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Digital transformation: A multidisciplinary reflection and research agenda☆

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ABSTRACT

Digital transformation and resultant business model innovation have fundamentally altered consumers' expectations and behaviors, putting immense pressure on traditional firms, and disrupting numerous markets. Drawing on extant literature, we identify three stages of digital transformation: digitization, digitalization, and digital transformation. We identify and delineate growth strategies for digital firms as well as the assets and capabilities required in order to successfully transform digitally. We posit that digital transformation requires specific organizational structures and bears consequences for the metrics used to calibrate performance. Finally, we provide a research agenda to stimulate and guide future research on digital transformation.

1. Introduction

Digital transformation and resultant business model innovation have fundamentally altered consumers' expectations and behaviors, pressured traditional firms, and disrupted numerous markets. Consumers have access to dozens of media channels, actively and effortlessly communicate with firms and other consumers, and pass through rapidly increasing number of touchpoints in their customer journey, many of which are digital (e.g., Lemon & Verhoef, 2016). At the company level, many traditional firms have been surpassed by innovative fast-growing digital entrants, and suffered as a result of this. For example, fast growth of online retailers, such as Alibaba and Amazon, has strongly affected traditional retailers, as evidenced by the bankruptcies of several former retail giants such as Toys 'R'Us, Claire's and RadioShack. However, these new online retailers do not limit their reach to traditional retail industry; they use their digital resources to enter markets that were previously thought to be completely unrelated to retail, in search of further growth opportunities. Banks such as ING, consider Amazon as a major potential competitor, while one of the largest global shipping companies Maersk is facing potential competition of Alibaba. Such market disruptions have affected other industries as well: with Spotify substantially changing the music industry (e.g., Wölmert & Papies, 2016), TiVo and Netflix disrupting the TV broadcasting and film industry (Ansari, Garud, & Kumaraswamy, 2016), and Booking.com and Airbnb fundamentally altering the hotel industry.

Despite the ubiquity and visible impact of digital transformation and resultant new digital business models, the academic literature has so far paid surprisingly little attention to these developments, only recently starting to address the topics of digitization, digitalization, and digital transformation (e.g., Venkatraman, 2017). Until now, digital change has received most attention within specific business disciplines. For instance, marketing researchers have mainly focused on digital advertising and social media effects including attribution model developments (cf. Lamberton & Stephen, 2016; Kannan & Li, 2017) and multi-channel and omni-channel developments (e.g., Verhoef, Kannan, & Inman, 2015). The strategic management literature has mostly focused on the conceptualization, operationalization and renewal of (digital) business models (e.g., Foss & Saebi, 2017; Osterwalder & Pigneur, 2010). In the information systems literature, researchers have traditionally paid strong attention to technical developments regarding adoption and use of digital technologies and resultant business value (e.g., Nambisan, Lyytinen, Majchrzak, & Song, 2017; Sambamurthy, Bharadwaj, & Grover, 2003).

To the best of our knowledge, there has been no multidisciplinary discussion on digital transformation, which we define as *a change in how a firm employs digital technologies, to develop a new digital business model that helps to create and appropriate more value for the firm* (Kane, Palmer, Philips, Kiron, & Buckley, 2015; Liu, Chen, & Chou, 2011; Schallmo,

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Williams, & Boardman, 2017). We believe that such a multidisciplinary discussion is required, given that digital transformation is multidisciplinary by nature, as it involves changes in strategy, organization, information technology, supply chains and marketing. In today's business world, managers are increasingly confronted with responding to the advent of new digital technologies that blur market boundaries and change agent roles (e.g., customers become co-producers, competitors become collaborators, and firms that vertically integrate or bypass existing parties). In order to provide managerial guidance for digital transformation, we must increase our understanding of how firms can gain a sustainable competitive advantage by building on specific resources, which strategies they should adopt to win, and how the firm's internal organization structure must change to support these strategies. This paper thus contributes to existing discussions on digital transformation by taking a multidisciplinary focus. Moreover, this paper contributes to existing literature on digital transformation in itself (e.g., Kumar, Ramachandran, & Kumar, in press; Verhoef & Bijmolt, in press), because the emergence of digital transformation requires the building of a scientific knowledge base and development of a research agenda to stimulate the cumulativeness of future research in the multiple domains on this important topic.

In this paper, we aim to reflect on the phenomenon and the literature from multiple fields to aid an understanding of digital transformation and to stimulate future research by providing strategic imperatives and presenting a research agenda. We have the following three objectives: First, to identify the external factors that have strengthened the need for digital transformation. Second, to discuss the strategic imperatives that result from digital transformation regarding (1) required digital resources, (2) required organizational structure, (3) growth strategies, and (4) required metrics. Third, to present a research agenda that guides future (inter)disciplinary research on digital transformation.

In our discussion, we follow a commonly used flow model (depicted in Fig. 1) to describe the drivers, phases or levels, and imperatives of digital transformation (cf. Parker, Van Alstyne, & Choudary, 2016; Shah, Rust, Parasuraman, Staelin, & Day, 2006; Van Doorn et al., 2010). We start with a discussion on the external drivers of digital transformation, which presents the background of our discussion. Next, we analyze the literature from multiple disciplines to discuss the phases of digital transformation. Based on an understanding of these phases, we discuss the strategic imperatives that result from digital transformation, including digital resources, organizational structure, growth strategy, and metrics and goals. To conclude our discussion, we propose a research agenda for future research on digital transformation.

2. The need for digital transformation

We identify three major external factors driving the need for digital transformation. First, already since the coming of the World Wide Web and its worldwide adoption, an increasing number of accompanying technologies (e.g., broadband internet, smartphones, Web 2.0, SEO, cloud computing, speech recognition, online payment systems, and crypto-currencies) have risen that have strengthened the development of e-commerce. E-commerce global sales were $2.3 trillion in 2017 and e-retail revenues are projected to grow to $4.88 trillion in 2021 (Statista, 2019). The omnipresence of big data (e.g., Dong & Yang, in press; Wedel & Kannan, 2016) and advent of emerging digital technologies, such as artificial intelligence (AI), blockchain, internet-of-things (IoT), and robotics, are projected to have far-reaching effects on business (Chen, Chiang, & Storey, 2012; Iansiti & Lakhani, 2014; Ng & Wakenshaw, 2017). Although perhaps not each of these technologies will be as powerful as expected, the wide entrance of new digital technologies clearly signals the need for firms to transform their business digitally. Moreover, these new digital technologies may also affect the firm's cost structure through replacing costlier humans during service delivery with the help of robots or virtual agents or optimizing logistic streams and reducing supply chain costs through the use of AI and blockchain.

