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Influential Variables and Causal Relations Impact on Innovative Performance and Sustainable Growth of SMEs in Aspect of Industry 4.0 and Digital Transformation

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Abstract: Digital Transformation is essential in the global industry for survival and sustainable growth, and SMEs are mainly required to apply digital technology for sustainable growth. This study aims to verify the causal relationship between the variables significantly affecting Digital Transformation's sustainable growth and innovative performance and suggest critical variables and strategies in which Digital Transformation's constituent factors affect sustainable growth. Data were collected from an online survey of 303 CEOs of SMEs. Using Smart PLS, analyzed the factors affecting the sustainable growth of SMEs and verified the causal relationship. We found that applying Digital Transformation in SMEs is necessary because Digital Transformation affects innovation performance and ultimately impacts sustainable growth. By verifying the variables that affect the sustainable growth of 7 industrial sectors, we establish sustainable growth strategies suitable for each industry and provide the variables that affect sustainable growth. The findings imply that DT is essential for the sustainable growth of SMEs and that impact variables appropriate to the industry should be applied. The study results will be a new area of interest for future researchers.

Keywords: sustainable growth; sustainability; small and medium-sized enterprises; digital transformation; sustainable innovation; sustainable business; innovative performance; technology competency

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1. Introduction

The evolution of technology (Industry 4.0; I4.0) is an essential trend in the global economy. Although I4.0 technology offers many benefits to the manufacturing industry, studies on the impact of I4.0 and DT on SMEs are in their infancy [1,2]. I4.0 is very important for the sustainable performance and growth of SMEs, and the term that can convey the concept of I4.0 is digital transformation that changes products, services, and business models using the Internet of Things (IoT) and big data (BD) [3,4]. Meanwhile, a clear definition of digital transformation (DT) must be fully considered [5]. Nevertheless, it has been argued that DT maintains a sustainable business and positively impacts performance [6]. Researchers noted that I4.0 directly correlates with performance in the production service sectors [7–9]. The main drivers of I4.0 were defined as DT technologies such as the Big Data (BD), Internet of Things (IoT), Cyber-Physical Systems (CPS), Smart Factory (SFR), and Interoperability (IOP), and suggested that they could cause a paradigm shift in industrial production [10]. Previous literature on DT has been defined and approached from various perspectives. The three challenges SMEs face when adopting I4.0 are limited financial resources, knowledge resources, and technology awareness [11–13]. The main benefits of I4.0 include cost reduction, quality improvement, efficiency, flexibility, and productivity; Competitive advantages are included [14,15]. Conceptual studies of DT are as follows. The drivers of DT, structure, success factors, and the inductive framework leading to corporate performance were studied [5,16,17]. DT encompasses the ability to create new value-creation paths [18] and strategies to secure them [19,20], organizational structure [21], process [22], and organizational level change, including culture [17,23]. As for related studies, BD, SFR, CPS, and IoT affect industry performance, although I4.0 technology has many advantages in manufacturing [1], studies on the impact of I4.0 and DT on SMEs are in an early stage by 2018 [2], and I4.0 and DT are critical to the sustainable performance and growth of SMEs also BD, IoT, and SF affect Sustainable Business Performance [3]. Therefore, the researcher conceived a research question about the impact of DT on the sustainable growth of SMEs. It was argued that high investment costs and returns regarding innovation, organization, environment, and cost hinder SMEs from introducing and applying DT, such as smart factories [2]. In addition, the main advantages of adopting I4.0 in SMEs are flexibility, cost, efficiency, quality, and competitive advantage, and analyzed that about 20 studies on I4.0 and SMEs are not enough [2]. Research since 2016 has continued to highlight the discrepancy between current research on I4.0 and the requirements of SMEs [2]. Jung & Jin (2018) [24] mentioned in a case study of DT technology implementation by Korean SMEs that they are hesitant to build a smart factory in consideration of financial issues, but are interested in building a low-level implementation optimized for their primary business and factory environment. Sevinc (2018) [25] found that organizational and cost criteria are more important for SMEs to be unsure about transitioning to I4.0. High investment costs and returns based on technology are suggested as barriers to confidence.

The purpose of this study is an empirical study on the relationship between digital transformation and the sustainable growth of SMEs. A clear definition of digital transformation should be fully considered [5], and digital transformation maintains a sustainable business and positively impacts performance [6]. To overcome the research limitations of previous studies and establish a survival strategy for SMEs in the age of I4.0, necessary to investigate the variables that influence SMEs' performance and systematically and scientifically verify the causal relationship. The study aimed to identify the causal relationship between the variables significantly affecting DT's Technology Competency (TC), Innovative Performance (IP), and Sustainable Growth (SUSG). In addition, verifying the difference in performance impact according to the industry category to which small and medium-sized enterprises (SMEs) belong provides key influencing variables for sustainable growth and strategies for sustainable growth. Therefore, it is necessary to study the impact of DT as a sustainable growth strategy for SMEs, focusing on the academic and industrial significance of identifying the factors of overcoming and growing through internal transformation (innovation, technology) of SMEs. The detailed purpose of this study was derived through the analysis of conceptual definitions of research variables and research questions. First, by analyzing and re-establishing previous studies of DT, the causal relationship was identified by empirically analyzing the effect of specific DT components on SMEs' IP and SUSG. Second, an empirical analysis was conducted on the effect of innovative performance from DT on sustainable growth. Third, the empirical analysis of the influence factors of IP and SUSG through TC was conducted, and the causal relationship was identified. Fourth, an empirical analysis was conducted on the effect of TC on SUSG. Fifth, the empirical analysis of the factors influencing the SUSG of IP and the causal relationship was identified.

Therefore, the researcher studied the effect of sub-variables constituting DT, an independent variable, on performance to overcome the problems of previous studies, which were fragmentary studied in previous studies. An integrated research model and hypotheses were established to identify structural influence relationships. The effect of DT on TC was confirmed by using the sub-variables constituting DT as the independent variable and TC. The effect of TC on IP was studied, and the impact of IP on the SUSG of SMEs. An empirical analysis was conducted on the influence of a subcomponent of DT, an independent variable, on IP and sustainable growth, a dependent variable, through TC. Finally, variables that affect sustainable growth according to seven industrial sectors were identified and verified, and a sustainable growth strategy suitable for the industry was established. The findings are that DT greatly influences IP and SUSG. (1) DT affects IP, and IP affects SUSG. (2) TC mediates DT, affecting IP and SUSG. (3) TC directly affects IP and SUSG.

2. Theoretical Background and Hypothesis

2.1. I4.0 and DT

Regarding corporate operation, I4.0 connects things related to the company's production activities to collect, analyze, and process data and create new values by learning independently [4]. In connection with the definition of I4.0, it was argued that the term that can represent the specific concept of I4.0 is DT [4]. Industry officials, scholars, and academic definitions differ because DT is widely applied to society, economy, academia, and industry and is a significant driver influencing corporate management activities, society, and the country. Scholars have described I4.0 from various perspectives. A new value chain organization and management level were defined and managed through the entire product life cycle [26]. According to various researchers, the academic definition of DT is as follows. A company's strategy is to reshape its business structure by applying digital technologies to account for customer interactions [20]. A strategy to create new business value in both technical and non-technical areas by leveraging digital technologies, considering the consumer side [27]. A process of innovation in which advanced digital technologies are used to unlock market value and surpass conventional thinking in speed and scale [28]. In terms of industry, it is the opportunity and social impact of digital technology and the overall impact of digitalization on individuals, organizations, and society [29]. It was utilizing digital knowledge and realizing creative innovation using digital technology [30].

A scholarly definition of DT is as follows:

First, looking at the arguments of scholars who studied from the process point of view, Warner (2019) [17] argued that it is a continuous process that utilizes digital technology for strategic reconstruction, including business models and collaboration methods. Vial (2019) [5] referred to it as improving an entity by inducing significant property changes. [31] studied a company's business model, process, and evolutionary process that aims to create customer value. Second, looking at the arguments of scholars who studied from the innovation point of view, Heilig (2017) [32] argued that a new IT/IS solution and organizational innovation lead the trend. Berghaus [33] referred to digital innovation as improving existing tangible products. In addition, several scholars have studied that digital capabilities and technologies can improve customer experience, streamline operational processes, or dramatically improve through new business models [31,34–38].

