Digital transformation of industrial firms: an innovation diffusion perspective

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Abstract

Purpose – The digitization process has increased the pressure on large firms to transform. However, current frameworks on digital transformation are not well explaining what factors contribute to, or hinder, a firm's digital transformation. Innovation diffusion theories could complement existing frameworks, and for this reason, the purpose of this paper is to expand the existing body of knowledge on what contributes to, or hinders, an industrial firm's digital transformation by applying a validated framework based on innovation diffusion theories on two pioneer cases: General Electric and Siemens EHR/Health Services.

Design/methodology/approach – The framework used in this paper is based on several years' empirical studies and iterative literature reviews on innovation diffusion theories. Further, each use case is based on literature reviews and unique empirical data, collected by the authors of this paper as a result of taking active part of respective company's multi-years transformation.

Findings – Common drivers of, and clear inhibitors to the two firms' transformation, were identified. The innovation diffusion framework was found to work very well in identifying those factors.

Research limitations/implications – The implications are that researchers better can analyze/explain a digital transformation of a firm, and business managers can better plan or improve their firms' transformation processes.

Originality/value – The theoretical contributions of this paper are two: first, complement existing frameworks with a validated framework for innovation diffusion; second, provide an extension of our body of knowledge on factors that contributes to, or hinders, industrial firm's digital transformation.

Keywords Innovation, Diffusion, Digital, Transformation, Siemens, GE

Paper type Research paper

1. Introduction

New digital technologies are transforming every industry and the digitization process has triggered a broader "digital transformation" phenomenon across most industries (Loebbecke and Picot, 2015; Richter *et al.*, 2018; Ghosh *et al.*, 2017; Butschan *et al.*, 2018). Further, the challenge for firms is not to add a digital touch to current practices and products, but to fully exploit digital technologies transformative potential (Venkatraman, 1994; Fitzgerald *et al.*, 2013; Birkinshaw *et al.*, 2016; Teece, 2018). In addition, according to Steiber and Alänge (2020), with an increasing pace of technological development, the large firms' dilemma is that "...there is little evidence that industrial giants are needed in all or even most industries to ensure rapid technological change and rapid utilization of new techniques" (Teece, 2006, p: 1,132). Also, innovation success is not so related to the innovator's *ex ante* market share, but "...to the (complementary) asset structure of the innovator, management's market entry timing decisions, and the contractual structures employed to access missing complementary assets"

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(Teece, 2006, p: 1,132). The challenge for large firms is therefore not only to explore and exploit new technologies, but also in parallel to be able to make necessary organizational changes.

There is no commonly accepted definition for the term digital transformation (Schallmo *et al.*, 2017). Therefore, in this paper, "digital transformation" of a firm is defined according to Fitzgerald *et al.* (2013): *The firm uses new digital innovations to enable major business improvements*. According to Nambisan *et al.* (2017), a "digital innovation" is digital technologies and associated digitizing processes that form the innate part of the new idea and its development, diffusion or assimilation. A digital transformation of a firm could therefore be viewed as a sociotechnical phenomenon (Yoo *et al.*, 2012b; Nambisan *et al.*, 2017). In addition this phenomenon could be viewed from an institutional perspective (Hinings *et al.*, 2018), in which the digital innovation could be a result of both technical and organizational innovations and the transformation process is affected by factors on both an organizational (e.g. culture and politics (Hinings *et al.*, 2018)) and institutional level (e.g. institutional infrastructure and building blocks (Hinings *et al.*, 2018)).

Interestingly, a minority of large firms has managed to explore and exploit disruptive digital technologies (Ahuja and Lampert, 2001; Christensen and Bower, 1996; Hill and Rothaermel, 2003; Paap and Katz, 2004; Rothaermel, 2001) and gain transformational effects from these (Fitzgerald *et al.*, 2013). This raises the question on why some firms struggle, while others successfully transform (Yu and Chieh Hang, 2010). What would contribute to large industrial firms' success in digitally transforming themselves? What are the drivers and inhibitors for a successful transformation?

Validated frameworks for analyzing digital transformations of firms are limited (Schallmo *et al.*, 2017). In addition, diverse theoretical perspectives and new research methodologies are needed in order to understand the major challenges that block or hinder firms' deployment of digital technologies (Yoo *et al.*, 2012a; Nambisan *et al.*, 2017).

One stream of research that has developed a validated framework in the context of digital transformation of firms is the area of strategic management and information systems. For example, the MIT-developed framework presented in Venkatraman (1994) does support in the analysis of firms' different degrees of IT-enabled business transformation. Further, in the area of Innovation Management, a framework on different phases and activities necessary for a digital transformation is presented in Schallmo (2016), which supports in analyzing how to plan and implement a digital transformation. However, none of these existing frameworks explain what factors that *contribute to, or hinder*, a successful digital transformation.

Perspectives that have been used in studies on the diffusion of innovations are the social network analysis (Rogers, 1983), the institutional-, fashion- (fads), cultural- and rational-perspective (Birkinshaw *et al.*, 2008). As could be learned from above, a digital transformation of a firm is a complex sociotechnical phenomenon, affected also by the institutional infrastructure and its building blocks. In addition, we can assume the national and international fads (Abrahamson, 1996) in, e.g. how to organize for the digital Age would affect firms in their desire to transform.

Innovation diffusion theories might therefore complement existing frameworks used in areas such as strategic management, information systems and innovation management. In addition, earlier studies applying innovation diffusion theories on the transformation of firms into, e.g. quality centric organizations have been able to pinpoint factors that positively and negatively affected the transformation processes (Alänge and Steiber, 2009; Steiber and Alänge, 2015a).

For this reason, the purpose of this paper is *to extend the existing body of knowledge on what contributes to, or hinders, an industrial firm's digital transformation by complementing existing frameworks with a validated analytical framework based on Innovation Diffusion theories on two pioneer cases: General Electric (GE) and Siemens EHR/Health Services.*

The theoretical contributions of this paper are primarily two: first, complement existing frameworks for studying digital transformation of firms with a previously tested, but in the context of digital transformation of firms, *new* framework, based on innovation diffusion theories, and second, provide an extension of our body of knowledge on factors that contributes to, or hinders, industrial firms' digital transformations.

Next, methodology and the validated analytical framework will be presented, followed by the two use cases, a discussion, and finally a conclusion, together with implications.

2. Methodology

The trigger for this paper was the paper by Steiber and Alänge (2020). Their finding was that in prior work on digital transformation (Hsiao and Ormerod, 1998; Macredie and Sandom, 1999; Sauer *et al.*, 1997), a limited number of validated frameworks for evaluating new or complementing resources' effect on large firms' business transformations have been identified. Steiber and Alänge (2020) identified one, presented in Venkatraman (1994), which in turn is based on early research literature on IT-enabled transformation (Scott-Morton, 1991; Galliers and Baets, 1998).

For this reason a literature review covering digital transformation and framework, model or process in research areas such as management, innovation management and innovation diffusion research was conducted by the authors in order to identify other validated frameworks for analyzing and explaining a digital transformation of a firm. Again, the authors found that the number of validated frameworks that have been used for analyzing firms' digital transformation is limited (Schallmo *et al.*, 2017). However, in the area of innovation management, one was found, consisting of different phases and activities necessary for a digital transformation. (Schallmo, 2016).

However, neither the framework presented in Venkatraman (1994), nor the one presented in Schallmo (2016) explain what factors that *contribute to, or hinder*, a successful digital transformation. Innovation diffusion theories have, however, supported in identifying factors contributing to, or hinder, e.g. a quality management transformation of firms (Alänge and Steiber, 2009; Steiber and Alänge, 2015a). In 2019, a literature review was therefore conducted, now focused on the "innovation diffusion perspective" and "digital transformation" (e.g. Fichman and Kemerer, 1999; Bradford and Florin, 2003; and Zhu and Kraemer, 2005). Based on this literature review, it was identified that innovation diffusion theories had been applied also in cases of digital transformation, but not with the support of a *validated, analytical framework based on all perspectives mentioned above, and not focused on a firm-level transformation* (e.g. Chiu *et al.*, 2017).