Second, due to these new digital technologies, competition is changing dramatically. In retail, technologies have disrupted the competition landscape, shifting sales to relatively young digital firms. Not only has the competition become more global, the intensity has also increased as big, information-rich firms from the U.S. (e.g., Amazon, Alphabet, Apple, and Facebook) and China (e.g. Alibaba, and JD) start

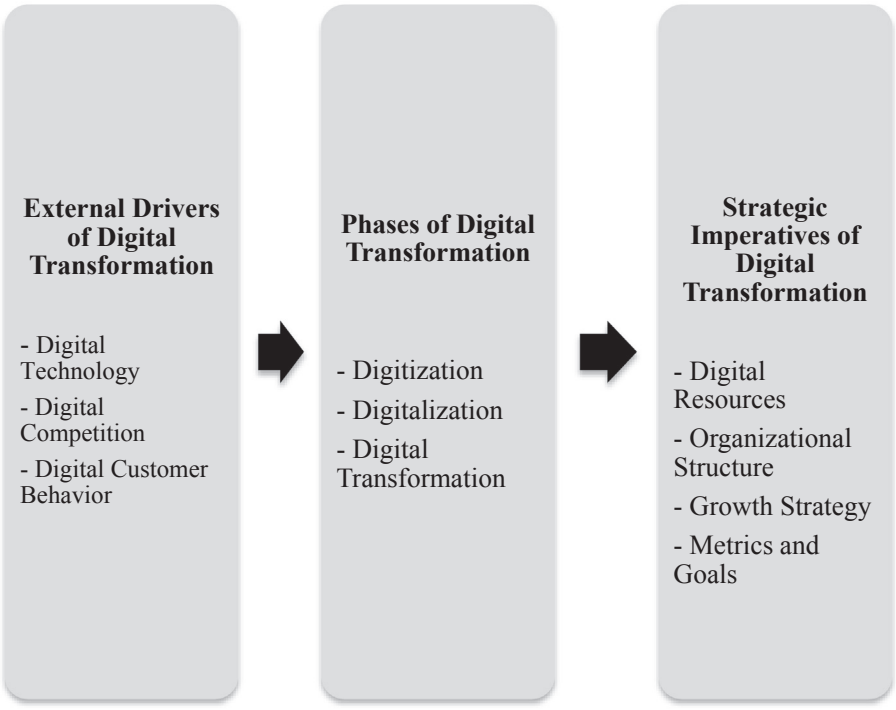

Fig. 1. Flow Model for Discussion on Digital Transformation.

to dominate numerous industries. Notably, changes in firm valuations strongly reflect this shift. Just a decade ago, the five most valuable firms of the S&P 500 Index included Exxon, GE, Microsoft, Gazprom and Citigroup, only one of which was truly digital. On May 2018, the S&P's top five most valuable firms were all digital including Apple, Alphabet, Microsoft, Amazon and Facebook. The dramatic rise of digital firms is even more noticeable given that the FAANG stocks (Facebook, Apple, Amazon, Netflix and Google), which constitute just 1% of the S&P 500, caused a massive surge between March and May 2017 of $260 billion in market valuation, while the remaining 99% lost $260 billion in the same period (Insider, 2017a).

Third, consumer behavior is changing as a response to the digital revolution. Market figures show that consumers are shifting their purchases to online stores, and digital touchpoints have an important role in the customer journey affecting both online and offline sales (Kannan & Li, 2017). With the help of new search and social media tools, consumers have become more connected, informed, empowered, and active (e.g., Lamberton & Stephen, 2016; Verhoef et al., 2017). Digital technologies allow consumers to co-create value by designing and customizing products, perform last-mile distribution activities, and help other customers by sharing product reviews (Beckers, van Doorn, & Verhoef, 2018; Grönroos & Voima, 2013). Mobile devices have become important in today's consumer behavior and facilitate showrooming behavior, the practice of examining merchandise offline, and then buying it online (e.g., Gensler, Neslin, & Verhoef, 2017). Consumers also strongly rely on apps, and new AI-based technologies, like Amazon's Echo and Google Home, that are entering consumers' lives. These new digital technologies are likely to structurally change consumer behavior (cf. Hoffman & Novak, 2017; Verhoef et al., 2017), and, consequently, the use of new digital technologies can easily become the new norm and defy traditional business rules. If firms cannot adapt to these changes, they become less attractive to customers, and are likely to be replaced by firms that do leverage such technologies.

3. The phases of digital transformation

Given the multidisciplinary nature and broad coverage of digital transformation research, we reviewed the multidisciplinary literature to understand what is known about firms' digital transformation. To better understand the existent knowledge, the intersection of different fields must be studied rather than relying on a single field (Tarafdar & Davison, 2018). A cross-discipline exchange of knowledge helps to better grasp the strategic imperatives of digital transformation, as it involves multiple functional areas, including marketing, information systems, innovations, strategic and operations management. Treating digital transformation — as existent research has done — in functional silos would potentially lead to ignoring relevant aspects or not optimizing cross-fertilization opportunities. For scholars, understanding the different research streams helps to stimulate the cumulativeness of research (cf. Foss & Saebi, 2017). For practitioners, it is necessary to bring together the insights from information systems, marketing, strategic management, innovation, and operations management in order to make sound organization-wide decisions about how to respond to digital technologies and implement digital organizational changes.

We conducted a scoping review approach (Paré, Trudel, Jaana, & Kitsiou, 2015) to understand how the multiple disciplines have conceptualized and defined digital transformation (See Appendix A). Our review of the different fields of information systems, marketing, innovation, and strategy reveals that all streams identify multiple phases or stages[1] of digital change, ranging from relatively simple to more pervasive changes. Based on our scoping review, we identify three phases of digital transformation: digitization, digitalization, and digital transformation. Most of the literature subscribes that the first two more incremental phases are needed to attain the most pervasive phase of digital transformation (Loebbecke & Picot, 2015; Matt, Hess, & Benlian, 2015; Parviainen, Tihinen, Kääriäinen, & Teppola, 2017).

Digitization is the encoding of analog information into a digital format (i.e., into zeros and ones) such that computers can store process, and transmit such information (Dougherty & Dunne, 2012; Loebbecke & Picot, 2015; Tan & Pan, 2003; Yoo, Henfridsson, & Lyytinen, 2010). Research also refers to digitization as a change of analog to digital tasks (Li, Nucciarelli, Roden, & Graham, 2016; Sebastian et al., 2017), or conceptualized it as the integration of IT with existing tasks, and, more broadly, as the development or enabler of cost-effective resource configurations using IT (Lai, Wong, & Cheng, 2010; Vendrell-Herrero, Bustinza, Parry, & Georgantzis, 2017). Based on the above, we define digitization to describe the action to convert analog information into digital information. Examples concern the use of digital forms in ordering processes, the use of digital surveys, or the use digital applications for internal financial declarations. Typically, digitization mainly digitalizes internal and external documentation processes, but does not change value creation activities.

Digitalization describes how IT or digital technologies can be used to alter existing business processes (Li et al., 2016). For example, the creation of new online or mobile communication channels that allow all customers to easily connect with firms, and which change traditional firm-customer interactions (Ramaswamy & Ozcan, 2016). Such a change often involves the organization of new sociotechnical structures with digital artifacts, which were not possible without digital technologies (Dougherty & Dunne, 2012). In digitalization, IT serves as a key enabler to seize new business possibilities by changing existing business processes, such as communication (Ramaswamy & Ozcan, 2016; Van Doorn et al., 2010), distribution (Leviäkangas, 2016), or business relationship management (Baraldi & Nadin, 2006). Through digitalization firms apply digital technologies to optimize existing business processes by allowing a more efficient coordination between processes, and/or by creating additional customer value through enhancing user experiences (Pagani & Pardo, 2017). Hence, digitalization is not only focused on cost savings, but also includes process improvements that may enhance customer experiences.

Digital transformation is the most pervasive phase, and describes a company-wide change that leads to the development of new business models (Iansiti & Lakhani, 2014; Kane et al., 2015; Pagani & Pardo, 2017), which may be new to the focal firm or industry. Firms compete and can attain a competitive advantage through their business models (e.g., Casadesus-Masanell & Ricart, 2010), which is defined to represent "how the enterprise creates and delivers value to customers, and then converts payment received to profits" (Teece, 2010: 173). Digital transformation introduces a new business model by implementing a new business logic to create and capture value (e.g., Pagani & Pardo, 2017; Zott & Amit, 2008).

