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ORIGINAL RESEARCH

Digital Double Diamond (DiDD) Model Analysis of National Competitiveness Under Digital Transformation: An Application to Healthcare and Pharmaceutical Industries in South Korea and Switzerland

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Abstract
The healthcare and pharmaceutical industries are rapidly changing under the digital transformation environment in the 2020s. Investments in this field are given priority, both at the business level and also at the national level, to enhance national competitiveness. However, a very limited number of studies examine the impact of digital transformation on the broader scope of the industry and national competitiveness. Furthermore, the existing studies and competitiveness indices focus rather on general country-level innovation indicators. To mend this gap and to provide a more specific framework to evaluate digital transformation in the healthcare and pharmaceutical industries, this study proposes a new model called the Digital Double Diamond (DiDD), which is an extension of Porter's Diamond model for national competitiveness. The DiDD model consists of three factors: endogenous factor, centric factor, and exogenous factor containing nine variables and 36 sub-variables that capture the impact of digital transformation in healthcare and pharmaceutical industries to assess national competitiveness. The new DiDD model emphasizes the importance of having a balance between the traditional national competitiveness and digital convergence elements in the healthcare and pharmaceutical industries. As an illustration of the new DiDD model, we compare South Korea and Switzerland's digital transformation competitiveness in the healthcare and pharmaceutical industries.

Keywords Digital Double Diamond (DiDD) model · Healthcare and pharmaceutical industries · Digital transformation · National competitiveness

JEL Classification I11 · I18 · L65 · O32

Introduction

The broad umbrella of the healthcare and pharmaceutical sectors includes the pharmaceutical, biopharmaceutical, biotechnology, medical devices industries, and healthcare providers and systems. Despite their differences, the terms pharmaceutical and biopharmaceutical are often interchangeably used in the field. For example, the pharmaceutical industry includes biologic products and the biopharmaceutical industry can include chemical-based products (Rader, 2008). Hence, we use the term "healthcare and pharmaceutical industries" in this paper.

There is a growing interest in healthcare worldwide where the pharmaceutical industry is among the top government agenda in nearly all countries in the world. In recent years,

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even prior to the COVID-19 pandemic, there have been many changes in the healthcare and pharmaceutical industries under the force of digital transformation. Adaptation to changes in the industry's internal and external environments has been positioned as an essential area, since many firms and industries have been pressured to transform by the Industry 4.0 technology and lifestyle changes. The healthcare and pharmaceutical industries are garnering efforts and investing tremendously to adapt to the environment following these changes, and these innovations can be seen in various fields by focusing investment on therapeutic areas and company portfolio changes. Further with the COVID-19 pandemic, the healthcare and pharmaceutical industries started to expand their investment areas for the therapeutics and vaccines of COVID-19, thereby catalyzing the speed and process for new drug development. Governments also make efforts on adopting new technologies such as AI to create successful and sustainable digital transformation (Ahn & Chen, 2022). This calls for the need to enhance investments as soon as possible for the governments. In addition, this paper can shed light on establishing more effective global healthcare strategies in the context of SDG 3, and achieving the SDG 9 by focusing on the improvement of national competitiveness. It can also provide insights for the stakeholders, such as healthcare providers, patients, policymakers, and experts in the healthcare and pharmaceutical industries, to understand the impact of digital transformation on the field and its link to national competitiveness.

On a similar note, digital transformation has been popularized and is considered an attractive investment issue for many firms. However, there is still confusion when firms implement it in practice, not to mention many failures during the adaptation process. When digital competitiveness alone is compared at the industrial and national scope, there are even more intertwined confusion and misunderstandings. For example, many pharmaceutical companies make efforts on new drug development adopting new technologies and launching new way of business activities to improve their operational efficiencies using digital technologies under digital transformation. Also, many trials and errors occur inside the firms due to the changes in the internal structure and portfolio of the company. In particular, it becomes a serious problem, since there are no tools or systematic frameworks that allow businesses or research to compare competitiveness at the industry or national level with consensus on common ground. Hence, there are increasing challenges and confusion related to digital transformation. In addition, internal and external environments are continuously changing. In this regard, the need for agile adoption is increased and a structured approach related to digital transformation becomes important (Palfreyman & Morton, 2022). In this regard, we offer a new framework for the impact of digital transformation on the healthcare and pharmaceutical industries on the value chain and it can be helpful to improve competitiveness not only industry but also national level.

The current literature on competitiveness in these industries lacks studies that explore the implications of the digital healthcare environment on national competitiveness. This paper aims to fill this gap by extending Porter's Diamond model of national competitiveness by including a digital transformation dimension in the healthcare and pharmaceutical industries. The new framework is coined as the Digital Double Diamond (DiDD) model. The DiDD model focuses not only on national competitiveness but also on convergence trends among industries. More importance on the role of government support compared to the original single Diamond Model is also a unique and important feature of the DiDD model. As an illustration of the DiDD framework, we compare South Korea and Switzerland with a focus on the effects of digital innovation, healthcare and pharmaceutical investments, and government policies in these areas on each country's national competitiveness positions.

The paper is organized as follows. In "The Business Landscape of the Healthcare and Pharmaceutical Industries", we provide an overview of the recent business environment in the healthcare and pharmaceutical industry. In "Theoretical Background and Literature Review on Digital Competitiveness of the Healthcare and Pharmaceutical Sectors", we review the theoretical background and the literature on how digital transformation is effectively incorporated into the processes of healthcare, diagnosis, new drug development, and clinical trials. Next, we will examine the latest trends in digital healthcare technology adoption by different countries and analyze how their pharmaceutical industries have changed their business models under the digital healthcare environment. In "The Digital Double Diamond (DiDD) as the New Competitiveness Model", we review the earlier "diamond" models and introduce the "Digital Double Diamond (DiDD)" model. We particularly address the questions of (1) "how to apply the Double Diamond Model to the pharmaceutical industry?" and (2) "how to integrate the digital transformation process into the Double Diamond Model"? "Application of the DiDD Model in South Korea and Switzerland's Healthcare and Pharmaceutical Sectors" discusses the current state of the healthcare and pharmaceutical industries in Switzerland and South Korea to provide a background for the DiDD analysis. "Results of the Analysis Using the Digital Double Diamond (DiDD) Model index" applies the DiDD model to compare the competitiveness of healthcare and pharmaceutical industries in Switzerland and South Korea. Based on the results obtained from the DiDD model, we suggest the "Critical Success Factors" and elaborate on how they could be applied within the healthcare and pharmaceutical industry under the ongoing digital transformation in the industry. "Discussion of the Results" discusses the findings in more detail and discusses their policy implications. "Conclusions" concludes by providing an overview of the possible shortcomings of the study and directions for future research.

The fight against COVID-19 will continue, and the national government will require more effort and coordination to speed up technology adoption and accuracy in this field. The industry needs to change along with multiple, parallel, and complementary tracks, including healthcare innovation, to further build capacity, recycle existing capacity, mitigate the effects of the pandemic, and address the future challenges of delivering healthcare in the twenty-first century (MEED, 2020). This new digital competitiveness measurement tool is proposed to contribute to this regard.