Academic definitions of DT vary widely, as shown below. DT refers to organizational changes that integrate business processes [39], Augmenting customer experiences with digital capabilities and technologies, streamlining processes, or dramatically improving them through new business models [31,34–38]. DT is a blueprint to support enterprises through the integration of digital technologies, post-transformation operations [20], and leveraging digital technologies to improve corporate performance [40]. DT is Digital innovations that improve existing tangible products [33]. Strategic transformation by digital technology [41], A digital business model induces strategic business and creates new value [42,43]. Changes in business models through product, organizational structure, and process changes [44,45]. Innovation in business models that can optimize customer needs and experience [46]. The impact of digital technologies acting rationally [47]. Novel IT/IS solutions, trend-setting organizational innovation [32]. Changes in the use of IT to automate overall tasks [48], An evolutionary process aimed at creating value for a company's business models, processes, and customers [31].

DT is the transition for companies to exploit opportunities and avoid threats [38]. The process of improvement by inducing significant changes in object properties [5], An ongoing process of leveraging digital technologies to reshape business models, collaborations, etc. strategically [17]. Imran & Haque (2018) [1] defined the components of I4.0 (DT) as Big Data (BD), Internet of Things (IoT), Inter-Operability (IOP), Smart Factory (SFR), and Cyber-Physical Systems (CPS). These five sub-factors affect products and services, and the effects on industry performance through mediating effects of production and services were studied. As a result of the study, it was argued that the five components of DT, BD, IOP, IoT, SFR, and CPS all had a positive effect on production service, and production service had a positive effect on performance. The goals of I4.0 were stated to be achieving advanced levels of operational efficiency and productivity and higher levels of automation [49,50]. Since I4.0 plays an essential role in the production and service fields, there is a direct relationship with performance [7–9]. Roblek et al. (2016) & Posada et al. (2015) [51,52] noted that the various features of I4.0 are closely related to Internet technologies and progressive algorithms. However, they also stated that I4.0 is a technical process for effective knowledge management. Despite extensive research on I4.0, a systematic and comprehensive review of research on I4.0 should be included [53].

As a result, this study proposed a framework of subcomponents of I4.0 and tried to verify the influence of DT representing I4.0 in the continuous growth of SMEs. Thus, the researchers validated how DT can be helpful for SMEs to overcome various technical challenges and improve sustainable business performance. The focus of this study was derived from the research question of verifying the causal relationship between business performance and sustainable business performance of DT components. It is also based on the five DT sub-elements of Big Data, Smart Factory, Internet of Things, Interoperability, and Cyber-Physical Systems. The researcher verified how these factors affect performance and sustainable growth in the seven industrial sectors, such as manufacturing and service.

2.2. DT and SG

The company's performance improvement using digital technology was mentioned [42]. Digital transformation also affects several organizational performances: Innovation [18], Financial Performance [23], Organizational Growth [54], Reputation [55,56], the improvement of several organizational performances, and the competitive advantage of the firm [57]. SMEs must develop sustainable business excellence, leading to high performance and reducing business risk [58]. Therefore, digital transformation directly or indirectly affects corporate performance and various performance indicators [16]. Based on these preceding studies, the innovativeness and sustainable growth impact of digital transformation were established, and a hypothesis for the performance impact of digital transformation was established. BD, SFR, CPS, the Internet of Things, and IOP, which are components of digital transformation, all significantly affect performance [1]. The researcher selected BD, SFR, CPS, IoT, and IOP as measurement indicators. Digital transformation is emphasized as a continuous process of transformation and evolution, not a one-off project [5,17,31]. A structural causal relationship between digital transformation and performance was studied [59].

Therefore, the researcher set hypotheses 1 and 2 of the effect on performance: Digital transformation affects innovative, continuous performance.

2.3. DT and TC

Digital competence and digital orientation complement each other to achieve product innovation. It has been demonstrated that innovation is driven by technology orientation [60] and enabled by technological competencies [61,62]. To explain the disruptive impact of digital technologies on companies from a digital transformation perspective, a study on corporate strategy [19,45] and innovation [63,64] and business models [65,66] were studied from the perspective of digital technology. In this study, the effect of digital transformation on technological competencies was set as a research question from the innovation point of view. IT compatibility with current work practices enhances technological innovation in SMEs and finds evidence that companies willing to exploit their digital potential fully have higher returns and higher technology orientation and capabilities than average companies [67,68]. Therefore, digital orientation and competence can indirectly, but not directly, impact organizational performance through innovation that can mediate [62]. It was emphasized that DT is not a one-time project, but a process of continuous change and evolution [5,17,31]. DT is about leveraging and integrating new digital technologies in business processes to enable business improvement [69]. I4's advancements in technology offer the possibility to create entirely new ways of delivering products through technological innovation [70,71]. It was defined as technological innovation competency in the industrial sector based on the fourth industrial revolution [72].

However, new skills are required as new digital technologies are introduced into the enterprise [5,73]. The research question was selected from the analysis of previous studies: Does digital innovation lead to better organizational performance? The researcher proposed a proposition: Does digital transformation affect the performance of SMEs?

2.4. TC, IP, and SUSG

It has been argued that I4.0 is critical to sustainable business performance growth for SMEs [74–76]. In addition, elements of I4.0, such as BD, IoT, and SFR, play a crucial role in enhancing information technology implementation, contributing to sustainable performance [3]. Sustainable growth refers to a company's increase in market share, sales growth, net profit margin, return on assets, return on equity, etc. The sustainable performance combines economic, environmental, and social performance [77–82]. Sustainable performance always leads to better business viability [83,84]. According to scholars' research, technological competence is a critical competency that leads to the sustainable growth of enterprises. However, recent research in innovation management argues for a more comprehensive approach [85,86]. Argued that I4.0's technological advances give entrepreneurs the potential to create entirely new ways of delivering goods and services through technological innovation [87]. Furthermore, able to set TC as an influencing variable on IP [70,71].

Therefore, in this study, technology marketing competency (TMC), technological innovation competency (TIC), and technology commercialization competency (TCC) were composed as sub-factors of new TC, and the research problem of IP and SUSG impact of TC was set. The research question was established as requiring an intermediate variable between IP and the impact of SUSG. Eventually, this study set SUSG as a dependent variable through consideration of previous studies.

2.5. Conceptual Definition of Constructs

Digital Transformation (DT): Corporate activities that strengthen current business competitiveness in response to changes in the business environment triggered by new digital technologies such as big data, artificial intelligence, IoT, smart factory, cyber-physical system, and interoperability [1,4].

Technology competency (TC): Critical competency that leads to the continuous growth of the company, and at the same time, it is a comprehensive corporate characteristic that promotes and supports technological innovation [87]. It consists of technology marketing competency, technology innovation competency, and technology commercialization competency.

Innovation Performance (IP): A company's perceived performance relative to its perceived performance prior to this period as the innovative result of its activities during a year [88,89]: Marketing Performance, Consists of Innovation Performance, Networking, Human Capital, Customer, Process, Incremental Innovation performance, and Radical performance.

Sustainable growth (SUSG): A combination of economic, environmental, and social performance [83] and consists of technical performance, Financial Performance, Non-financial performance, Economic performance, Environmental performance, and Social performance.

2.6. Research Questions and Differences

2.6.1. Research Questions

This researcher summarized the problems and limitations by considering previous studies as follows. First, studies on the effect of DT [4], which represents I4.0, on the performance of SMEs varied according to scholars, but only on the direct effect. In other words, as DT is defined as technological innovation in the industrial field based on I4.0 [73], there are causal variables that play a mediating role, which can further accelerate or promote performance. The limit was to focus on identifying fragmentary relationships. Therefore, to solve the problem of previous studies, the researcher tried to verify whether IP can affect sustainable growth and DT's influence on IP. In addition, mediators of TC were introduced to verify the impact of IP and SUSG. Second, as it was rarely addressed in previous studies, the research question that DT will affect IP and SUSG through TCs was identified in more detail by seven industrial sectors. In other words, it was verified and suggested what kind of difference there is in the influence depending on the industry, how the influencing variable differs, why the difference in the influence occurs depending on the industry, and what kind of strategy to overcome the difference.

The verification of the difference in influence according to the industrial field is an excellent achievement as it has not been dealt with much in previous studies. The research proposition and questions raised in this study are as follows.

- Research proposition: DT affects Sustainable Growth
- Research question (RQ 1): Does DT affect innovative performance?
- Research question (RQ 2): Does innovative performance affect sustainable growth?
- Research question (RQ 3): Does DT affect technology competency?
- Research question (RQ 4): Does technology competency affect innovative performance?
- Research question (RQ 5): Does technology competency affect sustainable growth?
- Research Question (RQ 6): Will the variables that affect innovative performance and sustainable growth differ by industry?

