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Technology Impact Types for Digital Transformation

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Abstract—*Digital transformation is based on direct and indirect effects of the application of digital technologies and techniques on organizational and economic conditions on the one hand and new products and services on the other. Its impact can be distinguished in three dimensions: value creation model, value proposition model and customer interaction model. The paper provides a generic model that helps exploring potential cause-effect relationships between the application of digital technologies and their impact on a company along the three dimensions. Based on 75 case studies, the outcome is threefold: (1) a systematic categorization of digital technologies, (2) a set of 10 detailed impact types of digital transformation along with their subgroups, and (3) a coherent model of technologies, causes and impact types along the three dimensions of digital transformation.*

Keywords—digital transformation, digitalization, technology impact, digital technologies, ICT

1 Introduction

Digital transformation is based on direct and indirect effects of the application of digital technologies and techniques on organizational and economic conditions on the one hand and new products and services on the other. Besides constantly increasing computing power and miniaturization of classical IT components, the ubiquitous integration of these components into all types of technology has to be taken into account, especially in conjunction with:

- comprehensive use of sensors and actors including audio and video recordings,
- use of mobile communication technologies for networking and automated communication with very low latency (Internet of Things),
- elicitation, archiving and processing of very large data sets with the application of big data techniques,
- various techniques of machine learning,
- advanced forms of human-computer interaction.

Particularly, the combination of these factors leads to new potentials for comprehensive automation of cognitive und mixed mechanical-cognitive tasks. Current examples for the first are automated comparisons of legal documents, for the latter self-driving cars or the autonomously flying drones. Further relevant techniques simulate or extend reality with digitally generated information (virtual/augmented reality).

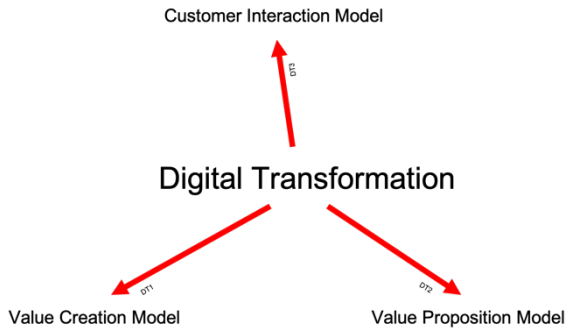

Figure 1: Dimensions of Digital Transformation

The impact on enterprises and industries can be distinguished in three dimensions (fig. 1): *value creation*, *value proposition* and *customer interaction* [43]. The first dimension includes the technology influence on business processes, the general organization of an enterprise, and its workforce. The second dimension includes the influence on the selection of products and services proposed to the market and their according revenue models. The third dimension includes all types and mechanisms of interaction with customers, and especially impacts of platform-economy dynamics [44]. Digital transformation does highly impact a company's business activities and therefore its success as available academic and practical contributions indicate. However, there is still little knowledge on the implications in their entirety and how this is induced by the exploitation of specific digital technologies. Against this background, the aim of the paper is to provide a theoretical foundation that helps to further explore potential cause-effect relationships between the application of digital technologies and their impact on the enterprise along the three different dimensions. Based on 75 case studies, the outcome is a technology categorization with 22 characteristics to be considered in a digital transformation project on the one hand and a set of 10 detailed impact types of digital transformation along with their subgroups on the other hand.

The rest of the paper is organized as follows: In section 2 we conduct a literature review and describe our methodical approach. In section 3 we identify relevant technology characteristics and their instances. In section 4 we develop a full set of technology impact types and their subgroups, resulting in a generic, coherent model that summarizes technologies, causes, and impact types and followed by a conclusion in section 5.