The Business Landscape of the Healthcare and Pharmaceutical Industries

Digital transformation in the healthcare and pharmaceutical industries is one of the critical areas of the Fourth Industrial Revolution. Specifically, the healthcare and pharmaceutical industries include biotechnology, pharmaceutical, and medical device industries, and innovative technologies often referred to in this sector are medical imaging equipment, in vitro diagnostics, patient monitoring, and medical IT. The healthcare and pharmaceutical industries combine big data with artificial intelligence (AI) clouds to provide disease treatment, healthcare products, and services based on biotechnology. The healthcare and pharmaceutical industries are fields that can lead to economic growth and welfare at the same time as the aging population. Hence, in the era of the Fourth Industrial Revolution, the healthcare and pharmaceutical industries have received priority attention at the national and global levels. Moreover, the importance of digital healthcare due to COVID-19 has increased. Even in countries where there is no integrated digital healthcare in the national healthcare system, steps are being taken to adopt the necessary regulatory framework to support the widespread adoption of digital healthcare (Ohannessian et al., 2020).

Technologies such as AI are rapidly integrating the healthcare sector, and they can support the digital transformation of healthcare by improving the efficiency, safety, and accessibility of medical services. AI is starting to affect almost every aspect of the healthcare area ranging from support for clinical decision-making at the point of treatment to patient self-management of chronic conditions at home and drug development research in the real world (Chen & Decary, 2020).

In the past, the healthcare and pharmaceutical industries developed mostly through their own industry dynamics with independent research and development (R&D) and investments. The current trend is the growing collaborations between sectors. Convergence through technological development and innovation is also taking place in the healthcare and pharmaceutical industries. According to Allen et al. (2020), this sector faces challenges in the four main areas of financial (i.e., financial operations and performance improvement), strategic (i.e., care-model innovation), digital (i.e., digital transformation and interoperability), and talent-related (i.e., future of work). Overall, while the four distinguished areas are important segments of their own for the healthcare industry's competitiveness, the specific issues under the four areas are closely linked to the digitalization for efficiency improvement that leads to sectoral competitiveness (Allen et al., 2020).

Under the efforts to speed up digitalization, healthcare organizations are transforming their traditional data management approaches from simple storing of data sets for operational reasons to engaging in more active insight and knowledge extractions that can be monetized to support the various actors and agents that belong to the sector (e.g., healthcare providers, clinics/labs, payers, patients, med-tech companies, technology providers, and government).

Likewise, the rise of AI is considered one of the key technology trends in the coming years beyond 2020 together with the increasing demand for telemedicine, Internet of medical things (IoMT), privacy issues, virtual reality (VR), augmented reality (AR), and blockchain. Particularly to AI-based healthcare digitalization includes the areas of pandemic detection, thermal screening, facial recognition with masks, and CT scan analysis for COVID-19-related aspects, while the general adoption of AI is foreseen to improve precision, speed, and efficiency of diagnosis, early treatment, and drug development using machine learning algorithm (MobiDev, 2020). In addition to this future landscape of this sector, more holistic impacts of AI and digital technology include virtual care/remote medicine, genomics and gene editing, fairer healthcare insurance and coverage, and connection to smart cities and IoT to detect and respond to future outbreaks (Marr, 2020).

With this ongoing change in the industry, forward-thinking governments and institutions are actively harnessing the transformation as well. Now, governments are broadly transforming to catalyze their innovation ecosystems to enhance digitalization and health system, since Deloitte reported in 2020 that government trends put AI-augmented government as the first step for the fourth industrial revolution era. The agenda includes growing digital citizens, managing AI ethics, predictive analytics, and smart government (Deloitte, 2020, 2022). Since the advancement of digital technologies and their integration into the healthcare and pharmaceutical industries, the importance of digital ethics has been increasing. In particular, when it comes to big data, there are privacy issues associated with patient information, data governance, and relevant policies are also emerging as challenges (Vayena et al., 2018).

Overall, a new fundamental change is taking shape which leads to the development of the healthcare and pharmaceutical industries through more efficient and new attempts, while many structural changes in the business environment are affecting the healthcare industry through broader and multiple spectrums of convergence among industries, stakeholders, and ecosystem participants.

Theoretical Background and Literature Review on Digital Competitiveness of the Healthcare and Pharmaceutical Sectors

This section provides a review of the literature on the healthcare and pharmaceutical sectors. As noted in the Introduction, there is a lack of studies on national competitiveness that directly compares the digital transformation impact, particularly in the healthcare and pharmaceutical industries. In "Digital Transformation of the Healthcare and Pharmaceutical Environment", we focus on the literature on the effects of the digital transformation of the health environment. In "The Need for a New Approach", we examine the digital healthcare technology adoption at the country level and an examination of the literature on business models in the pharmaceutical industry under the influence the developments in digital healthcare.

Digital Transformation of the Healthcare and Pharmaceutical Environment

The research on the digital transformation of the healthcare environment focused individually on each category of competitiveness of digital healthcare. Convergence trends in digital healthcare have only recently come to the fore. Furthermore, there have not been many prior studies on national competitiveness comparisons under the digital transformation in healthcare and pharmaceutical industries. The insights from a small number of papers found in the literature are discussed in the rest of this section.

Digital Convergence in the Healthcare Industry

The topic of healthcare is facing the challenge of economic growth and population aging. In the data-based precision medical field, pharmaceutical companies as well as healthcare providers, hospitals are now facing turning points in the traditional models due to the digital transformation in the internal and external business environment. Furthermore, major stakeholders of healthcare payers, such as patients, insurance companies, and governments, are also included in these changes.

Fundamentally, there are needs for a balance between the healthcare budget and cost. Future affordability of healthcare cost, patient treatment efficacy, and efficiency of the healthcare system depends on the use of electronic health information and record exchange platforms (Tardieu et al., 2020). The "Health Information Technology (HIT)" has a positive impact on cost reduction and quality improvement. The HIT is associated with a safer healthcare system centered on focusing on the implementation of digital transformation (Agarwal et al., 2010).

These challenges are connected to business environment changes that arise under the digital healthcare transformation. Not only healthcare providers and payers but also technology companies have started to collaborate for efficiency increase and development of digital healthcare infrastructure. Hence, digital convergence is relevant for stakeholders and the assessment of operational efficiencies after implementation considering key factors is needed in the healthcare industry (Kraus et al., 2021).

Leveraging a variety of AI platforms, tools, and services, many healthcare organizations are working with technology companies to enhance their AI capabilities. For example, machine learning is a dominant approach proven to be reliable in disease detection, diagnosis, and management. Collaborations between fields are essential for the development of AI in the healthcare field. For example, Apple has worked with more than 100 hospitals and clinics for health record projects, enabling consumers to exchange health data with healthcare providers. Similarly, IBM has developed partnerships with many hospitals, allowing them to make cancer diagnoses and treatment recommendations using Watson Health. Such collaboration across sectors for the leverage of both AI firms and health organizations will have a significant impact on the advancement of AI in healthcare (Chen & Decary, 2020). With advanced digital healthcare technologies and regulations, AI applications accelerate patient healthcare accessibility with improved efficacy while reducing the burden on the healthcare system (Trenfield et al., 2022).

Digital Convergence in the Pharmaceutical Industry

One of the most likely and essential changes under the digital transformation age is the drug discovery and development process. Vast amounts of biological and medical data are available, and machine learning algorithms are well established, allowing the design of largely automated drug development pipelines to be conceived. These pipelines can induce or accelerate drug discovery, provide a better understanding of diseases and related biological phenomena, and can also help pre-clinical wet laboratory experimental plans and future clinical trial plans. Automation of these drug development processes could be key to the current issue of low production rates facing pharmaceutical companies (Réda et al., 2019).

Usually, drug development has four steps before commercialization with pharmaceutical product marketing from "Drug discovery", "Pre-clinical phase", and "Clinical development" to "Phase IV" (Kaitin, 2010). Every 10,000–15,000 new compounds are identified during the discovery phase and only one of these compounds is typically approved as a marketed drug. It takes about 10–15 years and costs $1 billion to develop one drug (PPD, 2020). Even after commercialization, the post-management process is also complex and primarily to be managed. Therefore, the new drug development needs to pass many trials and challenges, and there has always been a challenge to return on investment (ROI).