The analytical framework used in this paper does take into consideration all perspectives mentioned above, e.g. social network systems, the institutional perspective. It is further based on an abductive approach (Dubois and Gadde, 2002), in which several years' literature reviews on innovation diffusion theories and frameworks, complemented by several empirical studies on the diffusion of technological and organizational innovations (Alänge *et al.*, 1998; Alänge and Steiber, 2009; and Steiber and Alänge, 2015a) resulted in the framework used in this paper. The main research question that was asked in those previous studies was how the diffusion of both technical and organizational innovations can be conceptualized and therefore better understood. The framework was then validated in several studies (Alänge and Steiber, 2011; Steiber and Alänge, 2015b; Steiber, 2020). The focus in those studies was on the inter-firm and intra-firm diffusion of major organizational innovations, such as TQM, Lean, the Google Model and FirstBuilt, developed by GE Appliances. The framework was not only validated through those studies, but factors supporting, or hindering, the inter-firm and intra-firm diffusion of the above-mentioned organizational innovations were also identified. Therefore, the underlying research question in this paper is if the same framework could complement existing frameworks on *digital transformation of firms,* and thereby extend our knowledge on what factors support and hinder the digital transformation of firms.

Though digitalization is going on in the industry for a while, an organization-wide digital transformation initiative is resource intensive and top management buy-in is a must for success. We chose GE and Siemens EHR as our use cases, because both were pioneers with a digital strategy as a product platform operator (Schallmo *et al.*, 2019). In addition, they both started an organization-wide digital transformation process, committed a significant amount of resources and had total support from their respective executive group.

Given limited information about the phenomenon of interest, exploratory case studies are highly appropriate. Since the relationships and factors are unknown, a qualitative analysis is needed to understand the intricacies of digital transformation (Denzin and Lincoln, 2000). For this reason, each case description is based on empirical data, collected by the authors of this paper as a result of taking part of respective company's multi-years transformation. In the case of Siemens EHR, one of the co-authors was directly involved as a manager already from the unit's formation in 2001 and participated as a middle manager, with reporting personnel in Europe, India and the US, in its digital transformation process 2004–2008. During this period as an insider, the author kept a diary and later on summarized the experiences of the transformation in a presentation format. Before starting to write the Siemens case, the insider researcher was interviewed by one of the other authors based on a questionnaire with open questions, generated from an innovation diffusion perspective. This interview was recorded digitally and transcribed. This insider data has been supplemented with interviews with Siemens EHR employees who after the initial transformation continued working for the unit during the 2004–2019 period, and with secondary data, from research articles and the web. In addition, less formal information gathering from three managers with experiences from other Siemens units were conducted in 2019. The empirical data was then validated and complemented with findings from several literature reviews conducted during August to December 2019.

In the case of GE Digital, one of the authors was directly involved in the digital transformation initiatives at GE and participated in GE's Predix platform development. Though all the information for the case study was taken from publicly available information in business journals and GE annual reports, the author validated this information by interviewing ten senior executives from different groups within GE. All interviews, each lasting between 45 and 60 minutes, were recorded digitally for transcription, analyzed and used in improving the GE case study. The identities of participants were kept confidential via pseudonyms and forward-looking and proprietary information was omitted from the discussion. This was a necessary and important action so that participants could feel comfortable disclosing and discussing elements that would have strategic relevance to outside audiences.

Both studies followed best practices guidelines as suggested by Aguinis and Solarino (2019).

3. The innovation diffusion framework

The Internet, cheap information processing and artificial intelligence, as well as cloud technology and Internet of Things (IoT), have not only shorten product life cycles in many industries but created a need among companies for assessing complementing or totally new resources and organizational structures, in order to stay relevant in a changing competitive landscape. A digital transformation of a firm, or part of a firm, is in this paper defined as the use of new technologies to enable *major business improvements*.

Innovation diffusion theories could support in identifying factors contributing to or hinder a digital transformation of a firm as this kind of transformation could be viewed as the result of the adoption and implementation of technological, as well as organizational innovations. Älänge *et al.* (1998) explored the extent to which the literature on innovation and diffusion, (Rogers, 1983) although focused on technical innovations, can contribute to a useful analytical framework for studying the diffusion of organizational innovations [1]. Their finding was that organizational and technical innovations share a set of characteristics.

Based on Älänge *et al.* (1998) and several empirical studies conducted by Älänge and Steiber (2009, 2011), as well as the study of innovation programs, Steiber and Älänge (2015a) published a comprehensive conceptual model for the diffusion of organizational and technical innovations.

The framework includes five steps that a firm goes through when searching for, adopting, and implementing, either a technical or organizational innovation. The five steps are: *desirability, feasibility, first trial, implementing, and sustaining*. The five steps are in turn dependent on a firm's organizational *improvement trajectory*, which is cumulative and path-dependent due to increased return on investment on existing innovations, as well as on internal inertia among board members, top managers and employees.

The five steps are all subject to three sets of influencing factors: The *characteristics of the innovation* itself, the *internal context*, and the *external context* and *diffusion mechanisms*. The trigger for initiating a search for new solutions could typically be a perceived economic crisis; a new market/owner demand; changes initiated by "role models" (other companies, including competitors, suppliers or customers); initiatives driven by the government; management's previous experience; standardization work (e.g. packaging and description of new technical or organizational solutions) done by industry organizations, consultants and/or universities; and global, national or industry specific management fads.

In Figure 1, the five steps are visualized as a circular pattern around an organizational *improvement trajectory*. The re-invention of the organizational improvement trajectory is cumulative and path-dependent due to increased return on investment on existing innovations, as well as on internal inertia among top managers and employees.

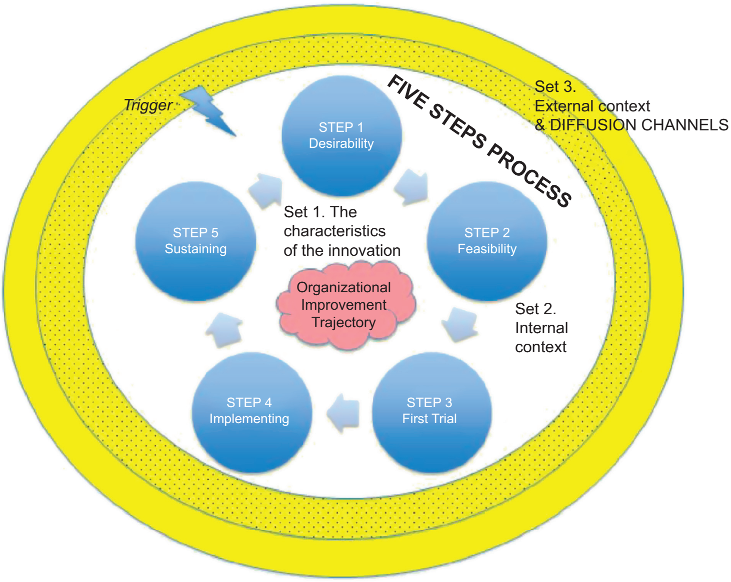

Figure 1.
An analytical framework for the diffusion of innovations (Steiber and Älänge, 2015a)

Thus, the desirability and perceived feasibility of any new innovation, as well as the decision whether to try it and implement it, is affected by previously chosen innovations, and also by the local institutional set-up and technological systems.

Interestingly, on a national and even international level, there are organizational improvement trajectories as well, in which innovations diffuse between firms or organizations and are gradually re-invented, and at a certain point in time are challenged by new innovations. These national/international improvement trajectories have a considerable influence on an organization's improvement trajectory (Alänge and Steiber, 2011).

The inner circle in Figure 1 represents the internal context in an organization. Here, the top management and even the board [2] are crucial for the diffusion of the new innovation. Top management's past culture (Kim and Toh, 2019), as well as their own inertia, user competence, and commitment to the innovation and the organization's current or new improvement trajectory are important, too, and can either limit or increase the internal inertia/path dependency and resistance to change. Further, the search and learning processes are cumulative and path-dependent, but the firm's people could break through potential path-dependency and inertia by becoming more conscious and systematic in their search for new solutions. The two outer circles represent the external context and diffusion channels that transfer knowledge and experience into the organization.

