Business Horizons (2020) 63, 313—323

Available online at www.sciencedirect.com

ScienceDirect

KELLEY SCHOOL OF BUSINESS
INDIANA UNIVERSITY
www.journals.elsevier.com/business-horizons

Growth paths for overcoming the digitalization paradox

Heiko Gebauer [a,b,c,*], Elgar Fleisch [b,d], Claudio Lamprecht [b], Felix Wortmann [b]

[a] Linkoping University, Sweden
[b] ITEM-HSG, University of St. Gallen, Dufourstrasse 40a, 9000 St. Gallen, Switzerland
[c] Fraunhofer IMW, Germany
[d] ETH Zurich, Switzerland

KEYWORDS
Digitalization;
Digitalization paradox;
Growth traps;
Growth strategy;
Business-model modifications;
Innovation capability;
Strategic partnerships

Abstract Despite the demonstrated opportunities for revenue enhancement through digitalization, companies often experience a digitalization paradox. This paradox suggests that although companies may invest in digitalization, they often fail to achieve the expected revenue enhancement. In reporting research on 52 companies, we make the following four contributions: First, we focus on industrial companies in the business-to-business context, which largely have been neglected in previous research on digitalization. Second, we introduce the digitalization paradox as an important phenomenon in the discussion of revenue enhancement through digitalization. Third, we describe three growth paths: (1) commercializing digital solutions, (2) utilizing product connectivity, and (3) establishing an IoT-platform-based application business. For each growth path, the article takes a dynamic perspective on business models, highlighting triggers and modifications in business-model components (including value proposition, value-creation activities, and profit equation). Fourth, while the described modifications require initial investments to let these growth paths develop, we highlight how growth traps can prevent investments in business-model modifications from leading to revenue enhancement and how they can ultimately lead to the digitalization paradox.

1. Embracing revenue growth through digitalization

Digitalization has become a strategic imperative for practitioners and a popular subject of analysis among academics. Digitalization describes the convergence of the physical world with the digital world through widespread technologies; consider, for example, the Internet of Things (IoT), ubiquitous computing, data analytics, machine learning (ML), artificial intelligence (AI), smart devices, sensors, and platforms (Lee, 2017; Ng & Wakenshaw, 2017). In this article, we focus on digitalization around IoT, which enables a wide

* Corresponding author
E-mail addresses: heiko.gebauer@liu.se (H. Gebauer), elgar.fleisch@unisg.ch (E. Fleisch), claudio.lamprecht@unisg.ch (C. Lamprecht), felix.wortmann@unisg.ch (F. Wortmann)

https://doi.org/10.1016/j.bushor.2020.01.005
0007-6813/

array of products to connect through the internet (Fleisch, Weinberger, & Wortmann, 2015; Saarikko, Westergren, & Blomquist, 2017).

The existing research on digitalization mainly focuses on the consumer context and largely neglects industrial companies operating in the business-to-business context (e.g., ABB, Bosch, General Electric, Siemens, SKF, and ZF). Such industrial companies are incumbents that have previously modified their business models to become more service-oriented and are now exploring digitalization opportunities.

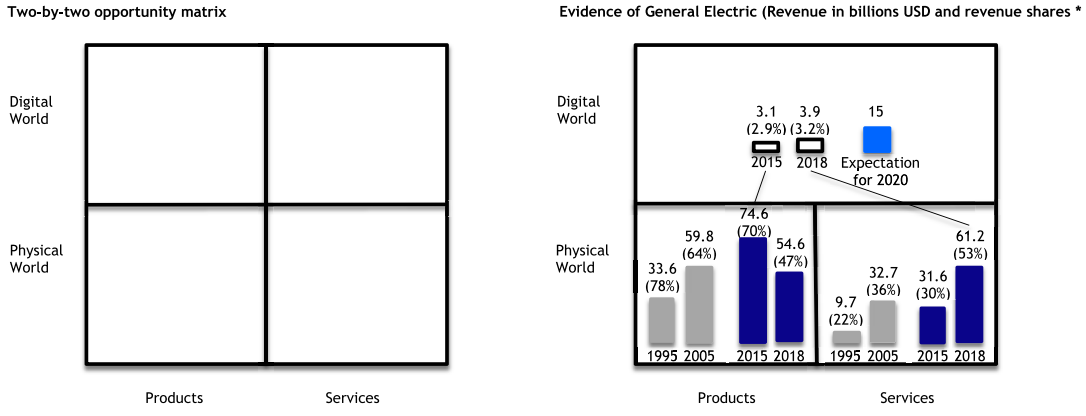
Thus, revenue enhancement through digitalization is embedded in previous service-revenue growth (Baines, Ziaee Bigdeli, Bustinza, Shi, Baldwin, & Ridgway, 2017). Accordingly, revenue growth can be illustrated in a two-by-two matrix (see Figure 1). The horizontal axis distinguishes between product and service revenues, whereas the vertical axis depicts the revenues generated in the physical and digital worlds. Moving along the horizontal axis suggests that industrial companies create increasing value by integrating products and services into tailored offerings for solving customer problems rather than by selling products. As part of these tailored offerings, services have become an important source of revenue. One company that clearly illustrates this is General Electric (GE). In keeping with the statement of former GE CEO Jack Welch that "The [service] market is bigger than we ever dreamt" (Slater, 1998, p. 183), GE has expanded its service business. In 1995, services generated about 22% of GE's revenues. By 2005, services represented 36% of GE's revenues (General Electric, 1995, 2005).