2 Background

2.1 Literature Review

Digital transformation affects many industries as digital technologies increasingly change the way companies create and offer their propositions and interact with their customers [43]. The combination of new technologies with innovative methods of data processing and analysis not only improves and disrupts existing business processes, but also enables completely new business models and markets [11][48]. Consequently, companies need to react properly to such digitally induced changes (Gimpel16) by developing and pursuing adequate strategies to exploit digital technologies in order to ensure or enhance competitiveness in global markets [6][31][39]. The notion of digital transformation has been conceptualized in several ways. What most definitions have in common, is that they refer to digital transformation as a (massive) change process that companies undergo due to the emergence of new technologies and its social and economic implications [43][33]. Research on digital transformation has proliferated within the last years as the number of contributions and research calls indicates.

Some research papers shed light on the current state of the art by providing literature reviews on certain facets of digital transformation, e.g. concepts [33], impact areas [20], drivers, success factors, implications [38], or the IT of organizations [16]. Empirical contributions often concentrate on specific aspects. Some of this research delivers insights on digital transformation processes or effects within specific industries, such as automotive [ChHe18], healthcare [1][50][17], fashion retailing [22], newspapers [26], financial services [12], or public procurement [35]. Other contributions focus on specific components of digital transformation within companies, such as strategies [17][53][31] and its implementation [4], agility [15][32], drivers [30][28], challenges [21], or customer experience [47], decision-making [42] and engagement [51]. Likewise, the role of social media [2], enterprise architecture [18][25], or staff, organization and culture is examined [34][19][14][27].

However, there is only little knowledge on the potential impact of digital transformation processes of companies. [33] derive the following key impacts by means of a concept-oriented literature review: value creation, operational efficiency, competitive advantage, and improved relationships. Likewise, [20] conduct a systematic literature review to explore how digitalization transforms business models, operational processes, and user experience. [38] pursue a similar approach and deduce the following three implications as a result of digital transformation: reformed IS organization, new business models, effects on outcome and performance. [24] review the role of bimodal IT in organizations and conclude that digital transformation will raise the coexistence of traditional *and* digital IT. [3] propose approaches to manage the impact of digital transformation on information systems.

Empirical contributions, in contrast, often focus on very context-specific impacts (e.g. automotive [8]). [40] investigate the impact of digital transformation on automotive organizations highlighting the emergence of physical-digital paradoxes, while [23] find out that OEMs are more likely to master digital transformation if they are able to acquire, integrate and commercialize external knowledge on digital technologies. Likewise, other researchers reveal how digital transformation affects the organization of large manufacturing companies [7] or sourcing strategies of companies. Specifically, [13] demonstrate that a financial service provider's outsourcing motivation has shifted from cost reduction to innovation, resulting in a decline in offshoring activities. [45] explore the increasing role of multi-sided platforms in the insurance value network, which get empowered by exploiting digital technologies.

Other contributions investigate the role of cloud-based process changes. ICT service providers might benefit from the virtualization of their services in terms of a cloud-based digital transformation [10], while SMEs can improve their organizational performance resulting from service-oriented digital transformation activities, such as B2B-portal functionality [9]. [37] ascertain the positive influence of digital transformation on the performance and innovation competencies of a company. Similarly, digital transformation can improve information quality and therefore help firms sense and respond to customer needs [49] or to increase performance due to the visibility of work, respectively [52].

Altogether, the existent literature examines several aspects of digital transformation activities. However, it is missing a generic framework that covers digital transformation in its entirety and contextualizes causes, impacts and potentials of digital transformation activities in a structured manner. Therefore, the aim of this paper is to pursue a holistic and concept-oriented approach to provide such a generic model on an empirical, technology-focused basis that might give direction to explore potential cause-relationships of digital transformation activities and projects.