The outermost circle area depicts the external environment in the form of institutional set-up, local norms, history and existing weak ties that the organization has through its employees with networks that are active outside the local context. The external environment also represents factors such as the sector's characteristic competitive pressure and dynamic, due to, e.g. the pace of technological development. Increased competitive pressure and dynamic were found to increase desirability for organizational change. The dotted area represents diffusion channels such as movement of people (including CEOs), boards, user networks (e.g. competitors, customers, suppliers, other role models), bridging institutions (e.g. an industry organization), professors, and consultants. These diffusion channels could all play a role in "showing" and "proving" what is desirable and feasible, e.g. in regard to "new ways of working."

The triggers (visualized as flashes in Figure 1) for each step in the five-step process could typically be any of several things. They could be a perceived crisis, a new market or owner demand (which in turn could have been triggered by technological development and lower entry barriers in a certain sector), imitation of organizational concepts developed by other companies in the user network, management's previous experience and beliefs in the innovation, standardization work done by bridging institutions, consultants and university professors, and/or management fads. An example of a trigger that influences several steps is "management beliefs," which in turn are based on management's perception of, or experience of the innovation. An example of a trigger that was found to be more related to a single step was "consultant experience," which was commonly found in the first trial step and less so in earlier or later steps.

During the last two steps, "implementing" and "sustaining" an organizational innovation, management beliefs about the innovation do play an important role. Visible benefits from the new innovation are also important in order to sustain or strengthen management beliefs and increase overall internal support for change.

4. Two pioneer cases

4.1 The digital transformation of GE

Digital transformation is not about digitalization of existing business but to transform the products and services to software-defined assets and to utilize these digital assets to redefine the business (Govindarajan and Immelt, 2019). GE is a big industrial conglomerate and in 2010, GE operated major businesses such as aviation, healthcare, energy, oil and gas, transportation, home and business solutions and GE Capital, with a revenue of $149.5B. GE businesses sold industrial equipment and service contracts (to maintain those equipment) to their customers. The contribution of service revenue from those contracts was 58.5% in 2010 (GE Annual Report, 2011). GE's executives realized that GE could increase their earnings from service contracts by making their machines "Smart Machines." However, software service businesses were dominated by software service providers such as IBM, Toshiba and HP and the industrial businesses such as GE, Siemens and others were not aggressively engaged in digital initiatives. Most of the industrial companies were relying on software service providers and they outsourced their digital operations to many software vendors. Also, average gross profit margin from manufacturing industry is around 10–15%, whereas for software industry, median gross profit margin is around 30–40% (Winfrey, 2019). By analyzing the trend, GE management decided that investing in digital initiatives would be a game changer for them as it could take the company to the next level of higher profitability and revenue.

Intrigued by software revenue potential, GE's then CEO, Jeff Immelt visited GE's control and analytics laboratories worldwide and met with technology leaders such as Jeff Bezos of Amazon; Paul Otellini of Intel; Marc Benioff of Salesforce; Steve Balmer and Satya Nadela of Microsoft. He was also influenced by Marc Andreessen's article "Why Software is eating the world" (Andreessen, 2011) and Eric Ries's book, *The Lean Startup* (Immelt *et al.*, 2017). GE's digital innovation journey stared with these visits in 2010.

To start the digital initiatives across GE, in 2011 Immelt hired Bill Ruh from Cisco and established GE Software in Silicon Valley (San Ramon, California). GE Software was a part of GE Research and it was established as a software center of excellence (CoE). GE also coined the term "Industrial Internet" and hoped that by adding more sensors into its machines, GE could collect and analyze machine data on a real-time basis and it could make its machines more efficient (Leber, 2012). Immelt wanted to transform GE as a software and analytics company along with its industrial business (McBride, 2012). So, in 2012, GE invested more than $1B to build the software CoE and hired more than 1,000 software engineers and data scientists in Silicon Valley. GE's then chief economist, Marco Annunziata suggested that GE was not just selling jet engine, locomotive or wind turbine but they were bringing data and actionable insights to their customers with the hardware to reduce cost and to improve efficiency (Power, 2015). GE's Marco Annunziata and Peter Evans, wrote a policy paper in 2012 (Evans and Annunziata, 2012) and they highlighted that 1 percent fuel saving in aviation could save $30B in fifteen years worldwide, in power 1% fuel saving could save $66B in 15 years worldwide, 1% reduction in system inefficiencies in healthcare could save $63B in 15 years globally and 1% capital expenditure saving in oil and gas could save $90B in 15 years globally. GE economists highlighted the power of industrial Internet and how it could disrupt the industrial businesses.

In 2013, GE launched, PredixTM, an industrial strength cloud platform for big data and analytics. GE stated that the Predix platform was robust enough to handle large volume of data generated by its jet engines and wind turbines (Rath, 2013). Since GE's Predix cloud based analytics platform was built top of Pivotal's Cloud Foundry, platform-as-as-service (PaaS) platform, GE invested $105M in Pivotal software and took 10% stake in the company (Kellner, 2013). GE also wanted to change its image and wanted to project itself as a digital industrial company. In September 2015 GE launched an advertisement campaign, where a recent college graduate was breaking the news to his parents and friends that he had joined GE. In one advertisement, Owen's friends were very excited and in another advertisement Owen's father told Owen that he was not macho enough to work for an industrial manufacturing company (Winig, 2015). GE wanted to reposition itself to recruit Millennials.

GE's Predix platform was used by GE businesses. One such business was, GE Oil and Gas. GE's then Oil and Gas Digital Solution's CEO, Matthias Heilmann, suggested that traditional software companies like Oracle, SAP and Microsoft were essentially providing back-office software such as Enterprise Resource Planning (ERP), Finance and Human Resource Management software (Information Technology – IT software), whereas GE believed that operational technology software (OT software) which interacts with industrial automation and machinery could have a huge business potential and in oil and gas business alone, it could generate $1B or more (Winig, 2015). Like any other software, GE offered pilot programs to its customers. In early 2015, GE engaged in a four-week pilot with one of its strategic energy customer. The customer used to manage a large number of storage tanks for its oil and gas products. However, they were not able to manage these assets proactively. GE positioned Predix software to proactively monitor and manage these assets and during the pilot, GE Predix designers and software engineers met with energy company's reliability engineers, process engineers and subject matter experts to understand the corrosion problem and together they came up with a software solution. The project was successful and GE also discovered a new way to engage with the customers (Winig, 2015). GE Digital collaborated with Pitney Bowes and together they implemented Predix based solution for Pitney Bowe's mail delivery system. The project started with a pilot project and once the project was successful, Pitney Bowes implemented the industrial Internet solution in their mail delivery facilities (Kellner, 2016a, 2016b). In late 2015, to accelerate the digital industrial initiative, GE created a separate business unit, GE Digital combining GE Software, GE IT operations and Wurldtech industrial security system and Bill Ruh became the CEO of GE Digital and Chief Digital Officer (CDO) of GE (Dignan, 2015).

As industrial Internet footprints were expanding in GE, the management decided to create a new role, Chief Digital Officer (CDO) in all GE businesses. The CDOs of the respective business groups reported to the group CEO and also to the CEO of GE Digital. This matrix structure allowed the CDO of GE (CEO of GE Digital) to influence each business in their digital transformation journey. Since there was strong strategic focus and intent to transform GE businesses digitally, all business CDOs started implementing Predix platform and made it a base platform for developing digital products. GE Oil and Gas started new digital initiatives to improve oil well operations and developed asset optimization solution leveraging Predix platform. Ashley Hanes-Gasper, the software and services GM of GE Oil and Gas at that time, suggested that if GE could help 1% increase in oil well recovery, it could translate into 80 billion barrels per year worldwide and the economic implications could be huge for such operation (Winig, 2015). Similarly, in other GE businesses, digital initiatives were in full swing. Ganesh Bell was the CDO of GE Power and he championed digital power plant initiatives. According to Bell, a gas fired combined cycle power plant, could generate $50M to $250M additional value over the life of a single power plant by leveraging Predix powered smart digital solutions (Bell, 2016).