The vertical axis in Figure 1 illustrates digital revenue growth. In 2015, GE announced that it would look for new growth opportunities through digitalization, and the company projected it would increase digital revenues to $15 billion annually in 2020. Accordingly, digital revenue accounted for 2.9% ($3.1 billion) of the company's revenue in 2015 and 3.2% ($3.9 billion) of its revenue in 2018 (see Figure 1). A similar example is IBM, which grew its service business from 27% of revenue in 1993 to 57% of revenue in 2005. More recently, IBM (1993, 2005, 2018) has also become a pioneer in digital growth and reports that it generates 39% of its revenue in the digital world, with the remaining revenue generated through products (10%), services (49%), and other sources (2%).

Besides being an additional revenue stream, digitalization can enhance product and service revenues in the physical world. Digitalization also helps to differentiate existing products and services by increasing perceived customer value. For example, Voith reports both types of revenues: For 2017–2018, it reported digital revenues with direct revenues (€40 million, 1% of Voith's revenue) and physical revenues supported by digitalization (€ 233 million, 5.5% of Voith's revenue) (Voith, 2018).

Despite the demonstrated ability of digitalization to enhance revenue, many companies struggle to capitalize on the potential of digitalization. GE, for example, reached $3.9 billion in digital revenue in 2018, but this is still nowhere near the company's goal of reaching $15 billion in digital revenue in 2020. We refer to this phenomenon as the *digitalization paradox*. To better understand

Figure 1. Two-by-two matrix for visualizing revenue enhancement through digitalization



Source: General Electric Annual Reports, 1995, 2005, 2015, 2018

Notes:

1. Revenues in 1995 and 2005 do not include GECS (GE Capital Services).
2. Product and service revenue are cumulative and indicate GE's total revenue. Revenue through digital offerings is included in the total revenue.

this paradox, we build on case-study research of 52 industrial companies operating in the business-to-business context. We study the possible growth paths for increasing revenues through digitalization from a business-model perspective (Wirtz, Göttel, & Daiser, 2016; Zott, Amit, & Massa, 2011).

In so doing, we make four main contributions in this article. First, we focus on industrial companies in the business-to-business context, companies that largely have been neglected in previous research. Second, we introduce the digitalization paradox as an important phenomenon in the discussion of revenue enhancement through digitalization. Third, we describe three growth paths: (1) commercializing digital solutions, (2) utilizing product connectivity, and (3) establishing an IoT-platform-based application business. For each growth path, we highlight triggers and modifications in business-model components. Fourth, we point out the growth traps that these companies may face as they develop their growth paths—traps that ultimately give rise to the digitalization paradox.

2. The digitalization paradox

We consider revenue enhancement through digitalization a strategic priority because of the risk that a competitor could establish a market position first, which would thereby make it more difficult to gain shares of overall digital revenues. This argument is in line with Gartner's (2019) definition of digitalization: "Digitalization is the use of digital technologies to change a business model and provide new revenue and value-producing opportunities; it is the process of moving to a digital business." We define the digitalization paradox as a situation in which companies invest in digitalization but struggle to earn the expected revenue growth. We call this a paradox since it stands to reason that revenue enhancement through digitalization is a likely outcome because of the growth potential of digital technologies; yet we have seen evidence of companies struggling to earn the expected revenue growth, which contradicts this premise. Figure 2 illustrates this kind of contradictory evidence obtained from the 52 companies in our research. The figure shows that when cumulative investments in digitalization are relatively small, revenue enhancement remains in line with expectations. But as cumulative investments increase, companies increasingly face the digitalization paradox and do not obtain the projected revenue enhancement. As companies invest more and more in digitalization, the paradox becomes more likely, and only a few companies actually achieve high revenue enhancement that corresponds to their high investments.

Our term *digitalization paradox* differs from the term *productivity paradox*, which has been used for information and communication technologies (ICT). The productivity paradox highlights how ICT investments often do not lead to the expected productivity or cost improvements (Brynjolfsson, 1993; Stratopoulos & Dehning, 2000). Our definition links investments in digitalization with revenue enhancement and not with productivity and cost improvements. We thus assume that digitalization involves more than digitizing operational processes in order to make processes more efficient.

