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Where Is the Age of Digitalization Heading? The Meaning, Characteristics, and Implications of Contemporary Digital Transformation

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Abstract: Digital transformation is perceived not only as a change in certain technology but also as a large transition that will ultimately change our lives for the better. Industry convergence, the key to digital transformation, entails, for firms, both various opportunities for innovation and the crisis of falling behind. Therefore, from the perspective of firms, it is critical to examine how digital transformation affects their industries and products as well as how they perceive and respond to digital transformation. This is ultimately a matter of how firms survive and maintain sustainable growth in this great upheaval of digital transformation. Based on the understanding of the concept of digital transformation, this study explores how high-growth firms perceive various aspects of digital transformation. The findings show that digital transformation involves a change of firms based on constant innovation, not simply the acceptance of technology, and that there is a large digital divide that depends on the firm size and industry type. Based on the above, this study derives implications in terms of the innovation activities of firms to ensure that digital transformation does not serve as a handicap and barrier for firms.

Keywords: digital transformation; high-growth firm; firm size; industry heterogeneity; Korea; COVID-19



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1. Introduction

In recent years, the world has faced the great issue of digital transformation. If we track interest in digital transformation among firms and industries over the last 15 years, we see a rapid increase starting in 2014–2015.

Figure 1 shows the level of interest in searches compared to the highest point of the graph based on a specific area and search period (when the frequency of search is the highest, the value of the graph is marked as 100, whereas the search word with half the highest frequency is marked as 50. Source: Google Trends [1] (accessed on 20 May 2021)).



Figure 1. The keyword trends of digital transformation.

From a similar perspective, Reis et al. [2] performed keyword searches with the two terms “digital transformation” and “digitalization” to determine the academic interest in the term digital transformation. The results of search indicated that, in 2016, when

the number increased significantly, 45% of all publications were articles, and 55% were conference papers, with the United States (21%) making the greatest contributions to publications, followed by Germany (19%) and China (5%). Digitalization and digital transformation are terms used in relation to computerization and digitization since the 1960s to respond to analog; however, recently, interest in digital transformation has been growing rapidly, which has led to a new definition of the term.

Digital transformation is expected to play a key role as a means to overcome pandemics, such as COVID-19, as well as an opportunity for growth. The global financial crisis in 2008 brought an economic crisis due to purchasing power loss caused by the destruction of the financial system. Moreover, the recent COVID-19 pandemic led to economic recession by making it difficult to conduct economic activities face to face. Contactless technologies and the contactless economy that are receiving attention in this pandemic situation can be regarded as the typical fields of technology and business that can be implemented by digital transformation [3].

Digital transformation was perceived as a motive and means for future growth along with the issue of the Fourth Industrial Revolution even before COVID-19. While the Fourth Industrial Revolution is a comprehensive term that refers to the abstract society overall, digital transformation, especially digital transformation technology, indicates the core technology itself that reveals and leads to change [2]. Terms like “digital transformation” and “digital” have existed for a long time; however, the term “digital transformation” today is needed to newly interpreted and comprehended as it seamlessly connects the physical environment with the cyber environment.

Accordingly, digital transformation is expected to bring a developmental change to the international economy and society in crisis as well as individual life, for which it must successfully extend and apply to firms that will develop and provide products and services to lead change. In particular, for the sustainable growth of firms and exchange and the cooperation and balance between small and medium-sized enterprises (SMEs) and large firms, it is necessary to examine whether digital transformation also provides SMEs with opportunities for growth when they are different from large firms with abundant resources and competencies, and how SMEs perceive digital transformation and what help they need.

Recent survey results demonstrated that firms, especially SMEs, are adjusting and responding poorly to digital transformation. For instance, Grebe et al.’s analysis on digital maturity showed that, due to digital transformation, the number of digital champion companies in 2018 was significantly decreased compared to 2017 [4]. Furthermore, a survey of high-growth firms in Korea demonstrated that only about 33.7% were planning on or already implementing digital transformation [5].

SMEs were seriously marginalized in digital transformation, with only about 6.2% implementing digital transformation, which is much lower than the percentage of larger firms at 15.1%. However, 69.4% of SMEs and 53.5% of large firms responded that, although digital transformation is important, they were not sure how to deal with it. In other words, to reduce alienation and the gap from digital transformation in business activities, it is necessary to understand digital transformation and determine how it affects business activities. Moreover, corporate and industrial strategies must be established considering the different competencies between SMEs and non-SMEs.

In this study, we aim to unravel the meaning of digital transformation and its influence on firms and to analyze how firms are currently perceiving digital transformation. Using the Korean high-growth firm data, we provide a comparative analysis considering firm characteristics (size and industry type) on (1) the importance of digital transformation and preparations, (2) the expected change digital transformation would bring to the industry and main products, (3) the capabilities necessary to prepare for digital transformation, and (4) the anticipated performance improvement from digital transformation.

This study reveals that firms’ perception of and preparations for digital transformation have various characteristics as well as a digital divide. As the digital divide in the past

has threatened the survival of countless firms, this study also considers the digital divide brought back by digital transformation as a factor that has a critical impact on firm survival.

This study is structured as follows. Section 2 examines the development process of digital transformation from a historical viewpoint and defines its meaning, and Section 3 examines the technical characteristics and potential risks of digital transformation and its influence on business through a literature review. Section 4 categorizes firms by size (large firms vs. SMEs) and industry type (manufacturing vs. non-manufacturing) to explore the gap in terms of how firms perceive and respond to digital transformation. Finally, Section 5 provides the conclusions and implications.

2. Digital Transformation: Concept and Historical Approach

2.1. The Historical Origin of Digital Transformation

The origin and development of the term “digital transformation” can be examined based on Germany’s Industry 4.0, the Fourth Industrial Revolution, and the development of the digital economy. First, Industry 4.0 was a policy adopted in November 2011 as a strategy for information and communications as a part of Germany’s High-Tech Strategy 2020. Its goal is to achieve innovation in the manufacturing business [6], and according to Deloitte [7], the goal of this policy encompasses not only the development of specific technology but also a paradigm shift in the manufacturing business.

