GROWTH PATHS FOR OVERCOMING THE DIGITALIZATION PARADOX

Abstract

Despite the demonstrated opportunities for revenue enhancement through digitalization, companies often experience a digitalization paradox. This paradox suggests that although companies invest in digitalization, they often fail to achieve the expected revenue enhancement. By reporting research on 52 companies, this article makes the following contributions. First, the article focusses on industrial companies in the business-to-business context, which have largely been neglected in previous research on digitalization. Second, it introduces the digitalization paradox as an important phenomenon in the discussion of revenue enhancement through digitalization. Third, it describes 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 (value proposition, value-creation activities, and profit equation). Fourth, the described modifications require initial investments to let these growth paths develop. However, we highlight how growth traps can prevent investments in business model modifications from leading to revenue enhancement and can, ultimately, lead to the digitalization paradox.

Key words: digitalization, internet of things (IoT), business model innovations, revenue growth, growth traps, business model modifications.

GROWTH PATHS FOR OVERCOMING THE DIGITALIZATION PARADOX

1. EMBRACING REVENUE GROWTH THROUGH DIGITALIZATION

Digitalization has become a strategic imperative for practitioners and a popular unit of analysis among academics. Digitalization describes the convergence of the physical world with the digital world through widespread technologies (e.g. the internet of things (IoT), ubiquitous computing, data analytics, machine learning, artificial intelligence, smart devices, sensors, platforms, etc.) (e.g. Lee, 2017; Ng, & Wakenshaw, 2017). In this article, we focus on digitalization around IoT, which enables 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, ZF). Such industrial companies are incumbent companies 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 *et al.*, 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 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). By following the statement of (former GE CEO) Jack Welch that “The [service] market is bigger than we ever dreamt’’ (Slater, 1999, p. 183), GE has expanded the service business. In

1995, services generated about 22% of GE's revenues. By 2005, services represented 36% of GE's revenues (GE, 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 projected that the company 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 has also become a pioneer in digital growth and reported that it has generated 39% percent of its revenue in the digital world, with the remaining revenue generated through products (10%), services (49%) and other sources (2%) (IBM, 1993, 2005, 2018).

Besides being an additional revenue stream, digitalization can enhance product and service revenues in the physical world. In that case, digitalization helps to differentiate existing products and services by increasing perceived customer value. For example, Voith reports both types of revenues: 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) in 2017/18 (Voith , 2018).

Despite the demonstrated ability of digitalization to enhance revenue, many companies struggle to capitalize 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 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 *et al.*, 2016; Zott *et al.*, 2011).

In turn, this article makes four main contributions. First, it focusses on industrial companies in the business-to-business context, companies that have largely been neglected in previous research. Second, it introduces the digitalization paradox as an important phenomenon in the discussion of revenue enhancement through digitalization. Third, it describes 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 highlight the growth traps that these companies face as they develop their growth paths – traps that ultimately result in the digitalization paradox.

2. DIGITALIZATION PARADOX

We consider revenue enhancement through digitalization as a strategic priority, because there is a risk that a competitor could establish a market position first, which thereby makes it more difficult to gain shares of overall digital revenues. This argument is in line with Gartner's (2019) definition on 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 based on valid reasoning about 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 is still in line with expectations. However, as cumulative investments increase, companies increasingly face the digitalization paradox and do not obtain the projected revenue enhancement. As companies invest more and more into 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 and/or cost improvements (Brynjolfsson, 1993; Stratopoulos & Dehning, 2000). Our definition links investments in digitalization with revenue enhancement and not with productivity and cost improvements. Thus, we assume that digitalization is more than digitizing operational processes in order to make processes more efficient.

Insert Figure 2 around here

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 (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 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 the digitalization, which pay off through revenue enhancement and cost improvements. Furthermore, companies leverage digital technologies to charge for product usage, thereby generating revenue from pay-per-use services rather than products and services (Cusumano *et al.*, 2015). Such modifications in the profit equation relate back to the above-mentioned value proposition of improving product availability, uptime, usage, and performance.

All three components need 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 *et al.*, 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). However, 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 *et al.*, 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 navigate simultaneously along the modifications of all the growth paths. Each description of the growth paths starts with the growth triggers, and then highlights key modifications and possible growth traps (see Figure 3).

4.1. Commercializing digital solutions

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, drones, etc.) and customers demanding more personalized experiences and smooth digital touchpoints (Nylén & Holmstöm, 2015).