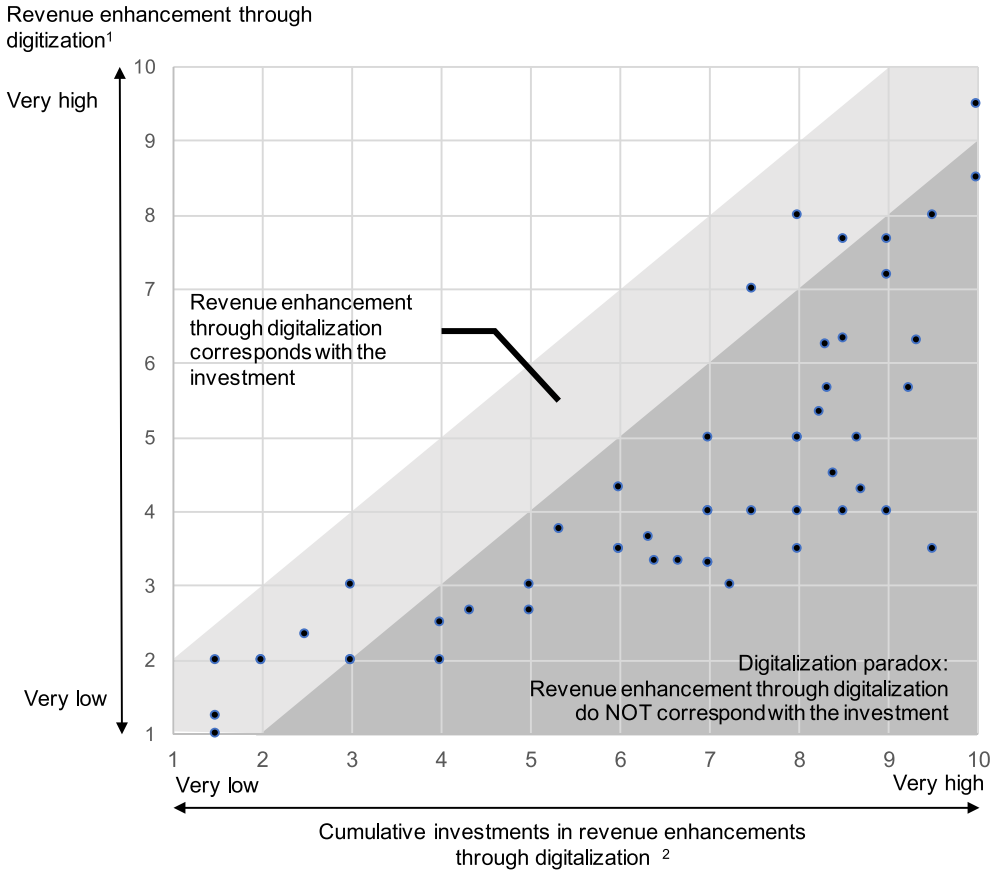
3. Business models and digitalization

Digitalization motivates incumbent companies in the business-to-business sector to alter their business models and to modify their business-model components (Casadesus-Masanell & Zhu, 2013; Pauwels & Weiss, 2008). Thus, a possible reason for the digitalization paradox could be that companies struggle to successfully modify their business models.

Business models generally reflect the holistic logic of businesses, and they are typically conceptualized through three key components: value proposition, value creation (or delivery), and profit equation (Teece, 2010). The *value proposition* subsumes all facets of a firm's offerings that render value to customers (Chesbrough & Rosenbloom, 2002). In this sense, it addresses particular customer needs or problems. Firms must consider relevant customer segments and determine which communication and delivery channels will reach these segments (Osterwalder & Pigneur, 2010). In our context, sensors allow for monitoring product-usage data in real time. The data gathered about product usage can then be analyzed through machine learning to better predict product breakdowns. This can alter the value proposition by improving product availability, uptime, and performance (Ulaga & Reinartz, 2011).

To deliver their value propositions, firms require certain resources, capabilities, and processes. This enactment of the value proposition is referred to as firms' *value-creation activities* (Amit & Zott, 2001). Firms can manage value creation on their own, or they can collaborate with external partners (Chesbrough, 2010). IoT-related connectivity of products changes value-creation activities by

Figure 2. Empirical evidence of the digitalization paradox



Note: Revenue enhancement and cumulative investments were measured through subjective indicators..

1 – Representatives from 52 companies were asked to indicate the level of revenue enhancement for the last three years on a 1 to 10 scale with very low and very high level at the extremes. Revenue enhancement was calculated as an average of the representatives from each company and through index composed of direct and indirect financial benefits. Direct financial benefits refers to growing digital revenue. Indirect financial benefits include digitalization for improving the quality of the customer relationship and competitive advantages, which both would increase the product and service revenues.

2 – Representatives from each participating company were asked to indicate the level of cumulative investments into digitalization for the last three years on a 1 to 10 scale with very low and very high level at the extremes. Investment levels were calculated as an average of the representatives from each company.

replacing the on-site provision of services with remote services, and data analytics allows companies to predict product breakdowns.

The *profit equation* is the financial manifestation of the value proposition and value-creation mechanisms; it addresses how customer value is captured and how costs should be structured for value creation (Bowman & Ambrosini, 2000). Costs include investments in digitalization, which pay off through revenue enhancement and cost improvements. Furthermore, companies use digital technologies to charge for product usage, thereby generating revenue from pay-per-use services rather than products or other services (Cusumano, Kahl, & Suarez, 2015). Such modifications in the profit equation relate back to the abovementioned value proposition insofar as they improve product availability, uptime, usage, and performance.