Since 2013, in the early stage of the policy, research began on digital transformation as a research agenda by industry associations (BITKOM, VDMA, ZVEI). Then, starting in April 2015, this was expanded to Platform Industry 4.0 by the Federal Ministry for Economic Affairs and Energy and Federal Ministry of Education and Research, driving the digital transformation of firms in earnest. This concept was extended to the Fourth Industrial Revolution through “Mastering the Fourth Industrial Revolution” at the 46th World Economic Forum, indicating that digital transformation is the key to the Fourth Industrial Revolution.

Next, digital transformation can be examined in the development process of the digital economy. The term “digital economy” refers to a concept that is contrary to the analogue economy and has been widely used since 1994. However, it was actually developed back in the 1960s. Its development can be seen in the terms “digitization” in the 1960s, “digitalization” in the 1990s, and “digital transformation” since the 2010s.

Digitization converts offline analogue data to digital values, enabling offline transactions to be conducted online as well. This does not entail much of a change in terms of improving processes or developing new business models within the firm but merely indicates converting its various resources and assets online.

Digitalization refers to digitalizing a firm’s various business activities, which include the entire process of planning, producing, and distributing products and services. In other words, digitalization encompasses digitalizing processes as well as products and services. Process digitalization refers to converting one analogue process carried out in the real world into multiple segments of processes in the virtual world. Product digitalization refers to converting products with physical form into digital products that can be traded in virtual space. Service digitalization refers to providing in virtual space services that had been offered in physical space.

According to Kim [8], transforming face-to-face transactions between sellers and buyers in the market into contactless transactions on a website with a connection of multiple players (e.g., people, firms, and SW) in online shopping can be regarded as process digitalization; converting music CDs and maps into digital products, such as music files and navigation, can be regarded as product digitalization; and providing real estate agent services, consulting, education, and performances in virtual space can be regarded as service digitalization.

However, digital transformation refers to a drastic transformation brought about by digital technologies to not only a firm’s business but also the entire economy and society (see Table 1). At a corporate level, digital transformation refers to a significant change in

firms' business models and the main fields of business overall based on performance in digitalization. For example, the main fields of business for firms, like Apple or GE, were converted from analogue to digital, and online to offline service providers, such as Amazon in the United States and Delivery Hero in Germany, are blurring the lines between online and offline platforms.

Table 1. The digital transformation concept in the development process of the digital economy (Kim [5], Kim [8]).

Classification	Digitization (Late 1960s)	Digitalization (Early 1994s)	Digital Transformation (Early 2010s)
Focus	Digitization of data/content	Digitalization of processes and products/services	System changes of business/ industrial/economic activities
Main purpose	Improving efficiency and effectiveness in terms of cost, time, and other business activities	Improving efficiency and effectiveness in terms of business relationship including value chains through value co-creation and sharing	New business models for firms New opportunities for startups
Fundamental strategy	Transforming transactions and commerce from offline to online	Transforming business online or creating new online business	Innovation of all business processes and customer experiences

In other words, while digitization focuses on data/content and digitalization on processes and products/services, digital transformation focuses on all sectors, such as firms' products/services, production process, business process, corporate strategies, business models, working methods, organizational culture, and leadership. In terms of business activities, digital transformation is a term that embraces not only input–output and process digitalization in the middle but also the strategies and implementation plans to create new business models or market opportunities through the digitalization of the entire life cycle of business activities.

2.2. Concepts and Definitions of Digital Transformation

As previously mentioned, digital transformation is strongly influenced by Industry 4.0 and the Fourth Industrial Revolution; thus, some regard the three as the same thing [9–12], and the terms “digitization”, “digitalization”, and “digital transformation” are conceptually linked to one another. One thing that is clear is that digital transformation is a term that encompasses the economic and social impacts of digitization and digitalization [13]. From this perspective, concepts and definitions of digital transformation have been emerging since the 2000s [1,14,15], and more specific definitions were introduced by various institutions and researchers in the 2010s as shown (see Table 2).

Table 2. Definition of digital transformation.

Author	Definition
Stolterman and Fors [14]	The changes that digital technology causes or influences in all aspects of human life
Martin [15]	Now commonly interpreted as such usage of information and communication technology, when trivial automation is not performed but fundamentally new capabilities are created in business, public government, and in the life of people and society
IBM [16]	Reshaping customer value propositions, and transforming operating models using digital technologies for greater customer interaction and collaboration
Solis. [17]	The realignment of, or new investment in, technology, business models, and processes to more effectively compete in an ever-changing digital economy
Ismail et al. [18]	The process through which companies converge multiple new digital technologies with the intention of reaching sustained competitive advantage in terms of business models, customer experience, operations and processes, and people and networks

Table 2. Cont.

Author	Definition
Reis et al. [2]	The use of new digital technologies that enables major business improvements and influences all aspects of customers' life
Veldhoven and Vanthienen [19]	The continuously increasing interaction between digital technologies, business, and society, which results in transformational effects and increases the change in process velocity, scope, and impact
OECD [20]	A multifaceted and fast-moving phenomenon that changes the business models of firms using new digital technologies

Stolterman and Fors [14] defined digital transformation as changes that can influence all aspects of human life. In other words, all aspects of human life may change due to digital transformation. This can be a revolution in human life, which can also be interpreted as the Fourth Industrial Revolution. Martin [15] defined digital transformation as the usage of information and communication technology without trivial automation but with the creation of fundamentally new capabilities. This indicates that information and communication technology is the fundamental technology of digital transformation, which creates new values and capabilities. IBM [16] stated that expanding global connectivity and improving customer capabilities are the driving forces that lead to digital transformation.

A few industries, such as music, entertainment, and electronic goods, were merely exploring digital products and services in the 1990s; however, as consumer demand for digital products and services continued to grow and evolve in the 2000s, customers began to have greater authority and expectations. As a result, improved customer capabilities have become a major driving force of digital transformation. Therefore, IBM [16] forecasted that, for firms to draw out the potential for devastating technology, they must reshape customer value propositions (CVP) and transform business operations so that they can provide CVP effectively, efficiently, and innovatively, thereby, bringing change to the entire industry.

Solis [17] defined digital transformation as realignment or investment, which includes overall corporate activities, such as technology, business models, and operations. This view describes how digital transformation can actually be achieved by firms. In a similar vein, Ismail et al. [18] defined digital transformation as the process through which companies converge multiple new digital technologies to secure sustained competitive advantage in terms of business models, customer experience, operations and processes, and people and networks.