Currently, the pharmaceutical industry is facing challenges in the drug development process because of increased R&D costs and decreased efficiency. In this regard, AI is expected to improve the efficiency of the drug development process and reduce development costs. Therefore, the pharmaceutical industry started to collaborate with the AI industry to overcome these challenges which will ultimately be connected to helping patients with treatment (Mak & Pichika, 2019). Digital transformation offers a mechanism to revise its business model, to improve production processes, to design new drugs faster using AI, and this allows the drug development pipeline to be performed automatically in a computational way, reducing and accelerating human-related technical errors (Réda et al., 2019).

As technology transforms, clinical trials evolve with innovative capabilities and designs (Raber-Johnson et al., 2019). The investment will make new designs for clinical trials feasible with more targeted interventions, lower costs, increased efficiency, and the development of new therapeutic drugs to market faster than before. Also, major pharmaceutical companies have already begun exploring applications for digital technologies in their early stage drug trials. The endpoints of digital technologies in clinical trials have the potential to drive innovation and opportunity in the pharmaceutical industry (Herrmann et al., 2018).

The Need for a New Approach

Each digital healthcare ecosystem's journey toward e-health is unique and connected with several factors, such as the size of the country, the structure of its healthcare system, political climate, and socio-economic culture. The key imperatives leading to the initiation of e-health to transform the healthcare ecosystem may also vary from country to country (Stephanie & Sharma, 2018). Applications in mobile computing and communication technology are rapidly applied in the healthcare and public health sectors. Hence, M-health technology is one of the digital healthcare categories and has begun to be recognized as one of the important national competitiveness areas in the digital healthcare industry (Free et al., 2010).

Nevertheless, the changes in the business environment related to the digital convergence in a broad range of health and health service outcomes are connected not only to the industry itself but also to the financial effectiveness of the governments. Therefore, the government's R&D investments in this area help continually improve the firms' competitiveness along with national competitiveness. Hill and Powell (2009) argue that a national agenda is needed to make digital health a reality and to identify government incentives as one of the key success factors for national e-health implementation (Hill & Powell, 2009).

A conclusion from the above studies is that digital transformation in healthcare and pharmaceutical industries must be conducted in relevance to the national circumstances to enhance national competitiveness. This is an important policy initiative, which in turn increases healthcare, patients' lives, and quality while also being directly linked to national competitiveness.

As a guide for implementing digital health, the World Health Organization (WHO) recommends that digital interventions in healthcare systems have to focus on areas such as governance, government policies, strategies, regulations, infrastructures, human resources, and leadership. These aspects will become essential in securing a benefit of international competitiveness. According to the WHO, a global strategy for digital health should focus on support and respond to the countries' growing needs to implement health priorities considering digital health situations, the planned or future status of digital health governance, resource constraints, capacity limits, risks, applicable digital technologies, and other influential factors. Therefore, countries are therefore encouraged to evaluate the level of health developments and select the most appropriate, cost-efficient, and optimized policies and measurement to improve healthcare system and expand health insurance coverage, sustainable goal setting, and the positive impact on national healthcare policies and performances (WHO, 2019).

Recent policy issues or regulatory issues in the pharmaceutical industry, such as strengthened regulations and difficulties in new drug development with patent expiration, have led to reduced investments. The future of healthcare and pharmaceutical solutions is an important agenda. The pharmaceutical industry may be slow to adapt to changes due to regulatory restrictions, but many leading pharmaceutical companies have made significant progress toward their digital transformation goals. While analytics, AI, and other advanced technologies will improve patient care, the pharmaceutical development industry will change. Through clinical trials and real-time patient information, pharmaceutical manufacturers can better understand how the drug affects users and how to optimize the drug's effectiveness and minimize side effects (Digital Marketing Institute, 2018).

The new business models, under the digital transformation in the pharmaceutical industry, link everything from the first stage of new drug development to the last stage of the post-commercialization process to AI technologies. Digital transformations improved many countries' digital healthcare systems and led to fundamental changes in the healthcare industry (El Sayed & Mansour, 2022). Hence, setting up an efficient methodology for the evaluation and implementation of enhanced healthcare policies and pharmaceutical industry investments will be essential.

The Digital Double Diamond (DiDD) as the New Competitiveness Model

This section introduces the background for the Digital Double Diamond (DiDD) model as an extension of Porter's (1990) Diamond Model by connecting the digital impact, particularly for the healthcare and pharmaceutical sectors. Competitiveness research has its roots in the government sector where the policymakers have actively utilized the determinants and factors that impact a nation's sustainable growth. For instance, the 1985 Competitiveness Policy Council in Washington, D.C., in the US has defined competitiveness in countries or industries to be "a condition in which it can supply products and services in a convenient free market to keep up with the standards of international markets while its citizens earn a standard of living that is both rising and sustainable over the long run" (Fathi & Ahmadian, 2016). Porter (1990) posits that a country's competitiveness is related to the industry's capacity to upgrade and innovate, and Porter & Van der Linde (1995) re-defined the competitiveness paradigm into more dynamic ones by emphasizing the role of innovation (Porter, 1990; Porter & Linde, 1995). However, the fundamental foundations of competitiveness are still derived from better productivity in terms of ability to deliver lower costs or to create better value than competitors. In 2011, the US' President's Council on Jobs and Competitiveness further exemplifies how competitiveness-oriented perspectives are put as a national economic policy's central objective (Delgado et al., 2012). To summarize, competitiveness can be understood as the capacity to increase market portion, revenue, creating value-added growth through effective balance between cost and value sustainably.

An Overview of Porter's Diamond Model and Its Extensions

The seminal work that established competitiveness research in the business and economics literature is Porter's (1990) Diamond Model. The model became an important analytical framework in assessing the competitive advantage of nations for other subsequent scholars. The model later evolved into other forms that specifically addressed the issue of international trade, such as the Double Diamond Model (Rugman & D'Cruz, 1993) and the Nine-Factor Model by Cho (1994), which embodied the human factors in closer details, and the Generalized Double Diamond Model (Moon et al., 1998) that holistically treated the international business dynamics.

This study is an extension of the earlier "Diamond" frameworks by embracing the original and earlier conditions and factors while adopting them to industry-specific realities of the digital transformation era in the healthcare and pharmaceutical industries. Hence, "Digital Double Diamond (DiDD)" model introduced in this study is based on Porter's (1990) Diamond Model which addresses the role of digital transformation by offering how variables can be chosen to best exemplify the ongoing digital impact. To meet the urgent needs in the healthcare and pharmaceutical sectors' digital transformation, this study specifies the model and its variables to be more industry-specific. However, the three categories and the variables can be applied to other industries for more generalized applicability. First, each of the earlier extensions of the Diamond Model is compared and discussed before introducing the Digital Double Diamond (DiDD) model.

Porter's (1990) Diamond Model provides an analytical framework for the determinants of national competitiveness at a macro-level based on the countries' overall business environment factors. Porter (1990) states that "the main body of competitiveness is business, the unit of competitiveness is an industry, and the scope of competitiveness is country." The Diamond Model points to the following four determinants as the fundamental endogenous factors that influence a country's competitive advantage: (1) Factor Conditions, (2) Demand Conditions, (3) Related and Supporting Industries, and (4) Firm Strategy, Structure, and Rivalry. Here, Government and Chance/Event are referred to as the exogenous factors, since they only play an indirect role but may impact the whole or any of the four endogenous factors.