2.2 **Methods**

In order to gain a deeper understanding on how digital transformation can affect a company, we aim to empirically explore the various impact types from exploiting digital technologies. For this purpose, we apply a three-step approach. First, we systematically screened and categorized digital technologies on the basis of existent literature resulting in a hierarchically structured technology framework. Second, we conducted a multiple, concept-oriented case-study analysis in order to explore the multiple facets of potential impacts on the basis of 75 companies that have undergone digital transformation processes. Third, we inductively aggregated these impacts, resulting in 10 impact types. Following this approach, our research started with a systematic technology screening. For the sake of completeness of the technological foundations of digital transformation, we detected and screened existent literature on digital technologies both from research and practice. Starting with the Gartner Hype Cycles from 2016 to 2018 and coherent guidelines on evaluating emerging technologies according [41], we progressively complemented our technology portfolio with findings from academic (Information Systems, (Business) Informatics, Technology Management, Computer Science) and practical contributions (white papers, trend reports, annual reports, IT association guidelines, technology manuals) until theoretical saturation. In academia, this includes research and catchword papers focusing on specific technologies (e.g. [36, 29]); in practice, we mainly screened publications from consulting and IT companies (e.g. PwC, SAP) as well as associations (e.g. Bitkom), complemented by an analysis of real-world cases.

For a systematic and complete categorization of the technologies identified, we applied the morphological method, a highly systematic approach for structuring multi-dimensional problems. It is particularly suitable for the exploration of complex problems that cannot be solved with formal (mathematical) methods, causal modeling, or simulation. The approach involves the identification and definition of the investigated problem's essential characteristics and the assignment of relevant instances to each characteristic. The aggregate of all critical characteristics and instances is represented by a morphological box, which allows for a structured analysis, systematization, and comparison of complex phenomena [55][46].

Hence, we first identified the main technology categories as characteristics before exploring and determining their distinct instances, i.e. subordinate digital technology types. The result is a complete morphological box with disjoint technology categories and types. The morphological box has been extended, modified and validated through the application and instantiation with real-world cases as well as discussions with practitioners and researchers. In order to provide a better understanding of how the technology categories related to each other we derived and developed

a hierarchically structured technology framework. The framework helps to classify the technology categories by means of convergence, networking and data processing capabilities, and thus, complexity and sophistication of the respective technology types.

Based on the theoretical foundation of digital transformation and the technology framework, we conducted a multiple, concept-oriented case-study analysis in order to identify impact types from digital transformation activities for companies. A multiple-case study design is a viable research strategy to describe and understand scarcely explained but complex phenomena and to develop or test theory from empirical evidence [5]. Empirical cases therefore help to both explore and substantiate knowledge about theoretical constructs by means of a theoretical replication, i.e. cases must be selected carefully so that the case-study design can lead to contrasting results for anticipatable reasons [54].

Following these guidelines of multiple-case study research we developed a concept-oriented documentation scheme to protocol and analyze 75 empirical cases of companies from 40 industries and of different size that have undergone digital transformation activities or processes. Besides basic data about the company (e.g. sector, size, customer focus), several concepts have been applied to analyze each case: industry maturity and innovativeness, company innovativeness, market position, initial situation, competitive strategy, motivation for digital transformation activity, added-values generated, and the impact of the digital transformation process or activity. These impacts have been categorized by means of the three dimensions of digital transformation, i.e. value creation, value proposition, and customer interaction model. Each identified impact has been documented, labeled and assigned to one the dimension until theoretical saturation (i.e. adding more cases is not expected to reveal further impacts). Finally, all labeled impacts have been aggregated successively and inductively. We identified a total of 60 possible impacts of digital transformation resulting in 10 impact types.

Based on these impact types, which resulted from our multiple-case study, and in combination with the systematic technology review, we finally propose a coherent model of technologies, causes and impact types along the three dimensions of digital transformation.

3 Technology Framework

Our combined literature review and case study analysis resulted in three major areas of technology:

- communication and other enabling technologies,
- technologies combining hardware and software in intelligent systems,
- data technologies.