Reis et al. [2] identified the three elements of technology, organization, and society that define digital transformation, and thus defined it as the use of new digital technologies that enable major business improvements and influence all aspects of customers' life. The definition takes account not only of business improvements of firms but also the impact in terms of changes in customers' lives.

Veldhoven and Vanthienen [19] regarded digital transformation as the continuously increasing interaction between digital technologies, business, and society, which results in transformational effects and increases the change in process velocity, scope, and impact. They interpreted digital transformation as a vector, referring to dynamic activity and direction itself as digital transformation. The OECD [20] also defined digital transformation as a multifaceted and fast-moving phenomenon that changes the business model, including the dynamic activity itself.

Digital transformation has different definitions according to various aspects of technology, industry, and society. Nonetheless, all definitions tend to interpret digital transformation not as a single technology or process but as an expanded concept that encompasses various changes brought by digital technologies. In this view, digital transformation can be regarded as a revolution that changes the values throughout industries and societies as well as all aspects of life by fundamentally changing all business-related activities of firms based on digital technologies. From the firm's perspective, therefore, the most important thing is

to determine which technologies are needed for digital transformation, what characteristics these technologies have, and how they affect business activities.

3. Digital Transformation: Technological Characteristics and Changes in Business

3.1. Component Technologies for Digital Transformation

In 2016 and 2018, the WEF mentioned the technologies leading the Fourth Industrial Revolution (4IR). As shown in Table 3, Schwab [21] classified these technologies into physical, digital, and biological spheres and examined over 10 technologies. Digital technologies include the Internet of Things (IoT), blockchain, bitcoin, on-demand economy (or sharing economy, platform business, or digital platform). Later, Schwab et al. [22] classified the technologies leading 4IR into the categories of extending digital technologies, reforming the physical world, altering the human being, and integrating the environment, and provided 12 technologies. The extended digital technologies include new computing, blockchain/distributed ledger, and IoT.

Table 3. Leading technologies of 4IR by WEF.

Digital Technologies Leading 4IR (2016)	Extended Digital Technologies Leading 4IR (2018)
IoT, blockchain/bitcoin, and on-demand economy (or sharing economy/platform business/digital platform) [21]	New computing (e.g., centralized cloud, quantum computing, optical computing, and neural network processing), blockchain/distributed ledger, and IoT [22]

From a similar view, the WEF [23] classified the motives for 4IR technologies into nine types. These motives include internet and cloud technology (34%), information-processing capability and big data (26%), new/renewable energy and related technology (22%), IoT (14%), sharing economy and crowdsourcing (12%), robotics and autonomous vehicles (9%), artificial intelligence (AI) (7%), advanced manufacturing and 3D printing (6%), and advanced materials and biotechnology (6%) depending on their influence. The technologies with the biggest influence are mobile internet and cloud technology.

The former has increased the convenience of individual life with smartphones, various smart devices, and mobile apps, and the latter has improved the quality of decision making by contributing to increased work productivity of firms and promoting the production and distribution of big data. The IoT provides constant connections of people, objects, and devices, thereby, enabling autonomous decision making and implementation, and the development of various platforms has contributed to the sharing and supply of labor forces, knowledge, and assets. Later, the WEF assumed that the development of the four technologies—ubiquitous high-speed mobile internet, AI, big-data analysis, and cloud technology—would have a positive impact on business growth in the next four years [22].

The OECD [24] mentioned the characteristics of digital transformation that affect technologies, data, business models, and policies. The digital technologies included IoT, next-generation 5G wireless communications, cloud computing, big data, AI, blockchain, high-performance computing (HPC), and quantum computing (QC). The ecosystem of interdependent digital technologies will support digital transformation and evolve in a way that leads to future socio-economic changes.

This ecosystem opens up a new window of opportunities through interoperation and complementarity, and it is, thus, much more powerful and functional than individual components. The report forecasts that data along with technology will result in digital transformation, which indicates that the ecosystem of digital technologies depends on data. Thus, it is necessary to understand data as a significant source of resources and values.

From this perspective, digital component technologies that accelerate digital transformation are not some fixed technologies or technology groups. Moreover, it can be seen that core or component technologies constantly change depending on the phases and maturation process of digital transformation. In other words, it is difficult for firms to develop or adopt technologies for digital transformation through specific technology development

projects. Rather, they must derive core technologies necessary for digital transformation considering their field and status, and thus they need to constantly determine, develop, and adopt adequate technologies in the process of digital transformation.

3.2. Characteristics of Digital Transformation Technologies

Kim [8] divided digital transformation technologies into four layers: application, service, platform, and infrastructure. This is consistent with the IT approach that originates from the seven layers of the Open Systems Interconnection (OSI) model. This indicates that, using an IT classification, digital technologies can be interpreted as new technologies, and digital transformation can be interpreted as an extension of IT.

Table 4 shows the classification of digital technologies. First, digital infrastructure refers to the computer system that firms must have. As manufacturing businesses need infrastructures, such as factories for production, digital transformation requires the foundation of computing systems, which include both hardware and software. A digital platform is an environment for using and developing various services. In other words, it includes common technologies to manage the data and implement the processes necessary for providing the service.

Table 4. Classification of digital technologies (Kim [8]).

Layer	Content	Examples
Digital infrastructure (base technology)	Computer HW, system SW, and wired/wireless network	Host computer, PC, smartphone UNIX, Android LAN, and WiFi
Digital platform (common technology)	Data management, process implementation, and information protection	Sensing, cloud, big data, AI, machine/electronic device control, and biometric authentication
Digital application	Included in various digital services and performing specific functions	Distributed ledger/blockchain, IoT, VR/AR/MR, and 3D printing
Digital service (applied technology)	Products/services and industries to support specific goal attainment	Component technology: Telematics, Biometric products/services: Autonomous vehicles Industry: Online shopping, car sharing, digital content, smart home, and smart city

Typical platform technologies include AI, machine learning and deep learning, big data, cloud, mobile, and 5G communications. Digital service refers to the form of products and services, or a business model, to provide specific applications. Most digital services include the function of sensing-control-actuation as well as various smart systems provided based on this function. Finally, the digital application refers to each unit of function, product, or package included in the service. To form an application, component technologies are required, such as distributed ledger/blockchain, IoT, VR/AR/MR, and 3D printing.