All three components need to be configured consistently to make business models successful.

Accordingly, business-model modifications represent the processes by which managers change one or multiple components of their business models (Saebi, Lien, & Foss, 2017). This perspective embraces a deeper understanding of the dynamics of business models by focusing on how companies modify their business-model components (Casadesus-Masanell & Zhu, 2013). But the configurational nature of business models complicates such modifications. The configurations among components are difficult to predict and to alter over time (Demil & Lecocq, 2010). This difficulty is especially notable when modifications lead to inconsistencies among components, causing traps that prevent revenue enhancement through digitalization (Berends, Smits, Reymen, & Podoynitsyna, 2016).

4. Growth paths

Our work together with 52 companies revealed three growth paths for revenue enhancement through digitalization: (1) commercializing digital solutions, (2) utilizing product connectivity, and (3) establishing an IoT-platform-based application business. Companies focus simultaneously on all three growth paths; rather than completing all the modifications for one growth path before continuing to the next, they enact modifications for all the growth paths at once. In the sections that follow, each description of the growth paths starts with the growth triggers before highlighting key modifications and possible growth traps (see Table 1).

4.1. Commercializing digital solutions

4.1.1. Triggers

The first growth path opens up new business opportunities for digital solutions. It is triggered by the availability of digital technologies (e.g., tablet computers, smart glasses, sensors, cameras, augmented-reality systems, and drones) and by customers demanding more personalized experiences and smooth digital touchpoints (Nylén & Holmström, 2015).

4.1.2. Modifications

To commercialize digital solutions, companies combine digital technologies to produce digital or digitally enabled solutions that can solve complex customer needs. Caterpillar's Cat Detect is an example of such a digital solution. Cat Detect proposes value by allowing operators to know what is happening around their construction equipment. Cat Detect combines CCTV cameras, vehicle-tracking systems, and RFID tags on vests to create a safer construction site, reducing the chance of accidents and the costs associated with them.

In addition to proposing value by combining digital technologies for solving customer problems (Yoo, Boland, Lyytinen, & Majchrzak, 2012), value-creation activities shift toward structured, iterative processes and merging customer needs with the benefits offered by digital technologies. This helps companies by creating demand, revealing sales opportunities, generating sales orders, and ultimately delivering new digital solutions (Storbacka, 2011). Delivering cost-effective digital solutions requires modularization through standardizing and customizing solution components.

4.1.3. Traps

While such modifications sound relatively easy, companies can become caught in growth traps as this path unfolds. Companies tend to focus too much on the technical possibilities of their products rather than on developing a deep understanding of customer needs. This represents an important sales hurdle and often limits the attractiveness of digital solutions for their customers. Rather than combining multiple technologies, companies often focus only on a single one.

The machine-tool manufacturer Trumpf illustrated this trap in the deployment of a portable tablet PC as a machine user interface. Trumpf developed its MobileControl solution to transfer the machine interface to a portable tablet PC. With this device, machine operators can move around on the shop floor, thereby simplifying their machine operations. But since customers do not perceive the value as high enough to want to pay for it separately, MobileControl only augments machine offerings. This example shows how companies can struggle to develop digital solutions with a high enough perceived customer value that customers are convinced to pay for them, which means missing out on revenue enhancement in the digital world.

Even if a company offers a digital solution with a high perceived value, it can struggle to achieve sufficient modularization, which is what enables cost-efficient customization of digital solutions for individual customers and customers segments. Companies can become trapped by either favoring standardization too much, which makes it impossible to tailor offerings to individual customer needs, or conversely favoring customization too greatly, which makes it difficult to deliver digital solutions in a cost-efficient way.

The aforementioned Cat Detect solution illustrates the importance of modularization of digital solutions for balancing standardization and customization successfully. Cat Detect is modularized

Table 1. Growth paths: Triggers, modifications, and traps

Growth Paths	Triggers	Modifications	Traps
Commercializing digital solutions	• Availability of manifold digital technologies • Customers demanding personalized experiences and smooth digitalized touchpoints	*Value proposition* • Combining digital technologies for solving problems *Value-creation activities* • Implementing structured, iterative processes to merge customer needs with digital technologies • Creating demand, revealing sales opportunities, generating sales orders, and ultimately delivering new digital solutions • Modularizing digital solutions by standardizing and customizing solution components *Profit equation* • Creating additional revenue through digital solutions	• Thinking about technical possibilities rather than customer needs • Sticking to single digital technologies for digital solutions • Developing digital solutions with too little perceived customer value • Favoring either a too-strong standardization or customization
Utilizing product connectivity	• The increasing number of products connected through the internet • Customers demanding to pay for product usage and performance (i.e., pay-per-use) rather than buying the products	*Value proposition* • Guaranteeing levels of performance (e.g., 98% machine availability) • Offering customers the opportunity to pay for product usage rather than buying the product *Value-creation activities* • Monitoring, inspecting, and diagnosing products remotely • Creating new interactions between service teams tracking the connected products and local service engineers • Configuring pricing and cost schemes for various payment options *Profit equation* • Securing spare-parts revenues • Replacing field-service revenues with revenues from combining digital and traditional services	• Incomplete and fuzzy accounting of cost savings • Assuming a cannibalization of existing service revenues • Preventing component-condition monitoring with key suppliers • Attracting only highly demanding and low-usage customers • Promoting payment schemes based on performance levels and product usages