Communication and other enabling technologies comprise all digital technologies and techniques which provide the basis for the development of complex systems and are used across all industries. This starts with *mobile communication systems*. For Wide Area Networks (WAN), mobile telecommunications according to 2G/3G/4G/5G standards are used. Local area networks (LAN) within buildings or compounds typically rely on Wi-Fi connections according to IEEE 802.11 standard family, personal area networks (PAN) and ad-hoc networks on Bluetooth or near-field communication (NFC). *Auto-identification systems (Auto-ID)* are typically based on barcodes, radio-frequency identification (RFID), or biometrical systems. *Positioning* can be realized with different systems outside of or within buildings. Relevant characteristics are cell-of-origin in mobile telecommunication networks as well as satellite-based Global Positioning System (GPS) and its European/Russian/ Chinese equivalents GALILEO/GLONASS/BeiDou. *Additive manufacturing* produces workpieces by layering shapeless or shape-neutral materials on the basis of 3D construction data. 3D printing is especially suited to build complex, light and stable three-dimensional structures and integrate functions. 4D printing adds another dimension. This refers, e.g., to objects that change over time or over differing environmental conditions, such as self-arranging furniture or clothing that adapts to different weather conditions. Printed electronics bring integrated circuits directly on a basis material, such as RFID tags on badges or stickers. *Computer architectures* comprise traditional semiconductor electronics as well as the developing of nano electronics, quantum computing, neuromorphic chips, and biocomputers.

Table I: Technology Framework

	Characteristic	Instances							
Communication and other enabling technologies	*Mobile communication systems*	Mobile communications	WLAN	Bluetooth	NFC	Other	None / wired only		
	Auto-identification systems	Barcode	RFID	Biometrical systems	Other	None			
	Positioning	Cell of Origin	GPS	Indoor positioning	Other	None			
	Additive manufacturing	3D printing	4D printing		Printed electronics		None		
	Computer architecture	Semiconductor electronics	Nano electronics	Quantum computing	Neuromorphic chips	Biocomputer	Other		
	Operating systems (OS)	Desktop OS	Mobile OS	Embedded OS	Realtime OS	Other			
	Application software	Native desktop application	Native mobile app	Web app	Hybrid app	Embedded application	Other		
Combining hardware and software to intelligent systems	*Mobile devices*	Smartphone	Tablet	Wearable	Other	None			
	Stationary devices	Desktop computer		Laptop		None			
	Ubiquitous computing	Smart speaker	Smart clothing	Smart object / Embedded system	Reactive environment	None			
	Human-computer interface	(Multi-touch) display	Virtual reality	Augmented reality	Volumetric display	Conversational user interface	Virtual assistant	Gesture control	Other
	Technical augmentation of human body and mind	Brain-computer interface	Implants	Prostheses & Ortheses	Other		None		
	Robotics	Industry robot	Collaborative robot	Service robot	Humanoid robot	Autonomous mobile robot	Modular robot	Soft robot	Other	None
	Mobility	Connected vehicle	Autonomous vehicle	Drone	Vehicle sharing	Other	None		
	Internet of Things	Virtual equivalent	Spontaneous networking	Cyber-physical systems	IoT platform	None			
Data technologies	*Established database technologies*	Relational data model	Object-oriented data model	Hierarchal data model	Other	None			
	New database technologies	NoSQL database	In-memory database	Distributed file system	Blockchain	Other	None		
	IT infrastructure	Local	On-premise	Cloud computing	Serverless computing	Edge computing	Other		
	Data analytics	Data mining	Text & Sentiment	Video & Audio	Web	Geospatial	Predictive	Other	
	Big Data	Data integration	Batch processing (MapReduce)	Stream processing	Search & Discovery	Visualization & Dashboards	Self-service analytics	Realtime analytics	Other	None
	Artificial intelligence	Rule-based systems	Machine learning	Neural networks	General artificial intelligence	Other	None		
	Information security	Encryption	Biometrical systems	Hardware security	Software-defined security	Browser isolation	Cloud security	Deception	Other

While most of the latter might not be relevant to today's digital transformation projects, we include them to enable a holistic view on future technology options. Finally, the relevant type(s) of operating system(s) and of application software have to be specified.