3.3. Potential Risks of Digital Transformation to Existing Business System

As mentioned above, digital transformation is a macro-level revolution caused by unprecedented convergences of multiple radical innovations across technological domains and industries as well. While digital transformation makes products/services “smart” and offers diverse collaboration opportunities to all members in present value chains [25], it can also bring unpredictable and unintended changes to established technologies, business models, industry systems, and customer perceptions.

During this transformation time, existing standards of both technologies and business models will be changed or challenged [26] and eventually replaced by new dominant standards. Therefore, it is worth noticing that, despite the numerous potential benefits expected due to digital transformation, various risks may be inherently embedded in the digital transformation process. In this section, we discuss how digital transformation may

threaten the sustainable competitiveness of incumbents in existing business systems in three aspects.

First, digital transformation generates many disruptive technologies that will fundamentally change the established “rules of the game” in many industries, thus, requiring firms to make various risky investments in developing new technologies, business models, and processes to adapt to the new rules. For instance, the emergence of cryptocurrency such as Bitcoin can significantly influence performance of traditional finance firms or the rule of conventional financial system [27]. Second, as digital integration via technological convergence increases the complexity of knowledge embedded in products or systems, it may be more vulnerable to external-attacks, such as cyber-hacking or unanticipated system errors.

For example, the Industrial Internet of Things (IIoT), the new industrial environment based on the convergence of Informational Technology (IT) and Operational Technology (OT) environments, is more likely to be exposed to various cyber-attacks due to the time lag between the development of new systems and defense strategies for those new systems [28]. This type of risk can be applied to a wide spectrum of industrial sectors, including energy service sectors, financial services, nuclear reactor sectors, healthcare, communication, manufacturing, etc. Lastly, during the rapid transitional period, not only new requirements for existing business models but also new customer preferences for products/services may emerge.

These changes and pressures significantly challenge the efficacy of operating business models and, furthermore, force firms to redesign their business models with unprecedented customer value propositions. In this vein, Javaria et al. [29] investigated ongoing dynamics in e-commerce markets and found that consumers considered diverse perception of risks, such as financial, performance, functional, and time-related risks, when making purchasing decisions under changing environments. In a nutshell, although digital transformation is expected to bring a positive change for the sustainable growth of firms, it is important to investigate further how digital transformation potentially increase risks that influence the business strategies and competitiveness of the firm.

3.4. Changes in Business Due to Digital Transformation

According to Rogers [30], firms can be affected by digital transformation in five domains: customers, competition, data, innovation, and value. First, digital transformation will change customers who are passive targets of marketing (one-way) to targets of mutual communication (two-way). In other words, firms can have customers as a constantly changing dynamic network, not as predetermined mass-market customers. The competition will also transform from competition within the industry to fluid inter-industry competition or competition over the formation of new industries. This can be a connection-based competition in which the major assets to secure competitive advantage are transferred from the internal to the external networks of the firm.

The purpose of data will be shifted from storage and management for internal efficiency to core assets for value creation. Innovation will also change from innovation that focuses on finished products to innovation with upgraded versions through quick prototype releases and iterations. Traditionally, innovation was considered expensive, high-risk, and exclusive and was managed with a focus on finished products. Since it was difficult and expensive to test new ideas, firms relied on the managers’ analysis and intuition to predict what kind of product to develop before releasing anything in the market. Due to the high costs of failure, the most important thing was to avoid failure at all.

However, digital technologies enable firms to develop products at the low cost based on quick experiments and continuous learning, helping them to test the products quickly with user communities. Finally, past values were fulfilled by optimizing one business model for a long time; however, after digital transformation, values will be defined based on customer needs, resulting in a constant evolution of the business model into the next business. Depending on unchanging value propositions has become so risky that it may

even affect firm survival, and repeating and settling for the same successful value proposition is equally dangerous. The only way to deal with the changing business environment is to watch all technologies as a method to expand and improve our value propositions for customers and continue evolving.

In terms of business activities, these can be divided into development processes and operations of products and services, products and services themselves, business models, business goals, and strategies [4]. First, intellectualization (or smartization) of processes and operations may increase the nonlinear and multilayered connections between processes. This may also enable digitization and connection of the entire processes of production and operations, thereby, changing the production method from a centralized control system to an autonomous decentralized system [31,32].

This operation method will enable customized production by changing the existing method of mass-producing small product varieties to mass-producing multi-variety products [33]. Second, products and services may change themselves. Turning products into services or services into products will result in the convergence of the two. In particular, platforms as a medium may activate the connection between users and suppliers with a focus on products and services. Third, innovation in business models can be made possible. Firms cannot constantly provide new values for customers with only product and service innovation, and the competition between firms will also be intense.

As a solution, firms will seek a new business model to provide personalized and customized values for customers using AI and big-data technology. Fourth, firms' business goals and strategies may also change fundamentally. The traditional business goal of firms is to maximize shareholder value or their own profits. However, with the increasing cooperation among the players in the industrial ecosystem (e.g., producers, consumers, developers, suppliers, and retailers/distributors/sellers) individual firms will seek incentives for joint development with their partners within the industrial ecosystem in addition to maximizing their shareholders' values.

3.5. Firm Size and Industry Type for Digital Transformation

The association between firm size and innovation has received constant attention from innovation and management scholars. On the one hand, small firms may possess more advantages in adopting and pursuing innovation based on their flexibility and agility, while large firms may suffer from organizational inertia. On the other hand, one can argue that large firms might be advantageous in pursuing innovation with the abundant resources and experience that small firms usually lack. As digital transformation is a macro-trend innovation related to the competitiveness and survival of firms across industries, the debate on the relationship between firm size and digital transformation has received attention from recent studies [34–36]. These studies explored the question of how SMEs, compared to large firms, recognize, prepare, and implement digital transformation strategies.

Another emerging stream of research investigates how digital transformation strategy and performance vary by industry type. As digital transformation is analogous to Industry 4.0, smart factories, and cyber-physical systems, the manufacturing industry has been viewed as the core industrial area to understand the nature of digital transformation [37–39]. In addition, as digital transformation significantly influences the existing business model [40], and its impact on the service sector has become a salient issue [41,42]. As digital transformation is basically knowledge convergence across sectors, identifying which sector plays a leading role and grasps hegemony becomes important. By recognizing these research trends, our study employs firm size and industry type (manufacturing and service sector) as classification instruments to explore how a firm's perceptions of, and responses to, digital transformation vary.