Modifications: To do so, 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 in terms of allowing operators to know what is happening around their construction equipment. Cat® Detect combines CCTV cameras, vehicle tracking systems, RFID tags on vests, etc. Combining these digital technologies creates 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 *et al.*, 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 a modularization in terms of standardizing and customizing solution components.

Traps: While such modifications sound relatively easy, companies might be caught in growth traps as this path unfolds. Companies tend to focus too much thinking 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 the customers. Rather than combining multiple technologies, companies often still 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 pc, machine operators can move around on the shop floor simplifying their machine operations. Since customers do not perceive the value high enough to pay for it separately, MobileControl only augments machine offerings.

As this example suggests, 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 have sufficient modularization, which allows a cost-efficient customization of the digital solutions for individual customers and customers segments. Companies can become trapped by either favoring standardization too much, which makes it impossible to tailor the offering to individual customer needs or, conversely, favoring customization too greatly, which makes it difficult to deliver digital solutions in a cost-efficient way. The Cat® Detect solution mentioned above illustrates the importance of modularization of digital solutions for balancing standardization and customization successfully.

Cat® Detect is modularized with the solution components for personnel protection and to increase the operator’s view. The first module provides a layer of protection through RFID safety vests and alarms when a tagged person is in the detection zone for ground personnel working in the vicinity of construction equipment. 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 the growth path on digital solutions.

4.2. Utilizing product connectivity

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/or performance (i.e., pay-per-use) rather than buying and owning the product. Siemens, with its Inspiro trains that 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 less than 100. Utilizing the train connectivity to gain insights into train usage and conditions, Siemens was able to make the deal with 96 Inspiro trains. The connectivity allowed the company to minimize train failures, which can cause delays, thereby protecting the stability of the Underground system and maximizing the availability of trains through predictive maintenance.

Modification: To utilize connectivity, companies modify their value-creation activities toward monitoring, inspecting, and diagnosing products remotely. This leads to collaborations between service teams, which track the connected products, and local service engineers who are providing services (e.g. inspections, repairs, or maintenance). Companies continue modifying by balancing higher product costs with cost improvements. Integrating connectivity into the products increases product costs, but as the following GE example illustrates, these costs pay off by reducing GE's warranty costs and service costs.

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

Companies continue modifying by strengthening their existing service businesses. Connectivity modifies the profit equation in terms of changing the cost structures through increasing predictability of service demand over installed products, and by supporting greater average utilization of service capacity. In addition, connectivity strengthens service revenues because it secures spare-parts revenue by automatizing the parts identification and purchasing processes, which makes service contracts more attractive since fewer service interventions are necessary. An example is rConnect of GF Machining Solutions:

rConnect, a remote analysis system from GF Machining Solutions, connects machines and increases the predictability of service activities – and thus capacity utilization – improves sales of spare parts, consumables, and service contracts, and enables a better prediction of machine failures.

Through better prediction of product failures, companies shift their value propositions toward guaranteeing product usage and levels of performance (e.g. 98% machine availability). In addition, they 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 align costs with a customer's degree of product usage. To succeed with having customers pay for guaranteed levels of performance and product usage, companies 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, paying per ton transported, etc.).

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

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. As in the case of Siemens' performance guarantee of 27 trains every hour on the London Underground, it was a success because Siemens allowed all critical train components to be monitored together with suppliers in order to minimize train component failures. But many companies keep data to themselves and rarely exchange them with their suppliers.

Companies can be caught in the situation that 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, making it necessary for companies to 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 payments schemes attractive for customers without jeopardizing profitability. For example, Michelin, a tire manufacturer, ensured profitability as following:

Truck operators pay per kilometer that the tire actually runs, attracting operators who drive few kilometers. Michelin utilizes connectivity to better manage tire usage and tire lifecycle costs. Connectivity provided Michelin with sufficient tire usage data to determine price buffers that could 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.

Renault Trucks embeds pay-per-kilometer 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 recognized that the 2,000 kilometers are achieved, customers pay €0.06 per kilometer.