Digital transformation affects the whole company and its ways of doing business (Amit & Zott, 2001) and goes beyond digitalization — the changing of simple organizational processes and tasks. It rearranges the processes to change the business logic of a firm (Li, Su, Zhang, & Mao, 2018) or its value creation process (Gölzer & Fritzsche, 2017). For instance, digital transformation in the healthcare sector is manifested by broad and deep use of IT that fundamentally changes the provision of healthcare services (Agarwal, Gao, DesRoches, & Jha, 2010). The use of IT is transformative and leads to fundamental changes to existing business processes, routines and capabilities, and allow healthcare providers to enter new or exit current markets (Li et al., 2018). Moreover, digital transformation utilizes digital technologies to enable interactions across borders with suppliers, customers and competitors (Singh & Hess, 2017). Hence, digital technologies can help to attain a competitive advantage by transforming the organization to leverage existing core competences or develop new ones (Liu et al., 2011).

[1] The literature uses phases and stages interchangeably. In the remaining of the paper, we refer to phases to indicate the pervasiveness of the digital change a firm undertakes.

Table 1
Strategic Imperatives according to Phases of Digital Transformation.

Type	Examples	Digital Resources	Organizational Structure	Digital Growth Strategies	Metrics	Goal
Digitization	Automated routines and tasks; Conversion of analog into digital information	Digital assets	Standard top-down hierarchy	Market penetration, (product-based) Market development, Product development	Traditional KPIs: Cost-to-serve, ROI, ROA	Cost savings: More efficient deployment of resources for existing activities.
Digitalization	Use of robots in production; Addition of digital components to product or service offering; Introduction of digital distribution and communication channels.	[Above] + Digital agility, Digital networking capability	Separate, agile units	[Above] + Platform-based market penetration, Co-creation platform	Traditional and Digital KPIs: User experience, Unique customers/users, active customers/users	Cost savings & increased revenues: More efficient production via business process re-engineering; Enhanced customer experience.
Digital transformation	Introduction of new business models like 'product-as-a-service', digital platforms, and pure data-driven business models	[Above] + Big data analytics capability	Separate units with flexible organizational forms, internalization of IT and analytical functional areas	[Above] + Platform diversification	Digital KPIs: Digital share, magnitude and momentum, co-creator sentiment	New cost-revenue model: Reconfiguration of assets to develop new business models.

Therefore, digital transformation is inherently linked to strategic changes in the business model as a result of the implementation of digital technologies (Sebastian et al., 2017).

In sum, digital transformation is a company-wide phenomenon with broad organizational implications in which, most notably, the core business model of the firm is subject to change through the use of digital technology (Agarwal et al., 2010; Iansiti & Lakhani, 2014; Li, in press). In pursuit of digital transformation, firms thus search for and implement business model innovation. To summarize, we describe the key characteristics of digitization, digitalization and digital transformation in Table 1.

Digital transformation is particularly relevant for incumbent firms. Incumbents will face challenges and barriers when searching and implementing business model innovation for digital transformation given their legacy. They are often forced to deal with conflicts and trade-offs between existing and new ways of doing business (Christensen, Bartman, & Van Bever, 2016; Markides, 2006). The move to digital may often require a marked departure from the status quo, and may lead to the obsolescence of existing business models (Teece, 2010). Incumbents may start with minor changes (e.g., digitization or digitalization) to gradually transform their traditional business into a digital one. For instance, automotive companies that enhance their customers' experiences by providing digital media access and enhanced security features via sensors that detect activity in blind spots to avoid accidents (Svahn, Mathiassen, & Lindgren, 2017). Ultimately, they may transform their businesses. For example, Volvo Cars is hiring C-suite digital officers and dedicates a major part of its R&D investment to digital initiatives to speed up digital projects such as autonomous driving and concierge services.

The different phases of digital changes toward digital transformation have important strategic imperatives for firms. We specify their impacts on required digital resources, organizational structure, digital growth strategies, and metrics in Table 1. In our subsequent discussion we mostly — but not exclusively — focus on the digital transformation stage, as this is the most pervasive and complex phase, and the main focus of our paper.

4. Strategic imperatives of digital transformation

4.1. Digital resources

Resources represent a firm's ownership and control of assets and capabilities (Barney, 1991). Assets represent the firm's resource endowments in physical and intellectual assets, while capabilities usually reside in the firm's human, information, or organizational capital, and glue assets together to enable their successful deployment. In pursuit of digital transformation, the firm's redefinition of how it creates and delivers value to customers often requires it to access, acquire or develop new digital assets and capabilities. In this section, we will highlight the most essential digital assets and capabilities needed for digital change: digital assets, digital agility, digital networking capability and big data analytics capability.[2]

Digital assets. Firms require digital assets, like the storage of data, information and communication infrastructure, and accompanying technologies to effectively compete in the digital era. Today's firms invest heavily in the development and acquisition of digital

[2] The focus of our discussion is on identifying relevant digital resources that firms need to transform their business digitally. We do not claim that our identified digital resources are unique to the digital context; for instance, digital agility and digital networking capability partially overlap with the resources of networking and dynamic capability as identified in the strategic management literature. We also do not claim that our list of resources is exhaustive as digital firms may require additional digital and nondigital resources to successfully transform their business.

technologies (hardware and software) to allow for AI, Machine Learning, IoT, and robotics. The endowments made in technologies and data provide the basic ingredients to leverage existing firm knowledge and other resources to create more value for customers. For example, big data (i.e., customer journey data) as a digital asset can be leveraged by using a firm's data analytical capabilities to personalize services and offers (e.g., Verhoef, Kooge, & Walk, 2016). We discuss these digital capabilities that can enhance the value of digital assets in the section below.

Digital agility. Digital agility concerns the ability to sense and seize market opportunities provided by digital technologies (Lee, Sambamurthy, Kim, & Wei, 2015; Lu & Ramamurthy, 2011; Tallon & Pinsonneault, 2011). Digital agility is vital for an incumbent's survival (Chakravarty, Grewal, & Sambamurthy, 2013). In today's dynamic and unpredictable markets, firms must be flexible: (1) to allow for the repeated switching of organizational roles; (2) to respond to the changing customer needs and introduction of new digital technologies; and (3) to respond to the intensified competition due to the blurring of market boundaries and removal of entry barriers (Chakravarty et al., 2013; Lee et al., 2015). To respond to these challenges, firms should be digitally agile to continuously modify and reconfigure existing digital assets and capabilities (Eggers & Park, 2018; Lavie, 2006). This will also have implications for the organization structure (see Section 4.2).

To achieve digital transformation, digital agility is needed to recombine digital assets with other organizational resources in order to change the way of doing business. By continuously sensing and seizing market opportunities, digital agility fosters the recombination and development of new products, services and business models that enhance the value created for the customer (Karimi & Walter, 2015; Sambamurthy et al., 2003; Teece, 2010). This capability becomes increasingly important when a firm shifts to more advanced phases of digital transformation; that is, from digitization to digitalization, and from digitalization to digital transformation.