4. Firms' Perceptions of and Responses to Digital Transformation: Korean High-Growth Firms

As previously examined, digital transformation will lead to changes and measures in the extensive innovation activities of firms beyond technology acceptance, such as

operations and processes, products and services, business models, and goals. Therefore, as shown in the Introduction, firms may have different perceptions and measures for digital transformation depending on their capabilities and preparations. The purpose of this section is to explore how firms perceive and respond to digital transformation depending on their size (large firms vs. SMEs) and industry type (manufacturing vs. non-manufacturing).

4.1. Data Collection

To investigate firms' perceptions of digital transformation and their practices, this study chose Korean firms as its sample data. Korea is one of the leading innovative digital economies worldwide. According to BloombergNEF [43], Korea was ranked third in 2019 and first in 2020 in the national industrial digitalization ranking. This indicator is derived based on national strategies and policies, and, in particular, Korea was evaluated as putting digital transformation as one of its top national priorities through a national AI strategy and a new Korean deal recovery package.

Thus, Korea is an ideal research setting to examine the various perceptions and views held by high-growth firms regarding digital transformation. Particularly, this study focuses on high-growth firms in Korea. The concept of a high-growth firm (also known as a scale-up firm) is widely known and has been defined by Eurostat and the OECD as enterprises with at least ten employees and an average annual growth in employment or revenue exceeding 20% over three consecutive years.

From the Science and Technology Policy Institute (STePI) database, we extracted a list of 3391 Korean high-growth firms with a 20% or more increase in sales in the last three years from 2016 to 2018. The survey was conducted for about six weeks between July and August 2020, and a final 439 valid responses were obtained. The data collected are comprised of large enterprises (9.83%) and SMEs (90.17%), in terms of company size, and manufacturing companies (53.64%) and non-manufacturing companies (46.36%) by industry classification. SME data followed the classification of Statistics Korea based on Korea's Framework Act on small and medium enterprises. According to this Act, SMEs are classified according to industry by differentiating their sales from about 35 million dollars or less to 130 million dollars or less. According to the Profit Corporation Statistics of Statistics Korea, as of 2018, SMEs accounted for 99% of all companies, and large enterprises, including mid-sized companies, accounted for about 1% [44]. The results of the survey include information on large enterprises (19.59%) and SMEs (80.41%) as well as the proportions of manufacturing companies (44.19%) and non-manufacturing companies (55.80%).

4.2. Analyses on Korean High-Growth Firms' Digital Transformation

The collected data were analyzed with a focus on the following four matters: (1) importance of digital transformation and preparations, (2) expected change digital transformation would bring to the industry and main products, (3) capabilities necessary to prepare for digital transformation, and (4) anticipated performance improvement from digital transformation. Digital transformation is a macro-trend phenomenon that affects all industries and many firms, but individual firms may have different views depending on their characteristics or the industry to which they belong. Therefore, this study applies the classification method according to firm size and industrial characteristics for each of the aforementioned matters.

Table 5 shows "How the firm perceives the importance of digital transformation and how it is prepared". Only 8% of all samples responded that they "recognized the importance and [were] well-prepared", whereas 66% responded that they "recognized the importance but [had] no concrete plan". Ninety-two percent were aware of the importance but lacked the effort to actually make a concrete plan.

Table 5. Firms' preparation for digital transformation.

Type	N	Recognized the Importance and Well-Prepared	Recognized the Importance and Plan to Prepare	Recognized the Importance but No Concrete Plan
SMEs	353	6%	24%	70%
Large	86	15%	31%	54%
MFG	194	11%	32%	57%
Non-MFG	245	5%	21%	74%
SMEs MFG	160	9%	30%	61%
Large MFG	34	21%	41%	38%
SMEs non-MFG	193	3%	20%	77%
Large non-MFG	52	12%	25%	63%
Total	439	8%	26%	66%

By firm size, large firms (15%) showed a response rate more than 2.5-times higher for “recognized the importance and well-prepared” than SMEs (6%), and the response rate for “recognized the importance but no concrete plan” was also significantly low (70% vs. 54%). By industry type, manufacturing firms (11%) showed a significantly higher rate than non-manufacturing firms (5%), and manufacturing firms also showed a significantly lower response rate for “recognized the importance but no concrete plan”.

As a result of the four cross-type groups of firm size and industry type, 21% of large manufacturing firms recognized the importance and prepared properly, and 41% recognized the importance and planned to prepare, indicating that more than 60% were at least preparing. However, only 3% of non-manufacturing SMEs responded that they recognized the importance and had prepared properly, whereas over 77% said they had recognized the importance but had no concrete plan, thus, demonstrating a huge gap depending on firm size and industry type.

Table 6 shows “the firm’s expectation for change that digital transformation would bring to the industry and main products”. Only 3% of all samples responded that they “expect[ed] a great change in both the industry and main products”, whereas 75% responded that they “expect[ed] a small change in both the industry and main products”. There was not much difference depending on firm size or industry type. However, among large firms, large manufacturing firms (67%) and large non-manufacturing firms (86%) showed a significant difference (20%) in the response that they “expect[ed] a small change in both the industry and main products”.

Table 6. Firms' expectation for changes from digital transformation.

Type	N	Stable Perspective		Dynamic Perspective	
		Industry (Minor Change)	Industry (Minor Change)	Industry (Major Change)	Industry (Major Change)
		Main Product (Minor Change)	Main Product (Major Change)	Main Product (Minor Change)	Main Product (Major Change)
SMEs	353	73%	8%	15%	3%
Large	86	79%	9%	7%	5%
MFG	194	70%	9%	17%	4%
Non-MFG	245	78%	9%	10%	3%
SMEs MFG	160	70%	8%	18%	4%
Large MFG	34	67%	12%	15%	6%
SMEs non-MFG	193	76%	9%	12%	3%
Large non-MFG	52	86%	8%	2%	4%
Total	439	75%	9%	13%	3%

Table 7 shows the firms' views on “capabilities considered important in preparing for digital transformation” depending on the firm size. Overall, 50% of both SMEs and

large firms had “neutral” views. A noticeable difference is that, in all three capabilities, more than 50% of SMEs held neutral views and had three times more negative views than large firms. Large firms accounted for the highest ratio of neutral views (approximately 40%) but generally accounted for more than 50% of positive views and fewer than 10% of negative views, implying that they were generally aware of the importance or necessity of each capability.