2.6.2. Differences in Research

To solve the research problem, the tasks to be addressed in this study are as follows. A DT maintains a sustainable business and positively affects overall business performance [6]. Imran & Haque (2018) [1] further elaborated on the claim that the problems of previous studies were disconnected from the needs of SMEs, And the purpose of this study is to verify the relationship between DT and SMEs for sustainable growth. The overall research flow of this study is that DT will lead a sustainable business and have a positive impact on overall business performance [6]. In addition, based on the study that sustainable growth leads to business viability [83,84], sustainable growth was set as a dependent variable and verified. Overall, the differences in this study are: First, studies on the impact of DT on the sustainable growth of SMEs were lacking, overcoming the limitations of previous studies that focused only on the impact of DT itself.; Second, this study is expected to contribute substantially by securing academic necessity and originality. Third, since there are no studies on the performance and growth impact of DT by industry group, the results of this study are provided to government policymakers, academic researchers, and industry workers to establish national policies to expand the growing base of SMEs and expand jobs.

This study is differentiated and original in that it can be used academically and for policy development. In addition, industrial contributions to the performance and sustainable growth of SMEs, including start-ups, are expected. Figure 1 shows the research's conceptual flow and theoretical framework.

The distinctive points of this study are shown in the flowchart in Figure 2. In other words, IP and SUSG were verified by introducing parameters of TC into the basic model. This study's distinctiveness and originality include IP, SUSG, and TC verification.

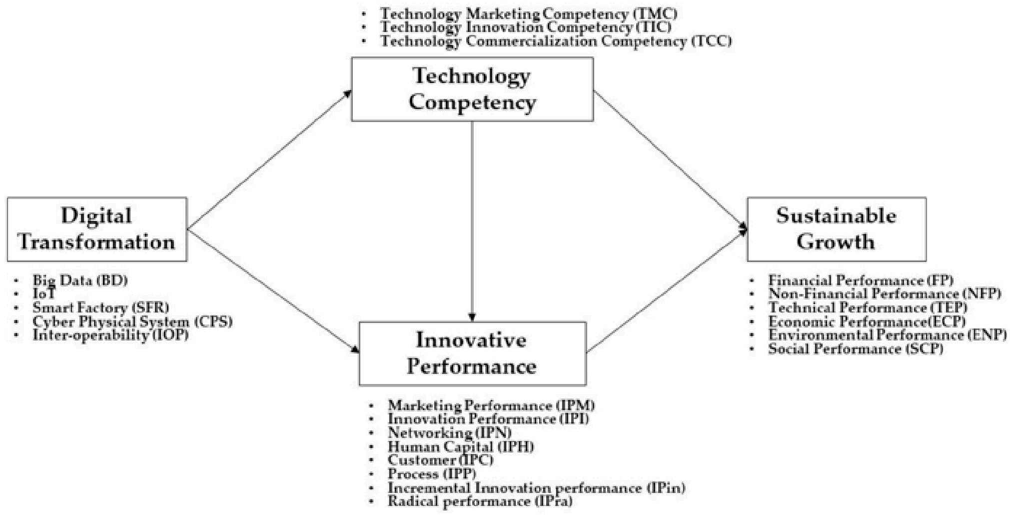

Figure 1. Conceptual flow chart of research and theoretical framework.

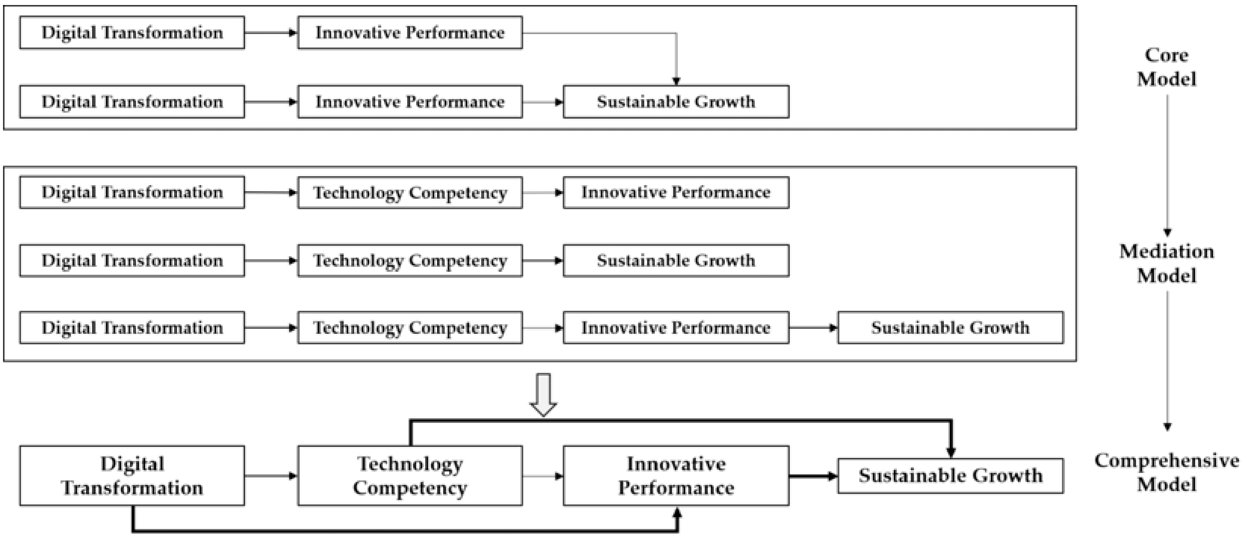

Figure 2. Distinctiveness and originality of research.

2.7. *Research Hypotheses and Research Model*

2.7.1. DT and IP

DT maintains a sustainable business and positively impacts overall business performance [6]. Bekkhus (2016) [40] studied the performance improvement of companies using digital technology and said that DT also affects organizational performance. Organizational performance includes innovativeness [18], financial performance [23], organizational growth [54], and Reputation [55,56]; said that it is also related to the improvement of various organizational performances and the competitive advantage of companies [57]. In addition, it was mentioned that SMEs should develop excellent sustainable businesses, as this will lead to high performance and reduce business risks [59]. Osmundsen et al. (2018) [16] suggested that directly and indirectly, DT affects corporate performance and various performance indicators. Therefore, this study established the performance effect hypothesis of DT. Imran & Haque (2018) [1] found that the components of DT that significantly affect performance are IOP, CPS, IoT, SFR, and BD. Park (2019) [59] suggested that DT significantly affects corporate performance in a study on the structural causal relationship between DT and performance. It was also mentioned that DT is not a one-off project, but a process of continuous change [5,17,31]. Therefore, the researcher presented the following research hypotheses through previous studies.

Hypothesis 1 (H1). *DT will affect IP.*

2.7.2. Innovative Performance and Sustainable Growth

A company's increase in market share, sales growth, net profit margin, return on assets, return on equity, and sustainability performance was a combination of economic, environmental, and social outcomes [78,80–82]. Sustainable growth is measured as follows by a combination of economic, environmental, and social performance [82], and the measurement indicators were technical performance (TP), financial performance (FP), non-financial performance (NFP), Economic Performance (ECP), Environmental Performance (ENP), and Social Performance (SCP). Applying the assertion that sustainable performance always leads to better business viability [83,84], sustainable performance was set as a dependent variable. Therefore, the following research hypotheses were presented through previous studies.

Hypothesis 2 (H2). *IP will affect SUSG.*

2.7.3. DT and TC

It has been argued that digital capabilities and directions are compatible and complementary in achieving product innovation. Innovation has proven to be driven by technology orientation and enabled by TC [61]. Explain the disruptive impact of digital technologies on companies from a DT perspective, the study of corporate strategy [19], and innovation [63–66] were studied from the digital technology perspective. This study established a hypothesis on the effect of DT on the TC from the innovation point of view. Ntwoku et al. (2017) [67] found that the compatibility of IT and current business practices enhances technological innovation in SMEs. Bughin and Van Zeebroeck (2017) [68] found that companies trying to make the most of their digital potential have higher returns than average companies and have higher technology orientation, and evidence of high technical ability was found. Therefore, it was argued that digital orientation and competence could have an indirect, but not direct, impact on organizational performance through innovation that can mediate [62]. DT means leveraging and integrating new digital technologies into processes to enable business improvement [69–71] and noted that I4.0's technological advances empower entrepreneurs to create new ways of delivering goods and services through technological innovation. It was argued that companies utilize digital technologies such as IoT, cloud, big data, and AI to achieve new products, services, and business model changes [4]. Research shows that technological improvements in I4.0 offer entrepreneurs new potential to deliver products through innovation [70,71]. It was defined as technological innovation in the industrial sector based on the fourth industrial revolution [72]. However, it was argued that new technologies are required as new digital technologies are introduced into companies [73]. Therefore, the following research hypotheses were presented through previous studies.