Table 1. (*continued*)

Growth Paths	Triggers	Modifications	Traps
Establishing an IoT-based application business	• Increasing data volume, velocity, and variety • Customers wanting to improve effectiveness and efficiency of the product's operation, usage, and maintenance	*Value proposition* • Solving customer problems through data and data analytics *Value-creation activities* • Identifying customers' key problems • Incorporating expertise in big data and machine-learning algorithms and applications • Initiating collaborations to share the costs of building a new digital ecosystem • Building an IoT platform *Profit equation* • Including payment schemes (e.g., subscriptions, licenses, and freemium approaches), as in the software business • Including investment and implementation costs for building IoT platforms and applications	• Sticking to the freemium approach, which can cause users to resist upgrading to the professional version • Failing to build trust among partners in a newly emerging digital ecosystem

with the solution components for personnel protection and to increase the operator's view. The first module helps protect ground personnel working in the vicinity of construction equipment through RFID safety vests and alarms that sound when a tagged person is in the detection zone. The second module is a work-area vision system, which enhances an operator's ability to see blind spots around equipment.

Altogether, if companies manage to cope with these traps, they can successfully develop this growth path for their digital solutions.

4.2. Utilizing product connectivity

4.2.1. Triggers

The second growth path is about utilizing product connectivity. The increasing number of products connected through the internet triggers this path. While the first growth path covers various digital technologies, the second one has a narrow focus on connectivity (Fleisch et al., 2015). This connectivity allows companies to access, monitor, and analyze product usage, leading to differentiation advantages through the improvement of product availability, uptime, usage, and performance (Ulaga & Reinartz, 2011). At the same time, customers expect to pay for product usage and performance (i.e., pay-per-use) rather than to buy and own the product.

Siemens, whose Inspiro trains operate on the Piccadilly line in London's Underground subway system, is a typical illustration. Overcrowding is a problem in the London Underground. To boost capacity along the 53 stations of the 73.4 km-long Piccadilly line, London Underground wanted to increase the number of metro trains per hour from 24 to 27. Due to cost reasons, London Underground wanted to limit the total number of trains to fewer than 100. By using train connectivity to gain insights into train usage and conditions, Siemens was able to fulfill the deal with 96 Inspiro trains. The connectivity allowed the company to minimize train failures and delays, thereby protecting the stability of the Underground system and maximizing the availability of trains through predictive maintenance.

4.2.2. Modifications

To utilize connectivity, companies modify their value-creation activities to emphasize monitoring, inspecting, and diagnosing products remotely. This leads to collaborations between the service teams that track the connected products and the local service engineers who perform inspections, repairs, and maintenance. Companies further modify their value-creation activities by balancing higher product costs with cost improvements. Integrating connectivity into the products increases product costs, but these costs can pay off by reducing warranty and service costs.

GE provides a good example of this tendency. By integrating connectivity into their products, GE solves 95% of product failures by remotely accessing the product, which means the company very rarely has to send local field-service staff for inspections and diagnosis. The cost of connectivity increased GE's product costs but lowered its warranty and service costs.

Companies can also modify their value-creation activities by strengthening their existing service businesses. Connectivity modifies the profit equation by changing the cost structures through increasing predictability of service demands over installed products, and by supporting greater average usage of service capacity. In addition, connectivity strengthens service revenues because it secures spare-parts revenue by automating the parts-identification and purchasing processes, which makes service contracts more attractive since fewer service interventions are necessary. An example is the remote-analysis system rConnect from GF Machining Solutions. rConnect connects machines and increases the predictability of service activities (and thus capacity utilization). It improves sales of spare parts, consumables, and service contracts, and it enables better prediction of machine failures.

Through better prediction of product failures, companies can shift their value propositions toward guaranteeing product usage and levels of performance (e.g., 98% machine availability). In addition, they can leverage connectivity with real-time monitoring and analytics of actual product usage and lifecycle costs. This enables companies to facilitate the value proposition of having customers pay for usage (i.e., pay-per-use) and to align costs with the customer's degree of product usage. To incentivize customers to pay for guaranteed levels of performance and product usage, companies can configure and customize the pricing and cost schemes so that they can offer a variety of payment options (e.g., product availability of 90%, 95%, or 98%, or paying per kilometer or ton transported).

4.2.3. Traps

Companies should be aware of following growth traps as this path unfolds. Companies often become trapped in incomplete and fuzzy accounting of their actual savings on warranty and service costs. This makes it difficult to justify the investment costs of embedding connectivity costs into product-manufacturing costs. Furthermore, companies are afraid that connectivity can cannibalize existing service revenues, even when customers would receive more value from greater product uptime and availability. Since fewer personal service interventions are necessary, companies may think that customers would also want to pay less for them.