Digital networking capability. The digital networking capability, which refers to the firm's ability to bring together and match distinct users to address their mutual needs via digital means, becomes more important in digital settings. In environments increasingly permeated with digital technologies, firms realize that they need to take a network-centric view and co-create value with a set of digitally connected firms (Koch & Windsperger, 2017; Libert, Beck, & Wind, 2016). In a recent study, 75% of executives indicated that their competitive advantage is not determined internally, but by the strength of partners and ecosystems they choose to work with (Accenture, 2017). That could explain why more than one-third of the firms had doubled the number of partners they work with in just two years (Accenture, 2018). Furthermore, firms may allow customers on their digital platforms to co-create value by generating own content, customize their products, and become brand ambassadors via the use of social media technologies (Dong & Wu, 2015), making customers a valuable asset for generating competitive advantage (Prahalad & Ramaswamy, 2000). The capability of firms to select, attract, link and engage a heterogeneous set of network stakeholders like customers, suppliers, and third parties strongly stimulates the value creation and growth of platforms (McIntyre & Srinivasan, 2017; Thomas, Autio, & Gann, 2014), and is important to realize digitalization and digital transformation.

Big data analytics capability. In the phase of digital transformation, the capability to acquire and analyze big data for decision making is crucial (Dremel, Wulf, Herterich, Waizmann, & Brenner, 2017; Loebbecke & Picot, 2015), given that the functionality of digital technologies all rely on digital data. Despite the wide availability and ease of collecting big data, firms struggle to develop this capability to analyze and utilize big data: 79% of surveyed executives admit that their most critical systems and strategies rely on data, but that many of them have not invested in verifying the reliability of these data (Accenture, 2018). Furthermore, employees with strong digital and analytical skills are required to create value from big data for both firms and customers. Firms should have big data teams that have analytical, data management, data visualization and business skills (Verhoef et al., 2016). Pure digital firms like Amazon and Booking.com constantly use analytics to tailor new offerings to customers as well as to optimize revenues with dynamic pricing and revenue management. Once the big data analytics capability is built in, continuous training programs need to be put in place to update skills, as techniques become more advanced (e.g., Kübler, Wieringa, & Pauwels, 2017).

4.2. Organizational structure

Apart from the digital resources needed to achieve digital transformation, a key issue to consider is the organizational changes needed to adapt to digital change (Eggers & Park, 2018), especially regarding organizational structure that is flexible for digital change. Past research argues that digital transformation has implications for the organizational structure (Sklyar, Kowalkowski, Tronvoll, & Sörhammar, in press), favoring a flexible structure composed of separate business units, agile organizational forms, and digital functional areas.

Separate business units. As incumbents tend to be slow when it comes to detecting valuable technologies, recognizing the need to react fast, and/or overcoming the often conflictive and competence-destroying nature of digital technologies is critical (Christensen & Overdorf, 2000; Christensen et al., 2016; Venkatraman, 2017). To deal with this, business model innovation research recommends to develop such new and often disruptive business models in autonomous business units that are separated from the headquarters, allowing for experimentation and quick learning, as well as avoiding cannibalization perils and conflicts (Broekhuizen, Bakker, & Postma, 2018; Christensen et al., 2016).

Agile organizational forms. The use of standard, more hierarchical organization schemes, with multiple management layers and a strong top-down approach, may no longer be effective in fast-changing digital environments, as the bureaucracy involved reduces response speed and innovativeness. To stimulate their digital agility (see Section 4.1), firms require flexible organization forms that allow for fast responses to constant digital change. For example, in their digital transformation journey ING has adopted the so-called Spotify-model with self-steering teams that have their own responsibility to act. This approach emphasizes an agile way of working, implying short cycles to quickly test and update market assumptions via trial-and-error (McGrath, 2010). Some organizations also adopt so-called holacratic organization approach, which is a self-management practice for running purpose-driven, responsive firms (cf. Robertson, 2015).

Digital functional areas. An important feature of digital transformation is the increased reliance on IT and analytical functions. Most notably, the IT function itself needs to transform from a line function focused on enabling communication or data flows into a more proactive and orchestrating role supportive to digital value creation via fast and explorative responses (Leonhardt, Haffke, Kranz, & Benlian, 2017). Firms often do not realize that — apart from changing the functional role of IT department — the employees' digital skills in marketing and service operations also need to be upgraded to enhance value creation (e.g., Lemon & Verhoef, 2016; Vomberg, Homburg, & Bornemann, 2015). From a human resource management perspective, digital transformation implies the attraction of employees with digital and analytical skills that may replace existing workforce. For example, in marketing, traditional brand and product marketers are replaced by online and mobile marketing experts, while data analysts may take over the role of marketing researchers. One key challenge for incumbents is to compete for talent with these skills with new digital entrants. Young digital and analytical talents tend to prefer tech giants like Google and Apple, or FinTech startups to a traditional bank like Deutsche Bank (Deloitte, 2015).

4.3. Digital growth strategies

A variety of digital growth strategies exist for digital firms, but the most prominent growth strategy involves the use of digital platforms (Broekhuizen et al., in press; Parker et al., 2016). Table 1 shows the variety of growth strategies across digital transformation phases, and indicates that platform strategies are more common for the more pervasive phases of digital change. This section explains the origins of the fast-paced growth of digital platforms, and identifies new digital growth strategies based on the classic Ansoff matrix (Ansoff, 1957).

A near ubiquitous characteristic of digital firms, and digital platforms in particular, is their impressive growth figures. Google, for example, grew from 1 billion searches per year in 1999 to 2 trillion in 2016, implying a growth rate 50% per year over a 17-year period (Digital, 2017). The ride-sharing platform Lyft grew from 2.7 million rides in 2013 to 162.6 million in 2016, resulting in an annual growth rate of nearly 300% (Business Insider, 2017b). Similarly, the number of active Facebook users grew by roughly 25% per year between 2009 and 2017 (Statista, 2018).

While many factors could have contributed to these impressive numbers, two key drivers behind such growth are the platform's high scalability and reinforcing network effects. Platforms can grow quickly and handle a growing number of users, including customers, suppliers, complementary service providers, because the costs of serving additional users are low and in the case of digital platforms sometimes negligible (Eisenmann, Parker, & Van Alstyne, 2006). Next, the platform model implies that a growth in the number of users on one side (e.g., customers or suppliers) attracts users from the other side, as they receive higher utility from using the platform, due to increasing network effects that create virtuous loops (Eisenmann et al., 2006).

To illustrate the power of the platform-based business model, Table 2 shows the financial performance statistics of a self-selected set of platform and non-platform firms. Platform firms realize much higher net income and equity per employee than non-platform firms.

While platforms' growth initially strongly hinges on the introduction of a successful product, over time the focus increasingly shifts away from a product-based mindset towards a platform-based mindset (Zhu & Furr, 2016). This shift implies moving away from focusing on the creation of new products towards the management of platform partners such as suppliers and customers (McIntyre & Srinivasan, 2017), even if this results in lower sales on a per-product basis (Rietveld & Eggers, 2018).

To better understand how digital firms can grow using a platform business model, we rely on the Ansoff matrix, which identifies four growth strategies: market penetration, product development, market development and diversification. The Ansoff matrix shows the opportunities for revenue growth through the development of new products, new markets or both. In Fig. 2 we relate Ansoff's growth strategies to platform firms to assess the growth opportunities that may emerge. Using the lens of a digital platform, we find new themes and growth strategies that broaden the conceptualization of Ansoff's growth matrix.