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

4.3. Establishing an IoT-platform-based application business

Triggers: The third growth path is about establishing an IoT-platform-based application business. The increasing data volume obtained from the connected products triggers this path. For example, a fully equipped wind farm from Vestas provides data on approximately 150,000 data points every second, or a fully instrumented jet engine from Rolls-Royce provides approximately 51,200 Gigabytes every hour. If customers want to improve the effectiveness and efficiency of the 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 on big data, machine learning, and artificial intelligence (Opresnik & Taisch, 2015); it includes not only monitoring of product usage, but also all uses of sensors, actuators, and algorithms to obtain and analyze data on customer processes. One example is Heidelberger Printing Machines:

Heidelberger Printing Machines developed the application Prinect to analyze data on the customers' printing process in order to improve this process. Heidelberger strengthened software development and enhanced its revenues by selling software licenses and/or Prinect subscriptions.

Modification: This growth path requires following modifications. The profit equation is modified toward selling software applications as digital products and/or services with payment schemes that rely on subscriptions, licenses, and freemium approaches like those in the software business. As the example of GE suggests, the profit equation also entails investment costs for developing and implementing the building blocks for IoT platforms and for the applications:

GE invested intensively into its Predix^{TM} platform. This platform allows GE to offer *digital product twins that incorporate comprehensive building blocks: (1) creating digital twin models for physical product assets, (2) building analytics using rich asset context, data, and history, (3) operationalizing digital twins in industrial IoT applications, and (4) understanding, predicting, and optimizing complex asset performance.*

The applications propose value by discovering how data and data analytics can contribute to solving customer problems. As the example of Bühler suggests, companies introduce value-creation activities in terms of identifying the customer's key problems, which can be solved by data analytics:

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 shift towards 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 when an operator of a wind farm collects sensor data from its Siemens wind turbine. However, companies report that, despite addressing their key problems, customers are still skeptical about sharing data on IoT-platforms. Thus, companies 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 collaboration partners, leading to newly emerging digital ecosystem. Siemens, for example, formed a MindSphere alliance that includes a robotic builder, Kuka, the specialist in industrial automation, Festo, and Trumpf machine tools.

Traps: While these modifications sound rational, companies should be aware of falling into following traps. Companies 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 only a few companies will dominate the ecosystem, thereby capturing a disproportionate share of the economic value. As many examples suggest (e.g. for search engines, online marketplaces, maps, music services, etc.), there have been many examples of "winner takes all" and quasi-monopoly platforms (Parker & Van Alstyne, 2011). Thus, a collaborative growth path can only unfold if there is sufficient trust among partner and if each partner understands its specific role. As Siemens' MindSphere platform suggests*:*

Partners specialized in certain roles, such as consulting partners, application developers, system integrators, technology partners, or connectivity partners. Siemens and these partners started to clarify their roles, like technology partners responsible for enhancing capabilities as well as the adoption of the MindSphere platform utilizing analytics, artificial intelligence, and big data, etc. Siemens developed a specific partner program for providing a comprehensive set of benefits (e.g. sales and technical training, application developer tools, technical support, marketing resources, legal support, business development funds, etc.) to help partners accelerate their application or service on the MindSphere platform.

Companies can be further trapped by embracing too great of a freemium approach, which is a common model used in the software industry to attract application users relatively rapidly. Companies offer a free version of their applications with basic functionality to build user trust and to promote the sales of a professional version with the full functionality. However, customers generally stick to using the basic functionality and seldom upgrade to the full functionality of the applications. Companies are trapped by not being able to make clear distinctions between free versions and full functionality 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. Yet on the other hand, if too many functionalities are included in the free versions, customers are unlikely to upgrade to the premium version. A promising way to overcome this trap is to introduce a trial period for applications, as in subscription model, rather than a free version, as in the freemium model. As the example of Bühler suggests, companies might prefer a subscription model:

Bühler offers the ThermalSuite application with subscription fees as a payment scheme. ThermalSuite provides a secure and reliable cloud infrastructure so customers can monitor, visualize, and run insightful analytics on production data and industry-leading thermal processing expertise from Bühler's dryer machines. Customers can use a trial version for a few months. Afterwards, companies can subscribe to basic or professional versions with annual subscription fees of €75,000 or €100,000.

Only if companies are able to circumnavigate these growth traps, can they successfully develop a platform-based application business.

Insert Figure 3 around here

5. SUMMARY OF FINDINGS

The motivation for this study was to expand knowledge about revenue enhancement through digitalization. We add four important insights for academics and practitioners. First, our findings shed light on the digitalization in incumbent industrial companies operating in the business-to-business sector. This sector has largely 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. Interestingly, our findings are not limited to industrial companies, but can likely be transferred to other sectors.

