is at the forefront of innovating new technologies		x					x	B: If we are not on the forefront of innovation, our partners are not interested in a cooperation anymore. G: The question was what could we do with circuit boards; why not put them into clothes?
		Early adopter	The firm actively looks for opportunities to implement new technologies	x		x	x	x			A: We already started using CAD-programs in the year 2000, when this was far from standard. Same with CNC production machines. C: We saw that this technology will become standard - so why not be among the first users?
		Follower	The firm relies on well-established solutions							x	F: We include digital part tracking systems, if our clients want it; not because we consider it necessary.

Appendix 2-2: Digital transformation strategy – Changes in Value Creation (1/2)

Strategic Dimension	Strategic Question	Strategic Option	Description	A	B	C	D	E	F	G	Highlighting Examples
Changes in value creation (1/2)	How can your firm adapt its product portfolio?	Present products on website or in social media	Company uses website and/or social media as a digital showroom	x			x	x	x	x	A: Three years ago, we decided to set up a new website. Today we have an enormous digital interaction with our clients. F: It is so easy to show pictures that are seen by clients, who decide "I want the same".
		Establish web shop	Sell products via own or platform-based web shop				x	x	x		D: We are engaged in the establishment of a sole B2B solutions platform where customers order system components as a package.
		Engage in SEO/SEM	Company uses SEO/SEM for marketing purpose	x							E: We are only selling our products online, there is no offline purchasing.
		Communicate with customers online	Company wants to enter a mutual dialogue with the customer, using website or social platforms	x			x	x			E: We reduced our marketing budget by 80% with replacing printed products by a structured, self-administered SEO/SEM approach
		Fully digital products	Self elaborate digital design/production plans or software tools				x				E: With a little creativity, we manage SEO/SEM successfully without great financial effort
		Production techniques/ patent usage	Sell innovative, patented production techniques								A: We see many product requests coming in via our Website. The dialogue via digital channels gets more and more intense.
	How can your firm increase the efficiency of its processes?	Individualization	Digitally enabled customization via design or functionality		x						D: In an international context, business oriented social media is the best option to start relationships with new partners and customers.
		Standardization	Automated production where customers do not value manually enabled individualization	x	x		x	x			A: Many people made us do the design and then went away to have it realized by a competitor, causing loss via wasted time for us. Now we are selling the digital planning and design of our product, independently from the realization, we do not have to care whether we get the final order or not.
		Reduce manual tasks	Realize speed advantages of automated production vs. Manual production	x	x		x	x	x		B: We developed this utility model some time ago. Now a US industrial corporation is using it and I am participating in their turnover at 5%.
		Superior quality of goods/ services	Reduce trash, reduce processing time	x	x	x	x	x	x		B: We are best in the interpretation of x-ray and other digital pictures. For every implant, we can deliver an individual drilling template.
		Shift effort from operations to production planning	Centralize NC-programming efforts in production	x	x		x	x			E: As craftsman, we are used to lot size 1; digital techniques enable us to realize it efficiently at higher scale.
		Use data for process optimization	ERP, operational data collection, one-click-feedback								A: Clients do not care about plug drill holes, so in NC production we standardize it.
	How can your firm increase the efficiency of its processes?	Use data for process optimization	Use digital tools (cloud access to databases, platforms, route planning) for internal communication				x				E: Our whole business model is focused on products with low complexity, so we only have to alternate design and size.
		Increase speed in communication	Reduce average wages in production	x							B: We have clients all over Germany; they just send us the data and we start production without necessity of manual modelling.
		Employ lower skilled people in production									F: We invested in the latest robot technology for reducing manual work steps.
											C: We maintainance and resulting down time of our clients at a much more detailed based on data from our automated database.
											D: Automated troubleshooting & control steps reduce the human factor as source of failure.
											A: We shift time towards preparation of production and client advisory; but production itself and assembly work much faster.
	How can your firm increase the efficiency of its processes?										E: All stations of production are computerized. Based on the data of our web configurator, we send the production program to all machines.
											C: Our products have Ethernet interfaces, enabling us to offer remote service, and to improve products, production & assembly processes constantly.
											D: We use web-based ERP and other software for process optimization.
											C: Our staff is a way from the office for weeks. Via cloud access, they do time recording constantly, which enables us to send invoices within 1-2 weeks.
											D: We have a lot of knowledge within the company; emails are often deleted without being read, so we use a platform for sustainable knowledge sharing.
											A: With our digitized production processes, already an apprentice can build a full-fledged wardrobe.