Looking horizontally, i.e., growing across markets or industries, we identify three strategies. The first two are (1) *market penetration* and (2) *(product-based) market development*, representing two traditional dimensions of Ansoff's original work. Platforms can leverage their digital – and disruptive (Christensen, 1997) – technologies to achieve significant growth by attracting non-users, who have never consumed the product or a traditional substitute before, into customers. About 30% of Netflix users do not watch TV, but stream content using tablets, laptops or mobile phones (Recode, 2018). In some cases, this may lead to creating entirely new markets. The introduction of the Apple Watch jumpstarted the growth of the smartwatch market (Business Insider, 2017c), while Google and Amazon created the market for smart speakers when introducing their voice-controlled products. Importantly, not only firms in the digital transformation phase, but also firms in the digitalization phase can embrace these market-development strategies. For example, traditional retailers can add an online channel to attract customers from other retail stores to increase their market share, but also target and serve new business markets.

In addition to these more traditional strategies, digital firms can also execute (3) *platform-based market penetration*, introducing a platform consisting of various existing products into a new market that are offered by external parties. The Norwegian telecommunications company Telenor has developed a platform consisting of mobile, fixed-line machine-to-machine technologies serving a wide range of markets across Europe. Similarly, Apple has developed a global eco-system for its phones, tablet computers, wearable devices and TV.

Looking at the vertical dimension, we observe two distinct strategies. The first strategy, (4) *product development,* introduced by Ansoff, can also be followed by digital firms. Digital firms can often more efficiently develop and launch new products in a platform environment, as platforms allow for stronger synergies among products. Mobile gaming companies, such as Ketchapp, for example, use gaming platforms to introduce a constant stream of mobile games into the market with relatively limited development and promotional costs. The second strategy consists of developing a (5) *co-creation platform* that allows external users to actively co-create value by giving them the authority to perform certain activities themselves on the platform (Cui & Wu, 2016; Grönroos & Voima, 2013). Relatively simple forms of co-creation exist in which digital platforms allow customers to engage in word-of-mouth or write product reviews (TripAdvisor, Booking) or share innovative ideas on crowdsourcing platforms (Dell IdeaStorm). At the same time, platforms can also allow customers to perform more substantive activities by shifting roles, such that customers become suppliers, like on online marketplaces (Airbnb and eBay), or become co-producers as they design, modify, or assemble products (Dell PCs, NikeID, Threadless). The shifting of customer roles into producers or suppliers is rather firms that have transformed digitally, while we do rarely observe these far-stretched co-creation strategies for firms in earlier phases.

Finally, some firms are able to combine all approaches in a single strategy, which we label as (6) *platform diversification*. This growth strategy is often deployed by large, successful platforms aiming to create additional growth in unexplored markets with new products.

Table 2
Financial Performance in 2017 of Selected Non-Platform and Platform Firms.

Company	EBIT ($B)	Net Income ($B)	Total Equity ($B)	Number of employees	EBIT/Employee	**Net Income/ Employee**	**Total Equity/ Employee**
IBM Corp.	11.98	5.75	17.59	366,300	$32,705	$15,698	$48,021
Walmart Inc.	22.76	13.64	77.80	2,300,000	$9,896	$5,930	$33,826
Daimler AG	17.55	12.60	78.31	289,000	$60,727	$43,667	$270,969
	Average Non-Platform Firms				**$34,443**	**$21,742**	**$117,605**
Facebook Inc.	20.20	15.93	74.35	25,105	$804,621	$634,535	$2,961,561
Alphabet Inc.	28.89	12.66	152.50	80,110	$360,629	$158,033	$1,903,633
Apple Inc.	61.34	48.35	134.05	123,000	$498,699	$393,089	$1,089,837
	Average Platform Firms				**$554,650**	**$395,221**	**$1,985,010**

Notes: Data are retrieved from Orbis and refer to the fiscal year 2016–2017.

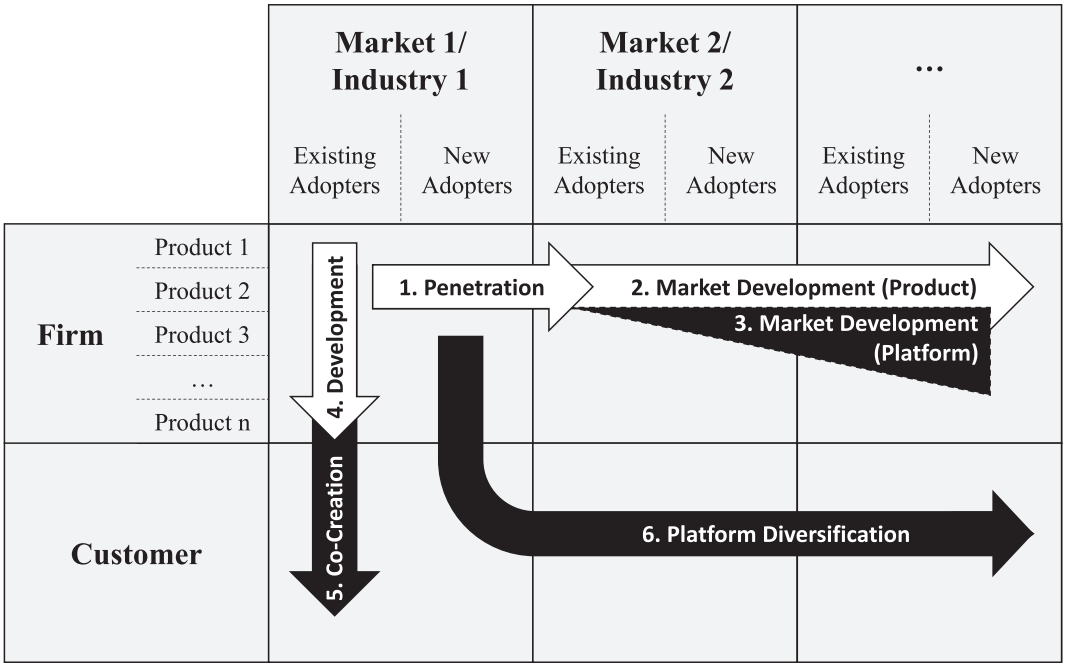

Fig. 2. Digital Growth Strategies for Platform Firms. *Notes:* Strategies represented by white arrows mirror the ones proposed by Ansoff, while strategies represented by black arrows are unique to digital platform-based firms.

This approach consists of expanding the platform to serve new markets, update the product and service assortment, and open the firm to co-create value by partnering with sponsors (Google and Android), or with other interoperable platforms, suppliers, consumers and complementary service providers (Facebook's Libra coin).

4.4. Metrics and goals

To realize the full potential of digital transformation, digital firms need to measure the performance improvements on key performance indicators (KPIs) to facilitate learning and fine-tune the business model, as we discuss in this subsection. The relevance and use of KPIs may differ across the phases of digital transformation.

While certain adjustments and updates of metrics usually happen when a firm goes through digitization and digitalization phases (e.g., measuring website clicks, video views and mobile downloads, after the introduction of online and mobile channels), overall outcome-related metrics like ROI, profitability and revenue growth, typically remain relevant for firms that engage in digitization and digitalization. Although the end goal of new business models — as generated by digital transformation — will also be to generate revenues, profits and improve investor value (Teece, 2010), here it is also particularly useful to track intermediate results via process-related metrics to assess how well the new digital business model is creating value (Libert et al., 2016). Especially in the digital transformation phase intermediate "digital" metrics are valuable, as they provide more fine-grained insights. For many digital platforms, this may include obtaining measures of online sentiment and engagement as well as network co-creation and value sharing. For instance, when judging the success of their app developer network, Apple and Google can benefit from measuring the number of developers creating apps for their app store, the revenues generated by those apps, and the customer satisfaction with those apps. The collective assessment of the multiple intermediate metrics shows how well the complex business activity system operates and performs, and where changes are needed.