Even when companies succeed in establishing connectivity across their installed product base, they can only make payments for performance and product usage feasible if they also connect key suppliers to monitor and automatically maintain component conditions in line with guaranteed performance and product-usage levels. Siemens' performance guarantee of 27 trains every hour on the London Underground was a success because Siemens allowed all critical train components to be monitored together with suppliers in order to minimize component failures. But many companies keep such data to themselves and rarely exchange them with their suppliers.

Companies can be caught in a situation in which paying for guaranteed performance levels attracts highly demanding customers, whereas paying for product usage attracts low-usage customers. Both types of customers make achieving profitability risky, so companies often pool and redistribute risks across customers, as is widely practiced in risk management. Through these risk-management activities, companies establish price buffers, which make these payment schemes attractive for customers without jeopardizing profitability. The tire manufacturer Michelin is a good example. Truck operators pay per kilometer that the tire actually runs, and this attracts operators who drive few kilometers. Michelin utilizes connectivity to better manage tire usage and tire lifecycle costs. Connectivity provides Michelin with sufficient tire-usage data to determine price buffers that can ensure the profitability of paying per kilometer.

Finally, companies assume that such payment schemes for guaranteeing performance levels and product usage can be promoted by stand-alone offerings. As a stand-alone offer, these schemes are too risky, but such payment schemes should be embedded in existing offerings, as illustrated by the case of Renault Trucks. The company embeds pay-per-kilometer pricing into its rental service,

including a monthly rental fee (€799) that covers 2,000 free kilometers per month and a full-service contract. Once the telematics system recognizes that the 2,000 kilometers are achieved, customers pay €0.06 per kilometer thereafter.

If companies can avoid these traps, they can successfully develop the path of utilizing product connectivity.

4.3. Establishing an IoT-platform-based application business

4.3.1. Triggers

The third growth path is about establishing an IoT-platform-based application business. The increasingly vast data volume obtained from connected products triggers this path. Consider that a fully equipped wind farm from Vestas provides data on approximately 150,000 data points every second, and a fully instrumented jet engine from Rolls-Royce provides approximately 51,200 gigabytes of data every hour. If customers want to improve the effectiveness and efficiency of product operation, usage, and maintenance, they will share these data with the product provider. This motivates companies to establish an IoT platform and to grow the application business around the algorithms for analyzing the data.

This path relates to the discussion of big data, machine learning, and artificial intelligence (Opresnik & Taisch, 2015); it includes not only monitoring product usage but also all uses of sensors, actuators, and algorithms to obtain and analyze data on customer processes. An example of a company that followed this path is Heidelberger Printing Machines, which developed the application Prinect to analyze data on its customers' printing process in order to improve that process. Heidelberger strengthened software development and enhanced its revenues by selling software licenses and Prinect subscriptions.

4.3.2. Modifications

This growth path requires the following modifications. The profit equation must be modified to enable selling software applications as digital products or services with payment schemes that rely on subscriptions, licenses, and freemium approaches, like in the software business. The profit equation also entails investment costs for developing and implementing the building blocks for IoT platforms and for the applications. An example of a company that followed this path is GE, which invested intensively into its Predix platform. This platform allows GE to offer digital product twins that incorporate comprehensive building blocks in order to: (1) create digital twin models for physical product assets, (2) build analytics using rich asset context, data, and history, (3) operationalize digital twins in industrial IoT applications, and (4) understand, predict, and optimize complex asset performance.

The applications propose value by discovering how data and data analytics can contribute to solving customer problems. Companies can introduce value-creation activities by identifying their customers' key problems, which can be solved by data analytics. For example, Bühler, an equipment supplier for the food-processing industry, mapped all customer activities around their equipment and prioritized energy efficiency, food supply-chain security, and production efficiency as key areas for applications. Once such key areas have been identified, value-creation activities can shift toward incorporating corresponding customer-application expertise in big data and machine-learning algorithms and applications.

In addition, companies can create value by building an IoT platform, which is necessary for storing, processing, and managing the data for such software applications. Siemens, for example, relies on its MindSphere platform to collect sensor data from wind turbines. But companies report that customers are still skeptical about sharing data on IoT-platforms, even when those very platforms address their key problems. Thus, companies should build the value propositions to incorporate platforms into customers' key performance indicators.

Taking advantage of IoT platforms is beyond the scope of a single company. Companies initiate alliances for sharing these investment and implementation costs with collaborative partners, leading to a newly emerging digital ecosystem. Siemens, for example, formed a MindSphere alliance of robotics builders and specialists in industrial automation, including Kuka, Festo, and Trumpf machine tools.

4.3.3. Traps

While these modifications may sound straightforward, companies should beware of falling into the following traps. Companies may recognize the need to collaborate with partners to build digital ecosystems, but they sometimes lack the necessary trust to succeed through such collaborations. Some firms are afraid that many companies will contribute to platform models but that only a few companies will dominate the ecosystem, thereby capturing a disproportionate share of the economic value. As many examples suggest (e.g., search engines, online marketplaces, maps, music services), winner-takes-all and quasimonopolistic platforms are not uncommon (Parker & van Alstyne, 2014).