Appendix 2-3: Digital transformation strategy – Changes in Value Creation (2/2)

Strategic Dimension	Strategic Question	Strategic Option	Description	A	B	C	D	E	F	G	Highlighting Examples
Changes in value creation (2/2)	How can your firm leverage efficiency across its value network?	Outsourcing in production	Efficient allocation of technological production capabilities across value chain, e.g. focus on production of selected goods, preliminary production steps, or design and on-site assembly	x	x			x			A: Suppliers do windows and doors today. B: For other laboratories, we do the milling, because they do not own the necessary machinery. E: Competitors have become clients.
		Outsourcing of program-ming/IT	self-explanatory, incl. IT conceptualization	x	x	x	x	x	x		B: Our management software is developed and hosted by a partner company, who works for other craft businesses as well. E: For IT conceptualization and programming we work in tight relation with a partner.
		Use standard interfaces for automated data exchange	Automated ex-change of product or process data between company, suppliers, or customers			x	x				C: Our electronic machine plans can be integrated in customers' production planning tools. D: We use EDI interfaces to our important customers, so they can place orders directly into our order management tools.
	Changes in value creation (2/2)	Technological education of business partners	Tight interaction between company and key business partners for joint digital progress		x					x	B: We offer apprenticeships for future dentists, so they understand what we do and why we do it. G: At the beginning, we were just involved in projects for sewing. Now we have the knowledge on technology, so we teach the engineers in team works.
		Never with regard to communication	Communication to customers or partners via website, email, social media etc.	x	x	x	x	x	x		B: One click - and insurance companies and doctors receive the correct data set based on our own production data E: Amazon et al. set the standards - we need to keep in touch with our customers, updating them on their order progress A: For us as a production-oriented enterprise, digitalization in production is necessary; otherwise, we cannot stay competitive. F: Digital supported cutting becomes the new industry standard, we have to stay competitive.
		Never in production	Digital production technology	x	x			x	x		A: Especially if you are a small business, you have evaluate carefully potential benefits of digital technologies. F: If I put digital cutting data in the hands of unreliable foreign production partners, there is a high risk of my data getting stolen.
	Where is it an option not to engage in digital transformation?	In case of negative economics	Proven economic disadvantages (incl. high risk of knowledge theft) or no impact of digital technology on craft	x	x			x			B: We send an electronic invoice, but our customers call and say: Please, we need a paper-based invoice with the delivery note. D: Digital invoicing technically is not a problem, but some customers require it for documentation reasons.
		In case of customer requirements	Customers require paper-based exchange of information, e.g. due to missing interfaces or not suitable processes	x			x				