Beyond the differences in metrics across phases, we also discuss some general differences between traditional incumbents and new digital entrants. Specifically, we observe that many traditional incumbents stick to profitability as a financial metric, while many digital firms focus on growth figures (e.g., growth in number of users, customers, and sales) instead of profitability. The primary objective of many digital firms is to achieve growth in the sheer number of users of the digital ecosystem (e.g., suppliers, customers, third parties) to create reinforcing network effects that enable further platform growth. A fast-growing customer base allows them to accumulate valuable data at scale, which can be leveraged both internally (within the firm), and externally (selling services to external partners, attaining legitimacy among investors). As long as shareholders expect that the firm is able to capitalize on their growing user bases, they are willing to accept (short-term) losses in return for growth.

For digitally transforming incumbents, achieving high growth is also important, but not at the cost of profitability. Hence, such incumbents face a strong disadvantage when competing against digital entrants. Hence, incumbents, which want to transform digitally, need to simultaneously attain two main objectives: reducing costs through automation and growing revenues through enhanced customer experience (e.g., Lemon & Verhoef, 2016; Verhoef et al., 2015). Given the possible incompatibility of realizing both objectives, some researchers suggest that digitally transforming incumbents should develop digital initiatives in new separate ventures that would function similarly to a digital start-up in order to justify a primary focus on growth (Christensen et al., 2016).

5. Conclusion and research agenda

The key goal of this paper is to provide a multidisciplinary perspective on digital transformation. We started with a discussion on why firms need to transform digitally and conclude that digital transformation occurs in response to changes in digital technologies, increasing digital competition and resulting digital customer behavior. Next, by analyzing the literature, we identify three stages for digital transformation: digitization, digitalization and digital transformation. Each phase places specific demands on firms' digital resources, organization structure, growth strategies and metrics. Firms aiming to transform digitally not only need to have digital assets, but also acquire or develop capabilities related to digital agility, digital networking and big

Table 3
Summary of Opportunities for Future Research.

Major Topic	Relevant Disciplines	Research Questions
Phases of Digital Transformation	Information systems, strategic management, innovation	• How should move firms through multiple digital transformation phases? • How can we measure digital transformation phases and digital readiness? • How resilient are incumbent firms against digital competition and digital change? • To what degree should firms transform digitally? • What is the impact of digital transformation on performance? • What firm and market variables moderate the relationship between digital transformation and performance?
Digital Resources	Information systems, strategic management, innovation	• How can firms develop specific digital resources? • What is the relative impact of identified assets and capabilities on digital transformation and performance? • What are digital networking capabilities and how can firms develop them? • How can digital resources facilitate digital transformation?
Organization Structure	Strategic management, innovation	• Which organizational structures enhance firms' digital agility? • What organizational structures are most effective for digital transformation? • How to balance agility with the need for control and efficiency? • How to construct self-organizing teams to attain digital transformation? • How can transforming firms benefit from new organizational structures and management styles?
Digital Growth Strategies	Strategic management, marketing	• What should be the diversification strategy of digital platforms? • What is driving the success of specific digital growth strategies? • Which growth strategies should incumbent firms use when digital transforming their firm?
Metrics and Goals	Strategic management, marketing, operations management	• Which metrics are essential for the different phases of digital transformation? • How does firms' use and importance of metrics evolve across the different phases of digital transformation? • Which metrics are important for digital platforms given the increasing reliance on networks and eco-systems?

data analytics. Internally, organizations need to develop agile structures with low levels of hierarchy, and internalize IT and analytical functional skills within the firm. Inspired by the Ansoff matrix, we identify specific growth strategies for firms that use platform-based strategies, namely: platform-based market development, customer co-creation and platform diversification. Finally, we discuss the importance of developing new (intermediate) digital metrics and objectives for digital firms.

Next, for each of the aforementioned topics, we discuss specific research opportunities and identify their corresponding disciplines (see Table 3). First, more research is required to understand how firms go through the *phases of digital transformation.* Based on prior literature, we assume that incumbent firms go through the same sequence of digitization, digitalization, and then to digital transformation. Is such a path always optimal? Perhaps incumbents should skip the phase of digitalization to realize digital transformation, as this phase may hinder or obstruct digital transformation. Future research can also try to measure and investigate how digital readiness of firms may help the transition through the phases of digital transformation. Another concept requiring scholarly attention is digital resilience of firms, focusing on whether incumbent firms are able to compete with (new) digital players and accommodate exogenous shocks from disruptive digital technologies. Finally, little is known about to which degree firms should transform digitally. Although digital transformation seems inevitable in many industries, still it should not be considered an end in itself, given the deep changes needed and high risks involved. The apparent lack of empirical research on the link between the different phases of digital transformation and performance leads to an important question: to what degree should firms transform digitally? And, what is the impact of the different phases of digital transformation on performance? In doing so, we need to gain a better understanding of the contextual influences and determine which internal firm (firm size, age, board composition) and external market factors (e.g., competition intensity, products vs. services, technological intensity) may moderate the impact of digital transformation on firm performance.

The second important research theme concerns *digital resources*. While we have identified several important digital assets and capabilities, future research is needed for answering an array of related questions: How can these digital resources be developed? What is the relative impact of each of them in shaping the success of digital transformation? In which assets and capabilities do firms have to invest? For instance, should the focus be on the acquisition of digital assets, the development of digital networking or big data analytics capabilities? To what extent do digital agility and digital networking capability only help digital firms, or are these capabilities also be relevant for less digital firms? If relevant, how can these firms measure, develop and excel at them? Overall, we need to know more on how digital resources facilitate digital transformation.

The *organization structure* of digital transformation is the third important theme. As discussed above, digital transformation has several important implications for the organization structure. However, empirical research on the organization structure within digital firms is scarce. We hope future research will focus on identifying the optimal forms of organizational structures that allow firms to succeed in executing their digital transformation strategies. For example, which organizational structure enhance firms' digital agility? And, more broadly, what organizational structures are most effective for firms that transform digitally? The literature streams on innovation management and software development have extensively investigated self-organizing teams (e.g., Takeuchi & Nonaka, 1986), but there is a paucity of research on how self-organizing teams enable digital transformation and its effect on performance. Should digital transforming firms adopt self-organizing teams instilled with autonomy and flexibility? And how to balance a focus on exploration and flexibility with control and efficiency? Should firms shift away from their traditional functional department structures with IT, operations, marketing and R&D, and be run like holacratic organizations using flexible teams (circles) comprised of employees with specific roles and responsibilities like customer service experience, security, and new ideas (Robertson, 2015)?