Hypothesis 3 (H3). *DT will affect TC.*

2.7.4. TC, IP, SUSG

Technology is a critical competency that drives the sustainable company's growth. Furthermore, it has broad corporate characteristics that promote and support technological innovation [85]. The researcher was composed of three subfactors of technology competency: technology marketing competency, technology innovation competency, and technology commercialization competency. This study established hypotheses on the impact of IP and SUSG on TC. However, recent research on innovation management has called for a more comprehensive approach [85,86]. Therefore, the following research hypotheses were presented through previous studies.

Hypothesis 4 (H4). *Technology competency will affect innovation performance.*

Hypothesis 5 (H5). *Technology competency will affect sustainable growth.*

Figure 3 shows the hypothesis and structural model.

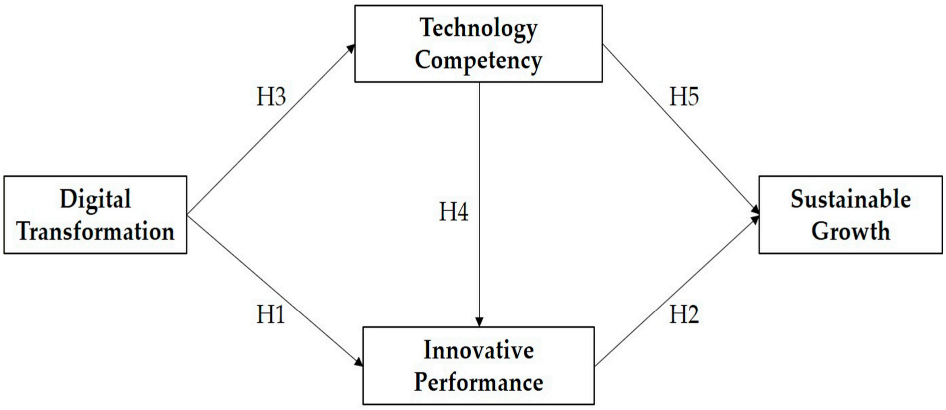

Figure 3. Final research model.

Research proposition is DT affects Sustainable Growth.

3. Materials and Methods

3.1. Conceptual Definition of Constructs

Digital Transformation (DT): Corporate activities that strengthen current business competitiveness in response to changes in the business environment triggered by new digital technologies such as BD, AI, IoT, AFR, CPS, and IOP [1,4].

Technology competency (TC): Critical competencies that drive the company's continued growth; It is a comprehensive corporate characteristic that simultaneously promotes and supports technological innovation [86]. It consists of technology marketing competency, technology innovation competency, and technology commercialization competency.

Innovation Performance (IP): A company's perceived performance relative to its perceived performance before this period as the innovative result of its activities during a year [88,89]: Marketing Performance, Consists of Innovation Performance, Networking, Human Capital, Customer, Process, Incremental Innovation performance, and Radical performance.

Sustainable growth (SUSG): A combination of economic, environmental, and social performance [82] and consists of technical performance (TP), Financial Performance (FP), Non-financial performance (NFP), Economic performance(ECP), Environmental performance(ENP), and Social performance(SCP).

3.2. Independent Variables (DT): BD, AI, IoT SFR, CPS, IOP

3.2.1. Measurement of (BD)

Xu and Lian (2018) [90] discuss all aspects of data processing used to process vast amounts of data or information, including structured and unstructured data, capture, security, transmission, storage, analysis, curation, retrieval, privacy, and visualization and defined it as a technology. Hashem et al. (2015) [91] defined it as a term used to analyze the growing amount of complex data to store, process, and analyze with the help of existing database technologies. The essence of BD consists of the critical process of recognizing data and transforming it into new insights [86]. It also defined BD as a lot of scientific data for visualization of information. They also defined BD as the amount of data that exceeds the ability of technology to store, manage and process it efficiently [85]. Manyika et al. (2011) and Duan et al. [92,93] also defined BD as a large amount of scientific data for visualization. They also defined BD as the amount of data that exceeds the ability of technology to store, manage and process it efficiently. Zikopoulos et al. (2013) [94] defined BD as having three main characteristics: volume, variety, and speed. Mayer-Schönberger (2013) [95] and Satell

(2014) [96] also defined BD as a collection of data from traditional and digital sources inside and outside a company representing a source for ongoing search and analysis.

In this study, referring to the study of [1], which was dealt with in the previous study, the operational definition of big data, related research literature, measurement items, and measurements are summarized in Table 1. The questionnaire was measured on a 5-point scale.

Table 1. Definition of BD.

Measurement Variable	Operational Definition	Previous Research
Big Data (BD)	Any technology used to process large amounts of data or information, including structured and unstructured data, including capture, security, transmission, storage, analysis, curation, search, privacy, and visualization	[1,92,94–96]

3.2.2. Measurement of IoT

IoT is a technology that connects to the Internet by embedding sensors and communication functions in various objects. In other words, defined as a technology that connects various things through wireless communication, and IoT plays a role in connecting all devices to the Internet. IoT components include hardware, middleware, and presentation [97]. A clear breakdown of each component can be found elsewhere [98]. IoT is critical to responding promptly, flexibly, and resource-efficiently through better planning and control principles.

In this study, referring to [1], which dealt with previous studies, the operational definition of IoT and related research literature and measurement items are shown in Table 2. The survey was measured on a 5-point scale.

Table 2. Definition of IoT.

Measurement Variable	Operational Definition	Previous Research
IoT	Technology that connects to the Internet by embedding sensors and communication functions in various objects. In other words, a technology that connects various things through wireless communication. Communication between people, machines and products, and the Internet of Things	[1,97–99]

3.2.3. Measurement of SFR

SFR is an intelligent production factory that can improve quality, productivity, and customer satisfaction by applying information and communication technology (ICT) combined with digital automation to the overall production process, such as design and development, manufacturing, and distribution. Saxby et al. (2020) [99] also defined it as an intelligent self-managed production process, a CPS, and a highly flexible, configurable, optimized, and efficient production process. In addition, defined as a future-oriented factory that can control itself by collecting and analyzing process data in real-time by applying IoT to facilities and machines in the factory [1,7,100–108].

In this study, referring to the study of [1], which dealt with previous studies, the operational definition of SFR, related research literature, and measurement items are shown in Table 3. The survey was measured on a 5-point scale.

Table 3. Definition of SFR.

Measurement Variable	Operational Definition	Previous Research
Smart Factory	An intelligent production plant that can improve quality, productivity, and customer satisfaction by applying information and communication technology (ICT) combined with digital automation to the entire production process, including design and development, manufacturing, and distribution. In addition, a future-oriented factory can control itself by collecting and analyzing process data in real-time by applying the Internet of Things (IoT) to facilities and machines in the factory.	[1,100–108]

3.2.4. Measurement of CPS

According to a study by [109], CPS is an intelligent system that performs reliable and safe distributed control by integrating physical systems such as people, processes, and facilities into virtual (cyber) systems and networks. It also means a new generation of systems with integrated computational and physical capabilities capable of interacting with humans in new modalities. The ability to interact with the physical world and expand capabilities with the help of computation, communication, and control is an essential driving force for future technological developments. It also argued that IoT plays a role in connecting all devices to the Internet. I4.0 focuses on the end-to-end digitization of all physical assets and their integration into the digital ecosystem through various technologies [102]. It was mentioned that this creates products and services by effectively utilizing technology to achieve synergies [110,111]. These synergies continued through emerging technologies such as augmented reality (AR), AI, autonomous robotics, BD analytics, cloud systems, and IoT, which have the potential for integration within value chains regardless of industry [102]. The key to this connectivity is CPS, which guarantees unprecedented interconnectivity [102,112,113].

In this study, referring to the study of [1], which dealt with previous studies, the operational definition of CPS, related research literature, and measurement items were summarized and shown in Table 4. The survey was measured on a 5-point scale.

Table 4. Definition of CPS.