The adoption of Predix platform was growing rapidly within GE businesses. To position the platform as an industrial Internet operating system, GE Digital decided to offer Predix platform as an industrial Internet application development platform for software engineers. During 2016 Mobile World Congress at Barcelona, then GE Digital Chief Technology Officer (CTO) Harol Kodesh announced that to unlock the full potential of Predix platform, GE Digital wanted outside developers to build industrial Internet solution using Predix platform (Kellner, 2016a, 2016b). Thus, GE Digital started its platform business and wanted to become a platform-as-a-service (PaaS) platform such as Amazon Web Services (AWS) or Microsoft Azure platform. This initiative added some complexities in the business as GE Digital needed to support the customer's software development initiatives either in GE Digital public cloud or customer's private cloud environments. GE started building its own cloud and assured its customers that GE could serve them better than their software partners (Darrow, 2015).

However, within two years, GE Digital realized that running its own data center might not have significant strategic advantages for the company and it was very difficult for GE Digital to compete with AWS and Microsoft Azure. So, in 2017, GE Digital decided to abandon its own data center plans. Then GE CEO, Bill Ruh told Fortune magazine "we pivoted" (Darrow, 2017).

Jeff Immelt stepped down as CEO of GE in June 2017 and a GE insider took over as CEO. In a linkedin.com posting in September 2017, John Flannery articulated his vision as "GE is all in on Digital," (Flannery, 2017), and he continued the digital transformation journey of GE. However, the digital transformation journey of GE was impacted by the overall financial situation of GE. The stock price of GE fell more than 30% during Jeff Immelt's time as a CEO and GE lost its market cap by $150B from September of 2001 to August of 2017. John Flannery stepped down as the CEO in October 2018 and the GE board appointed former Danaher CEO, Larry Culp as the CEO, who decided to spin off GE Digital business as a separate company in December 2018. GE Digital CEO, Bill Ruh decided to leave GE (Lohr, 2018). However, in July 2019, GE again changed its plan and retained GE Digital business as a part of GE and appointed Patrick Byrne as the CEO of GE Digital and decided to focus on four key markets; power generation, grid operations for power business, Oil and Gas, and digital manufacturing, as GE Digital has developed digital manufacturing software over the years (Patel, 2019).

4.2 The digital transformation of Siemens EHR/Health Services

Siemens Health Services division, responsible for the healthcare information system "Soarian" and part of the multinational company Siemens AG, was a pioneer conducting a digital transformation in an industrial firm. The digital transformation included the development of both a superior information system for large hospitals, as well as adopting and implementing "Agile" as an organizational innovation, supporting the realization and dissemination of the technical innovation. This case describes the development taking a starting point from the years 2001–2008, and then continues to 2016, when the software-based Health Services division was acquired by the company Cerner in order to create a dominant player in the Electronic Health Record (EHR) market.

The Health Services division had initially expanded by acquiring a US company in the early-2000 and the ambition was to create a new large enterprise product, a superior information system for large hospitals. In 2000, the division is a totally new unit, covering European, Indian and US operations. The total number of employees is around 1,400, where 1,300 working on developing "Soarian Clinical," and an additional 100 responsible for "Soarian Financial," a financial system for large hospitals. The ambition is to create an integrated enterprise system, to a large extent based on existing products from the development units across Europe, India and USA. The latter unit had developed a basic structure that served as a starting point for the technical development work, and the other units were aware that they would need to adjust to this structure. There was also an awareness that, given all units' different history and culture, the needed integration to build one enterprise system, would be demanding and take time. In 2001, the product development was organized according to the waterfall model (stage-gate), with a scope of six months. This way of organizing was experienced as too complex and it could not keep up with customer expectations in the new digital business. Thus, employees presented improvement suggestions and the company experimented with different approaches. In 2003, a classical incremental model with a scope of three months was tested. However, the overtime increased, and the situation became unsustainable. Feature development was then tried. One of the managers in Sweden proposed a user-centered development process as a response to experienced "show-stopper" late in the process when the beta-customers for the first time were exposed to the new product. The head of R&D responded positively and commented that the US unit had come to a similar conclusion and talked about agile organizing. Some of the people most active in the development of the Agile Manifesto in 2001 and subsequent trials of agile, e.g. at the Iacocca Institute at Lehigh University in Bethlehem, PA, were located in the vicinity of the US Siemens unit. Also, in 2001 Ken Schwaber, who would become an important influencer of the company, published his first book on Agile Software Development Using Scrum, together with Mike Beedle (Schwaber and Beedle, 2001). The US R&D manager gave the book to the head of the Health Services division, who read the book over the weekend and decided to test agile development. He invited the author, to share from his experience and spend two weeks with the division to introduce the subject. A firm of consultants, Thoughtworks, was then introduced and was contracted to assist with the agile transformation. The consultants from this firm included the Agile Manifesto's coauthors Jim Highsmith and Martin Fowler (Agile Alliance, 2001). In 2004, a first agile pilot was run by a team in the US Siemens Health Services unit with impressing results, which led to the division wide decision to implement the agile way of organizing in all product development units. The transformation meant that the organization was tipped upside-down, from a traditional hierarchical leadership to a flat structure with servant leadership and empowered teams. The transformation involved all parts of the units, including Sales, Product Management, R&D, Test and Verification, QA, Professional Services as well as 3rd level support, suppliers and Beta customers (large hospitals in the US and Europe). In fact, employees were involved through cross-disciplinary transformation- teams, managers and people together in the same teams. This approach created transparency, people empowerment, and was conducted alongside with the ongoing technical product innovation. This became key for Siemens' transformation. The transparency was a reality both internally and externally, towards external parties. This was probably one of the major challenges for senior managers to drive. Many of them were traveling to visit the different sites and promote the new culture and flat organizational structure. The agile cultural transformation needed for the digital transformation did not just require a major mind-set change but also a completely different leadership style, meaning a transformation of magnitude for all leaders and people within the organization at all levels and a flat structure that supports this type of culture (Goncalves *et al.*, 2019). Not everyone was able to transform from the traditional culture to the new agile culture. For those who did not fit with the agile culture had to find another position outside the organization. On the other hand, some people who were previously low performers, began to flourish in the new culture.

In 2005, the division-wide implementation of both a successful technical innovation and an agile culture was a fact across the USA, Europe and India. The implementation of "Agile development" was based on an approach developed by Goldman *et al.* (1995) at the Iacocca Institute at Lehigh University. In 1991, they presented the first Agile enterprise concept. At Siemens this was done by involving a large group of "Thoughtworks" consultants on all levels in the product development organization. In total approximately 70 consultants were active, working side-by-side with the employees and transferring their knowledge by doing and learning.