The fourth important theme concerns *digital growth strategies*. Gaining a deeper understanding of what makes different platform growth strategies successful involves answering several important questions, such as: What is the optimal growth path in a platform environment? Should platforms first expand horizontally and then vertically, vice versa, or simultaneously? And if the platform is a market leader, should it diversify to other markets in search of greater network

effects, or should it specialize to remain competitive in the existent market? Which firm and market characteristics can explain differences in performance for firms adopting different platform-based strategies? Based on this, which growth strategies should firms choose, and how can incumbent firms achieve similar growth figures as digital entrants? Although incumbents can be successful in deploying new digital technologies, successful business cases seem to be rare. Also, given the heterogeneity in productivity returns on digital investment, it is important to identify which factors can explain these differences. Hence, to what extent are digital industry leaders more capable of finding, selecting and executing digital projects, or does their success depend on other factors?

The fifth important research area is *metrics and goals*. Which sets of intermediate and outcome-based metrics should firms use to measure their value creation and business performance during the different phases of digital transformation? How does firms' use and importance of metrics evolve across the different phases of digital transformation? Prior research has considered the use of specific metrics within marketing (e.g., Katsikeas, Morgan, Leonidou, & Hult, 2016), but more research is required to assess how digital transformation may affect the usage and usefulness of performance metrics. Furthermore, given the increasing presence of digital platforms, more research is needed to understand how specific metrics affect these firms, and how such metrics may help them to make more informed strategic decisions. For instance, how can digital platforms that rely on the inputs of multiple users develop relevant metrics to capture users' sentiment and engagement in order to explain their co-creation and sharing willingness?

Naturally, given the multidisciplinary nature of digital transformation and interdependencies that exist in business models (Christensen et al., 2016), it is imperative that researchers from different fields work together to not only expand our knowledge on these five independent themes, but also actively establish linkages between these themes and disciplines to develop a more holistic understanding of why, how and when digital transformation works. Such interdisciplinary research helps practitioners to make sound strategic decisions about how to respond to digital technologies and implement digital change.

To conclude, we believe that digital transformation will be a very relevant, multidisciplinary area for future research given the recent developments of digital technologies. In this paper, we have provided a rich and timely discussion on digital transformation and proposed how digital transformation places specific demands on organizations. We hope that our discussion and research agenda will stimulate future research on digital transformation.

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Appendix A:. Review methodology

The goal of this scoping review is twofold. First, we aim to assess how digital transformation has been studied across fields to address how digital transformation has been conceptualized across the different fields to identify key similarities and differences. The reason to choose a multidisciplinary approach rather than focusing on contributions within one research field is because we believe that a broad phenomenon like digital transformation with wide implications for firms and society cannot be fully understood by only studying it within, for instance, the IS field (Loebbecke & Picot, 2015). A concept that exists at the intersection of different fields must be studied using an integrative approach rather than relying on a single field (Tarafdar & Davison, 2018). Hence, ignoring contributions from specific fields would bias our understanding of digital transformation.

The second goal of this review is to assess the different phases of digital transformation. Scholars have used a variety of concepts as substitutes or complimentary elements when theorizing about firms' digital transformation such as e-business usage to describe digital transformation (e.g., Zhu, Dong, Xu, & Kraemer, 2006). Therefore, we analyze the final set of papers thematically to assess the important themes of digital transformation. Given that the same keyword can have a (partly) different meaning in other disciplines, we argue that this thematic analysis helps us to better conceptualize digital transformation. Hence, this review also assesses how digital transformation has been studied across fields (including related constructs) to identify their similarities and differences.

Step 1: Selection of fields of interest. We use a systematic multistep concept-centric literature search (Webster & Watson, 2002), given the absence of widely accepted views on the topic and to account for the broad nature of the concept. The first decision for our literature search is to select the relevant fields of interest to conceptualize digital transformation. This study focuses on a firm level analysis, excluding fields that solely take an individual, group or industry level, such as the organizational behavior or entrepreneurship literature. Hence, a key criterion to include fields is that studies are conducted to a significant extend at firm level. Specifically, we focus on the following five business research fields: information systems, strategic management, marketing, innovation, and operations management. These fields include most of the "classic" business research fields and cover a variety of important views on digital transformation. We acknowledge that including other fields could be of interest to study digital transformation, but that we need to strike a balance between covering everything and being relevant.

Step 2: Selection of timeframe. We selected a timeframe to include papers published between January 2000 till October 2018. The reason for the year 2000 as cutoff line is that in this year the dotcom bubble collapsed and that firms such as Google, Amazon or eBay were among the survivors which today have huge influence on what we understand about digital transformation. Furthermore, this timeframe is in line with other recently published reviews about digital in general (e.g., Kannan & Li, 2017).

Step 3: Selection of academic sources. To determine which sources are included, we decided to include a broad set of 42 leading journals in each of the selected fields. To determine this list, we selected top journals and a wider list of very good journals (impact factor > 1). In the IS field, we included *MIS Quarterly*, *Information Systems Research*, *European Journal of Information Systems*, *Information Systems Journal, Journal of AIS, Journal of Information Technology, Journal of MIS, Journal of Strategic Information Systems, Decision Support Systems* and *Information & Management*. In the innovation filed, we included *Journal of Product and Innovation Management, Research Policy, Technological Forecasting and Social Change* and *Technovation.* In the marketing field, we included *International Journal of Research in Marketing, Journal of Marketing, Journal of Marketing Research, Marketing Science, Industrial Marketing Management, International Journal of Electronic Commerce* and *Journal of the Academy of Marketing Science.* In the operations management field, we included *Journal of Operations Management, Manufacturing and Service Operations Management, Production and Operations Management, IIE Transactions, International Journal of Operations and Production Management, International Journal of Production Research, Supply Chain Management: An International Journal* and *Transportation Science.* In the management field, we included *Academy of Management Journal, Academy of Management Review, Administrative Science Quarterly, Journal of Management, Journal of Management Studies, Management Science, Strategic Management Journal, Journal of Business Research, Organization Science, Academy of Management Annals, Academy of Management Review, California Management Review, Harvard Business Review* and *MIT Sloan Management Review*. To ensure that we did not miss any relevant papers published in other journals, we amended this search by using the Web of Science database.