While Porter's Diamond Model provided essential insights into understanding why some countries succeeded and others failed in international competition in the past, it required changes to integrate the new developments in the global economic and business environments. Rugman and D'Cruz (1993) extended Porter's (1990) Diamond Model by adding a foreign diamond to the home diamond to explicitly take conditions in the home and foreign trade situations. This is an important step in recognizing the role of globalization, because there is no country that secures the sources for the four determinants from domestic resources only. As an example, the case of Canada is examined within the overall context of North American diamond rather than

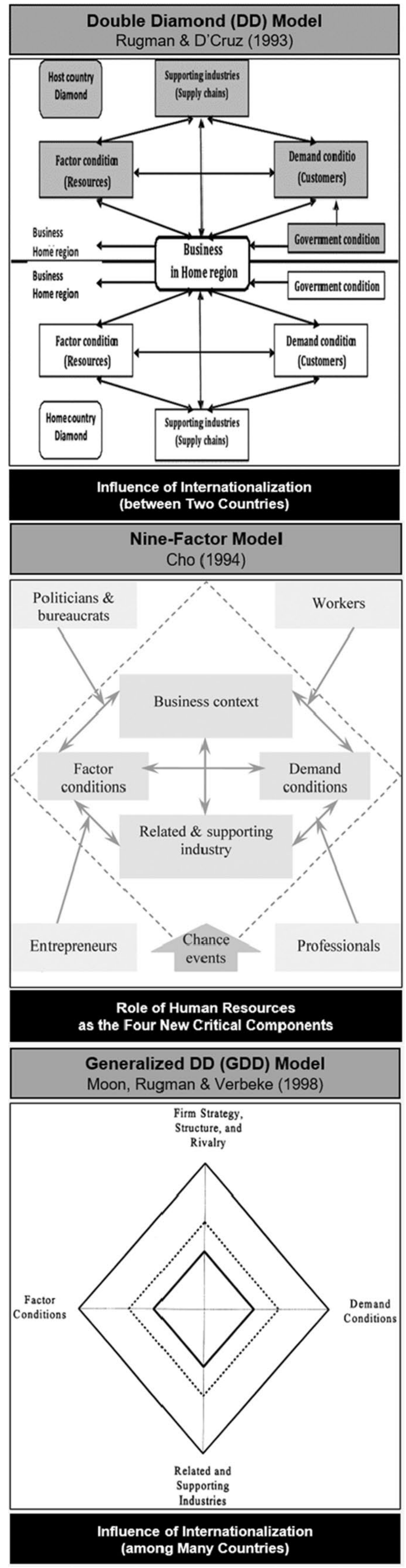

Fig. 1 Extensions to Porter's (1990) Diamond Model. Source: Rugman and D'Cruz (1993), Cho (1994), and Moon et al. (1998)

the Diamond analysis for Canada alone. Particularly, Rugman and D'Cruz (1993) argued that their newly created DD Model might be more relevant and important for small, open economies that actively engage in trade and international business to complement the country's lack of resources in the domestic front. This framework suggests that managers should build upon both domestic and foreign diamonds to become globally competitive in terms of survival, profitability, and growth (Rugman & D'Cruz, 1993) (Fig. 1).

Another example of extensions to Porter's (1990) original single Diamond Model and the DD Model is the Generalized Double Diamond (GDD) Model developed by Moon et al. (1998). The GDD Model generalizes the DD Model from the perspective of management in business firms with the incorporation of multinational activity (Vlados, 2019). The GDD Model is a better way to link foreign direct investment (FDI) and government roles to business, industry, and national competitiveness.

Cho (1994), on the other hand, uses a Nine-Factor Model to provide a framework for explaining the factors that play an important role in each stage of economic development, considering that the various elements that make up national competitiveness play different roles depending on the stage of economic development.

The above family of diamond models is used to analyze the international competitiveness of various industries and countries. Nevertheless, the question of the integration of the Industry 4.0 transformation into the Diamond Models remains, especially in the pharmaceutical and digital health industries. Overall national competitiveness is annually assessed by the International Institute for Management Development (IMD) and the World Economic Forum (WEF), among others. However, inter-country competitiveness in convergence industries based on pharmaceutical and healthcare has not been systematically investigated. This paper develops the Digital Double Diamond (DiDD) model and illustrates its application by comparing the competitiveness of the pharmaceutical and healthcare industries in Switzerland and South Korea.

As governments are nowadays expressing their policies of promoting convergence industries based on digital transformation trends as a next-generation national fostering industry, global digital healthcare research activities have recently received more attention. However, before establishing and implementing specific policies for the development of digital healthcare at the national level, the strengths, weaknesses, and degree of competitiveness of each country should first be identified to examine the current state of the industries. These considerations should be further customized for each country's industrial environment. Nevertheless, efficiency and sustainable policy and investment decisions in the new digital transformation environment may suffer from the lack of systematic analysis of the current positions of the pharmaceutical and digital healthcare industries in different countries. The proposed framework in this paper is aimed at addressing the need for a more systematic analysis of national competitiveness under the digital transformation in the healthcare and pharmaceutical industries.

The New Model: The Digital Double Diamond (DiDD) Model

Following the extensions of the earlier establishments in the academia, our paper introduces the Digital Double Diamond (DiDD) model which combines the perspectives of Digital Transformation with the DD Model. Figure 2 shows the general structure of the DiDD model. The new DiDD model will allow national competitiveness comparisons by explicitly taking the role of digital transformation into account.

The "Digital Double Diamond (DiDD) Model" presented in Fig. 2 consists of four internal and external factors. The model shares common features with Porter's (1990) Diamond Model, DD Model, GDD Model, and the Nine-Factor Model. It is, however, distinct as it explicitly introduces the digital transformation under Industry 4.0. Furthermore, the focus is not only on national competitiveness but also on converging trends among industries. It also places more importance on the role of the government compared to the original single Diamond Model.

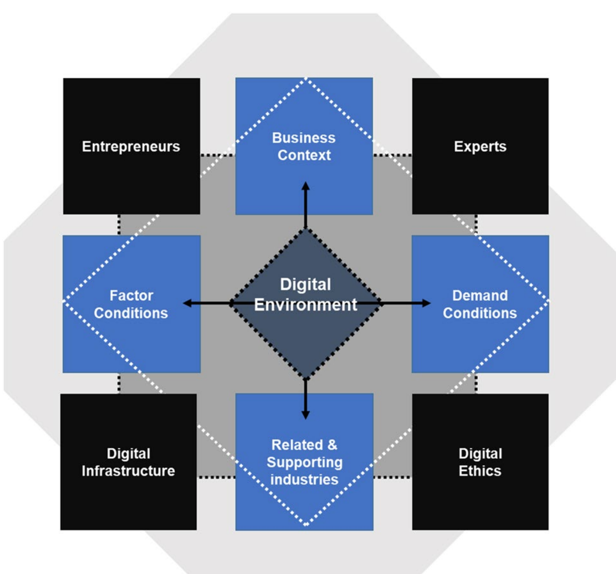

Fig. 2 Digital Double Diamond (DiDD) model. Source: Developed by the Authors as an extension of Porter's (1990) Diamond Model and the models by Rugman and D'Cruz (1993), Cho (1994), and Moon et al. (1998)

While the conceptual framework consists of a digital transformation perspective, it can be modified to fit the healthcare and pharmaceutical sectors by incorporating the technological perspective. The DiDD model consists of three factors: endogenous, exogenous, and centric. Each of these factors is further divided into variables and sub-variables in order to operationalize the factor elements. Figure 3 provides an outline of the DiDD Model with sub-components under the endogenous, exogenous, and centric factors.