A vital decision made was to use the Scrum-framework as the foundation for building a global virtual organization and improve the product development, cross-units. This was a difference from before when there was a separation between different departments and it was a major change for the leaders, starting to coach teams that were composed by people from different departments and from different countries. While the geographical physical organization took care of the HR and wage payments, the potential wage increase was decided based on performance in this new virtual organization. Agile organizing was introduced according to the Scrum book (and Manifesto), with different tools from the toolbox. For example, Scrum-of-Scrums was used as a way to scale, and XP practices were applied. One of the most important methods used was pairing in order to bridge knowledge gaps and improve learning. This meant that on every level there were pairs formed, from product management and R&D. Each team had developers, a business analyst, an Architect and testers, in total 7 plus/minus 2 people. This created a sounding board between product side and the technical side. If the pairs couldn't come to an agreement, then the product side had the last say and the total responsibility. This shift in power from R&D to Product Management enabled a mindset change from a tech-driven approach to a "customer"-driven approach. Further, while the basic ideas of agile were followed, the approach was adjusted to Siemens. One example was hazard identification and mitigation that are not part of Scrum. This simplified hazard process was incorporated into ongoing sprints, and it turned out to be a very effective risk management approach that was compliant with FDA regulations. Another major change was to bring Beta-customers to participate in the agile transformation and thereby be part of the early phases of development for enabling fast feedback loops to Siemens. All Beta-customers were invited, and it turned out that some of the customers became deeply involved. The Beta-customers were invited to, at the minimum, participate at all the sprint demos conducted by the team of their choice. The sprint demos took place every third to fourth week. The initial ambition to create an enterprise system was behind the need to find a more effective and efficient product development process. Built-in learning mechanisms and concepts were also implemented to ensure continuous learning, alongside with the transformation. This created a strong motivation to search for new ways of accomplishing both the technical and the organizational innovation simultaneously. As the development of the enterprise system was initially six months behind schedule, the agile transformation was necessary in order to digitally transform Siemens. The enterprise system was developed and delivered on time, although it started six months late, and delivered a higher quality than first was expected. The digital transformation also included the adoption of the new programming language Java. This was done simultaneously with the introduction of Scrum, XP (extreme programming), continuous integration (acceptance test driven development) and the implementation of a dynamic global virtual organization. In addition, as was mentioned, the digital transformation was made possible by the creation of a transparent and trusting agile culture where cross-disciplinary and cross-national teams took responsibility and delivered software and final products with amazing quality and with an extremely shorter lead-time. In 2007, Siemens Health Services had a successful digital platform as well as an agile organization, where everyone was involved and encouraged to pitch new ideas without asking for permission. This kind of "all-in" agile transformation dissolved unnecessary complexity in both organization and product, leading to a substantially increased product quality and shorter development time of deliverable minimum viable products to the market. In 2008, the organization had reached a "hyper" efficiency state, and product innovations were solely developed at the USA site, mainly for the reason of cost reduction. After one year, the organization realized that presence was needed at the different key markets, Europe & USA. The organization re-launched product innovation in Europe to better cover for the European customers' needs. Siemens Health Services, which went through the agile transformation in 2004–2005, had a background in software products. Other parts of Siemens AG did not learn from Siemens Health Services: "we were aware of the Health Services unit's achievements, but we were at that time living in silos, so it didn't affect our way of working" (personal communication in 2019). Digital technology and software were however developed and utilized in different applications in various business units within Siemens AG. It was an awareness of the possible digital future already during the time of the first IT revolution resulting in the IT-bubble, and later on it was revived several times. Some units with IT and software-based products were divested (e.g. telecom) and others were invested in, e.g. the acquisition of the US company UGS Corp. that made Siemens AG a pioneer in developing simulators for digital factories that could work as a digital twin. Measures were also taken to start learning from each other's experience in digitalization across different business units, such as CEO Summits every 6 months (starting in 2011) where business unit CEOs could learn from digital experts and be part of a learning community within Siemens AG. In December 2015, the CEO of Siemens AG took a major step to put digitization at the core of the new corporate strategy around electrification and automation. However, Siemens Health Services was only part of this for a limited time, as the division was formally acquired by its larger US competitor "Cerner" in 2016, a US$1.3 billion cash deal. Siemens AG, with strengths in the development of hardware products, such as X-ray in its Healthcare business, rebranded this division to Healthineers in 2016 and through an IPO in 2018 it became a fully independent company Siemens Healthineers AG, employing 50,000 people with the purpose: "… to enable healthcare providers to increase value by empowering them on their journey towards expanding precision medicine, transforming care delivery, and improving patient experience, all enabled by digitalizing healthcare" (SH homepage, 2019-12-24)). Agility and digitalization are still at the core of the agenda for this unit, as can be seen in this quote by the Global Head of HR at Siemens Healthineers.

We're experimenting with new agile working methods across various parts of the business, really clean methods to help us get new products to market faster via very-fast sprints. That's very promising, but also demands some caution, because agility should not be a euphemism for chaos. When things get chaotic, people complain, and they question the organization's agility. This way of working demands discipline. From an IT and HR perspective, I think digitization will become very important for the organization (Dunne, 2019).

In order for Siemens 2020 to succeed with the agile transformation as Siemens Health Services succeeded with back in 2004–2005, it is important to keep in mind that agile is not just a process, but an innovation culture that permeates the entire organization.

5. Discussion

The analysis of both cases is conducted by using *key dimensions of the analytical framework* presented earlier. Three primary areas will be investigated and discussed; triggers creating a desire to change; the use case's process of finding a feasible solution, conduct a pilot, implement and sustain the change; and finally how the characteristics of the innovation, as well as external (incl. diffusion mechanisms) and internal factors played a role in each use case's transformation process. At the end of this section, identified drivers and inhibitors will be discussed.

5.1 Triggers creating a desire to change

In the GE case, the search process was initiated by a decision from the top management to move the business from hardware to software, as the profit margin was higher in the software business. For Siemens Health Services, established to develop new digital enterprise systems for large hospitals, it was an experienced delay in the development of this strategic technological innovation and therefore a broadly sensed urgency to find new ways of working in order to shorten development time. Interestingly, the business triggers for change spurred the adoption and implementation of both technological and organizational innovations. In the case of GE, a new center of excellence was created in order to attract new software competence from outside, and develop the technological innovation that later would become the very foundation for GE's digital transformation. In the Siemens case, in parallel with the development of a superior information system for large hospitals, many employees were involved in the search for a way of drastically cutting the development time and various approaches were tested. Finally, Siemens Health Services adopted and implemented the agile methodology and tools, more suitable for a digital software Era.

5.2 The search for new feasible solutions

The CEO of GE visited GE's control- and analytics laboratories worldwide to better understand the future potential for GE. In addition, the CEO met with several software technology leaders as well as "gurus" in the venture capital industry such as Marc Andreessen. These people acted all as important sources and channels for new knowledge and insights. In the case of Siemens Health Services, the delay in product development led to the consequence that the division was empowered to experiment with different approaches to search for a better product development process. The head of the R&D acknowledged and responded positively to an internal request to center the development process on the user. Later, inspiration came from the US unit that recently had learned more about "Agile" organizing of product development. The US unit in turn had been influenced by local management gurus, developing the Agile manifesto. One of the main reasons for GE to start the center in Silicon Valley was to attract new talents, but also to create a new entrepreneurial culture within GE. Bill Ruh came from Cisco that themselves had one of their most transformative years in 2011 (Cisco's annual report, 2011). This together with Cisco's expertise in technologies, services and software platforms was of interest for GE, starting its own transformation journey in 2011. The result of this organizational change was a technology innovation in the form of the Predix platform that became the very backbone in GE's digital transformation. In the case of Siemens, the process was more or less the opposite. Siemens Health Services had the ambition to develop a new superior information system for large hospitals but did not have a product development process that could deliver on deadline. The need of technological digital innovation therefore stimulated organizational innovations. This triggered a search process for new ways of working in product development and "gurus" behind the agile manifesto got an audience with the head of the division. This in turn supported in the translation and adaption of the new principles for product development, to Siemens way of working.

5.3 Piloting

Both user cases did use pilots. In the case of GE they piloted initially the new platform in their Oil and Gas business in order to, together with customers try out the new platform and build use cases. The result was very positive. In the case of Siemens Health Services, the first pilot of agile organization of product development was conducted in one section of the US unit, with very positive results.

5.4 Broader implementation

As a result of the CEO's belief in the transformation of GE, and therefore his support for additional organizational changes, e.g. the implementation of a separate GE Digital business and, the implementation of a new role (CDO) in every business within the Group, the digital transformation of the group proceeded. In fact, the Predix platform and the CDOs became the very backbone for GE's enterprise-wide digital transformation. In the Siemens Health Services case, the focus was on the new information system to hospitals and on organizational innovations that could enable a shorter product development time, higher quality and improved digital technical innovation. In the Siemens case, the development of the technical innovation and the successfully launch and dissemination to the market, was therefore supported by the organizational innovation "agile organization," but also by the new virtual organization for product development. The backbone for Siemens Health Services' unit-wide digital transformation was the division head's belief in, and accountability for the implementation of the new superior information system to large hospitals together with organizational innovations realized with the support of new competences brought in from outside (consultants), together with the establishment of a global, virtual organization in which knowledge transfer was expected and assured by the 'pairing' mechanism. Of interest here is Siemens Health Services's choice of engaging a substantial number of consultants with knowledgeable of agile software development. This should be contrasted with GE's investment in a new knowledge center and later a separate organization headed up with people with new software platform competences and skills. In both cases, new competences and skills were needed, and the Siemens Health Services-consultants, as well as GE's Bill Ruh and the consultants he brought in, acted as diffusion mechanisms for these new competences and skills. The firms' strategies for how to secure these, however, differed. In the case of GE, GE Digital was formed to develop software competences and a software culture and then disseminate these through every business' newly hired CDO. In the case of Siemens Health Services, the new competences and skills were partly recruited from outside of the company (consultants) and then developed through co-working together with embedded consultants within the healthcare division through a global and virtual organization.