Measurement Variable	Operational Definition	Previous Research
Cyber-Physical System (CPS)	An intelligent system that performs reliable and safe distributed control by integrating virtual systems and physical systems such as people, processes, and facilities into virtual systems and networks.	[100,107,112,113]

3.2.5. Measurement of IOP

Lu (2017) [53] stated that I4.0 is an interoperability process and the integration of Information and Communication Technology, CPS, IoT, BD, and SFR. Romero and Vernadat (2016) [113] mentioned that I4.0 has two main elements: integration and interoperability. Also, Xu and Lian (2019) [91] demonstrated an unprecedented vertical and horizontal linkage of business functions and activities across business units and global value chains or production and production support activities and business management. Buyya et al. (2009), Tilak et al. (2002), and Tory et al. (2004) [98] mentioned that a precise classification of each component could find elsewhere, and IOP is what happens when the above elements are combined. It is a property that one system can be used interchangeably with another system (same or heterogeneous) without restrictions. Gubbi et al. (2013) [99] mentioned that IoT components comprise hardware, middleware, and presentation.

In this study, referring to previous studies, the operational definition of Interoperability (IOP), related research literature, and measurement items are summarized in Table 5. The survey was measured on a 5-point scale.

Table 5. Definition of IOP.

Measurement Variable	Operational Definition	Previous Research
Inter-operability (IOP)	The property that one system can be used interchangeably with another system (same or heterogeneous) without restrictions.	[53,91,98,99,113]

3.3. Mediation Variables

3.3.1. TC

Burgelman et al. (2004) [85] defined technological innovation capabilities as essential competencies that create sustainable growth while creating comprehensive corporate characteristics that promote and support technological innovation. Fitzgerald et al. (2014) & Foroudi et al. (2019) [34,114] argue that digital technologies can improve processes and growth and that organizations must adapt to new digital technologies to avoid the risk of being superior to their competitors. Refs. [70,71] emphasized the importance of technological competencies, saying that entrepreneurs can produce new ways of delivering goods through technological improvement and innovation. Technology innovation competency is the ability of a management system to carry out technological innovation efficiently, and various researchers referred to it [115–117].

Therefore, in this study, referring to previous studies, the technical competency, which is a parameter, was composed of three sub-factors: technology marketing competency, technology innovation competency, and technology commercialization competency. Each sub-factor was measured by setting the detailed items as follows. The operational definition of TC and related research literature are shown in Table 6. The questionnaire was measured on a 5-point scale.

Table 6. Definition of TC.

Measurement Variable	Operational Definition	Previous Research
Technology innovation competency	Management system and ability to efficiently carry out technological innovation	[92,115–117]
Technology marketing competency	Marketing ability of products that developed by new technology	[118]
Technology commercialization competency	Ability to commercialize development technology through production, commercialization, and marketing	[119]

3.3.2. IP

Hagedoorn & Cloodt (2003), Hagedoorn & Narayan (2012), Hult et al. (2004) [88,89] found that transformational performance is the innovative outcome of a firm's activities over one year, as compared to perceived performance prior to this period, as perceived by the firm. Furthermore, managing drivers such as reliability, productivity, and sustainability can help achieve optimal business performance. The ability to innovate is the most critical factor in influencing business performance and achieving strategic and business goals. The measurement items are Marketing Performance, Innovative Performance, Networking, Human Capital, Customer, Process, Incremental Innovation Performance, and Radical Performance [120–122] argued that companies must foster digital technology knowledge competencies to innovate and improve performance. Martín-de Castro et al. (2014) [28] noted that technological innovation is critical to product and process improvement, enabling organizations to increase innovation efficiency and performance (profitability) over non-innovators. Sandri and Widodo (2020) [120] used four indicators of innovation performance: marketing performance, innovation performance, networking, and human capital. Verbano and Crema (2016) [121] also used two metrics: Incremental Innovative Performance and Radical Performance. Joshi et al. (2010) [123] argued that companies must foster digital technology knowledge competencies to innovate and improve performance.

In this study, referring to the studies of [88,89], the operational definition of innovation performance and related research literature are shown in Table 7. The questionnaire was measured on a 5-point scale.

Table 7. Definition of IP.

Measurement Variable	Operational Definition	Previous Research
Marketing Performance	(a) Sales growth (b) Customer growth (c) Sales volume for existing and newly developed products.	[120]
Innovation Performance	Introduction of new technologies, frequency of product replacement and change, applicable technologies	[120]
Networking	Information sharing, resource sharing, market, and technology sharing	[120]
Human Capital	Knowledge, Competence, and Behavior	[120]
Customer	Increased market share growth, cost reduction, improved customer satisfaction, increased responsiveness, increased quality assurance	[121]
Process	Increased operational efficiency, increased need to understand internal and external processes	[124]
Incremental Innovation Performance	Incremental innovation for products/services	[122]
Radical Performance	A breakthrough innovation for products/services	[122]

3.4. Dependent Variable: SUSG

SUSG is a company's increase in market share, sales growth, net profit margin, return on assets, and return on equity, and sustainability performance is a combination of economic, environmental, and social performance [77,80–82]. In addition, Haseeb et al. (2019) [3] said that elements of I4.0, such as big data, the Internet of Things, and smart factories, positively promote information technology (IT) implementation, contributing to sustainable business performance. Therefore, it has been explained that sustainable performance leads to business viability [83]. The conceptual definition of SUSG has been argued to be a combination of economic, environmental, and social outcomes [77,80–82], and technical performance, financial performance, non-financial performance, economic performance, environmental performance, and social performance. SUSG is measured by economic, environmental, and social performance [82,87,125,126].

The operational definition of sustainability and the related research literature is shown in Table 8. The survey was measured on a 5-point scale.

Table 8. Definition of SUSG.

Measurement Variable	Operational Definition	Previous Research
Technical performance (TP)	Technology spillover effect and technological competitiveness, technological product, and process innovation	[127]
Financial performance (FP)	Increase in the operating profit rate, market share, assets, sales	[128]
Non-financial performance (NFP)	Qualitative indicators such as employee satisfaction, awareness, and service benefits	[129]
Economic performance (ECP)	Productivity, turnover, profit, business growth, and cost reduction	[82,87,125,130]
Environmental performance (ENP)	energy use, resource optimization, and waste reduction	[82,87,125,130–132]
Social performance (SCP)	CSR project investment, employee welfare initiative, accident reduction	[82,87,125,126,130–133]

3.5. Data Collection and Sample Characteristics

The sampling was about 100 CEOs of SMEs in each of the seven industries, with a total of 723 CEOs, and the response rate was 42.3%. The Ministry of Small and Medium Venture Business of the Republic of Korea officially uses the seven industries. Data were collected from 303 CEOs in seven industrial sectors in Korea from January to March 2023: Electrics/electronics, Machinery/parts, IT/SW, Bio-Health, Chemicals/fibers/materials, Life industry/food, and Crafts/others. For empirical analysis, frequency analysis was performed on the collected data using SPSS 22, reliability analysis of measurement tools was performed with Cronbach's α value, and Smart PLS 4.0.9.0 was used to verify the measurement model and hypotheses. The statistical analysis method is as follows. First, the sample's demographic characteristics, such as technology field, age, gender, sales, years in operation, and industry sectors, were confirmed, and SPSS frequency analysis was conducted. Second, Cronbach's α coefficient was determined by reliability factor analysis to verify the reliability of latent variables. Third, the validity of latent variables was verified with three measurement items: Convergent Validity, Discriminant Validity, and Cross-Loadings. Fourth, Smart PLS Structural Equation Modeling (PLS-Structural Equation Modeling) was executed to verify the relationship between latent variables and hypotheses. Fifth, the difference between industries was verified using Data Group Analysis (DGA) of Smart PLS. The characteristics of the sample are shown in Table 9.

Table 9. Demographic characteristics of the sample (Number of samples = 303).

	n = 303	Frequency	Percent
1. Business type	Private business	30	9.9
	Corporate business	273	90.1
2. Industry sector	IT/SW	61	20.1
	Craft/others	21	6.9
	Machinery/parts	38	12.5
	Bioindustry/foods	35	11.6
	Pharmaceutical/Bio-health	46	15.2
	Electrics/electronics	53	17.5
	Chemicals/fibers/materials	49	16.2

Table 9. *Cont.*

	n = 303	Frequency	Percent
3. Years in operation	Under 1 year	2	0.7
	1–2 years	15	5.0
	2–3 year	53	17.5
	3–5 years	158	52.1
	More than 5 years	75	24.8
4. Sales Volume (USD)	Less than \$0.1 million	133	43.9
	\$0.1–0.3 million	7	2.3
	\$0.3–0.5 million	15	5.0
	\$0.5–1 million	20	6.6
	More than \$1 million	45	14.9
5. Manufacturing	Outsourcing	278	91.7
	Outsourcing and in-house	15	5.0
	In-house	10	3.3
6. Employees	10–202 people	131	43.2
	More than 20 people	24	7.9
	3–55 people	26	8.6
	Fewer than three people	16	5.3
	5–10 people	106	35.0
7. Gender	Male	249	82.2
	Female	54	17.8
8. Age	20 s	3	1.0
	30 s	92	30.4
	40 s	167	55.1
	50 or over	41	13.5

4. Results

4.1. Verification of Measurement Model

Three hundred-three collected data were used (n = 303). There were no missing values, ten inappropriate metrics with Cronbach's α value of 0.7 or less were removed through reliability analysis, and inappropriate metrics were removed through factor analysis. As a detailed method, reliability and factor analysis were first performed using SPSS 22 (KMO-Bartlett test, principal components, Varimax rotation, etc.). The measurement model and structural model were verified using Smart PLS. The verification items and evaluation criteria of the measurement model are as follows:

- Internal consistency reliability was verified with three measurement items: Cronbach α (more than 0.7), Dijkstra-Henseler's rho_A (ρA; more than 0.7), and composite reliability (CR; more than 0.7).
- Convergent Validity was verified with two measurement items: Outer Loading Relevance (0.7 or higher) and AVE (Average Variance Extracted; 0.5 or higher).
- Discriminant Validity was verified with two measurement items: Fornell-Larcker Criterion and Cross-Loadings.