At *combining hardware and software to intelligent systems*, we refer to eight components. *Mobile devices* basically comprise smartphones, tablets, and wearables. *Stationary devices* are typically desktop or laptop computers. *Ubiquitous computing (UC)* might integrate smart speakers, smart clothes, smart objects/embedded systems or reactive environment. The *human computer interface (HCI)* uses (multi-touch) displays, virtual reality, augmented reality, volumetric displays, conversational user interfaces, virtual assistants, and gesture control.

The characteristic *technical augmentation of human body and mind*, often also referred to as *human enhancement*, comprises technologies and techniques used directly connected to or even integrated in the human body for recovery, performance improvement or functional enhancement. Relevant instances include brain computer interfaces, implants, and prostheses or orthoses. *Robotics* refers to robots as typical actors in a technical system which exert physical influence on the environment. Instances can be classic industry robots, collaborative robots, service robots, humanoid robots, autonomous mobile robots, modular robots, and soft robots, e.g. using soft plastic resembling to human arms for gripping devices, often also using pneumatic control in order to grip fragile objects. Robots can be used in very diverse form factors – in Japan, for instance, as pets. The last two categories are *mobility* in various settings and *IoT functionality*, especially including virtual equivalents ("digital twins"), spontaneous networking, and cyber-physical systems.

Finally, the characteristic *data technologies* consists of seven components. *Established database technologies* refer to the classic three data models, *new database technologies* to NoSQL, in-memory, distributed file systems, or blockchain. *IT infrastructure* can be local, on-premise, cloud, serverless or by means of edge computing. The characteristic *data analytics* comprises (classic) data mining and predictive analysis as well as in particular the distinction of text&sentiment, video&audio, web, and geospatial data. Next are *big data* techniques including data integration, batch processing (MapReduce), stream processing, search&discovery, visualization&dashboards, self-service analytics and real-time analytics. The use of *artificial intelligence* includes rule-based systems, machine learning, neuronal networks and general artificial intelligence. While the latter always draws special public (and political) attention, its existence seems to be a very far prospect. The final category is the use of *information security* techniques. Table 1 shows our categorization with all major areas, characteristics and instances of digital technologies by means of a morphological box according to [55].

4 Derivation of Impact Types

As our literature review indicates, digital transformation is a complex and multifaceted phenomenon. Its convergent character makes it barely possible to assign the eclectic impacts distinctly to their underlying causes and technologies (see section 3). In order to gain a deeper understanding of how these technologies might be exploited for digital transformation and how this finally affects a company’s business activities, we conducted a concept-oriented case-study analysis. Thus, we considered 75 real-world companies which have undergone a digital transformation process, of different size and from different industries (e.g. financial services, retail, telco, manufacturing, agriculture). As a result, we identified 60 possible impacts, which we inductively aggregated to a full set of 10 impact types. This section aims to discuss these impact types, resulting in our schematic impact model for digital transformation activities and processes (see table 2).

Digital transformation processes and activities can have various implications. Some are intended, others are not, some become immediately apparent, others arise years later. We grouped the impact types according to the dimensions shown in section 1.