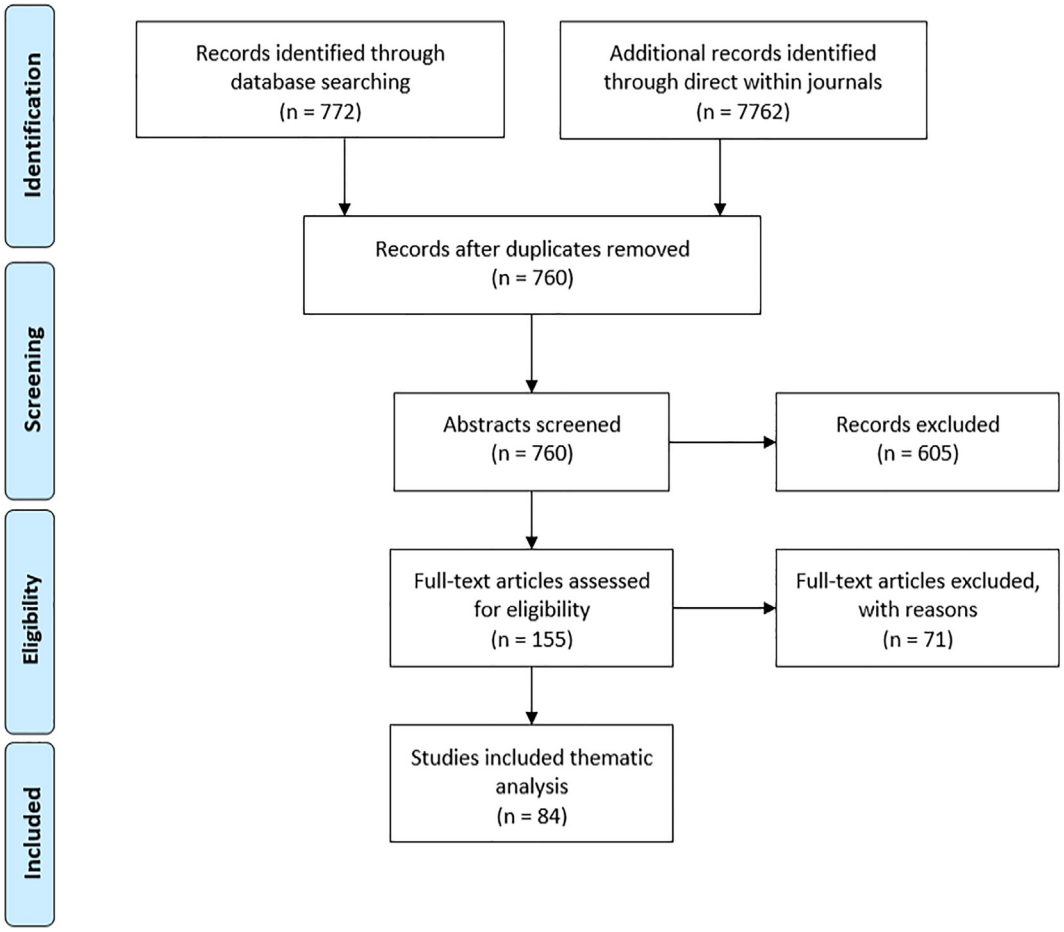

Fig. A1. Literature Search Process.

Step 4: Selection of keywords. In the next step, we made a preliminary search using different databases and articles to identify a set of keywords to guide our search. The criterion for keywords is that we have to include specific keywords for the topic but also general keywords to account for similar constructs that are similar but use a different name. We included the keywords "digitalize", "digital transformation", and "digitize" as well as "IT" or "IS" in combination with "transformation" to cover the broad meaning of digital transformation and account for varieties in the focus across different disciplines. We acknowledge that also other keywords can be interesting or relevant but believe that our set will sufficiently cover our key criterion.

Step 5: Identification and screening. The search process generated over 8500 papers that fitted the selected keywords (see Fig. A1). This large number is mainly caused by our broad set of keywords. Papers were first scanned by title; papers that were deemed relevant to the goal of the study were considered by reading their abstracts. In total, we screened the abstracts of 760 papers. From this list of papers, we derived our preliminary set by including papers for closer review that we perceived best fitted our study goal. We excluded 605 papers, leaving us with a preliminary sample of 155 papers (most of them in the IS field).

Step 6: Eligibility. We subjected the 155 papers to check their relevance, and exclude irrelevant studies. We follow apply three criteria to ensure that the selected papers are of high relevance and quality.

1. Papers should use digital transformation-related concepts as major constructs. Papers were excluded when the digital transformation was only included in the keywords, abstract or introduction but not further explained in the text. Furthermore, papers were excluded when mentioning digital transformation only as a possible implication of other research done.
2. Papers should include some theoretical notions for digital transformation (or related constructs); either by providing a theoretical notion based on earlier work, or by developing a notion of what is exactly meant with digital transformation. Papers that did not provide at least a conceptual or operational meaning were excluded.
3. Papers should use the concepts related to digital transformation in the core of the theoretical section (e.g., by being included in hypotheses, propositions and/or research model) to make sure that digital transformation played a key role in the development of the paper.

Step 7: Coding of articles. The eligibility process resulted in a final sample of 84 papers that fulfilled all three criteria. The identification, screening and coding of paper was done by a single coder.

Step 8: Thematic representation. We applied thematic analysis to the selected papers to address how the different terms were used and if their meaning is comparable or different across fields. In doing so, we used a second coder to independently code a 20% random sample. The interrater reliability using Cohen's kappa (Cohen, 1960) was very high (kappa = 0.82). In Table A1, we provide our results of coding across disciplines.

Table A1
Coding Results of Literature.

	Digitization	Digitalization	Digital Transformation
Information systems management	• Encode or transform analog to digital information/tasks (Agarwal et al., 2010; Anderson & Agarwal, 2011; Davison & Ou, 2017; Loebbecke & Picot, 2015; Matt et al., 2015; Parviainen et al., 2017; Tan & Pan, 2003; Whelan, Golden, & Donnellan, 2013; Xue, Zhang, Ling, & Zhao, 2013; Yoo et al., 2010; Zhu et al., 2006)	• Change processes by adding technology (Leviäkangas, 2016; Parviainen et al., 2017)	• Utilize digital technology to facilitate change (Agarwal et al., 2010; Zhu et al., 2006) • Change roles between company, customer and competitor (Karimi & Walter, 2015; Parviainen et al., 2017) • Create new value (Li et al., 2018; Matt et al., 2015)
Marketing management	• Implement IT to analog tasks to create information (Coreynen, Matthyssens, & Van Bockhaven, 2017; Johnson & Bharadwaj, 2005; Lai et al., 2010; Vendrell-Herrero et al., 2017)	• Connect customers and firms (Pagani & Pardo, 2017; Ramaswamy & Ozcan, 2016) • Connect machines with each other (IoT) (Lenka, Parida, & Wincent, 2017)	• Reshape consumer preferences, create new value for consumers, change firm relationships, develop new value propositions (Pagani & Pardo, 2017; Vendrell-Herrero et al., 2017)
Strategic management	• Encode or transform analog to digital information to enable new tasks (Dougherty & Dunne, 2012; Iansiti & Lakhani, 2014) • Reduce costs (Greenstein, Lerner, & Stern, 2013; Kohli & Johnson, 2011) • Enable new products (Saarikko, Westergren, & Blomquist, 2017; Sebastian et al., 2017)	• Generate new knowledge and business opportunities (Dougherty & Dunne, 2012; Hansen & Sia, 2015)	• Restructure business with digital technology to attain competitive advantage (Berman, 2012; Iansiti & Lakhani, 2014; Kane et al., 2015; Peppard, Edwards, & Lambert, 2011; Singh & Hess, 2017) • Create new business opportunities and business models (Andal-Ancion, Cartwright, & Yip, 2003; Hansen, Kraemmergaard, & Mathiassen, 2011; Liu et al., 2011; Peppard et al., 2011)
Innovation management	• Convert analog to digital information (Katz & Koutroumpis, 2013; Li, in press; Øiestad & Bugge, 2014) • Reduce costs (Øiestad & Bugge, 2014) • Enable new opportunities for the company to generate innovation (Aubert-Tarby, Escobar, & Rayna, 2016; Borreau, Gensollen, Moreau, & Waelbroeck, 2012; Kolloch & Dellermann, 2017)	• Connect or restructure processes to create opportunities (Baraldi & Nadin, 2006; Ho & Lee, 2015)	• Change a firm's value network, customers and competitors (Li, in press; Schallmo et al., 2017)
Operations management	• Convert analog to digital data (Gölzer & Fritzsche, 2017; Li et al., 2016) • Use ICT within firm (Plomp & Batenburg, 2010)	• Improve process quality or products with digital technology (Kompalla, Geldmacher, Just, & Lange, 2017; Li et al., 2016)	• Interconnect products and production systems to global product networks (Gölzer & Fritzsche, 2017)

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