Internal consistency reliability was evaluated in three ways: Cronbach's α, Composite reliability (CR), and rho_A. Convergent Validity was evaluated by external loading, measurement variable reliability, and AVE [126].

Discriminant Validity can be evaluated using the Fornell-Larcker Criterion [134]. Discriminant validity between latent variables was tested for significance according to the Fornell-Larcker standard. Since the AVE square root value was greater than the highest correlation among latent variables, discriminant Validity between latent variables was verified. Convergent Validity was verified with AVE value of 0.5 or higher [135].

Tables 10 and 11 show the internal consistency reliability, convergent validity, and discriminant validity of the measurement model constructs. The Cronbach's α, rho_A, C.R, AVE, and Fornell-Larcker values all satisfied the evaluation criterion reliability, and the validity of the measurement model is shown in Table 10.

Table 10. The reliability and validity of the constructs.

	Internal Consistency Reliability			Convergent Validity	Discriminant Validity
Variables	**Cronbach's α > 0.7**	**Composite Reliability (rho_A) > 0.7**	**Composite Reliability (C.R) > 0.7**	**Average Variance Extracted (AVE) > 0.5**	**Fornell–Larcker**
BD	0.881	0.891	0.918	0.737	Yes
CPS	0.768	0.807	0.863	0.678	Yes
IoT	0.811	0.820	0.875	0.638	Yes
SFR	0.868	0.877	0.910	0.717	Yes
DT	0.891	0.891	0.913	0.567	Yes
TIC	0.863	0.870	0.898	0.594	Yes
TMC	0.846	0.847	0.897	0.686	Yes
TC	0.881	0.884	0.908	0.587	Yes
IPC	0.877	0.879	0.924	0.802	Yes
IPra	0.800	0.800	0.882	0.714	Yes
IP	0.839	0.841	0.879	0.511	Yes
ENP	0.795	0.796	0.907	0.830	Yes
NFP	0.813	0.813	0.915	0.843	Yes
TEP	0.831	0.834	0.922	0.855	Yes
SUSG	0.845	0.849	0.886	0.565	Yes

BD: Big Data, IoT: Internet of Thing, SFR: Smart Factory, CPS: Cyber Physical System, DT: Digital Transformation, TIC: Technology Innovation Competency, TMC: Technology Marketing Competency, TC: Technology Competency, IPC: Customer, IPra: Radical performance, IP: Innovative Performance, ENP: Environmental Performance, NFP: Non-Financial Performance, TEP: Technical Performance, SUSG: Sustainable Growth.

Discriminant validity between latent variables was tested for significance according to the Fornell-Larcker standard. Since the AVE square root value was greater than the highest correlation among latent variables, discriminant validity between latent variables was verified [135]. Table 11 shows the discriminant validity.

Table 11. Discriminant validity (Fornell–Larcker criterion).

Variables	BD	CPS	DT	ENP	IP	IPC	IPH	IPra	IoT	NFP	SFR	SUSG	TC	TEP	TIC	TMC
BD	0.858															
CPS	0.557	0.824														
DT	0.769	0.700	0.753													
ENP	0.377	0.397	0.473	0.911												
IP	0.454	0.422	0.586	0.462	0.715											
IPC	0.347	0.344	0.483	0.355	0.856	0.896										
IPH	0.216	0.223	0.326	0.281	0.637	0.447	1.000									
IPra	0.443	0.381	0.515	0.426	0.812	0.434	0.393	0.845								
IoT	0.613	0.600	0.884	0.396	0.520	0.427	0.287	0.459	0.799							
NFP	0.477	0.458	0.649	0.507	0.555	0.446	0.319	0.496	0.625	0.918						
SFR	0.486	0.531	0.875	0.420	0.531	0.438	0.308	0.462	0.758	0.599	0.847					
SUSG	0.493	0.517	0.667	0.748	0.589	0.464	0.342	0.536	0.629	0.880	0.606	0.752				
TC	0.515	0.514	0.686	0.507	0.544	0.432	0.329	0.486	0.656	0.576	0.630	0.659	0.766			
TEP	0.352	0.413	0.505	0.381	0.426	0.333	0.241	0.393	0.508	0.619	0.457	0.822	0.533	0.925		
TIC	0.312	0.425	0.516	0.366	0.429	0.341	0.267	0.380	0.483	0.541	0.510	0.588	0.700	0.524	0.771	
TMC	0.522	0.486	0.656	0.485	0.537	0.418	0.321	0.491	0.635	0.557	0.603	0.630	0.958	0.503	0.580	0.828

BD: Big Data, IoT: Internet of Thing, SFR: Smart Factory, CPS: Cyber Physical System, DT: Digital Transformation, TIC: Technology Innovation Competency, TMC: Technology Marketing Competency, TC: Technology Competency, IPC: Customer, IPH: Human Capital, IPra: Radical performance, IP: Innovative Performance, ENP: Environmental Performance, NFP: Non-Financial Performance, TEP: Technical Performance, SUSG: Sustainable Growth.

4.2. Verification of Structural Model

In Table 12, since all VIF values were less than 5, it was confirmed that there was no multicollinearity between constructs.

Table 12. Inner variance inflation factor (VIF).

	BD	CPS	IP	IPC	IPH	IPra	IoT	SFR	SUSG	TC	TIC	TMC
DT	1.000	1.000	1.887				1.000	1.000		1.000		
IP				1.000	1.000	1.000			1.420			
TC			1.887						1.420		1.000	1.000

BD: Big Data, IoT: Internet of Thing, SFR: Smart Factory, CPS: Cyber Physical System, DT: Digital Transformation, TIC: Technology Innovation Competency, TMC: Technology Marketing Competency, TC: Technology Competency, IPC: Customer, IPH: Human Capital, IPra: Radical performance, IP: Innovative Performance, SUSG: Sustainable Growth.

Verification results in Table 13, the variables and paths that were significant in affecting Sustainable Growth are as follows.

In the results of hypothesis testing in Table 13, the variables and paths significant to SMEs' innovation performance (IP) and sustainable growth (SUSG) are as follows.

Table 13. Hypothesis and Model verification.

Hypothesis		Path	Path Coefficient		Verification
			T-Statistics	*p* Values	
Core Model	H1	DT → IP	4.955	0.000	Accept
	H2	IP → SUSG	5.626	0.000	Accept
	H3	DT → TC	16.506	0.000	Accept
	H4	TC → IP	3.010	0.003	Accept
	H5	TC → SUSG	9.421	0.000	Accept
Mediation Model	Specific indirect effects	DT → IP → SUSG	3.387	0.001	Accept
		DT → TC → SUSG	7.459	0.000	Accept
		DT → TC → IP → SUSG	2.729	0.006	Accept
		TC → IP → SUSG	2.779	0.005	Accept
		DT → TC → IP	2.929	0.003	Accept
Comprehensive Model	Total effects	DT → SUSG	12.313	0.000	Accept
Model fit: SRMR (standard root mean square residual) for the entire model				0.0081 (Saturated model)	
Construct cross-validated redundancy					
	BD	DT	IP	SUSG	TC
SSO	1212.000	2424.000	2121.000	909.000	4242.000
SSE	692.770	2021.000	1710.668	623.129	3310.044
Q^2 (=1-SSE/SSO)	0.428	0.000	0.193	0.314	0.220

DT: Digital Transformation, TC: Technology Competency, IP: Innovative Performance, SUSG: Sustainable Growth.