The endogenous factor includes factor conditions, demand conditions, related and supporting industries, and business context dimensions. Hence, the endogenous factor is close to a fundamental components of competitiveness at the country level, such as gross domestic expenditure on R&D, trade openness, competition, market scale, and general infrastructure. The DiDD model follows the conventional approach to national competitiveness and constructed the new conceptual development using similar variables to the original Diamond Model.

The exogenous factor is closer to a human and infrastructural resource-based analysis with entrepreneurs and experts' dimensions while integrating infrastructural and ethical systems of the country. In the healthcare and pharmaceutical sectors, the exogenous factor will include the infrastructure for new drug development and digital healthcare. The exogenous sector is also focused on the practical and more detailed index, including government policy for entrepreneurs, start-up environment, financing, and an index that accounts for the development of the pharmaceutical business.

The Centric factor is related to the core elements of digital competitiveness. This factor explains the national environment of political and regulatory business aspects and government policies that can serve as the foundations for digital advancements and upgrade throughout the country. This is an important element, because as the fundamental characteristic of the digital era, the converging qualities of the digital technologies require broader and deeper scale of engagement by multiple stakeholders. This brings out the growing role of government in establishing the environment for digital transformation by connecting different interest groups, government and business agents, research institutions, and education. Therefore, the existence of various environment factors joins as the centric influences, not the exogenous factors as in the original Single Diamond Model; this is one of the critical differences of this new model. The nine variables under the endogenous, exogenous, and centric factors in the DiDD model are established by having four sub-variables. This makes a total of 36 indicators in the model.

Fig. 3 Operational variables for the Digital Double Diamond (DiDD) model: the case of healthcare and pharmaceutical. Source: Developed by the Authors

Application of the DiDD Model in South Korea and Switzerland's Healthcare and Pharmaceutical Sectors

Background on South Korea and Switzerland

To clearly show the usefulness and specific implications of the DiDD Model, comparative analysis on the strengths and weaknesses of South Korea's and Switzerland's healthcare and pharmaceutical industries is conducted in this paper by examining the primary factors and analyzing the indicators that can be benchmarked in policy direction and setting to other countries.

We chose South Korea and Switzerland as an illustration of the application of the DiDD model, because South Korea is ranked as a top-tier country in digital innovation and electronics not only in Asia but also in the world. Despite this superior performance in the transforming the country into overall digital achievements, South Korea is positioned relatively behind in terms of the digital healthcare industry and technology adoption. Therefore, there are difficulties in establishing policies at the corporate and national level or start-up companies, and it is difficult to guarantee the efficiency of investment. There are many reasons for the difficulties of digital healthcare innovation in South Korea. One of them is partly due to related regulations which might also be a common factor in other countries, too. In South Korea, various efforts are currently being made to overcome these difficulties by collaborating across related functions in government, healthcare, pharmaceutical, and technology industries.

In the case of Switzerland, among the European countries, digital innovation has spearheaded the country's innovation performance by ranking at the top in the past 2–3 years. The country has been making many innovations in the digital healthcare field. Also, because of the activities of various pharmaceutical companies in Switzerland, it is considered a country that can play a leading role in the healthcare and pharmaceutical sectors. In addition, the pharmaceutical and biotechnology cluster in Switzerland is one of the world's biggest locations. Several headquarters of big pharmaceutical multinational corporations (MNCs), such as Novartis and Roche, are also located in Switzerland.

Finally, comparing the two countries is of immediate concern to evaluate the investment efficiency and strategy execution since the Swissmedic, the national authorization and supervisory authority of Switzerland, and the South Korean regulatory authority extend their cooperation in the area of therapeutic products. There has been a collaboration between Switzerland and South Korea through Swiss-Korean Life Science Symposia for Digital Healthcare Innovation since 2014. Into 2019, Swissmedic and the Korean Ministry of Food and Drug Safety (MFDS) signed an agreement on Good Manufacturing Practice in December 2019. This will drastically shorten the drug approval process for local pharmaceutical companies. The cooperation will respond quickly to drug risk information and proactively manage drug safety and for medicinal products and share information, documents, and inspection reports (Swissmedic, 2019). As Momaya (2008: 336) argues "…cooperative strategies…could hint at many opportunities".

South Korea and Switzerland can constitute a good case for comparing national competitiveness regarding digital healthcare and technology adoption in the healthcare and pharmaceutical industries. As Table 1 shows, Switzerland is the top-ranking country in Europe in terms of innovation, and South Korea is ranked first in South East Asia, East Asia, and Oceania.

It must be noted that some countries benefit more from investing in innovation than others. This is due to their differences in their absorptive capacity in how effectively they transform innovation inputs into innovation outputs. The differences exist not only between high- and low-income countries but also among high-income countries. For instance, Switzerland, Sweden, and UK more effectively produce high-level innovation outputs, whereas the innovation output to innovation input ratios is lower in Singapore and the United Arab Emirates (Dutta et al., 2022).

Improvements in healthcare over the past two centuries have consistently improved life expectancy and quality of life, greatly contributing to economic growth. Medical innovation has contributed significantly to this progress. Looking into the future, new technologies and innovations will continue to strengthen healthcare delivery at a rapid pace. Each country's ecosystem journey toward e-health is unique. Several factors influence the size of the country, the structure of the health care system, political climate, and socio-economic culture. The main challenge of launching e-Health to transform the healthcare ecosystem can vary from country to country (Stephanie & Sharma, 2018).

For example, one of the key factors that started Singapore on a journey toward healthcare innovation is the term 'silver tsunami', meaning a rapidly aging population. Singapore is one of the healthiest countries in the world with an efficient healthcare system (Stephanie, 2018). Regardless of the unique circumstances that make countries pursue e-health to change the healthcare industry positively, their fundamental interest in healthcare is similar in healthcare systems, countries, or continents. Concerning health care, each ecosystem is moving toward a common goal to improve citizens' life quality, accessibility, and equality, and e-Health is adopted as a promise to achieve these goals (Stephanie & Sharma, 2018).

Table 1 Digital innovation by country groupings

Top three innovation economies by region			
Northern America	Europe	Northern Africa and Western Asia	South East Asia, East Asia, and Oceania
1. USA	1. Switzerland	1. Israel	1. Republic of Korea
2. Canada	2. Sweden	2. United Arab Emirates	2. Singapore
	3. UK	3. Turkey	3. China
Top three innovation economies by income group			
High income	Upper middle income	Lower middle income	Low income
1. Switzerland	1. China	1. India	1. Rwanda
2. USA	2. Bulgaria	2. Viet Nam	2. Madagascar
3. Sweden	3. Malaysia	3. Iran (Islamic Republic of)	3. Ethiopia

Source: World Intellectual Property Organization (2022)

Comparison of the Global Innovation Index (GII) for Switzerland and South Korea

Before applying the DiDD Model, Fig. 4 compares the two countries using the Global Innovation Index (GII) dimensions calculated by Dutta et al. (2014, 2016, 2017, 2018, 2019, 2020, 2021, 2022) and Wunsch-Vincent et al. (2015). The comparison of the GII scores between South Korea and Switzerland indicates that there are gaps in *Knowledge & Technology outputs, Institutions, Market sophistication* during 2020 to 2022 (listed in the order of score difference). In regard to higher output, it indicates that Switzerland's efficiencies are higher and overall resources are more optimized than in South Korea. *Knowledge & Technology outputs* is linked to knowledge creation, impact, and diffusion. *Institutions* are linked to the countries' political, regulatory, and business environments. Also, *Market sophistication* represents creation, Investment, trade, diversification, and market scale. However, in terms of other factors, *Human capital & research, Infrastructure, Business sophistication, and Creative outputs* show a similar index score between South Korea and Switzerland.

