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SMART ENTERPRISE: THE ROLE OF DIGITAL TRANSFORMATION AND INTELLECTUAL CAPITAL IN MALAYSIAN HIGH-TECH INNOVATION

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Abstract: This study investigates the relationship between intellectual capital and digital transformation in enhancing innovation performance in high-tech firms in Malaysia. The study adopts Partial Least Squares-Structural Equation Modelling (PLS-SEM) and relies on a structured questionnaire to collect data from 187 Malaysian Electrical and Electronics sector firms. Results indicate that the dimensions of intellectual capital (human, structural, and relational) improve the innovation performance of firms. Furthermore, digital transformation fully mediates this relationship, highlighting the critical importance of digital transformation as a key driver of firms' innovation performance. The findings offer novel insights into the role of intellectual capital and digital transformation in high-tech firms' innovation performance and suggest that policy makers and firms should pay close attention to developing intellectual capital dimensions to realize the benefits of digital transformation. The study recommends investments in both product and process innovation since they lead to better performance outcomes and can help organizations achieve competitive advantage and enhance their ability to innovate and create value for stakeholders.

Keywords: intellectual capital, human capital, relational capital, digital transformation, innovation performance, high-tech firms, Malaysia

INTRODUCTION

Innovation is considered a vital source of growth and competitiveness in modern day economies. In fact, the era of knowledge economy has even more intensified its importance. Therefore, firms are paying an enormous amount of attention to research and development (Liu et al., 2021). In doing so, they put their efforts to improve the existing products as well as processes. Further, they utmost capitalize their resources towards offering new products in the market in order to grow in adsdition to achieve competitive advantage over rivals

(Khan et al., 2020). Firms, especially large ones, are putting tremendous amounts of resources to acquire knowledge and innovation sources in the form of human capital. Human capital is commonly referred to education, experience, skills, emotional, cognitive intelligence level and several attributes of firms' employees (Lee et al., 2021). It is one of the most important components of intellectual capital of firms. Furthermore, social or relational capital is also utilized by firms in order to collaborate and cooperate with external partners on various innovation related projects. In addition, the structural or organizational capital is also given a vital attention as it enhances the organizational learning that ultimately contributes to the efficient facilitation of innovation. Altogether, these three forms of capital – human, social, and structural – are known as intellectual capital (Mubarik et al., 2022). Intellectual capital is closely associated to the learning whether it is related to technological, relational or organization related (Mubarak et al., 2021). Since the locus of innovation is knowledge and learning, therefore, intellectual capital influences innovation performance directly or through improving the innovation absorption capacity.

Furthermore, firms nowadays are heavily adopting and using the technology in their processes in the quest of doing improvements in products or processes. Industry 4,0 technologies have played an enormous role in this scenario to transform the firms based on digital technologies. The most important technologies of Industry 4.0 include blockchain, machine learning, big data, smart manufacturing, cyber physical systems, internet of things, and 3D manufacturing. These technologies not only enhance the processes efficiency but also contribute to improve the production and planning processes of firms (Ghobakhloo et al., 2022). The investments in such digital technologies are increasingly in routine, especially after the aftermath of Covid-19 where the disruption of global supply chain and manufacturing was occurred. At one side firms are putting their financial resources towards digital transformation, however, the ineffectiveness and mismanagement still seems to be in place. Researchers have reported it as lack of technology related absorptive capacity that leads towards implementation and optimum utilization and functioning of digital transformation (Mubarik et al., 2022; Kusi-Sarpong et al., 2022). However, the question that what makes to improve such competence of firms to manage the digital transformation that should lead to improve innovation performance still remains ambiguous. Therefore, this study tends to explore the answer of this question by doing empirical investigation. We study the high-tech manufacturing sector of Malaysia by zooming in the Electrical and Electronics firms.

THEORETICAL EXPOSITION Innovation performance

Innovation is defined as a process of creating novel ideas, products, or services that contribute value to the current world. It requires a combination of creativity, problem-solving, and the readiness to take risks to generate something that is not only innovative but also practical and advantageous. Innovation takes on different forms including technological, social, and business innovation. Technological innovation involves the development of new technologies or the enhancement of existing ones, while social innovation focuses on the exploration of new methods to address social issues. Business innovation is centered around the creation of new business models, products, or services that can introduce new revenue streams or disrupt the existing markets.