5.5 Sustainability of the transformation

Finally, in both cases the sustainability of the transformation (adoption and implementation of both technical and organizational innovations) was organizationally limited but of very different reasons. In the GE case, the transformation was during some years limited due to several changes of the CEO. John Flannery that became the CEO after Immelt believed in the transformation but was faced with a negative financial situation of the company. The Board then decided to bring in a new CEO, Larry Culp from Danaher that had not been part of the previous transformation journey and had got a mission to increase GE's profitability. The exchange of the CEO during a larger transformation of a company does increase the risk for not being able to sustain the change (Alänge and Steiber, 2009). The financial situation together with the exchange of the CEO, most probably led to the later decision to divest GE Digital (a decision that was then reversed in 2019, which meant that the transformation was sustained after all). The GE-case therefore highlights the importance of another stakeholder, crucial for sustaining a larger transformation of a business, namely the Board (Alänge and Steiber, 2009). In the case of Siemens Health Services, further dissemination of the new approach within Siemens AG was limited due to the silos between the different businesses. Siemens AG had historically chosen to keep their different businesses separated and independent. In some cases, this "divisional form" of an organization can have great benefits, but in the case of a larger transformation of a whole group, this organizational form means that the Group management needs to play an essential role as the primary driver for a group-wide transformation. This means that the potential of utilizing the 1.400 employees Siemens Health Services successful transformation as a pilot for the +300,000 employees Siemens AG Corporation was never accomplished, not even for those organizations that were the foundation for Siemens Healthineers AG.

5.6 The effect of innovation characteristics, external and internal factors

According to Rogers (1995) six innovation-characteristics matter for its diffusion in a social system. These are: its relative advantage for the adopter, its compatibility with the pre-existing system, its complexity or difficulty to learn, its trialability or testability, its potential for re-inventions, and its observed effects. Interestingly, the GE case provides examples on all those factors above. The increased profit margin in the software business indicated the relative advantage to adopt/develop the Predix platform. Also the pilots served the same purpose. The innovation was also made compatible with the existing business model, as it was to focus on the "industrial Internet," a labeling that made it easier for GE employees to see the connection between the new and the current operation. The complexity was reduced for the CEO by actively learning from those who know the software business. By developing the Predix platform the technological innovation was made trial enabled and testable and by testing it in several businesses, the potential for re-inventions and actual effects were made clear to the management team and employees. The story telling around use cases and how much capital expenditure savings that was possible made it easier to diffuse the technological innovation not only within GE, but also to Beta clients. The positive innovation characteristics were further supported by external factors such as knowledge transfer from Cisco to GE through hiring Bill Ruh, and internal factors such as a determined top management, the development of a governance structure to catalyze further internal dissemination of the platform and active communication campaigns on the necessity for, and benefit of transformation. However, due to top management changes in GE (including GE Digital), the innovation diffusion has taken a separate trajectory. Earlier GE Digital wanted to develop an Industrial Internet Analytics platform for the Industrial Internet developers, but later on GE Digital decided to develop solutions for its core businesses using the Predix platform and not to make the platform as a default Industrial Internet platform. In the Siemens Health Services case the relative advantage of the new technological innovation mirrors the case of GE. Of interest is that also the organizational innovation “agile organizing” of product development was viewed as having relative advantages through the successful pilot in the US unit. The pilot, also supported in making the new innovation compatible with Siemens Health Services way of doing things and the pilot, together with case studies provided by the Lehigh University, also standardized the approach and indicated positive, observed effects of the change. In this way, together with books and direct contact with thought leaders behind the innovation, it became less complex, trialable and testable. Also in the Siemens case both external and internal factors were playing a very important role. External factors of importance were for example the access to the thought leaders behind the agile concept, the access to consultants that could help creating and implementing the agile way in Siemens Health Services, and bridging organizations such as Lehigh University that could provide other use cases and translate those lessons learned. Internal factors of importance were again; the determination of top management, together with a governance structure to disseminate the new organizational innovation to all Siemens Health Services locations and cross departments.

5.7 Drivers and inhibitors to digital transformation of the firm

As could be seen above, the two use cases had several “drivers” of change in common, most of them identified in previous literature and summarized in Figure 1. For example they both had an economic, and/or market incentive as the trigger to transform their business. This same trigger also made the relative advantage of the new technological innovation, and necessary organizational innovations clear. The fact that the technological innovation, with support of pilots, storytelling and a determined top management, was viewed as compatible with the existing system, made the adoption and internal diffusion of the technical innovation faster, as the innovation seemed to fit the organizations’ improvement trajectory. Over time this improvement trajectory became cumulative and path-dependent and was only broken at GE when a new trigger, low profitability, temporarily disrupted their new organizational trajectory. The mobility of external people with necessary competence, bridging organizations like the University in the Siemens’ case played a fundamental role for the diffusion of both the technical and organizational innovations. Another factor that was validated was the importance of the standardization of the innovation and its sub parts, e.g. tools in the case of agile organizing product development. Internally, top management conviction and support behind the diffusion/transformation was absolutely necessary. The new governance structure that involved key stakeholders, together with communication campaigns and storytelling including clear, observed effects also supported the transformation. Finally, corporate venturing and acquisition was used in both cases to quickly access new knowledge and learn about the new innovation and its pre- requisites. Factors like governance structure, internal storytelling, and corporate venturing or acquisition are all factors that are new findings, and therefore could be added to the framework in Figure 1. The inhibitors to change were: a leadership change, which does create a disruption in the transformation process; a silo oriented organizational structure that for both cases meant that the top management for the group had to be involved and a group level governance structure was needed IF to diffuse the innovation across the group. In the Siemens case this did not happen. Further a negative financial situation in the case of GE became an inhibitor to change. Interestingly, the increasing scope of the business model for the new technical innovation in the case of GE, most probably was the main inhibitor to transformation. Of these factors, the importance of a group level governance structure for a *corporate-wide transformation*, together with the factor business model transformation, could be added as drivers or inhibitors to a transformation of a firm (framework in Figure 1).

6. Conclusions and implications

The validated analytical framework for innovation diffusion was found to be useful in analyzing use cases on enterprise- and division-wide digital transformations. The five steps identified in the framework, and previously identified innovation characteristics, as well as external and internal factors of importance for the diffusion of both technical and organizational innovations, were all found valid and useful in analyzing the two cases on digital transformations of a firm.

By analyzing the two cases with the help of the validated analytical framework in Figure 1, drivers, as well as inhibiting factors were identified in both cases. Many of the drivers were shared between the two use cases. In regards to the inhibiting factors, they are assumed to affect the two companies in a similar way. The two cases in this paper, however, did not share the same financial constraint, why this inhibitor in the case of GE was not present in the case of Siemens. In addition to already identified factors, supporting or hindering the change, new factors were also identified such as the importance of a governance structure for the transformation, internal storytelling, and corporate venturing and acquisition to support, or speed up the transformation. These factors should be added to the framework.

Another conclusion is that, while the two companies did many things right, the problem seems to be in sustaining the change in which leadership changes (in the case of Siemens as an effect of an acquisition), new economic conditions and the Boards' commitment to the transformation, play crucial roles. By trying to plan for this up front, a transformation that usually takes years to realize, might sustain longer.

For general studies of digital transformation of firms, this result means that innovation diffusion theories, e.g. in the form of the validated framework in Figure 1, should complement existing frameworks used on analyzing digital transformation of firms. One interesting thought is to try to combine some of the existing frameworks, developed by using different theoretical perspectives, into a "blue print" on how to better analyze and measure the effectiveness and efficiency of digital transformations of firms.