Second, we substantiate the idea of the digitalization paradox. Despite revenue enhancement through digitalization, we highlight that companies 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 focusses 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. The use of product connectivity changes existing product and service revenue structures rather than generating 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 strengthen 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, but also the highest risks because they radically change business models. The idea of platforms has been dominated recently by discussions about matching platforms and two-sided markets in consumer contexts (Kenney & Zysman, 2016; Parker & Alstyne, 2015). 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 (e.g. triggers, 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, which pay off later through revenue enhancement. However, 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, with modifications as these paths unfold, representing 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.

6 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 & 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.

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.

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

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 IT Glossary > Digitalization*, Retrieved March 31, 2019, from https://www.gartner.com/it-glossary/digitalization/

General Electric (1995, 2005, 2015, 2018). *Annual reports 1995, 2005, 2015 and 2018*.

IBM (1993, 2005, 2018). *Annual reports 1993, 2005 and 2018.*

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, 174-184.

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

Parker, G., & van Alstyne, M.W. (2015). *Platform strategy*.

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.

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.

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.

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 & Management*, 38(2), 103-117.

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

Tuli, K. R., Kohli, A. K., & Bharadwaj, S. G. (2007). Rethinking customer solutions: From product bundles to relational processes. Journal of Marketing, 71(3), 1-17.

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

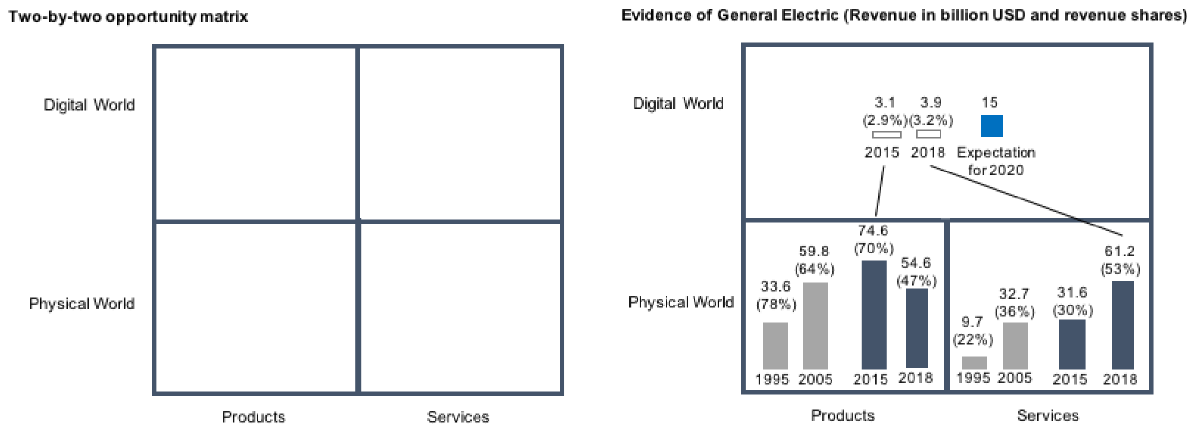
Yoo, Y., Boland Jr, R. J., Lyytinen, K., & Majchrzak, A. (2012). Organizing for innovation in the digitized world. *Organization Science*, 23(5), 1398-1408.

Voith (2018). *Annual report 2017/2018.*

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.