Table II: Technology Impact Types for Digital Transformation

#	Impact Type	Impact	Description
1	process alignment	transparency	transparency for management can be increased
		speed	processes get faster
		efficacy	processes get more effective
		efficiency	processes get more efficient
		integration	processes can be combined to new integrated processes
		automation	human work power can be replaced
		legal requirements	legal requirements are met
		customer involvement	degree of customers' process participation changes
		supply chain	upstream processes are tied in with internal processes
2	staff	skill shortage	skill shortage can be addressed
		empowerment	employees get involved in decision-making
		creativity	creativity is fostered or contained
		inspiration	inspiration can be drawn
		safety + health	importance of wellbeing of staff changes
		recruiting	new staff can be recruited with new approaches
3	exploitation of data	key performance indicators	digitization and digitalization allow for new KPI and testing
		digital twins	physical objects (and their states) can be mirrored digitally
		information gain	customers/employees can access more, better, or recent information
		customer data	data on customer behavior or needs is accessible
		market data	market data allows for improved market analyses and supply
		real-time data	real-time data can be processed and exploited
		monitoring	objects, facilities, or persons can be monitored (remotely)
		ubiquitous data	data and analyses can be accessed without time/space restrictions
4	networks	networking	different stakeholders can interact with each other
		cooperation	different stakeholders can cooperate with each other
		platforms	different stakeholders can trade with each other
		network effects	network effects impact the company's performance
5	business development	core business	(offline) core business is affected
		business model adjustment	new (data-based) business models are rendered possible
		business prospects	business can grow and decline
		organizational structure	intra-organizational structures are aligned
		outsourcing	units or tasks can be outsourced
		resource dependency	(digital) resources can be possessed or exploited more independently
		third-party dependency	degree of dependency on service or product providers changes
		structural dependency	degree of organizational flexibility changes
6	product development	product innovation	innovative products/services can be invented
		product creation	new or better products/services can be created
		product integration	products and/or services get combined
		aggregation	products and/or services are aggregated to portfolios or platforms
		design	new designs can be created
		customization	products or services can be customized to customer needs
		cost reduction	product/service helps customers to save money or time
		product quality	product/service quality can be modified
		update functionality	products or services can be updated (continuously)
		interoperability	products/services are compatible with other products/services
		add-ons	up-/cross-selling opportunities appear
		digital enabler	product/service helps customers with their digital transformation
7	customer behavior	customer attitude	company-related customer experience shifts
		customer decisions	the way customers make purchasing decisions is affected
8	customer relations	customer services pre-sales	pre-sales customers service quality changes
		customer services after-sales	after-sales customers service quality changes
		customer support	quality of customer support changes
		user experience	user experience quality changes
		community building	community building is rendered possible
		customer retention	customer retention is affected
		lock-in	customer is locked-in within the ecosystem
9	channel management	customer interface	style of communication, interaction, or transaction changes
		channel development	mode of communication, interaction, or transaction changes
10	marketing	marketing mix	new ways to promote the product/service are rendered possible
		brand	company brand is affected

With respect to the value creation model of a company the first impact type refers to *process alignment*. The implementation of digital technologies can affect the business processes in many ways, i.e. transparency, speed, efficacy, efficiency, integration, automation. In some cases, process alignment aimed at meeting (new) legal requirements, changing the degree of the customers' process involvement, or tying in upstream processes of suppliers with internal ones. Another impact type relates to the *staff* of a company. At this, digital transformation can change recruiting practices and help addressing skill shortage. Other activities can increase employee empowerment or foster creativity, inspiration, or safety and health of the staff.

The third impact type considers new opportunities resulting from the *exploitation of data*. Basically, the availability of new data sources allows for new key performance indicators and an accurate testing of processes or units for efficacy, efficiency, or profitability. Physical objects and their conditions can be mirrored (digital twins) and monitored digitally, supported with real-time data from anyplace (ubiquitous data). Likewise, more, new, better, or more recent data from market or customers can be retrieved. As a result, management, employees, or even suppliers, and customers can access more information individually. The forth impact type subsumes implications from *networks* that allow for interaction, cooperation, or transaction with other market participants, which eventually arise from or result in network effects.

Other impact types are rather related to the value proposition model of a company. Basically, digital transformation can impact the business or the product development activities. Hence, one impact type covers the *business development* of companies. Particularly, traditional companies sense the implications of digital transformation on their (offline-based) core business. The exploitation of digital technologies might either impair or promote the core business, if intended or not. Accordingly, the underlying business model might be modified by digital transformation. This includes the adaptation to new revenue sources, customer segments, resources, or suppliers. Digital transformation might also affect the business prospects of a company. For instance, extending the business model might lead to a growth of business, while external factors (e.g. a lack of demand) can easily force a decline. Such developments might require shifts within the organizational structures or a careful deliberation of the outsourcing strategies. Moreover, digital transformation can either increase or mitigate the dependency on resources, market participants, or structural circumstances (e.g. political or environmental).