Innovation plays a pivotal role in economic growth as it can generate new employment opportunities, increase productivity, and enhance competitiveness. Moreover, innovation is an important factor in addressing major societal challenges such as climate change, poverty, and inequality. Innovation performance refers to an organization's ability to generate and implement innovative ideas, products, and processes. It is a crucial factor in achieving economic growth and competitiveness. According to a study by Du Preez and Louw (2018),

innovation performance can be measured by various indicators, such as research and development investments, patent applications, and new product introductions. By focusing on these indicators, organizations can identify areas where improvements can be made and foster a culture of innovation. Improved innovation performance can lead to increased profitability, market share, and productivity, while also addressing societal challenges such as poverty and inequality.

Innovation performance is a critical aspect of organizational success, particularly in today's fastpaced and rapidly changing business environment. According to Fagerberg and Srholec (2008), innovation performance refers to an organization's ability to generate and successfully implement new and creative ideas, products, and processes. Several indicators can be used to measure innovation performance. One of the most commonly used indicators is research and development (R&D) expenditures, which can be a measure of the resources dedicated to innovation. This is supported by the findings of the study conducted by Baumol et al. (2007), which revealed that R&D investments play a significant role in driving innovation performance. In addition to R&D investments, other indicators of innovation performance include patent applications, new product introductions, and customer satisfaction. These indicators can provide insight into an organization's ability to create and successfully introduce new products and services to the market, and to meet the evolving needs of customers. This is consistent with the findings of a study by Damanpour and Aravind (2012), which demonstrated that innovation performance is positively associated with the introduction of new products. Improving innovation performance requires a supportive environment and a culture of innovation within an organization. This includes providing employees with the necessary resources and incentives to generate and implement new ideas, as well as promoting a culture of experimentation and risk-taking. As noted by von Stamm (2018), organizations can foster innovation by creating an environment that encourages and rewards creativity and innovation. In a nutshell, innovation performance is an essential aspect of organizational success in today's fast-changing business environment. Organizations that prioritize innovation performance can achieve a competitive advantage and drive economic growth. By measuring innovation performance using various indicators and fostering a culture of innovation, organizations can improve their ability to generate and implement new and creative ideas, products, and processes.

Furthermore, Product and process innovation are two critical types of innovation that can help organizations to improve their competitiveness and performance. According to a recent study by Su et al. (2021), product innovation involves the development of new or improved products, while process innovation involves changes to the way products are produced or delivered. Product innovation is essential for organizations seeking to remain competitive in today's marketplace. As noted by Montoya-Torres et al. (2021), product innovation can lead to increased customer satisfaction and loyalty, as well as higher profits and market share. Moreover, product innovation can help organizations to address emerging customer needs and preferences, and to keep pace with technological advancements. Process innovation, on the other hand, can help organizations to achieve operational efficiencies and reduce costs. According to a study by Park et al. (2021), process innovation can lead to improvements in production processes, supply chain management, and customer service delivery. Additionally, process innovation can enable organizations to achieve environmental sustainability goals by reducing waste and resource consumption.

In order to achieve both product and process innovation, organizations need to foster a culture of innovation and provide employees with the necessary resources and incentives to generate and implement new ideas. As noted by von Stamm (2018), organizations can achieve this by promoting a culture of experimentation and

risk-taking, providing training and development opportunities, and creating an environment that rewards creativity and innovation. Recapitulating the facts, product and process innovation are critical for organizations seeking to remain competitive and achieve long-term success. By investing in product and process innovation and fostering a culture of innovation, organizations can improve customer satisfaction, increase profitability, and achieve environmental sustainability goals.

Product and process innovation are widely considered suitable indicators of innovation performance due to their significant impact on organizational success and competitiveness. As noted by Hu et al. (2021), product and process innovations are essential for firms seeking to maintain their market position and drive sustainable growth. Product innovation is particularly crucial as it enables firms to introduce new or improved products that meet emerging customer needs and preferences. According to a recent study by Christensen and Overdorf (2021), product innovation can lead to higher sales, increased market share, and improved customer satisfaction. Similarly, process innovation can help firms improve their efficiency, reduce costs, and enhance customer service. As noted by Huenteler et al. (2021), process innovation can also enable firms to achieve environmental sustainability goals by reducing resource consumption and waste. Other indicators of innovation performance, such as R&D spending and patent filings, have limitations in measuring the actual impact of innovation on organizational success. As noted by Arora et al. (2021), R&D spending may not always lead to successful innovation outcomes, while patent filings may not capture all forms of innovation, particularly those that involve business model or service innovation. In contrast, product and process innovation are directly linked to organizational outcomes and can be measured through a range of metrics such as sales growth, profit margins, and customer satisfaction. According to a study by Su et al. (2021), firms that invest in both product and process innovation tend to perform better than those that focus solely on one or the other. Therefore, product and process innovation are suitable indicators of innovation performance due to their direct link to organizational outcomes and impact on competitiveness. While other indicators such as R&D spending and patent filings have their utility, they may not provide a comprehensive picture of organizational innovation performance.