Appendix 2-4: Digital transformation strategy – Organizational Changes

Strategic Dimension	Strategic Question	Strategic Option	Description	A	B	C	D	E	F	G	Highlighting Examples
Organizational changes	Who is in charge of the digital transformation endeavor?	Joint responsibility of management team	Management team as a whole	x	x	x	x	x	x		A: We have separated responsibilities among the management, but decisions for transforming actions we always take together. C: There is a technical director in charge of technological developments, but strategic decisions are taken among the whole management team.
	Do you plan to integrate new operations into existing structures or create separate entities?	Owner manager	Owner manager of company							x	G: I am the one responsible for digital transformation. The others are not interested in these topics.
		Integrated	Digital operations are fully integrated into an organization's current structures - default setting	x	x	x	x	x	x	x	A-F: The legal entity structure is determined by other considerations than digital advancements
		Separated	Digital operations are implemented separately from the core business	(x)							G: We are just about to found a separate entity for our technology topics; especially from a liability perspective there is no alternative. x (B): We have some developments in our pipeline. Maybe one day we will found a separate entity for their realization.
	What types of operational changes do you expect?	Business Processes	Improvement of business processes	x	x	x	x	x	x		B: Costs are lower; quality is higher with increasing use of digital production techniques. D: There are still so many processes involving paper and manual actions that can be digitally optimized.
		Skills	A new set of skills based on digital technologies		x	x	x	x	x		D: The usage of digital communication tools becomes mandatory; it must enclose non-digital as well as digital natives. F: The orchestration of sales via digital platforms, using digital CRM, will require other profiles than our current sales force.
		Products and services	Changed products and services	x	x	x	x	x		x	A: Clients' expectation increased due to exploding numbers of design & functional options. B: The handling of many new materials is enabled via digital production techniques.
	How can your firm realize a necessary employee structure?	Develop existing staff	Foster employee's general willingness to develop additional knowledge	x	x	x	x	x	x		A: Our staff acquires relevant competencies via education, mainly by the manufacturers of our machinery. D: The advent of digital technologies does not necessarily require new people; but some activities are added to existing jobs, becoming daily routine.
		Attract young/ digital affine employees	Attract young employees to adapt digital technology - also without formal qualification	x	x	x	x	x	x		B: We do many things in an individual way, so digital affinity and curiosity are more important than traditional, manual proficiency. C: External expertise helps analyzing own habits and find innovative solution.
		Regular feedback from staff	Self-explaining			x		x			C: We sit together once a month and discuss opportunities for improvements; the people who work outside in the field have good ideas. E: Our team meets weekly and we collect ideas, besides giving feedback and discussing other topics of importance.
How can you personally acquire necessary competencies and inspiration?	Professional associations	Chamber of skilled crafts, guilds, etc.	Chamber of skilled crafts, guilds, etc.	x	x	x	x	x	x		A: Companies organized in guilds typically are well informed on future developments, via information materials, training courses, etc. A-G: Technology experts of the chamber of skilled crafts help us, e.g. regarding public funding options, patent handling, events on digital topics, etc.
		Experience exchange groups	Voluntary networks with other company owners from same industrial background	x		x					A: We visit operating sites of the involved partners twice a year, and see how machines and programs work, and get inspiration. C: It is a group of machine tool manufacturers. We sit together and sometimes I get inspired for new products.
		Visit trade fairs	Self-explaining	x	x		x	x			A: Sometimes we see a new machine on a fair and think what we can do with it. B: It is important to visit some fairs, look around and talk to people on opportunities and market developments.
	Vertical network	Voluntary networks across industries, incl. practitioners and scholars	Voluntary networks across industries, incl. practitioners and scholars	x		x		x	x		D: For research and development we work in some university projects. F: We just developed a new product cooperating with a scientific research institute.

Appendix 2-5: Digital transformation strategy – Financial Aspects

Strategic Dimension	Strategic Question	Strategic Option	Description	A	B	C	D	E	F	G	Highlighting Examples
Financial aspects	How strong is the financial pressure on your current core business?	High	Digital technologies erode margins	x					x		A: In some core products, prices are declining since years without a perspective of bottoming up. F: There is a lot of competition; by working through the weekends, we were able to be profitable at yearend.
		Medium	Digital technologies affect core business margins, but the core business remains profitable	x	x						A: In other products we see declining margins due to investment necessities - if you start with digital technologies, you have to do updates regularly. B: We see margins declining, but slower than expected.
		Low	Margins in the core business remain mostly unaffected by digital technologies								
	How will you finance the digital transformation endeavor?	Internally	Finance digital transformation through internal funds	x	x	x	x	x	x		B: We fund all our year-round investments from our cash flow. F: We went the classical journey via our house bank and cash flow financing.
		Public funds	Publicly supported funding	x		x	x	x	x		D: We receive publicly subsidized loans via our savings bank. E: The "Digitalbonus" helps; this public grant backed half of our investments.
		Externally	External equity financing necessary to finance digital transformation						x		G: We have to use all financing options possible for gaining headroom for incremental growth, e.g. private equity in the form of venture capital.
		Crowdfunding	Self-explaining						x		G: Being innovative in financing issues is as important as being innovative in product development. That is why we also use crowdfunding.