Another impact type refers to digitally-induced implications on *product development* as digital transformation gives rise to completely new products and services (product innovation) or improved or modified versions of already existing ones (product creation). Additionally, products and services can be combined to integrated bundles or aggregated with complementary products or services with added value for the customer, e.g. on platforms. Digital technologies do also pave the way for new design configurations as well as customized products and services according to the customers' individual needs and configurations. Especially, mass customization can combine low-cost units of traditional manufacturing with the flexibility of individual customization. Moreover, digital technologies can be exploited for reasons of cost reduction or changes in product quality or simply to offer update functionalities, interoperability, or add-ons. Lastly, companies can purchase enabling products or services for their own digital transformation.

Impact types in the context of customer interaction imply customer behavior, customer relations, channel management, and marketing. Regarding *customer behavior*, companies might conduct digital transformation activities in order to influence the customer attitude towards the brand or manipulate the way they make (purchasing) decisions. As a consequence, the way companies maintain *customer relations* is adjusted alike. This implies changes in the quality of customer service (pre-/after-sales) and support and in the techniques to create user experience. Moreover, companies attempt to increase customer loyalty with digital transformation activities.

For that reason, innovative methods of community building and customer retention can be applied, while lock-in effects can be capitalized. Such activities require changes of the *channel management*, which involves modified styles and modes for communication, interaction, and transaction with the customers. On the one hand, look and feel of the channels can be redesigned. On the other hand, the channel portfolio can be adjusted accordingly, e.g. by pursuing either multichannel or omnichannel strategies. In terms of *marketing*, digital transformation can affect the marketing mix of a company as it allows for several new ways of promoting the products and services to the customers. In some cases, digital transformation affects the brand of a company as it can raise brand awareness or enable a rebranding, a brand refresh or the creation of new (affiliated or subordinate) brands.

All in all, our case-study research has revealed 10 impact types across the three dimensions, originating from digital transformation processes or activities of 75 companies. Such processes or activities have always entailed – intended or unintended – an impact on value creation, value proposition, or customer interaction. What is more, each digital intervention revealed a plethora of impacts which might even correlate or cross-fertilize. However, all impact types have their origin in the five underlying causes of digital transformation. Figure 2 illustrates the complex relationship among the underlying causes, resulting impact types, and affected dimensions of digital transformation by means of a coherent model.