The implication for business managers and researchers is that the digital transformation of an industrial firm could be analyzed, or even planned, by using the validated framework used in this paper. By doing this, the company/organization can improve primarily the efficiency of the transformation process for their company.

Notes

1. Organizational innovations are here defined as new organizational methods in business practices, workplace organization, or external relations (OECD, 2015). No distinction is made here between organizational, managerial and administrative innovations. The purpose with those new organizational methods is typically an increasing operational efficiency and employee satisfaction or/and at improving an organization's growth.
2. Boards as a diffusion mechanism for knowledge and experience of new innovations could play an important role as both an initial trigger to organizational change and for sustaining an implemented change in the organization. For this reason, the user competence among board members regarding the new innovation and their belief in its business value for the organization is important (Alänge and Steiber, 2009).

References

Abrahamson, E. (1996), "Management fashion", *Academy of Management Review*, Vol. 21 No. 1, pp. 254-285.

Agile Alliance (2001), "Manifesto for agile software development", available at: www.agilealliance.org.

Aguinis, H. and Solarino, A.M. (2019), "Transparency and replicability in qualitative research: the case of interviews with elite informants", *Strategic Management Journal*, Vol. 40, pp. 1291-1315.

Ahuja, G. and Lampert, C.M. (2001), "Entrepreneurship in the large corporation: a longitudinal study of how established firms create breakthrough discoveries", *Administrative Science Quarterly*, Vol. 38, pp. 51-73.

Alänge, S. and Steiber, A. (2009), "The board's role in sustaining major organizational change: An empirical analysis of three change programs", *International Journal of Quality Service Sciences*, Vol. 1 No. 3, pp. 280-293.

Alänge, S. and Steiber, A. (2011), "Diffusion of Organisational Innovations: an empirical test of an analytical framework", *Technology Analysis and Strategic Management*, Vol. 23 No. 8, pp. 881-897.

Alänge, S., Jacobsson, S. and Jarnehammar, A. (1998), "Some aspects of an analytical framework for studying the diffusion of organisational innovations", *Technology Analysis & Strategic Management*, Vol. 10 No. 1, pp. 3-21.

Andreessen, M. (2011), "Why software is eating the world", available at: https://www.wsj.com/articles/SB10001424053111903480904576512250915629460.

Bell, G. (2016), "Disruption in the power industry with ganesh Bell, chief digital officer, GE power", available at: https://www.cxotalk.com/episode/disruption-power-industry-ganesh-bell-chief-digital-officer-ge-power.

Birkinshaw, J., Hamel, G. and Mol, M.J. (2008), "Management innovation", *Academy of Management Review*, Vol. 33 No. 4, pp. 825-845.

Birkinshaw, J., Zimmerman, A. and Raisch, S. (2016), "How do firms adapt to discontinuous change? Bridging the dynamic capabilities and ambidexterity perspectives", *California Management Review*, Vol. 58 No. 4, pp. 36-58.

Bradford and Florin (2003), "Examining the role of innovation diffusion factors on the implementation success of enterprise resource planning systems", *International Journal of Accounting Information Systems*, Vol. 4, pp. 205-225.

Butschan, J., Heidenreich, S., Weber, B. and Kraemer, T. (2018), "Tackling hurdles to digital transformation-the role of competencies for successful industrial internet of things (IIoT) implementation", *International Journal of Innovation Management*, Vol. 23 No. 4, pp. 1-34.

Chiu, C.Y., Chen, S. and Chen, C.L. (2017), "An integrated perspective of TOE framework and innovation diffusion in broadband mobile applications adoption by enterprises", *International Journal of Management, Economics and Social Sciences*, Vol. 6 No. 1, pp. 14-39.

Christensen, C.M. and Bower, J.L. (1996), “Customer power, strategic investment, and the failure of leading firms”, *Strategic Management Journal*, Vol. 17 No. 3, pp. 197-218.

Cisco (2011), “Cisco’s annual report 2011”, available at: https://www.cisco.com/c/dam/assets/cdc_content_elements/docs/annualreports/media/2011-ar.pdf.

Darrow, B. (2015), “GE is building its own cloud; outsiders wonder why”, available at: https://fortune.com/2015/08/06/ge-is-building-its-own-cloud-outsiders-wonder-why/ (accessed October 2019).

Darrow, B. (2017), “Here’s why GE shelved plans to build its own amazon-like cloud”, available at: https://fortune.com/2017/09/06/general-electric-cloud-pivot/ (accessed October 2019).

Denzin, N.K. and Lincoln, Y.S. (2000), “Strategies of inquiry”, *Handbook of qualitative research*, Vol. 2, pp. 367-378.

Dignan, L. (2015), “GE forms GE Digital, aims to be top ten software company”, available at: https://www.zdnet.com/article/ge-forms-ge-digital-aims-to-be-top-10-software-company/.

Dubois, A. and Gadde, L.E. (2002), “Systematic combining: an abductive approach to case research”, *Journal of Business Research*, Vol. 55 No. 7, pp. 553-560.

Dunne, S. (2019), “How Siemens Healthineers is embracing disruption in healthcare”, available at: https://blog.workday.com/en-us/2019/how-siemens-healthineers-is-embracing-disruption-in-healthcare.html (accessed 24 December 2019).

Evans, P. and Annunziata, M. (2012), “Industrial internet: pushing the boundaries of minds and machines”, available at: https://www.ge.com/docs/chapters/Industrial_Internet.pdf.

Fichman and Kemerer (1999), “The illusory diffusion of innovation: an examination of assimilation gaps”, *Information Systems Research*, Vol. 10 No. 3, pp. 255-275.

Fitzgerald, M., Kruschwitz, N., Bonnet, D. and Welch, M. (2013), *Embracing Digital Technology: A New Strategic Imperative*, MIT Sloan Management Review Research Report with Capgemini Consulting, Massachusetts Institute of Technology, Cambridge, Massachusetts, USA.

Flannery, J. (2017), “Our future is digital”, available at: https://www.linkedin.com/pulse/our-future-digital-john-flannery/.

Galliers, R.D. and Baets, W. (1998), “Information technology and organisational transformation: the holy grail of IT?”, in Galliers, R.D. and Baets, W. (Eds), *Information Technology and Organizational Transformation: Innovation for the 21st Century Organization: 1-18*, John Wiley & Sons, Chichester, West Sussex.

GE (2011), “GE annual report, 2011”, available at: https://ddd.uab.cat/pub/infanu/46826/iaGEa2011ieng.pdf.

Ghosh, S., Hughes, M. and Hughes, P. (2017), “Developing dynamic transformation capabilities in high velocity environment: a study of industrial internet companies”, Working paper, Loughborough University Institutional Repository.

Goldman, S.L., Nagel, R.N. and Preiss, K. (1995), *Agile Competitors and Virtual Organizations: Strategies for Enriching the Customer*, Van Nostrand Reinhold, New York.

Goncalves, D., Bergquist, M., Bunk, R. and Alänge, S. (2019), “The influence of cultural values on organizational agility”, *AMCIS 2019 Proceedings*, pp. 1-10.

Govindarajan, V. and Immelt, J. (2019), “The only way manufacturers can survive”, *MIT Sloan Management Review*, available at: https://sloanreview.mit.edu/article/the-only-way-manufacturers-can-survive/ (accessed 12 March 2019).

Hill, C.W.L. and Rothaermel, F.T. (2003), “The performance of incumbent firms in the face of radical technological innovation”, *Academy of Management Review*, Vol. 28 No. 2, pp. 257-274.

Hinings, B., Gegenhuber, T. and Greenwood, R. (2018), “Digital innovation and transformation: an institutional perspective”, *Information and Organization*, Vol. 28 No. 1, pp. 52-61.

Hsiao, R.L. and Ormerod, R.J. (1998), “A new perspective of the dynamics of IT-enabled strategic change”, *Information Systems Journal*, January No. 8, pp. 21-52.

Immelt, J., Gulati, R. and Prokesch, S. (2017), "Leading transformation", *Harvard Business Review*, available at: https://hbsp.harvard.edu/product/R1705B-PDF-ENG/ (accessed 12 March 2019).