Table 7. Firms’ capabilities for digital transformation by firm size.

		Business Capability						
		Not at All	Not Much	Neutral	Somewhat	Very	Negative	Positive
SMEs	353	7.6	10.5	51.6	19.8	10.5	18.1	30.3
Large	86	1.2%	4.7	43.0	34.9	16.3	5.9	51.2
		Digital Capability						
		Not at All	Not Much	Neutral	Somewhat	Very	Negative	Positive
SMEs	353	8.5	14.2	50.1	17.8	9.3	22.7	27.2
Large	86	1.2	4.7	44.2	37.2	12.8	5.8	50.0
		Soft Capability						
		Not at All	Not Much	Neutral	Somewhat	Very	Negative	Positive
SMEs	353	7.4	12.5	51.8	18.1	10.2	19.8	28.3
Large	86	1.2	5.8	43.0	32.6	17.4	7.0	50.0

Note: Business capability indicates a firm’s ability for task management, process improvement, and data management; Digital capability indicates a firm’s technological capability for programming, software development, and data analysis; and Soft capability indicates a firm’s capability for problem-solving, collaboration, and creativity management.

Table 8 shows the firms’ views on “capabilities considered important in preparing for digital transformation” depending on the industry type. Overall, 50% of both manufacturing and non-manufacturing firms had “neutral” views. Manufacturing firms showed an extremely low ratio of “not at all” among all capabilities (approximately 3%), but “not at all” accounted for nearly 10% of all capabilities among non-manufacturing firms. There was not much difference in positive views by industry type (somewhat higher among manufacturing firms), but non-manufacturing firms were 1.5-times more likely to hold negative views compared with manufacturing firms.

Table 8. Firms’ capabilities for digital transformation by industry type.

Industry Type	N	Business Capability						
		Not at All	Not Much	Neutral	Somewhat	Very	Negative	Positive
MFG	194	3.1	9.3	51.0	23.2	13.4	12.4	36.6
Non-MFG	245	9.0	9.4	49.0	22.4	10.2	18.4	32.7
		Digital Capability						
		Not at All	Not Much	Neutral	Somewhat	Very	Negative	Positive
MFG	194	3.6	10.8	52.6	21.6	11.3	14.4	33.0
Non-MFG	245	9.8	13.5	46.1	21.6	9.0	23.3	30.6
		Soft Capability						
		Not at All	Not Much	Neutral	Somewhat	Very	Negative	Positive
MFG	194	2.6	10.8	53.6	19.1	13.9	13.4	33.0
Non-MFG	245	9.0	11.4	47.3	22.4	9.8	20.4	32.2

Table 9 shows cross-type groups’ views on “capabilities considered important in preparing for digital transformation” depending on the firm size and industry type. Interestingly, there was a consistent pattern of ranking by capability in positive views (large

MFG firms > large non-MFG firms > MFG SMEs > non-MFG SMEs). This implies that firm size serves as a more important factor than industry type for capabilities that are important in digital transformation. Within the same size, manufacturing firms showed more positive views compared with non-manufacturing firms.

Table 9. Firms' capabilities for digital transformation by industry type and firm size.

Type	N	Business Capability						
		Not at All	Not Much	Neutral	Somewhat	Very	Negative	Positive
SMEs MFG	160	3.1	10.6	54.4	18.1	13.8	13.8	31.9
Large MFG	34	2.9	2.9	35.3	47.1	11.8	5.9	58.8
SMEs non-MFG	193	11.4	10.4	49.2	21.2	7.8	21.8	29.0
Large non-MFG	52	0.0	5.8	48.1	26.9	19.2	5.8	46.2
		Digital Capability						
		Not at All	Not Much	Neutral	Somewhat	Very	Negative	Positive
SMEs MFG	160	3.8	13.1	54.4	16.9	11.9	16.9	28.8
Large MFG	34	2.9	0.0	44.1	44.1	8.8	2.9	52.9
SMEs non-MFG	193	12.4	15.0	46.6	18.7	7.3	27.5	25.9
Large non-MFG	52	0.0	7.7	44.2	32.7	15.4	7.7	48.1
		Soft Capability						
		Not at All	Not Much	Neutral	Somewhat	Very	Negative	Positive
SMEs MFG	160	2.5	12.5	56.3	15.6	13.1	15.0	28.8
Large MFG	34	2.9	2.9	41.2	35.3	17.6	5.9	52.9
SMEs non-MFG	193	11.4	12.4	48.2	20.2	7.8	23.8	28.0
Large non-MFG	52	0.0	7.7	44.2	30.8	17.3	7.7	48.1

Large manufacturing firms showed a 0% response rate for “not at all,” expressing the need for all capabilities to a certain extent and also showed the lowest response rate for negative views. However, non-manufacturing SMEs showed a significantly high response rate in each capability for negative views, including “not at all.” The interesting fact is that manufacturing SMEs, which tend to have a moderate character, showed a response rate of over 50% for “neutral” in all capabilities, taking a wait-and-see attitude.

Table 10 shows the firms' views on the “anticipated performance improvement from digital transformation” depending on the firm size. Overall, nearly 60% of the large firms took a “neutral” stance. In all aspects of anticipated performance, SMEs showed twice as many negative views as large firms, while the large firms showed twice as many positive views as SMEs, which proves the huge gap between the two groups. From a different perspective, the large firms tended to be extremely cautious, showing a combination and coexistence of negative and positive views, whereas, for SMEs, the difference between negative and positive views ranged from a factor of five to a factor of eight.

Table 11 shows the firms' views on the “anticipated performance improvement from digital transformation” depending on the industry type. Overall, nearly 40% of both manufacturing and non-manufacturing firms took a “neutral” stance. Both manufacturing and non-manufacturing firms showed much more negative views than positive views in terms of anticipated performance; however, manufacturing firms showed a smaller difference compared with non-manufacturing firms.

Table 10. Digital transformation and firm performance by firm size.

Firm Size	N	Profitability Growth						
		Not at All	Not Much	Neutral	Somewhat	Very	Negative	Positive
SMEs	353	30.3	23.8	35.7	8.2	2.0	54.1	10.2
Large	86	4.7	19.8	54.7	15.1	5.8	24.4	20.9
		New Product Development						
		Not at All	Not Much	Neutral	Somewhat	Very	Negative	Positive
SMEs	353	32.0	23.8	36.5	5.9	1.7	55.8	7.6
Large	86	5.8	19.8	59.3	12.8	2.3	25.6	15.1
		New Partnership						
		Not at All	Not Much	Neutral	Somewhat	Very	Negative	Positive
SMEs	353	31.4	24.6	37.1	5.4	1.4	56.1	6.8
Large	86	5.8	20.9	55.8	15.1	2.3	26.7	17.4

Table 11. Digital transformation and firm performance by industry type.