Thus, a collaborative growth path can only unfold if there is sufficient trust among partners and so long as each partner understands its specific role.

Siemens' development of its MindSphere platform illustrates this sort of collaborative growth. Its partners specialize in certain roles, such as consulting, application development, systems integration, technology, and connectivity. Over time, Siemens and its partners have worked to clarify their roles, like technology partners being responsible for enhancing the capabilities and ensuring the adoption of the MindSphere platform, which involves analytics, artificial intelligence, and big data. Siemens developed a partner program for providing a comprehensive set of benefits (e.g., sales and technical training, application-development tools, technical support, marketing resources, legal support, and business-development funds) to help its partners accelerate their applications and services on the MindSphere platform.

Companies can become further entrapped through overreliance on a freemium approach, which is a common model used in the software industry to attract application users relatively rapidly. Under a freemium model, companies offer a free version of their application with basic functionality to build user trust and to promote the sales of a professional version with full functionality. But customers generally stick to using the basic functionality and seldom upgrade to full functionality. Companies can become trapped if they are unable to make clear distinctions between free versions and fully functional versions. If a company includes too few functionalities in the free version, customers are unlikely to be satisfied or motivated enough to upgrade to the premium version. But if a company includes too many functionalities in the free version, customers are unlikely to see a need to upgrade to the premium version.

A promising way to overcome this trap is to introduce a trial period for applications rather than offering a free version; that is, to use a subscription model instead of a freemium model. The industrial food-drier manufacturer Bühler, for example, offers its ThermalSuite application with subscription fees as a payment scheme. ThermalSuite provides a cloud infrastructure so customers can monitor, visualize, and analyze production data while benefitting from Bühler's thermal-processing expertise. Customers can use a trial version for a few months; afterwards, they can subscribe to basic or professional versions with annual subscription fees of €75,000 or €100,000.

Companies must sidestep these growth traps in order to successfully develop a platform-based application business.

5. Summary of findings

The motivation for this study was to expand knowledge about revenue enhancement through digitalization. We offer four important insights for academics and practitioners. First, our findings shed light on digitalization in incumbent industrial companies operating in the business-to-business sector. This sector largely has been neglected in previous research. Of course, our findings are not meant to be exhaustive; there may be additional paths that sustain competitive advantage through revenue enhancement. Nevertheless, our findings should stimulate researchers to further investigate the progression of revenue growth through digitalization. Our findings are not limited to industrial companies and can likely be transferred to other sectors.

Second, we substantiate the idea of the digitalization paradox. We show that despite revenue enhancement through digitalization, companies often face a digitalization paradox: They invest in digitalization but rarely seem to achieve corresponding revenue enhancement. This paradox differs from previous discussions on the productivity paradox, which focused on cost and productivity improvements rather than revenue enhancement. We strongly encourage future research to further investigate the digitalization paradox.

Third, we identify three growth paths: (1) commercializing digital solutions, (2) utilizing product connectivity, and (3) establishing an IoT-platform-based application business for revenue enhancement. Commercializing digital solutions can grow digital revenue. Product connectivity changes existing product and service revenue structures rather than directly growing digital revenues. Establishing an IoT-platform-based application business can create growth through embedding applications into digital offerings.

Altogether, these paths revise the previous business logic of integrating products and services into tailored offerings over time, and they strengthen the case for a more digital business logic. After commercializing digital solutions and utilizing product connectivity, companies progress to establishing a software-application business by building IoT platforms. These IoT platforms entail the highest investments—and also the highest risks—because they radically change business models. Discussions of platforms have been dominated recently by the idea of matching platforms and two-sided markets in consumer contexts (Kenney & Zysman, 2016; Parker & van Alstyne, 2014). Thus, the third path demonstrates the future importance of

platforms in the business-to-business sector. By locking customers into a full range of product assets, IoT platforms can create competitive advantages for industrial companies.

Our outline of growth paths (including triggers and key activities) offers a more fine-grained view of how companies enhance revenues through digitalization. The modifications initiate a dynamic that makes it easier to revise the previous business logic. The paths substantiate the idea of continuous change in business models.

Fourth, the described modifications require initial investments that pay off later through revenue enhancement. We highlight how growth traps prevent those key modifications from leading to revenue enhancement through digitalization, and how those growth traps ultimately cause the digitalization paradox. These traps advance the configurational view of business models, in which, as these paths unfold, modifications can ensure a consistent configuration of the value proposition, value creation, and profit equation to achieve revenue enhancement. We hope our contributions provide new insights for academics and practitioners alike.

References

Amit, R., & Zott, C. (2001). Value creation in e-business. *Strategic Management Journal, 22*(6/7), 493—520.

Baines, T., Ziaee Bigdeli, A., Bustinza, O. F., Shi, V. G., Baldwin, J., & Ridgway, K. (2017). Servitization: Revisiting the state-of-the-art and research priorities. *International Journal of Operations and Production Management, 37*(2), 256—278.