Kellner, T. (2013), "GE invests in pivotal to accelerate new analytic service and solutions for the industrial internet", *GE Reports*, April 24th, 2013, available at: https://www.ge.com/reports/post/74545148994/ge-invests-in-pivotal-to-accelerate-new-analytic/.

Kellner, T. (2016a), "Ready for prime time: intel joins GE as its opens predix, its digital platform for the industrial internet, to all users", *GE Reports*, 2016, available at: https://www.ge.com/reports/ready-for-prime-time-ge-opens-predix-its-digital-platform-for-the-industrial-internet-to-everyone/.

Kellner, T. (2016b), "The power of predix: an inside look of how Pitney Bowes is using the industrial internet platform", *GE Reports*, 2016, available at: https://www.ge.com/reports/the-power-of-predix-an-inside-look-at-how-pitney-bowes-has-been-using-the-industrial-internet-platform/.

Kim, J. and Toh, S.M. (2019), "Stuck in the past? The influence of a leader's past cultural experience on group culture and positive and negative group deviance", *Academy of Management Journal*, Vol. 62 No. 3, pp. 1-57.

Leber, J. (2012), "General electric pitches an industrial internet", *MIT Technology Review*, November, 2012, available at: https://www.technologyreview.com/s/507831/general-electric-pitches-an-industrial-internet/.

Loebbecke, C. and Picot, A. (2015), "Reflections on societal and business model transformation arising from digitization and big data analytis: a research agenda", *The Journal of Strategic Information Systems*, Vol. 24 No. 3, pp. 149-157.

Lohr, S. (2018), "GE to spin off its digital business", December 13, 2018, available at: https://www.nytimes.com/2018/12/13/business/ge-digital-spinoff.html.

Macredie, R.D. and Sandom, C. (1999), "IT-enabled change: evaluating an improvisational perspective", *European Journal of Information Systems*, Vol. 8 No. 4, pp. 247-259.

McBride, S. (2012), "GE CEO Immelt embraces software; VC Andreessen embraces hardwareReuter Business News", November, 29th, 2012, available at: https://www.reuters.com/article/us-ge-software-venture/ge-ceo-immelt-embraces-software-vc-andreessen-embraces-hardware-idUSBRE8AS1HK20121129.

Nambisan, S., Lyytinen, K., Majchrzak, A. and Song, M. (2017), "Digital innovation management: reinventing innovation management research in a digital world", *MIS Quarterly*, Vol. 41 No. 1, pp. 223-238.

OECD (2015), *OECD Innovation Strategy*, available at: https://www.oecd.org/site/innovationstrategy/defininginnovation.htm (accessed 2 June 2020).

Paap, J. and Katz, R. (2004), "Anticipating disruptive innovation", *Research-Technology Management*, Vol. 47 No. 5, pp. 13-22.

Patel, S. (2019), "The power interview: new directions for GE digital", available at: https://www.iiotconnection.com/the-power-interview-new-directions-for-ge-digital/?oly_enc_id=6244E2827012E6A.

Power, B. (2015), "Building a software startup inside GE", *Harvard Business Review*, January 29th, 2015, available at: https://hbr.org/2015/01/building-a-software-start-up-inside-ge.

Rath, J. (2013), "GE launches cloud platform for the industrial internet", *Data Center Knowledge*, June 21st, 2013, available at: https://www.datacenterknowledge.com/archives/2013/06/21/ge-moves-machines-to-the-cloud.

Richter, A., Heinrich, P., Stocker, A. and Schwabe, G. (2018), "Digital work design-the interplay of human and computer in future work practices as an interdisciplinary (grand) challenge", *Business Information Systems Engineering*, Vol. 60, pp. 259-264.

Rogers, E.M. (1983), *Diffusion of Innovations: Third Edition*, Free Press, New York, NY.

Rogers, E.M. (1995), "Diffusion of innovations: modifications of a model for telecommunications", in Stoetzer, M.W. and Mahler, A. (Eds), *Die Diffusion von Innovationen in der Telekommunikation. Schriftenreihe des Wissenschaftlichen Instituts für Kommunikationsdienste*, Vol. 17, Springer, Berlin, Heidelberg.

Rothaermel, F.T. (2001), "Incumbent's advantage through exploiting complementary assets via interfirm cooperation", *Strategic Management Journal*, Vol. 22 Nos 6/7, pp. 687-699.

Sauer, C., Yetton, P.W. and Associates (Eds) (1997), *Steps to the Future: Fresh Thinking on the IT-Based Organizational Transformation*, Jossey-Bass, San Francisco.

Schallmo, D., Williams, C. and Boardman, L. (2017), "Digital transformation OF business models — best practice, enablers, and roadmap", *International Journal of Innovation Management*, Vol. 21 No. 8, p. 1740014 (17 pages).

Schallmo, D., Williams, C. and Lohse, J. (2019), "Digital strategy-integrated approach and generic options", *International Journal of Innovation Management*, Vol. 23 No. 8, pp. 1-23.

Schallmo, D.R. (2016), *Jetzt Digital Transformieren: So Gelingt die Erfolgreiche Digitale Transformation Ihres Geschaftsmodells*, Springer-Verlag, Berlin.

Schwaber, K. and Beedle, M. (2001), *Agile Software Development Using Scrum*, Prentice Hall, Upper Saddle River, New York.

Scott-Morton, M. (Ed.) (1991), *The Corporation of the 1990s: Information Technology and Organizational Transformation*, Oxford University Press, Oxford.

Steiber, A. and Alänge, S. (2015a), "Organizational innovation: a comprehensive model for catalyzing organizational development and change in a rapidly changing world", *The Triple Helix Journal*, Vol. 2 No. 1, pp. 1-25.

Steiber, A. and Alänge, S. (2015b), "Organizational innovations: verifying a comprehensive model for catalyzing organizational development and change", *The Triple Helix Journal*, Vol. 2 No. 14, pp. 1-28.

Steiber, A. and Alänge, S. (2020), "Corporate-Startup collaboration: effects on large firms' business transformation", *European Journal of Innovation Management*, Vol. ahead of print, No. ahead of print.

Steiber, A. (2020), "Corporate-Startup collaboration: its diffusion to and within the firm", *Triple Helix Journal*, Vol. ahead of print, No. ahead of print.

Teece, D.J. (2006), "Reflections on profiting from innovation", *Research Policy*, Vol. 35, pp. 1131-1146.

Teece, D.J. (2018), "Business models and Dynamic capabilities", *Long Range Planning* No. 51, pp. 40-49.

Venkatraman, N. (1994), "IT-enabled business transformation: from automation to business scope redefinition", *Sloan Management Review*, Vol. 35 No. 2, pp. 73-87.

Winfrey, G. (2019), "The 5 most profitable industries in the U.S", available at: https://www.inc.com/graham-winfrey/the-5-most-profitable-industries-in-the-us.html.

Winig, L. (2015), "GE's big bet on data and analytics", *MIT Sloan Management Review*, February, 2016, available at: https://sloanreview.mit.edu/case-study/ge-big-bet-on-data-and-analytics/.

Yoo, Y., Boland, R.J. Jr, Lyytinen, K. and Majchrzak, A. (2012a), "Organizing for innovation in the digitized world", *Organization Science*, Vol. 23 No. 5, pp. 1398-1408.

Yoo, S.J., Huang, W.H. and Lee, D.Y. (2012b), "The impact of employee's perception of organizational climate on their technology acceptance toward e-learning in South Korea", *Knowledge Management and E-Learning: International Journal*, Vol. 4 No. 3, pp. 359-378.

Yu, D. and Chieh Hang, C. (2010), "A reflective review of disruptive innovation theory", *International Journal of Management Reviews*, Vol. 12, pp. 435-452.

Zhu, K. and Kraemer, K. (2005), "Post-adoption variations in usage and value of E-business by organizations: cross-country evidence from the retail industry", *Information Systems Research*, Vol. 16 No. 1, pp. 61-84.

Further reading

Rothaermel, F.T. (2003), "Technological discontinuities and interfirm cooperation: what determines a startup's attractiveness as alliance partner?", *IEEE Transactions on Engineering Management*, Vol. 49 No. 4, pp. 388-397.

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