South Korea keeps global top 10 in the overall GII ranking with sixth in 2022. On the input side, South Korea shows its good performance and state in *Human capital and research* (first) and *Business sophistication* (ninth) improved the most. On the output side, the pillar of *Creative outputs* shows gradual improvement over time [time frame 1 (2014–2016); time frame 2 (2017–2019); time frame 3 (2020–2022)] in South Korea ranks fourth in 2022. Also, South Korea maintains its good ranks in several crucial variables, including *knowledge and technology outputs* which is ranked tenth. Despite this good performance, South Korea presents areas of relative weakness, including Institutions, Market sophistication.

As seen above, Switzerland shows an overall better Global Innovation Index (GII) performance compared to South Korea. This analysis further indicates that Switzerland obtains the best performance in the overall Global Innovation Index (GII) 2022. Especially, Switzerland ranks first in the output area which includes *Knowledge and technology outputs* and *Creative outputs* and ranks third in the input area which includes *Institutions, Human capital and research, Infrastructure, Market sophistication,* and *Business sophistication* in 2022. Switzerland achieves more return on its innovation investments than other economies including South Korea (Dutta et al., 2022). In particular, on the output side, Switzerland positions the top outcome efficiencies and ranks first in the pillar of *Knowledge and technology outputs* and *Creative outputs*.

Results of the Analysis Using the Digital Double Diamond (DiDD) Model index

Based on the DiDD Model presented in "The New Model: The Digital Double Diamond (DiDD) Model", the data on the 36 indicators were collected from Global Innovation Index, OEDC, WHO, Global Entrepreneurship Monitor, World Bank, and IMD World Digital Competitiveness. All of these indicators are standardized data and show the

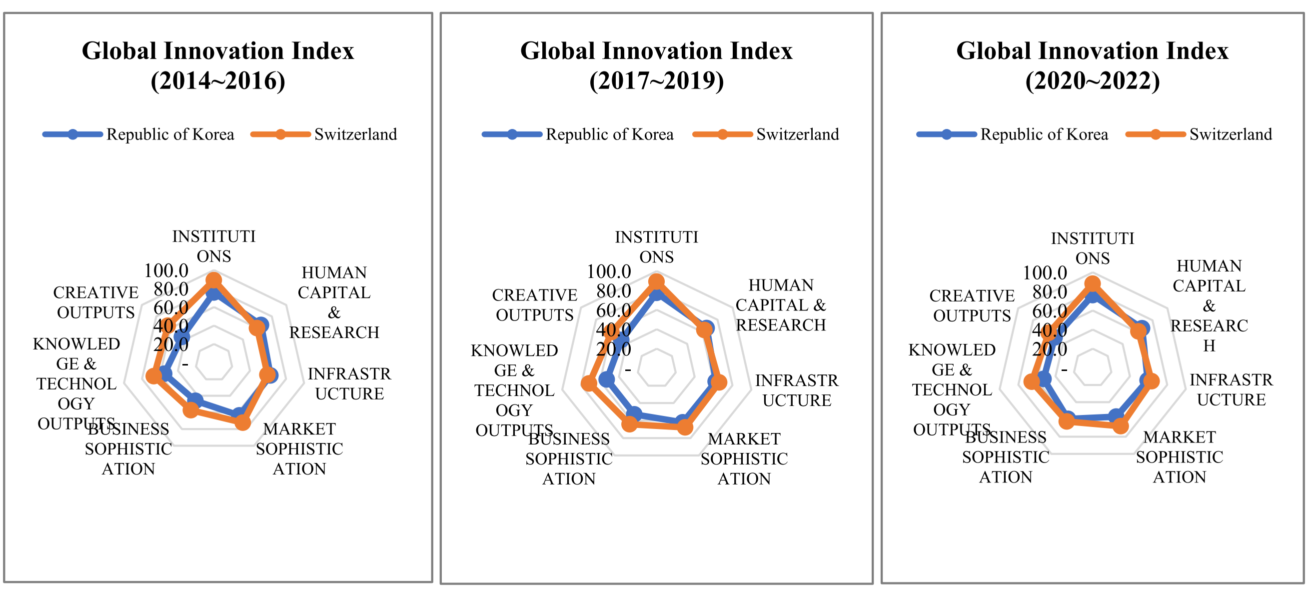

Fig. 4 Global Innovation Index (GII) comparison between Switzerland and South Korea. Source: World Intellectual Property Organization, 2022

infrastructure of each country. Among the many indicators in the indexes, they are composed of indicators related to this paper's subject.

The dataset refers to 2022. We use the latest available data at the time of writing as digital transformation is a fast-evolving process. The results of each sub-index were all expressed in comparable standardized units. The weight for each of the four sub-indexes is given as 25% and the values of each index are summed to a score of 100 for inter-country comparison purposes. It should be noted that the results obtained indicated the relative difference between the two countries, not the absolute differences. Table 2 shows the details and the results of the DiDD model analysis for Switzerland and South Korea.

The average of each of the four sub-indices for each broad index is summarized below. It indicates the pharmaceutical and digital healthcare national competitiveness between the two countries by each index score and gap.

The results presented in Table 3 can best be shown using radial graphs in Fig. 5.

The left-side panel of Fig. 5 shows a comparison of Switzerland and South Korea in terms of the components of the GII 2020–2022. As discussed earlier, the GII is a summary metric for a country's overall infrastructure and competitiveness. Most of the indexes in Switzerland have advanced over South Korea, while South Korea's *Human Capital & Research* score shows better than Switzerland's one. Two variables of *Infrastructure* and *Business sophistication* are similar between South Korea and Switzerland.

The right side of Fig. 5, on the other hand, presents the radial graph comparison of the nine components of the DiDD model between South Korea and Switzerland. A first look at the DiDD comparison suggests that Switzerland shows an overall more advanced DiDD Model. The most significant differences between Switzerland and South Korea arise from the areas of *Business Context*, *Digital Infrastructure*, and *Digital Environment*. That also means Switzerland has a more competitive situation as of overall sub-index of *Business Context* as of Investment, Ecological sustainability, and GDP share of the pharmaceutical industry except for Intangible assets. Switzerland also shows a superior *Digital Infrastructure,* which is *Pharmaceutical Trade by Export*, *Pharmaceutical Trade by Import* except for *PCT national phase entries from applicants*, and *R&D of pipeline in the pharmaceutical industry*. Thirdly, *Digital Environment* is Switzerland's strong area following sub-variables of *Political environment, Regulatory environment, Business environment*, and *Government policies: support and relevance*.

This is related to Switzerland's strengths in the competitiveness of the pharmaceutical industry and the environment of key research clusters. These circumstances and clusters make Switzerland's national competitiveness strong in digital healthcare, pharmaceutical, and Med-tech industry in further.

South Korea, on the other hand, has an advantage as in the areas of *Demand Conditions*, which includes the sub-variables on *gross domestic expenditure on R&D, domestic general government health expenditure, general infrastructure except for knowledge impact*. South Korea focuses on accelerating the adoption of AI for pharmaceutical and medical purposes such as new drug development and the use of medical data under the strategy of the government. However, South Korea should complement two of the biggest indicators of the gap with Switzerland are the parts of *Business Context*, *Digital Infrastructure* than the others. Of course, the gap seems to be wider, because Switzerland is the mecca of the world's top healthcare and pharmaceutical and related industries have been developed. As South Korea is superior or equal to Switzerland in terms of *Demand Conditions*, *Factor Conditions, and Expert*, the country should maintain these areas and will further continue to improve.