Intellectual capital

Intellectual capital (IC) has been recognized as a crucial source of competitive advantage for organizations. According to Bontis and Chua (2019), IC refers to the intangible assets of an organization that are not recorded in financial statements but can have a significant impact on its value and performance. The three main components of IC are human capital, structural capital, and relational capital (Marr and Moustaghfir, 2019). Human capital is the knowledge, skills, and capabilities of individuals within the organization (Sveiby, 2019). It is important for organizations to attract and retain talented employees who possess the necessary knowledge and expertise to drive innovation and growth (Li and Guo, 2020). Research has shown that investing in human capital can lead to improved organizational performance and financial outcomes (Huang and Chen, 2020). Structural capital, on the other hand, refers to the processes, systems, and intellectual property of an organization (Bontis and Chua, 2019). It includes the organization's patents, trademarks, and other proprietary assets that are used to create value and support its operations (Marr and Moustaghfir, 2019). Structural capital can be developed through investments in research and development, technology, and organizational learning (Jamil et al., 2021). Finally, relational capital refers to the relationships and networks that an organization has with its stakeholders, including customers, suppliers, and partners (Sveiby, 2019). These relationships can be a source of valuable information, resources, and support that can help organizations to innovate and create

value (Marr and Moustaghfir, 2019). Research has shown that organizations that invest in building strong relationships with their stakeholders can achieve better performance outcomes (Bharadwaj et al., 2021). Altogether, IC is a valuable asset that can help organizations to achieve competitive advantage in today's knowledge-based economy. By investing in human, structural, and relational capital, organizations can enhance their ability to innovate and create value for their stakeholders.

The role of intellectual capital (IC) in enhancing digital transformation and innovation performance has gained increasing attention in recent years. IC comprises of human, structural, and relational capital, and has been identified as a critical resource that enables organizations to innovate and create value in the digital age (Ahmed et al., 2021). Human capital, which includes the knowledge, skills, and expertise of individuals within the organization, is particularly important for digital transformation and innovation (Jiang et al., 2021). Organizations need to attract and retain employees who possess digital skills and expertise and invest in training and development to build a digital-savvy workforce (Lee et al., 2020). Research has shown that organizations that prioritize the development of human capital for digital transformation can achieve better innovation performance and financial outcomes (Qazi et al., 2021). Structural capital, which comprises of the organization's processes, systems, and intellectual property, is also important for digital transformation and innovation (Ahmed et al., 2021). Organizations need to invest in digital technologies and tools, such as artificial intelligence and data analytics, to enhance their capabilities for innovation and value creation (Gallardo-Vázquez et al., 2020). Structural capital can also be leveraged to create digital platforms and ecosystems that enable collaboration and knowledge sharing among stakeholders, leading to enhanced innovation performance (Liu et al., 2021). Moreover, relational capital, which refers to the organization's relationships and networks with stakeholders, is also critical for digital transformation and innovation (Jiang et al., 2021). Organizations need to build strong partnerships with technology vendors, customers, and other stakeholders to access new technologies and markets, and to leverage external expertise for innovation (Liu et al., 2021). Research has shown that relational capital can positively influence innovation performance in the digital era (Gallardo-Vázquez et al., 2020). In summary, IC is a valuable resource that can enable organizations to enhance their digital transformation and innovation performance. By investing in human, structural, and relational capital, organizations can build a digital-savvy workforce, develop digital capabilities, and create collaborative networks that support innovation and value creation.