- Core Model: Validation of hypotheses, variables, ad pathways affecting SUSG
    1. H1 (Accept): DT affects Innovative Performance (IP)
    2. H2 (Accept): IP affects Sustainable Growth (SUSG)
    3. H3 (Accept): DT affects Technology Competency (TC)
    4. H4 (Accept): TC affects Innovative Achievements (IP)
    5. H5 (Accept): TC affects Sustainable Growth (SUSG)
- Mediation Model: Specific indirect effects
    1. DT affects IP affects SUSG (Accept)
    2. DT affects TC affects SUSG (Accept)
    3. DT affects TC affects IP affects SUSG (Accept)
    4. TC affects IP affects SUSG (Accept)
    5. DT affects TC affect IP (Accept)

- Comprehensive Model: Total effects

  DT affects SUSG (Accept)

  Does DT affect the SUSG of SMEs? Which is the research question of this study. As a result of verification, it verified that not only DT affects SUSG, but also TC and IP are parameters that affect SUSG. Figure 4 shows the results of hypothesis testing of the structural model and details the variables that affect sustainable growth.

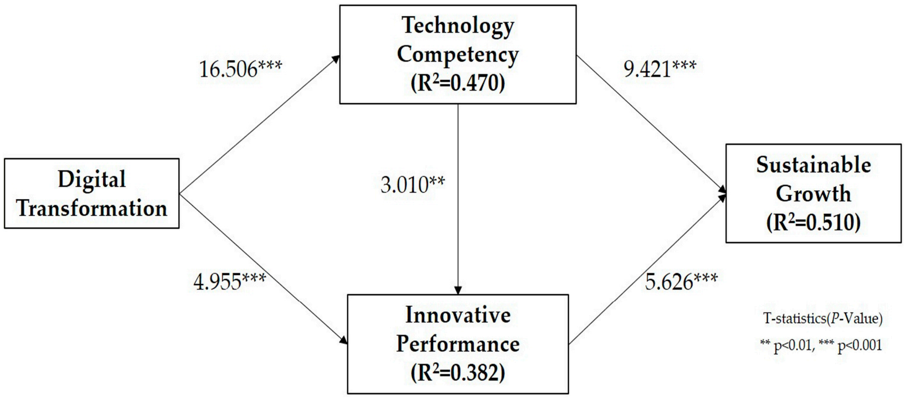

Figure 4. The structural model and hypothesis verification results.

Table 14 and Figure 5 present the most important results of this study. The influential variables affecting the SUSG of SMEs differed by industry sectors.

Table 14. Total Effects on Variables vs. Seven Industry Divisions.

	Total Effects (Overall)	Total Effects (Division 1)	Total Effects (Division 2)	Total Effects (Division 3)	Total Effects (Division 4)	Total Effects (Division 5)	Total Effects (Division 6)	Total Effects (Division 7)
	T Statistics/*p*-Value							
(H1) DT → IP	13.848/0.000	4.807/0.000	8.354/0.000	5.922/0.000	5.584/0.000	5.980/0.000	1.467/0.143	5.278/0.112
(H2) IP → SUSG	3.498/0.000	0.944/0.345	2.707/0.007	1.497/0.134	0.397/0.691	1.599/0.000	0.876/0.381	1.589/0.000
(H3) DT → TC	19.023/0.000	6.186/0.000	12.311/0.000	5.132/0.000	17.944/0.000	12.191/0.000	1.675/0.094	12.251/0.000
(H4) TC → IP	3.438/0.000	5.756/0.000	0.520/0.012	2.504/0.012	1.091/0.275	3.309/0.110	0.843/0.400	4.270/0.000
(H5) TC → SUSG	10.302/0.000	14.830/0.000	2.058/0.000	3.515/0.000	6.822/0.000	4.111/0.000	1.405/0.160	5.596/0.000
(Comprehensive) DT → SUSG	12.878/0.000	5.512/0.000	6.326/0.000	4.027/0.000	6.607/0.000	7.537/0.000	1.701/0.089	5.514/0.000

Overall: Sum of Division 1 to Division 7, Division 1: electrics/electronics, Division 2: machinery/parts, Division 3: IT/S, Division 4: chemicals/textiles/materials. Division 5: life/food, Division 6 (craft/other, Division 7: Bio-health, DT: Digital Transformation, TC: Technology Competency, IP: Innovative Performance, SUSG: Sustainable Growth.

The difference in the total effect on the variables representing the sustainable growth of SMEs by industry was shown. Figure 5 is the graph of Table 14, showing that the SUSG influence variables differ depending on the industry. This result showed that for SUSG, change or innovation of SMEs requires different directions and strategies depending on the industry.

Figure 5 shows the most important findings of this study, the influential variables by industry divisions.

In the total effect of DT affects SUSG, there is no difference in Overall (12.878) and Division 1, Division 2, Division 3, Division 4, Division 5, and Division 7, but Division 6 is insignificant.

In the total effect of DT affects TC, there is no significant difference in Overall (19.023) and Division 2, Division 4, Division 5, and Division 7, but there is a difference in Division 1 and Division 3, Division 6 is not significant.

In the total effect of TC affects SUSG, Division 1 showed a considerable value (14.830) compared to Overall (10.302), and Division 2, Division 3, Division 4, Division 5, and Division 7 showed small values, but Division 6is not significant.

These differences are surprising results confirmed in this study. It was verified that DT affects SUSG in all industries, but it is verified that the size of the effect is different depending on the industry. In other words, SMEs can apply DT for SUSG depending on the industry but can choose the TC-focused strategy method and the IP-focused strategy. By doing so, the effect of TC on SUSG and the effect of IP on SUSG can be compared and determined with the results of this study, which can be used to establish corporate strategies for SUSG of SMEs.

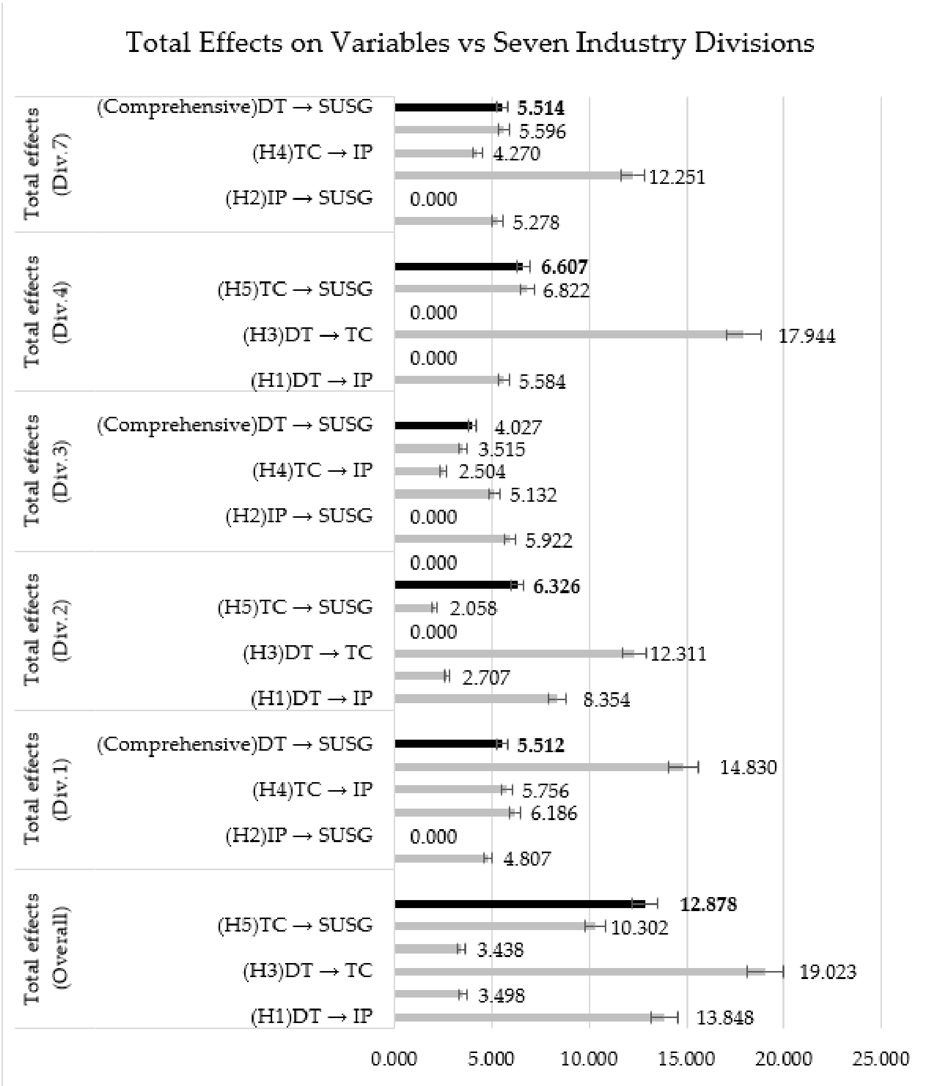

Figure 5. The total effect of the variables that influenced SUSG according to industry divisions. Overall: Sum of Division 1 to Division 7, Division 1: electrics/electronics, Division 2: machinery/parts, Division 3: IT/S, Division 4: chemicals/textiles/materials. Division 5: life/food, Division 6 (craft/other, Division 7: Bio-health, DT: Digital Transformation, TC: Technology Competency, IP: Innovative Performance, SUSG: Sustainable Growth.