Discussion of the Results

Traditionally, Switzerland has strengths in the pharmaceutical, life science, and ICT sector and a favorable environment for innovative companies that bring innovations in personalized health to the market. In Switzerland, science and industry have a uniquely close relationship that secures fast technology transfer in a versatile and compact ecosystem. Switzerland also links industrial partners directly with research competencies in the field of biotechnology. For example, the Basel Pharma Cluster, where there is a strong ecosystem in life sciences and healthcare with close collaboration across companies and industries, represents one of the most important economic areas in the pharma industry in Switzerland. Big pharmaceutical companies, such as Roche and Novartis, are located in Basel (Switzerland). In 2019, Basel-based Novartis and Microsoft established the AI Innovation Lab for developing intelligent and personalized therapies. They launched Novartis Biome, a new laboratory for digital innovation to further develop healthcare through the use of data and digital technologies. Some other examples of collaborative projects across companies, university institutions, clinical physicians, and researchers are: The Swiss Institute of Bioinformatics (SIB), The Swiss Cancer Center Léman (SCCL), Personalized Health Basel (PHB), Botnar Research Center for Child Health (BRCCH), and Bern Center for Precision Medicine (BCPM). In addition, Switzerland is investing massively in harmonized data infrastructures, while at the same time placing great importance on data protection (Gaudet-Blavignac et al., 2021).

In areas where South Korea has strengths, it seeks to "select and concentration" and seeks a balance between

Table 2 DiDD model analysis for Switzerland and South Korea

Factor	Variable	Sub-variable	Unit alignment		After data weighted (sub-variable * 25%)	
			Republic of Korea	Switzerland	Republic of Korea	Switzerland
Endogenous factor	Factor conditions	Research & development (R&D)	86.8	78.3	21.7	19.6
		Credit	54.8	57.9	13.7	14.5
		Trade, competition and market scale	72.7	62.4	18.2	15.6
		Creative goods and services	33.9	37.1	8.5	9.3
	Demand conditions	Gross domestic expenditure on R&D (GERD) as a percentage of GDP	100.0	66.7	25.0	16.7
		Domestic general government health expenditure (% of general government expenditure)	100.0	78.6	25.0	19.6
		General infrastructure	58.7	54.3	14.7	13.6
		Knowledge impact	42.1	51.3	10.5	12.8
	Related and supporting industries	Chemicals (% of value-added in manufacturing)	39.3	100.0	9.8	25.0
		High-technology exports (% of manufactured exports)	100.0	38.9	25.0	9.7
		Information and communication technologies (ICTs)	95.6	88.7	23.9	22.2
		Innovation linkages	47.9	64.3	12.0	16.1
	Business context	Investment	16.6	59.0	4.2	14.8
		Ecological sustainability	26.7	54.0	6.7	13.5
		Intangible assets	85.7	63.6	21.4	15.9
		GDP share of pharmaceutical industry	20.7	100.0	5.2	25.0
Centric factor	Digital environment	Political environment	81.9	89.3	20.5	22.3
		Regulatory environment	67.7	92.4	16.9	23.1
		Business environment	61.9	85.8	15.5	21.5
		Government policies: support and relevance	64.0	51.0	16.0	12.8
Exogenous factor	Entrepreneurs	Entrepreneurial finance	56.0	58.0	14.0	14.5
		Government policies: taxes and bureaucracy	59.0	63.0	14.8	15.8
		Commercial and Professional Infrastructure	50.0	61.0	12.5	15.3
		Cost of business start-up procedures (% of GNI per capita)	85.4	97.7	21.4	24.4
	Experts	Knowledge workers	75.2	67.9	18.8	17.0
		R&D transfer	45.0	61.0	11.3	15.3
		Researchers in R&D (per million people)	100.0	63.7	25.0	15.9
		Knowledge creation	67.0	86.7	16.8	21.7
	Digital infrastructure	Pharmaceutical Trade by Export	4.5	100.0	1.1	25.0
		Pharmaceutical Trade by Import	20.8	100.0	5.2	25.0
		PCT national phase entries from applicants	100.0	63.3	25.0	15.8
		R&D of pipeline in pharmaceutical industry	100.0	51.1	25.0	12.8
	Digital ethics	E-Government	98.0	84.0	24.5	21.0
		Public–private partnerships	54.0	93.0	13.5	23.3
		Software piracy	80.0	90.0	20.0	22.5
		Government cyber security capacity	94.0	73.0	23.5	18.3

Source: Global Innovation Index, OECD, WHO, Global Entrepreneurship Monitor, World Bank, IMD World Digital competitiveness

upgrading AI-using technology and placing humans at the center of AI development. In particular, the government announced that it would foster the biotechnology and medical industries as the key growth industries for the next generation using AI. The government supports the establishment of an AI platform for pharmaceutical companies to develop new drugs, drastically reduce the average development period of new drugs from 15 years to 7 or 8 years, and

Table 3 DiDD model analysis for Switzerland and South Korea: summary

Factor	Index	South Korea	Switzerland	Gap
Endogenous factor	Factor conditions	62.1	58.9	− 3.1
	Demand conditions	75.2	62.7	− 12.5
	Related and supporting industries	70.7	73.0	2.3
	Business context	37.4	69.2	31.7
Centric factor	Digital environment	68.9	79.6	10.8
Exogenous factor	Entrepreneurs	62.6	69.9	7.3
	Experts	71.8	69.8	− 2.0
	Digital infrastructure	56.3	78.6	22.3
	Digital ethics	81.5	85.0	3.5

Source: Calculated by the Authors

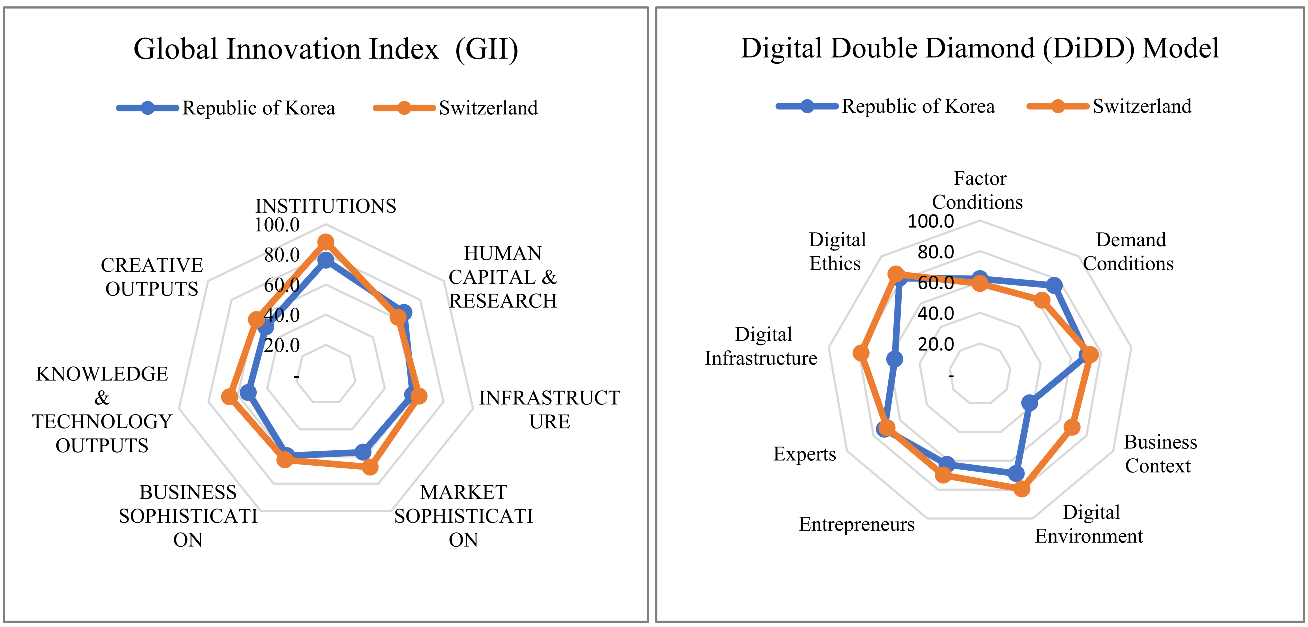

Fig. 5 Comparison of GII vs. DiDD model using the Radial Graph. Source: Developed by the Authors based on the results presented in Table 3