Digital transformation

Digital transformation (DT) has become a popular buzzword in recent years, referring to the adoption of digital technologies to transform business processes, operations, and customer experiences (Khan et al., 2020). DT has been identified as a critical driver of innovation and competitive advantage in the digital age (Liu et al., 2020). DT involves the integration of digital technologies such as cloud computing, big data analytics, artificial intelligence, and the Internet of Things into an organization's processes and systems (Chen et al., 2021). This enables organizations to improve efficiency, agility, and innovation capabilities, leading to enhanced customer experiences and value creation (Lee et al., 2018; Mubarak et al., 2023). However, DT is not a onesize-fits-all solution, and its success depends on various factors such as organizational culture, leadership, and capabilities (Liu et al., 2020; Shahbaz et al., 2019; Mobashar and Mubarak, 2020). Research has shown that organizations that prioritize the development of digital capabilities, such as digital literacy and skills, can achieve better DT outcomes and financial performance (Chen et al., 2021). Moreover, organizations that embrace a customer-centric approach to DT can improve customer satisfaction and loyalty (Khan et al.,

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2020). Succinctly, DT is a key driver of innovation and value creation in the digital age. By integrating digital technologies into their processes and systems, organizations can improve efficiency, agility, and innovation capabilities, leading to enhanced customer experiences and financial performance.

Digital transformation (DT) has emerged as a key driver of product and process innovation in firms (Liu et al., 2021). By integrating digital technologies into their operations and processes, firms can improve their innovation capabilities, leading to increased competitiveness and improved financial performance (Palludari et al., 2021). DT can improve product innovation by enabling firms to leverage advanced data analytics and machine learning algorithms to identify customer needs and preferences, leading to the development of more customer-centric products (Gupta et al., 2020). Moreover, DT can improve the speed and efficiency of the product development process, enabling firms to bring products to market faster and more cost-effectively (Sohrabi et al., 2021). In addition to product innovation, DT can also enhance process innovation by enabling firms to streamline their operations, reduce costs, and improve efficiency (Liu et al., 2021). DT can enable firms to automate routine tasks, freeing up resources to focus on higher-value activities such as innovation and customer engagement (Kuusisto et al., 2020). Altogether, DT has the potential to significantly improve the product and process innovation capabilities of firms. By leveraging advanced data analytics, machine learning, and automation technologies, firms can develop more customercentric products and streamline their operations, leading to increased competitiveness and improved financial performance.

Conceptual framework

This study undertakes the theoretical underpinning of dynamic capability view that posits that firms should adjust their competencies and capabilities corresponding to the dynamic market conditions (Teece et al., 1997). Therefore, the vital competence of nowadays' knowledge economy is intellectual capital capability that is considered as a critical form of intangible asset of firms that can not only enable the competitiveness but also enhance the innovation related performance (Mubarak et al., 2022). Furthermore, in current times firms are increasingly adopting and shifting their entire process on technology that highlights the vitality of digital transformation. It is one of the capabilities that can also contributes to the firm's growth and success (Ghobakhloo et al., 2022). Therefore, this study hypothesize that intellectual capital is an essential capability of firms that can improve the innovation performance. Moreover, the digital transformation can be improved with the help of intellectual capital that can lead to upgrade the innovation performance. These facts are illustrated in the conceptual framework of study shown in figure 1.

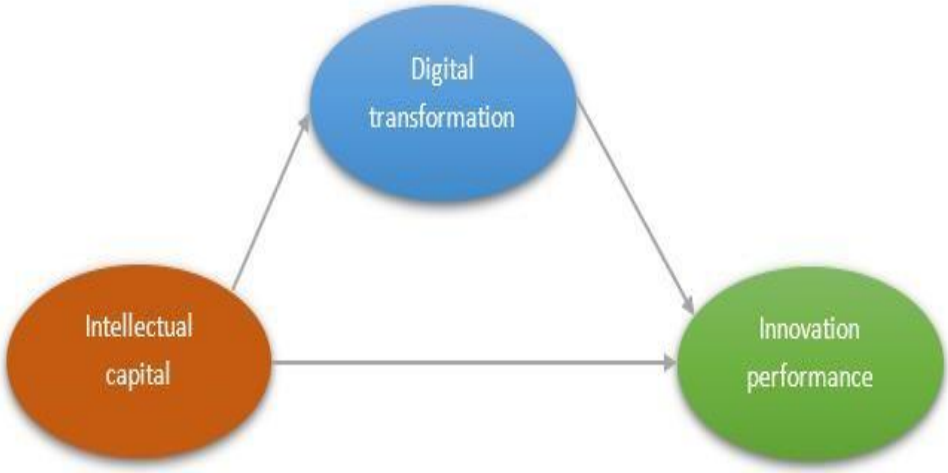

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Figure 1: Conceptual framework of study

RESEARCH METHODOLOGY

This study applies the quantitative research method by adopting the deductive approach of research. In doing we embrace the positivism philosophy of research and report the hypothesized relationship of study through empirical investigation. In order to collect the data, we developed a structured questionnaire based on the variables of study. The questionnaire is developed based on the extant literature by considering the questionnaire items of intellectual capital that are taken from Mubarik et al. (2022), Digital transformation from Ghobakhloo et al. (2020), and innovation performance taken from Su et al. (2021) By applying the purposive sampling, we sent questionnaire to 412 Electrical and Electronics sector firms of Malaysia by using online mode.