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

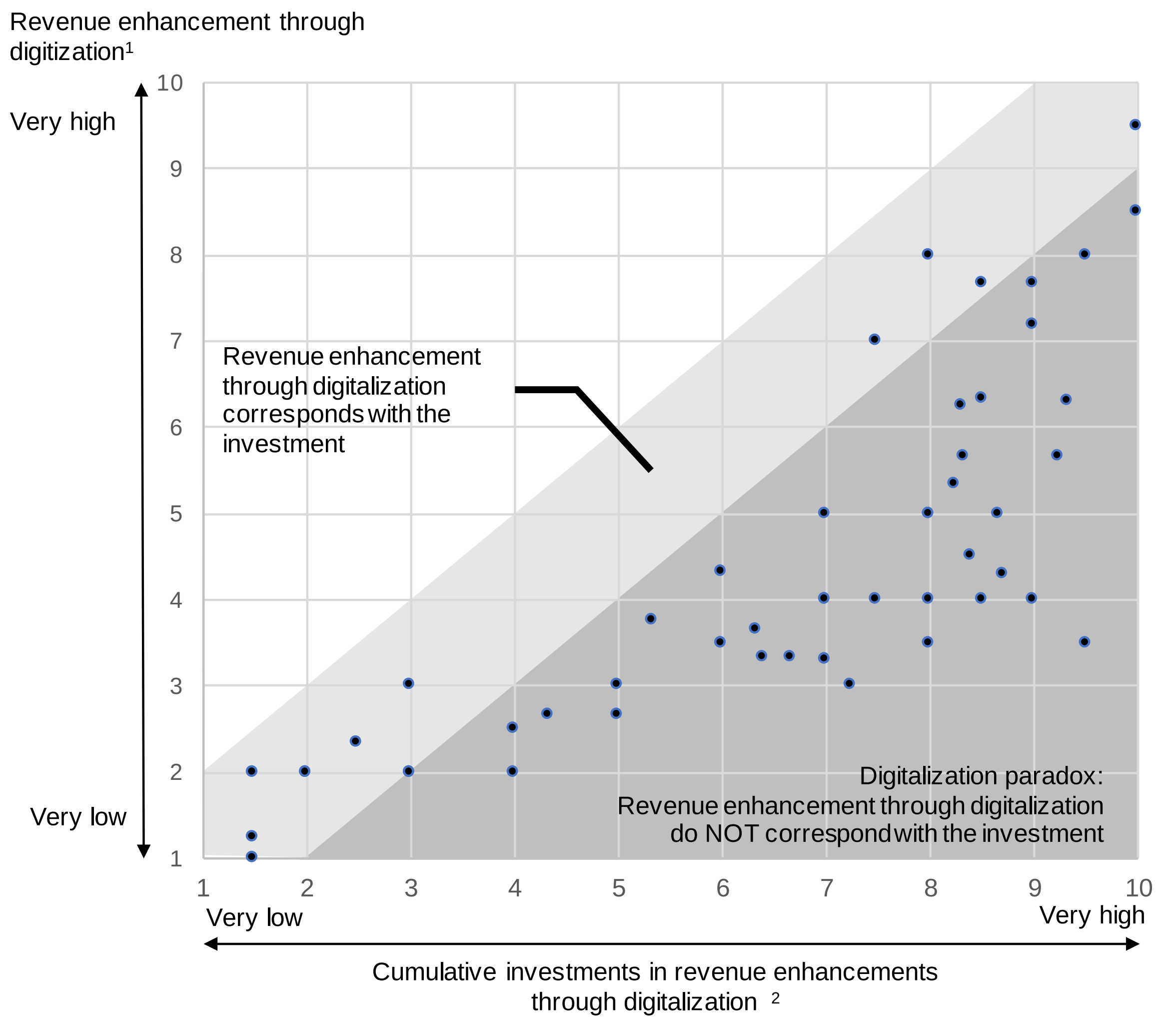
7. FIGURES



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.

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



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.

Figure 2: Empirical evidence of the digitalization paradox

Growth paths	*Triggers*	*Modifications*	*Traps*
Commercializing digital solutions	– Availability of manifold digital technologies – Customers demanding personalized experiences and smooth digitalized touch points	*Value proposition* – Combining digital technologies for solving customer problems *Value-creation activities* – Implementing a structured, iterative processes on merging customer needs with digital technologies – Creating demand, revealing sales opportunities, generating sales orders, and ultimately delivering new digital solutions – Modularizing digital solutions in terms of standardizing and customizing solution components *Profit equation* – Creating additional revenue through digital solutions	– Thinking on technical possibilities rather than customer needs – Sticking to single digital technologies for digital solution – 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, which are connected through the internet – Customers demanding to pay for product usage and/or performance (i.e., pay-per-use) rather than buying the products	*Value proposition* – Guaranteeing levels of performance (e.g., 98% machine availability) – Offering customers 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 option *Profit equation* – Securing pare-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 high-demanding and low-usage customers – Promoting payment schemes on performance levels and product usage as
Establishing an IoT-based application business	– Increasing data volume, velocity, and variety – Customers wanting to improve effectiveness and efficiency of the product operation, usage and maintenance	*Value proposition* – Solving customer problems through data and data analytics *Value-creation activities* – Identifying the customers' key problems – Incorporating expertise in big data and machine learning algorithms and applications – Initiating collaborations for costs on 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 leading to a situation where users do not upgrade to the professional version – Missing trust among partners in a newly emerging digital ecosystems

Figure 3: Growth paths (triggers, modifications, and traps).