discover and verify optimal new drug candidates using AI. Medical data-driven hospitals are supported. A favorable environment is created for providing medical AI services, demonstrating clinical practice, building datasets in hospitals, and developing medical AI. In addition, the South Korean government supports the preparation of standardized data for clinical validation and establishes a professional review system to improve the quality of AI-enabled medical devices and shorten the period for commercialization in line with its "AI National Strategy" (Korea Biomedical Review, 2019).

South Korea's digital healthcare market has grown rapidly. With active support from the government, the commercialization of smart healthcare products and services should increase in the coming years both in the domestic market and in consumer goods produced in Korea for global markets. Despite these activities, Korea's digital health market is lagging behind major countries in the world due to regulatory barriers to data sharing and telemedicine that have put an investment in the development and application of new technologies. The government has identified the country's strict data regulations as a major obstacle to innovation in the digital healthcare sector and announced the deregulation of the local data market. Therefore, promoting deregulation where appropriate to drive innovation is key to strengthening international competitiveness (Department for International Trade Report, 2019).

Based on the rapid technological development and achievement of medical AI along with efforts to revise regulations and reimbursement for digital healthcare products and clinical adoption, consistent investments have been made in academia and fields at different national and industrial levels around the world in this regard. In addition, numerous companies have attempted to implement commercial medical AI products. Thus, digital health can be applied and developed much more widely in the medical field, such as clinical decisions in diagnosis or treatment, telemedicine, remote patient monitoring, clinical trials, lifestyle management, patient care, hospital management, and drug development worldwide (Shin, 2019).

Not only Switzerland and South Korea but also many countries put effort into supporting the digital health and pharmaceutical industry as one of the new economic growth sectors and try to implement technology adoption. Many countries have priority to improve regulation and guidelines regarding regulatory guidelines and approval processes of digital healthcare products and systems. Therefore, the system should be systematically reorganized through a strategy of selection and concentration, and the opportunity to study and share success cases at the corporate level or the national level will increase, leading to a model of collaboration and convergence.

Besides, as data are becoming the new healthcare currency, protecting it will be key. Clinical innovations, connected medical devices, and market complexity have amplified the continued need for evolving government policies, regulatory oversight, and risk management. Maintaining *regulatory compliance and cybersecurity* is a common crucial point worldwide (Deloitte, 2019).

This field is an important area of study for the development of competitiveness not only for the country but also for the industry. As seen in this study, the research model and results above show that the infrastructure part showing the country's overall competitiveness is important. In particular, in South Korea, *Demand conditions* and *Factor conditions* are a key part of the digital healthcare field and a competitive index in the DiDD model, and it is necessary to improve competitiveness in *Business context and Digital infrastructure*. By investing systemically in the environment, we will have to build a solid foundation, which leads to synergy with other excellent factors.

In Switzerland, the overall indicator is excellent and world-class, but for *Demand Conditions*, it must be compensated. In particular, if *Gross domestic expenditure on R&D* and *Domestic general government health expenditure* portion of the sub-variables are intensively complemented, it will demonstrate a more successful adoption of digital healthcare across the country and industry, while maintaining its current level. So far, we have compared two countries using the DiDD model focusing on the healthcare and pharmaceutical industries. And this could be applied and developed not only in these two countries but also in other countries for the further enhancement of national competitiveness in the digital transformation era.

Conclusions

Through the development of the digital healthcare industry globally, countries need to develop investment and collaboration models to strengthen their national competitiveness and prepare for the aging era. We developed the DiDD model in this paper and classify the indicators that can improve digital healthcare competitiveness under the fourth industrial revolution with digital healthcare and technology adoption environment. Strong points and weak points can be compared for each indicator through sub-indices, and the insufficient parts can be improved. The DiDD model could be used for policymaking and implementation at the country and industry levels.

Industries, such as healthcare and pharmaceuticals, are eager to find appropriate strategies and standardized platforms for new drug development and new business structures that could combine digital healthcare and new environment adoption. The industrial convergence model shows the part that is seeking cooperation. It will be able to reduce costs and increase operational efficiencies, which will create a sustainable structure for the healthcare and pharmaceutical industries and increase national competitiveness. In this regard, the "Digital Double Diamond" model framework presented in this paper connects well with SDG 3 (Good Health and Well-Being) and SDG 9 (Industry, Innovation, and Infrastructure). In addition, this paper discusses what indicators can guide the direction of corporate sustainability through industrial transformation, how important the general infrastructure is at the national level, and how to invest and set up policy as a national growth engine. This would be practically referred to as one of the criteria for the country, the healthcare environment, the real industry, and worldwide.

In the healthcare and pharmaceutical industry, digital innovation has begun to integrate, and there are not many relevant prior research or systematic models. Therefore, there are currently limitations in collecting the values of indicators corresponding to this research model by country, and it is difficult to use the same continuity indicators by country. If future investments by country and industry level are continuous and gradually improved, then related data could be managed more systematically. The DiDD model framework enables the linking of changes in one determinant or factor to the overall development of national competitiveness in the healthcare and pharmaceutical industries. Hence, analysis of the interactions among the determinants and factors over time with a focus on stakeholders would be a topic for further studies.

Key Questions Reflecting Applicability in Real Life

(1) How can the efficiency of the digital competitiveness of healthcare and pharmaceutical industries at the country and industry be measured?
(2) What is the county-level financial impact of digital transformation and how can it be reinvested for sustainable development in the healthcare and pharmaceutical industries?
(3) What is the new role of the key stakeholders under digital transformation in the healthcare and pharmaceutical industries?
(4) How can the relevant policies and regulations under digital transformation be efficiently updated?
(5) How can the DiDD model be applied to other industries and how their future collaborations with the healthcare and pharmaceutical industries can improve competitiveness?

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Declarations

Conflict of interest The research presented in this paper is based on a chapter of the Dual Degree (DBA/Ph.D.) doctoral dissertation of Dr. YongChan Kim completed in February 2021 at BSL Business School Lausanne (Switzerland) and Seoul Business School (Republic of Korea). Dr. Erdal Atukeren and Dr. YeonWoo Lee are academic supervisors. Dr. YongChan Kim is an employee of a pharmaceutical company, Sanofi, in the Republic of Korea. The research presented in this paper is solely for academic purposes and the authors have no relevant financial or non-financial interests to disclose. The authors have no competing interests to declare that are relevant to the content of this article.

Ethical statement The data used in this paper were obtained from publicly available sources. No interviews or questionnaires were used. No experiments were conducted. Ethical committee approval is not applicable.

Consent No interviews or questionnaire data were used in this paper. Not applicable.

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