Berends, H., Smits, A., Reymen, I., & Podoynitsyna, K. (2016). Learning while (re)configuring: Business model innovation processes in established firms. *Strategic Organization, 14*(3), 181—219.

Bowman, C., & Ambrosini, V. (2000). Value creation versus value capture: Towards a coherent definition of value in strategy. *British Journal of Management, 11*(1), 1—15.

Brynjolfsson, E. (1993). The productivity paradox of information technology. *Communications of the ACM, 36*(12), 66—77.

Casadesus-Masanell, R., & Zhu, F. (2013). Business model innovation and competitive imitation: The case of sponsor-based business models. *Strategic Management Journal, 34*(4), 464—482.

Chesbrough, H. (2010). Business model innovation: Opportunities and barriers. *Long Range Planning, 43*(2/3), 354—363.

Chesbrough, H., & Rosenbloom, R. S. (2002). The role of the business model in capturing value from innovation: Evidence from Xerox Corporation's technology spin-off companies. *Industrial and Corporate Change, 11*(3), 529—555.

Cusumano, M. A., Kahl, S. J., & Suarez, F. F. (2015). Services, industry evolution, and the competitive strategies of product firms. *Strategic Management Journal, 36*(4), 559—575.

Demil, B., & Lecocq, X. (2010). Business model evolution: In search of dynamic consistency. *Long Range Planning, 43*(2/3), 227—246.

Fleisch, E., Weinberger, M., & Wortmann, F. (2015). Geschäftsmodelle im Internet der Dinge. *Schmalenbachs zeitschrift für betriebswirtschaftliche forschung, 67*(4), 444—465.

Gartner. (2019). *Gartner glossary > digitalization*. Available at https://www.gartner.com/en/information-technology/glossary/digitalization

General Electric. (1995). *Annual report*. Boston, MA: GE.

General Electric. (2005). *Annual report*. Boston, MA: GE.

General Electric. (2015). *Annual report*. Boston, MA: GE.

General Electric. (2018). *Annual report*. Boston, MA: GE.

IBM. (1993). *Annual report*. Armonk, NY: IBM.

IBM. (2005). *Annual report*. Armonk, NY: IBM.

IBM. (2018). *Annual report*. Armonk, NY: IBM.

Kenney, M., & Zysman, J. (2016). The rise of the platform economy. *Issues in Science and Technology, 32*(1), 61—69.

Lee, I. (2017). Big data: Dimensions, evolution, impacts, and challenges. *Business Horizons, 60*(3), 293—303.

Ng, I. C., & Wakenshaw, S. Y. (2017). The Internet-of-Things: Review and research directions. *International Journal of Research in Marketing, 34*(1), 3—21.

Nylén, D., & Holmström, J. (2015). Digital innovation strategy: A framework for diagnosing and improving digital product and service innovation. *Business Horizons, 58*(1), 57—67.

Opresnik, D., & Taisch, M. (2015). The value of big data in servitization. *International Journal of Production Economics, 165*(C), 174—184.

Osterwalder, A., & Pigneur, Y. (2010). *Business model generation: A handbook for visionaries, game changers, and challengers*. Hoboken, NJ: John Wiley & Sons.

Parker, G., & van Alstyne, M. W. (2014). Platform strategy. *The Palgrave encyclopedia of strategic management*. London, UK: Palgrave Macmillan.

Pauwels, K., & Weiss, A. (2008). Moving from free to fee: How online firms market to change their business model successfully. *Journal of Marketing, 72*(3), 14—31.

Saarikko, T., Westergren, U. H., & Blomquist, T. (2017). The Internet of Things: Are you ready for what's coming? *Business Horizons, 60*(5), 667—676.

Saebi, T., Lien, L., & Foss, N. J. (2017). What drives business model adaptation? The impact of opportunities, threats, and strategic orientation. *Long Range Planning, 50*(5), 567—581.

Slater, R. (1998). *Jack Welch and the GE way*. New York, NY: McGraw-Hill.

Storbacka, K. (2011). A solution business model: Capabilities and management practices for integrated solutions. *Industrial Marketing Management, 40*(5), 699—711.

Stratopoulos, T., & Dehning, B. (2000). Does successful investment in information technology solve the productivity paradox? *Information and Management, 38*(2), 103—117.

Teece, D. J. (2010). Business models, business strategy, and innovation. *Long Range Planning, 43*(2/3), 172—194.

Ulaga, W., & Reinartz, W. J. (2011). Hybrid offerings: How manufacturing firms combine goods and services successfully. *Journal of Marketing, 75*(6), 5—23.

Voith. (2018). *Annual report 2017/2018*. Heidenheim, Germany: Voith.

Wirtz, B. W., Göttel, V., & Daiser, P. (2016). Business model innovation: Development, concept, and future research directions. *Journal of Business Models, 4*(1), 1—28.

Yoo, Y., Boland, R. J., Jr., Lyytinen, K., & Majchrzak, A. (2012). Organizing for innovation in the digitized world. *Organization Science, 23*(5), 1398—1408.

Zott, C., Amit, R., & Massa, L. (2011). The business model: Recent developments and future research. *Journal of Management, 37*(4), 1019—1042.