RESULTS

We received 190 questionnaires out of which 3 were incomplete and 187 were considered for data analysis. The age of the respondents' firms was 27% from 1 to 5 years, 44% were 6 to 10 years, 19% of 11 to 15, while 18% were more than 16 years of age. It shows that responding firms considered for data analysis well address the newly entrants, medium level experts, and highest expert level of responses. However, the employees of entrant level, and medium level often have experience from the oldest firms that rules out the significant level of difference across the agerelated categories.

In order to check the quality of construct reliability, consistency and validity were checked. In doing so factor loadings, Cronbach Alpha, composite reliability (CR), average variance extracted (AVE) were assessed. The results shows that Cronbach alpha values are higher than 0.60 that are acceptable as per Hair et al. (2014). Moreover, Cronbach alpha values are also higher than 0.70, CR values are more than 0.80, and AVE are more than 0.50 that are within the acceptable threshold according to the guidelines of Hair et al. (2014) required for the suitable quality of construct. Hence, we establish that the construct is reliable, consistent, and valid enough to proceed further for model testing. The results are shown in table 1.

Table 1: Reliability, Consistency and Validity

Construct	Items	Loadings	CB alpha	CR	AVE
Intellectual capital	HC1	0.83	0.81	0.83	0.52
	HC2	0.71			
	HC3	0.69			
	SC1	0.82			
	SC2	0.76			
	SC3	0.78			
	RC1	0.71			
	RC2	0.68			
	RC3	0.72			
Digital transformation	DG1	0.73	0.79	0.87	0.54
	DG2	0.75			
	DG3	0.84			
	DG4	0.79			

	PDI1	0.76	0.77	0.86	0.55
Innovation performance	PDI2	0.77			
	PDI3	0.71			
	PC1	0.74			
	PC2	0.72			
	PC3	0.81			

Note: *The items' loading less than 0.60 were removed.*

Before testing the hypotheses of study, the discriminant validity was assessed by testing the Fornell-Larcker criteria. The values shows that the study variables are distinct enough to each other to focus the different concepts they have in their ambit. In a nutshell, the results shows that there are not any issues such as collinearity between items, and hints the construct as discriminant valid. The results are shown in table 2.

Table 2: Fornell-Larcker Criteria for Discriminant Validity

				INP
	VIF	**INC**	**DTR**	
Intellectual capital (INC)	1.99	***0.72***		
Digital transformation (DTR)	2.14	0.36	***0.73***	
Innovation performance (INP)	2.87	0.39	0.41	***0.74***

Note: Diagonal values are square root of AVE

Finally, after assessing the construct diagnostic tests related to reliability, validity, and other aspects, the hypothesis testing was performed. The results shows that Intellectual capital positively impacted the innovation performance of firms with respect to product as well as process related where the values are B=0.46, p-value=0.004. It confirms the acceptance of first hypothesis. In addition, the mediating role of digital transformation between intellectual capital and innovation performance was also tested. The results reveal that digital transformation mediates the association of intellectual capital and innovation at B=0.62, p-value 0.000. The results are shown in table 3.

Table 3: Hypotheses testing

Hypotheses		**p-value**		**Accept/Reject**
Hypothesis 1	Intellectual capital → Innovation performance	0.00	4	Accepted
	Intellectual capital → Digital transformation			Accepted
Hypothesis 2	→Innovation performance	0.000		

DISCUSSION AND IMPLICATIONS

Firms are increasingly focusing their innovation performance where they put efforts to improve innovation linked with products as well processes. In addition to financial investments for innovation performance where they adopt and utilize the digital technologies. Firms aim to elevate their innovation performance while achieving the growth and competitiveness. However, the set of intangible capital and competence is also inevitable to achieve the very purpose. This study confirms that intellectual capital supports innovation performance of firms. In its ambit where human, relational, and organizational capital exist, they play role to improve the knowledge, firms' relationships, and organizational learning that led to enhance the overall innovation performance of firms, as also confirmed by Mubarik et al. (2022) and others. Furthermore, the components of intellectual capital improve the technology absorption through knowledge, relationships, and organizational learning. These together cultivate the technology related absorption that leads to upgrade the

digital transformation. Not only this, but they also enable the optimum utilization of digital transformation in several aspects and functions that leads to improve the innovation performance. In doing so the firms are equipped to improve the existing products or offer a new product. As well, they tend to improve their processes that increase the overall efficiency and streamlined the functions as also described by Kusi-Sarpong et al. (2022) who confirmed the intellectual capital and blockchain based digital transformation that led to upgrade the entire value chain.