Industry Type	N	Profitability Growth						
		Not at All	Not Much	Neutral	Somewhat	Very	Negative	Positive
MFG	194	21.6	24.2	38.7	12.9	2.6	45.9	15.5
Non-MFG	245	28.2	22.0	40.0	6.9	2.9	50.2	9.8
		New Product Development						
		Not at All	Not Much	Neutral	Somewhat	Very	Negative	Positive
MFG	194	22.2	23.7	41.8	10.3	2.1	45.9	12.4
Non-MFG	245	30.6	22.4	40.4	4.9	1.6	53.1	6.5
		New Partnership						
		Not at All	Not Much	Neutral	Somewhat	Very	Negative	Positive
MFG	194	22.7	24.7	40.2	10.8	1.5	47.4	12.4
Non-MFG	245	29.4	23.3	41.2	4.5	1.6	52.7	6.1

Table 12 shows cross-type groups' views on the "anticipated performance improvement from digital transformation" depending on the firm size and industry type. Interestingly, there was a consistent pattern of ranking by capability in positive views (large MFG firms > large non-MFG firms > MFG SMEs > non-MFG SMEs). This implies that, like the important capabilities for digital transformation that were previously analyzed, firm size served as a more important factor than industry type in anticipated performance improvement from digital transformation as well.

Table 12. Digital transformation and firm performance by industry size and firm size.

Type	N	Profitability Growth						
		Not at All	Not Much	Neutral	Somewhat	Very	Negative	Positive
SMEs MFG	160	25.6	28.1	33.8	10.6	1.9	53.8	12.5
Large MFG	34	2.9	5.9	61.8	23.5	5.9	8.8	29.4
SMEs non-MFG	193	34.2	20.2	37.3	6.2	2.1	54.4	8.3
Large non-MFG	52	5.8	28.8	50.0	9.6	5.8	34.6	15.4
		New Product Development						
		Not at All	Not Much	Neutral	Somewhat	Very	Negative	Positive
SMEs MFG	160	26.3	27.5	35.6	8.8	1.9	53.8	10.6
Large MFG	34	2.9	5.9	70.6	17.6	2.9	8.8	20.6
SMEs non-MFG	193	36.8	20.7	37.3	3.6	1.6	57.5	5.2
Large non-MFG	52	7.7	28.8	51.9	9.6	1.9	36.5	11.5

Table 12. Cont.

Type	N	New Partnership						
		Not at All	Not Much	Neutral	Somewhat	Very	Negative	Positive
SMEs MFG	160	26.3	28.8	35.6	8.1	1.3	55.0	9.4
Large MFG	34	5.9	5.9	61.8	23.5	2.9	11.8	26.5
SMEs non-MFG	193	35.8	21.2	38.3	3.1	1.6	57.0	4.7
Large non-MFG	52	5.8	30.8	51.9	9.6	1.9	36.5	11.5

This was also proved by the as much as five-to-six-fold difference in negative views between large manufacturing firms and manufacturing SMEs. This difference exceeded the difference in necessary capabilities (by two to three times), indicating that sensitivity of firm size served as a more apparent factor of differentiation in anticipated outcomes.

5. Discussion and Conclusion

5.1. Theoretical Implications

This study offers useful insights into (1) the meaning and characteristics of digital transformation, and (2) the digital divide between firms due to digital transformation. First, digital transformation is the product of constant technological innovations, not the emergence of wholly new technology, and firms must pursue their own transformation instead of merely introducing technologies. From the perspective of technological innovation, digital transformation is an incremental innovation process continued by digital technologies.

Digital technologies can be regarded as wholly new technologies that are different from analogue technologies, but digital transformation is a process that combines the digital technologies developed recently with long-existing analogue technologies. Therefore, it is necessary to take an approach in terms of technological convergence or systems instead of developing and adopting a single technology. ICTs are the technologies that form such convergence and systems, and combinations of these technologies can be used in changes in firms' operation and production processes, products and services, business models, visions, and main fields of business.

In other words, all innovation activities of firms are changed by connecting the physical environment and cyber environment. Therefore, firms must take measures in an entirely different direction than technology acceptance. Technological innovations of firms have maintained competitiveness and evolved through the process of developing, introducing, or imitating certain technologies in the same industry. However, digital transformation requires the capabilities for firms to set the goals in how they will change certain fields; understand technological convergence or systems; and plan, manage, and operate for implementation. These changes enable firms to promote competitiveness within the industry, expand into new fields, or change their main fields altogether and try something entirely new.

Therefore, for firms to actively survive in the environment, they must plan and apply digital transformation based on their understanding of the concept and prepare the organization and human resources to continuously operate and manage digital transformation. The public sector or the government must take preemptive measures or establish a system to quickly cope with each issue by responding to the convergence of multiple industries and changes in the value chain brought about by digital transformation, so that regulations among industries or different policies of firms do not serve as handicaps or entry barriers for firms in different fields.

Next, there were various implications regarding the digital divide between firms. Digital transformation requires firms to have capabilities in not only technological innovation but also planning, management, and operation, overall. Therefore, the divide in digital transformation is expected to grow extremely large due to the difference in capabilities. This can be easily predicted considering the characteristics of digital transformation as well.

When digitization first appeared in earlier content, there was a huge issue over the digital divide among people enjoying content.

This divide is fully applied even to firms that are the main agents of digital transformation. Moreover, the core technology of digital transformation is mostly ICT, and the ICT industry is a typical field where the winner takes all. Thus, the digital divide between firms can be predicted by technological characteristics, and this divide could be identified in this study from three perspectives, namely, “perception and response” to crises, “capability”, and “performance”.

First, in the perception of and response to (or preparation for) digital transformation, there was a gap at least twice as large between large firms (15%) and SMEs (6%) and between non-manufacturing firms (11%) and manufacturing firms (5%) (see Table 5). This demonstrates that the divide between firms can turn out to be huge depending on both firm size and industry type. Moreover, there was an interesting result in terms of how changes in products and the industry overall were perceived due to the response.