5. Discussion

The basic previous research theory to present the conclusion is as follows.

DT maintains a sustainable business and positively impacts overall business performance [6]. The components of DT that significantly affect performance are IOP, CPS, IoT, SFR, and BD [1]. Sandri and Widodo (2020) [120] stated that innovative performance affects the economic performance, which is one of the indicators of sustainable growth.

Technological advances in I4.0 help entrepreneurs create new ways of delivering goods and services through technological innovation [70,71]. Technological competency is a critical competency that drives a company's sustainable growth and has comprehensive corporate characteristics that promote and support technological innovation [86]. Based on the results verified in this study, the SUSG influencing variables of SMEs can be presented as follows:

- Significant variables for the SUSG impact on SMEs were DT, TC, and IP. These results confirmed that DT affects SUSG [6–8].
- The critical parameters for the SUSG impact on SMEs were TC and IP. These results confirm that TC and IP influence SUSG [1,73,74].
- Differences in SUSG impact on SMEs by industry

1. There was no difference in Division 1, Division 2, Division 3, Division 4, Division 5, and Division 7 in the total effect of DT affects SUSG.
2. Division 4 > Division 1 > Division 2 > Division 7 > Division 5was the order of most significant total effect of DT affects TC, but it was relatively low in Division 1 and Division 3.
3. In the total effect of TC affects SUSG, Division 1 showed a significant value (14.830) compared to Overall (10.302), and Division 3, Division 4, Division 5, and Division 7 showed small values.
4. In the total effect of IP affects SUSG, only Division 2was significant, and the other Divisions were not significant.
5. The order of the total effect of TC affects IP was Division 1 > Division 7 > Division 5 > Division 3, but Division 1 and Division 2 were not significant.
6. Division 6 (crafts/others) had no variable relationship affecting SUSG. It is an analysis of the characteristics of an industry that relies on handicrafts, and it is a unique point.

These results are the distinctive and unique achievements of this study because the study on SUSG, according to the industry, was not seen in previous studies.

5.1. Hypothesis Testing

After verifying the significance of the direct effect, the mediating effect, the total effect, and the path coefficient, all five hypotheses were accepted.

1. H1 (Accept): DT affects IP
2. H2 (Accept): IP affects SUSG
3. H3 (Accept): DT affects TC
4. H4 (Accept): TC affects IP
5. H5 (Accept): TC affects SUSG

DT affects IP, and IP is verified as a variable that affects SUSG.
DT affects TC, and TC is verified as a variable that affects IP.
TC is verified as a variable affecting SUSG.

- Mediation Model: Specific indirect effects

  1. DT affects IP affects SUSG (Accept)
  2. DT affects TC affects SUSG (Accept)
  3. DT affects TC affects IP affects SUSG (Accept)
  4. TC affects IP affects SUSG (Accept)
  5. DT affects TC affects IP (Accept)

  DT affects SUG through the mediating effect of IP and TC.
  TC affects SUSG through the mediating effect of IP.
  DT affects IP through the mediating effect of TC.

- Comprehensive Model: Total effects

  DT affects SUSG (Accept)

Does DT affect the SUSG of SMEs, which is the research question of this study? As a result of verification, it was verified that not only DT affects SUSG, but also TC and IP are parameters that affect SUSG.

5.2. Differences in Variables according to Industry Divisions

The researcher made an important finding in this study that the variables that DT affects the sustainable growth of SMEs are very different depending on the industry classification divisions. DT, TC, and IP were the influencing variables of SUSG. This result is consistent with previous studies [1,6,70,71,85,120]. Overall effects were compared to determine differences between each influence variable. It was confirmed that the total effect representing the sustainable growth of SMEs differs by industry.

The difference between each influence variable is verified and presented. The magnitudes of the effects of the four variables were different, and the variables that affected them were also different. Since the variables that have the greatest impact while enabling the sustainable growth of SMEs are different for each industry, strategic change or technological innovation shows that different directions and strategies are needed for each industry.

The industries considered in this study are Division 1: Electrics/Electronic, Division 2: Machine/Parts, Division 3: IT/SW, Division 4: Chemical/Textile/Material, Division 5: Lifestyle/Food, Division 6: Crafts/Others, Division 7: medical/bio health.

Overall, there was no difference by industry in the total effect of DT affects SUSG. However, the total effect of DT affects TC was significant Division 4 > Division 1 > Division 2 > Division 7 > Division 5 but relatively low in Division 1 and Division 3. It can be seen that application of DT is complex or less necessary in IT/SW, life/food, craft/other industries.

The total effect of TC affects SUSG showed a significant value in Division 1, proving that the technical capability through DT is essential for the company's sustainable growth in the Electrics/electronic industry.

In the total effect of IP affects SUSG, only Division 2 (Machine/Parts) was significant, and the other Divisions were insignificant. This means that in the Machine/Parts industry, IP through DT directly affects SUSG.

Division 1 > Division 7 > Division 5 > Division 3 was the order of the total effect of TC affects IP, but Division 2 and Division 4 were not significant. This means that TC through DT directly affects IP, and Division 1 and Division 2 mean that the TC directly affects the SUSG rather than the TC affecting the IP.

It is an outstanding result that Division 4—Chemical/Textile/Material, Division 2—Machine/Parts, and Division 7—medical/bio health industries showed the most significant total effect in DT affects TC. This means that DT affected TC in this industry and eventually SUSG. This is an actual result of verifying that SUSG is possible for these industries if they comprehensively introduce DT and enhance their TC.

6. Conclusions

In conclusion, it was found that different strategies are needed depending on the industry because the influential variables that have the significant impact while enabling the sustainable growth of SMEs by applying DT are different depending on the industry sectors. The contributions of this study, which presents the meaning of influencing variables and differentiated strategies for each industry for the SUSG of SMEs, are as follows.

- Theoretical implications: Influential variables for the SUSG of SMEs vary by industry. DT affected SUSG in all seven industries. TC and IP mediated the SUSG effect of DT. Through empirical verification of the DT application of SMEs, it was confirmed that SUSG could be achieved by comprehensively introducing DT and strengthening technological capabilities.
- In conclusion, it was suggested that DT is essential for the SUSG of SMEs and that influencing variables suitable for the industry should be applied. The results of this study will be a new field of interest for future researchers.
- Industry and business implications:

- By presenting variables that must be considered by industry when promoting strategy revision and innovation for SUSG, practical SUSG influence variables that can overcome the limitations of existing studies are presented.

It is an outstanding result that Division 4—Chemicals/Textiles/Materials, Division 2—Machines/Parts, and Division 7—Medical/bio health industries showed the most significant total effect. DT has impacted the industry and, eventually, SUSG's technological capabilities. Also, Division 1 and Division 2 mean that TC directly affects SUSG, not TC affects IP. Furthermore, the researchers verified that DT is not applied to all industries, implying that for sustainable growth, it is necessary to differentiate the application strategy of DT according to the characteristics of the industry.

Therefore, when SMEs establish an innovation strategy for SUSG, the CEO and practitioners must decide together on two things.

(1) A strategy to improve TC by introducing DT and achieving SUSG.
(2) A strategy to improve TC and pursue SUSG through IP.

Different industries require different strategies.

The limitation of this study is that the changes in SMEs according to the DT effect cannot be directly demonstrated through the interview. First, there was a limitation in that the number of companies surveyed to compare each industry's impact on the sustainable growth of DT was small. Second, there were limitations in studying the variables affecting the continuous growth of DT by focusing on one industry group. Third, there were limitations in studying the variables that affect the continuous growth of DT according to the size of the company's sales.

In the future, researchers plan to conduct longitudinal and industry-specific studies to determine the direct impact of the adoption of DT on the future sustainability performance of SMEs.

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