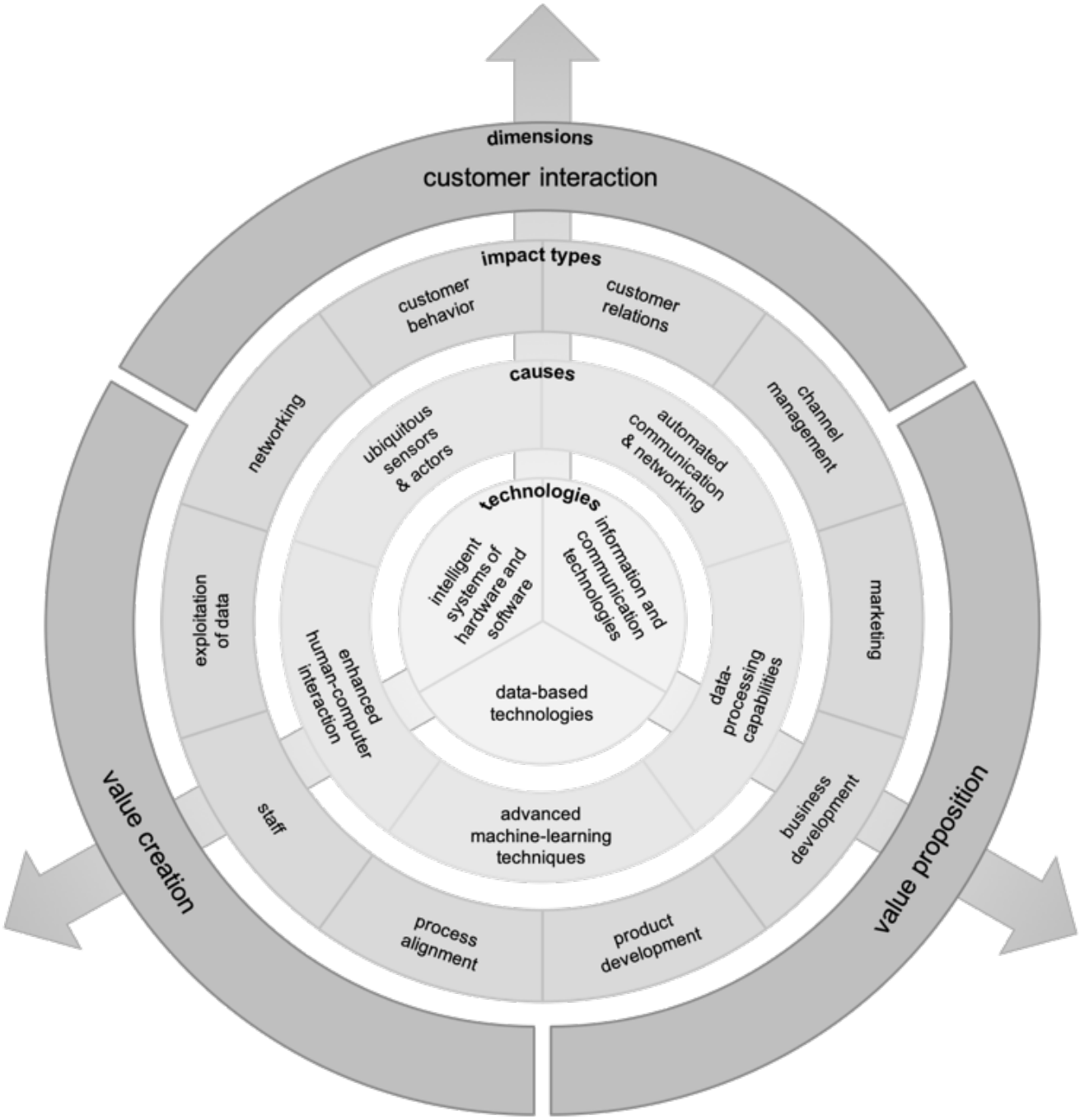

Figure 2: Technologies, causes, impact types, and dimensions

5 Conclusion

The starting point for our considerations was to better understand and systemize the impact of the application of digital technologies and techniques on organizational and economic conditions on the one hand and new products and services on the other. We explored the impact on companies along the three dimensions of digital transformation: value creation model, value proposition model, and customer interaction model, using data from 75 cases studies from 40 industries.

The outcome of the paper is threefold. First, we developed a technology categorization with 22 characteristics to be considered in a digital transformation project. Second, we derived a full set of 10 detailed technology impact types along with their subgroups. Third, we systemize our results in a coherent model of technologies, causes and impact types along the three dimensions of digital transformation.

For researchers, our results provide a more generic understanding of digital transformation by means of a holistic model that covers technologies, causes, and impact types along the three dimensions of digital transformation. Thus, the model give direction to potential cause-effect relationships of digital transformation activities and projects.

For practitioners, our results can be used as a reference and as a creativity tool to define a distinct technology mix or systematically develop the future business model along the three dimensions by considering both the technologies and impact types. For instance, our model could be used to explore the potential solution space for an enhanced digital customer interaction model by selecting and exploiting appropriate technologies consciously. Moreover, our results can serve as a basis for assessing a company's status quo of digital transformation and deliver a spectrum of potential implications of future digital transformation initiatives.

Future research could focus on further complement and conceptualize the impact types of digital transformation or even shed light on the correlation between the antecedents and implications of digital transformation processes and activities. Other contributions could differentiate between the exploration and exploitation of digital technologies to initiate transformation processes by empirical cases. From a more conceptual standpoint, research could extend existing theory to further explore and explain the phenomena of digital transformation, e.g., by applying the sociological concepts of hemostasis and entropy.

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