Many previous studies expected digital transformation to bring large changes, but surprisingly, only 16% of firms expected digital transformation to bring a great change to the industry to which they belonged, and even manufacturing SMEs that showed the highest ratio accounted for 22%. This was applied to their main product as well. Only 12% of firms expected digital transformation to bring a great change to their current main product in the groups, and even large manufacturing firms that showed the highest ratio accounted for 22%.

It was an unexpected result that even the group that was best prepared for digital transformation showed about a 20% response rate for the possibility of change in their main product and industry. Moreover, large non-manufacturing firms responded that there was the lowest possibility of change in their main product and industry. This result shows that, even if firms undergo digital transformation, they can accumulate small, consecutive changes rather than making an instant transformation in the form of a huge jump. In other words, digital transformation is not a one-time technology introduction or system transformation but a steady change, and firms require the capabilities to continue operating like this.

Second, in the important capabilities for digital transformation (business, digital, and soft capabilities), there was a difference in terms of size rather than industry type. As seen in Tables 7–9, all groups showed the highest ratio of neutrality in their capabilities for digital transformation. This indicates that firms in the actual scenes of management have not yet established the capabilities for digital transformation in general. However, by firm size, more than half of the large firms agreed that each capability was necessary and important, which is about twice the ratio for the SMEs.

Considering that there was not much difference between manufacturing firms (34%) and non-manufacturing firms (32%) in their responses regarding the importance of each capability, firm size appeared to affect how they perceived the capabilities necessary for digital transformation. Unlike the previous focus of technological innovations on the development of certain industries, the key to digital transformation is to create a new field of business by combining the technological or business model characteristics of industries that have developed individually. This process is naturally accompanied by great efforts and high risks, implying that large firms, which have a broad perspective that encompasses multiple industries and the resources to pursue convergence, can start from a more advantageous position.

This provides significant implications for business strategies and innovation. Since Schumpeter [45], many researchers have been interested in firm size and the possibility of innovation. There were many views to the effect that small firms are more advantageous in innovation with quick execution and flexibility; however, macro-level revolutions based on convergence, like digital transformation, can be applied with more benefit to large firms. It is important for firms to develop their own capabilities, but some policy efforts must also be made to reduce the digital divide due to firm size.

Many SMEs generally are not set up to handle digital transformation and cannot obtain relevant information or education. In particular, they lack the human resources to perform this role, which makes it impossible to take any measures at all. Therefore, it is necessary to create an environment in which SMEs can also engage with digital transformation and develop their own capabilities to use it by nurturing human resources for planning and operating digital transformation and establishing various training programs.

Third, in terms of anticipated performance, there was a difference by industry type and firm size. Large firms showed rates that were more than twice as high or low rates in both positive and negative responses than SMEs, indicating that they were more concrete and certain about the anticipated performance. However, unlike the important capabilities that were previously discussed, nearly 60% of large firms held neutral views. In other words, large firms showed strength in perceiving and preparing the capabilities necessary for digital transformation based on their resources and capabilities, but considering various technological factors and complicated business ecosystems, they were more cautious about anticipated performance compared with SMEs.

By industry type, the ratio of neutral views in both manufacturing and non-manufacturing firms was consistent at about 40%, whereas the ratio of positive views was twice as high in manufacturing as in non-manufacturing groups. This shows that manufacturing firms were considering digital transformation as a more positive opportunity. The difference among firms regarding important capabilities and anticipated performance is likely to bring many difficulties in establishing strategies for M&As or strategic alliances.

In terms of cooperation among firms, complementarities of capabilities and consistent goals are the most important. The difference in capabilities and anticipated performance by firm size or industry type is likely to serve as an obstacle to successful digital transformation as convergence-based innovation, which is why those responsible for digital transformation in each firm must further strengthen the process of due diligence.

Preparing for and adapting to change is essential for a firm's sustainable growth and survival. Unlike technological innovations of the past, contemporary digital transformation is a great change that affects industries and societies overall, thus, increasing the gap between firms that are taking advantage of it and firms that are not. Various discussions have been held about the universal characteristics of digital transformation and its impact on industries/firms or social actors.

However, the literature has not fully investigated how firms perceive and view digital transformation from their perspective. According to the analysis of this study, even high-growth firms with relatively remarkable capabilities are mostly unprepared for digital transformation, which is a meaningful result. Despite the high interest in digital transformation, all kinds of controversies over digital transformation remain as well as different perspectives in the actual scenes of management. This study is intended to fill this gap through exploratory research and to provide significant implications.

5.2. Managerial Implications

The most important key message delivered by this study is that digital transformation is the process that connects the analogue (or physical) and digital (or virtual) worlds, through which firms face changes in all innovation activities. There is a gap between firms depending on their individual characteristics in terms of how they perceive digital transformation and their views on the necessary capabilities and anticipated performance, and this gap may have a significant impact on firms' digital transformation strategies and on the government's digital transformation policies in the future. Therefore, firms must enhance their competencies on their own so that their size and industry type do not serve as handicaps, and the government must develop and apply policies that are suitable for each industry type and size to achieve the overall sustainability of firms.

5.3. Suggestions for Future Research

Follow-up studies must be conducted to further develop the results explored in this study. We recommend future researchers take an end-to-end perspective on innovation to investigate the characteristics and potential risks of digital transformation from upstream R&D activities to commercial value creation. In terms of how companies (including high-tech firms in this study) respond to digital transformation, their capabilities for digital transformation and sustainability performance may vary depending on the firm size, industry type, and country origin. Thus, future researchers need to empirically investigate various types of firms' digital transformation behaviors in different industrial and institutional settings.

Another possible avenue of research is to employ different industry classifications. For instance, high-tech industries can be classified into complex product-based industries where a product consists of considerable fragmented knowledge (e.g., electronic products) or be categorized as a discrete product-based industry where a product is built upon less distinct knowledge (e.g., drugs). Distinctions between these two types of industries require different innovation strategies and capabilities for firms in preparation for digital transformation.

Lastly, researchers can also investigate the relationship between the type of capability a firm focuses on and the performance type of digital transformation. For example, it is plausible that a firm with a strong business capability (one of the capabilities to prepare digital transformation in our analysis) will achieve greater profitability growth compared to other types of performance, such as new product development.

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