The digital transformation and intellectual capital (IC) have significant implications for firms to enhance product and process innovation. The use of IC, including human, structural, and relational capital, can foster innovation by generating and implementing new ideas, while digital transformation can offer efficient tools to enable knowledge sharing, communication, and collaboration. This essay aims to provide insights into the policy and practical implications of IC and digital transformation on product and process innovation of firms. Governments can play a vital role in promoting IC and digital transformation by supporting education and training programs to enhance skills and knowledge. Education can provide individuals with skills and knowledge to generate and utilize IC, while training can equip employees with the necessary digital skills to use digital tools efficiently. For instance, the European Union's Horizon Europe program aims to promote IC and digital transformation by allocating a budget of €95.5 billion to support research and innovation activities (European Commission, 2021). Moreover, governments can encourage firms to invest in IC by providing tax incentives and regulatory frameworks. For example, Japan's Act on Facilitation of Business Innovation allows companies to deduct a portion of their IC investment from their taxable income (Japanese Government, 2021). This policy can stimulate firms to invest in IC, leading to the creation and implementation of innovative ideas. Digital transformation provides firms with efficient tools to enhance communication, collaboration, and knowledge sharing, thereby improving product and process innovation. For example, digital platforms like Microsoft Teams, Slack, and Trello can facilitate real-time communication, collaboration, and project management, enabling firms to share knowledge and implement innovative ideas quickly (Acar & Tarhini, 2020). Moreover, digital transformation can enable firms to collect and analyze data, providing valuable insights to inform the development of innovative products and processes. For instance, the use of data analytics tools can help firms to identify customer preferences and market trends, leading to the creation of innovative products and services (Leydesdorff, 2020). Finally, firms can leverage IC to foster innovation by creating a culture that values and rewards innovation. This can be achieved by offering incentives, recognition, and training programs that encourage employees to generate and implement innovative ideas. For instance, Google's "20% time" policy allows employees to spend 20% of their work time on innovative projects, leading to the development of innovative products like Gmail and Google Maps (Dixon, 2021). In a nutshell, the use of IC and digital transformation can improve product and process innovation in firms. Governments can promote IC and digital transformation by supporting education and training programs, providing tax incentives, and creating regulatory frameworks. Firms can leverage digital tools to enhance communication, collaboration, and data analytics, while fostering a culture that values and rewards innovation. The given policy and practical implications can help firms to remain competitive in today's rapidly changing business environment.

CONCLUSIONS AND FUTURE RESEARCH DIRECTIONS

This study implies that in order to improve the innovation performance the soft side of capabilities should be developed. Since the intangible capabilities are hard to imitate that is why the source of competitive advantage

and growth can be taped through these. Intellectual capital is one of such key capabilities that encapsulates the holistic nature of competence that are related to education, skill, expertise, relational aspects, and organizational aspects. Its dimensions named human, social, and organizational or structural capital play an important role in improving the firm's innovation performance where they help to realize product and process related innovation. This study also dispels the conventional wisdom that says that digital transformation can lead to innovation or innovation performance, or innovation output. However, what makes the digital transformation works, as the people who are adopting, implementing, and using the technologies of digital transformation are of course human. Therefore, it is crucial to develop the capacity to absorb the knowledge of products and process as well as technology in the form of absorptive capacity and technology absorptive capacity. The intellectual capital level should be developed in order to enhance such absorption capacity of firm that will lead to the successful implementation and optimum usage of digital transformation technologies. By doing so, the technological infrastructure of digital transformation will ultimately promote the innovation in product and processes. This research has only focused the high-tech firms, future researchers are suggested to investigate across the typology of technology. Moreover, future research should consider taking the service sector firms as this study only considers manufacturing sector firms. Moreover, cross country comparison is also suggested between developed and developing countries in future research.

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