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Research Article / *Araştırma Makalesi*

THE CURVILINEAR INFLUENCE OF DIGITAL TECHNOLOGY SCOPE ON TECHNOLOGICAL VERSUS ORGANIZATIONAL INNOVATION

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ABSTRACT

The adoption of digital technologies, such as artificial intelligence, cloud computing, smart devices, robotics, and blockchain, has been an important topic for firms and organizations. This study examines the link between digital technology scope and innovation by highlighting differences between technological and organizational innovation. Existing studies have proposed that digital technologies have a positive influence on innovation. However, some studies have also highlighted the dark sides of digitalization. In particular, this study argues that firms using a wide range of digital technologies experience negative returns on innovation after a certain point. This study also proposes that this negative return is more likely to happen for organizational innovation. This study tests its hypotheses by using the Eurostat Flash Eurobarometer No. 486 dataset, with a final sample of 15,448 firms from EU and non-EU countries. The hypotheses are supported. The results suggest that digital technology scope negatively influences innovation after a certain point and this negative curvilinear effect is more pronounced for organizational innovation than technological innovation. This study advances the digitalization literature by highlighting the negative returns of digital technologies. It also contributes to digitalization literature by highlighting the differences between technological and organizational innovation when investigating the impact of digital technologies.

Keywords: *Digital Technology Scope, Technological Innovation, Organizational Innovation*

JEL Classification: *O32, M15, O33*

DİJİTAL TEKNOLOJİ KAPSAMININ TEKNOLOJİK VE ÖRGÜTSEL YENİLİK ÜZERİNDEKİ ETKİSİ

ÖZET

Yapay zeka, bulut bilişim, akıllı cihazlar, robotik ve blok zinciri gibi dijital teknolojilerin kullanılması firmalar ve örgütler için önemli bir konu başlığıdır. Bu çalışma, teknolojik ve örgütsel inovasyon arasındaki farkları vurgulayarak dijital teknoloji kapsamı ve inovasyon arasındaki ilişkiyi araştırmaktadır. Mevcut çalışmalar, dijital teknolojilerin inovasyon üzerinde olumlu etkisi olduğunu öne sürmüştür. Ancak, bazı çalışmalar dijitalleşmenin karanlık taraflarını da vurgulamıştır. Özellikle, bu çalışma, çok çeşitli dijital teknolojiler kullanan firmaların belirli bir noktadan sonra inovasyonda olumsuz getiriler yaşadığını öne sürmektedir. Bu çalışma ayrıca, bu olumsuz getirinin örgütsel inovasyon için gerçekleşme olasılığının daha yüksek olduğunu öne sürmektedir. Bu çalışma, hipotezlerini AB ve AB dışı ülkelerdeki 15,448 firmadan oluşan nihai bir örneklemle Eurostat Flash Eurobarometer No. 486 veri setini kullanarak test etmektedir. Çalışma sonuçları hipotezlerin desteklendiğini göstermektedir. Sonuçlar,

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dijital teknoloji kapsamının inovasyonu önce pozitif, belirli bir noktadan sonra negatif etkilediğini ve bu ters-U etkisinin teknolojik inovasyondan daha belirgin bir şekilde örgütsel inovasyon için geçerli olduğunu göstermektedir. Bu çalışma, dijital teknolojilerin olumsuz getirilerini vurgulayarak dijitalleşme literatürüne katkıda bulunmaktadır. Ayrıca, dijital teknolojilerin etkisini araştırırken teknolojik ve örgütsel inovasyon arasındaki farkları vurgulayarak dijitalleşme literatürüne katkıda bulunmaktadır.

Anahtar Kelimeler: *Dijital Teknoloji Kapsamı, Teknolojik Yenilik, Örgütsel Yenilik*

JEL Sınıflandırması: *O32, M15, O33*

1. Introduction

Digital technologies are defined as combinations of information, computing, communication, and connectivity technologies (Bharadwaj et al., 2013). Examples of digital technologies include artificial intelligence, blockchain, robotics, smart devices, big data analytics, and the internet of things. Digital technologies reshape manufacturing systems, workplace, business models, customer expectations, and markets thereby having dramatic impacts on businesses and societies (Dabrowska et al., 2022; Marsh et al., 2022; Nambisan et al., 2019). Digital technologies enable firms to access new digital resources, increase flow of knowledge, and lower transaction and production costs (Mithas & Rust, 2016; Yoo et al., 2012). In contrast, some studies have suggested the dark implications of digital technologies, such as complex interrelationships among digital technologies, lack of management skills for complex digital adoption, employee resistance, and coordination costs (Brynjolfsson & Mitchell, 2017; Elbanna & Newman, 2022; Marsh et al., 2022; Ruiz-Alba et al., 2020).

Extant studies investigating the implementation of digital technologies on innovation have neglected some important points. First of all, much of the literature has focused on the positive, linear impacts of the adoption of digital technologies on innovation (Ferreira et al., 2019; Hassan et al., 2024; Tsou & Chen, 2023; Zimmermann et al., 2024). Researchers have explored enabling technologies such as Industry 4.0 (Sarbu, 2021), information technology (Kroh et al., 2018; Qin et al., 2021), digital platforms (Li et al., 2025; Sarwar et al., 2024), artificial intelligence (Gama & Magistretti, 2025), and big data analytics (Niebel et al., 2019). Nevertheless, recent evidence suggests that the relationship between the adoption of digital technologies and innovation may follow a non-linear pattern (Kohtamaki et al., 2020; Usai et al., 2021).

Second, prior research has suggested that firms can adopt a single digital technology or multiple digital technologies at the same time or over time, which is called as digital technology scope (Blichfeldt & Faullant, 2021; Sinha et al., 2025; Wang et al., 2024). Most previous studies have focused on the effect of single digital technology, i.e. artificial intelligence, cloud computing, or metaverse on innovation. However, the impact of digital technologies on innovation based on a broader set of digital technologies (i.e. digital technology scope) has not yet been investigated. Digital technologies are interrelated and they build on each other (Blichfeldt & Faullant, 2021). Therefore, it is important to examine the impact of digital technology scope on innovation.

Third, we do not know whether the impact of the digital technology scope on innovation varies between technological and organizational innovation (Lee et al., 2020). During the

innovation process, firms can transform new ideas into new products, processes, organizational structures, and new management approaches (Birkinshaw, 2006; Damanpour, 2010). In this regard, existing literature makes a clear distinction between technological and organizational innovation. Technological innovation refers to "the implementation of an idea for a new product or a new service or the introduction of new elements in an organization's production process or service operation" (Damanpour & Evan, 1984: 394). Organizational innovation is defined as "new approaches in knowledge for performing the work of management and new processes that produce changes in the organization's strategy, structure, administrative procedures, and systems" (Damanpour & Aravind, 2011). This study argues that when studying the influence of digital technology scope on innovation, it is important to consider both technological and organizational innovations together. There is little research that investigates this topic from the perspective of different types of innovation in particular organizational innovation (Athaide et al., 2025; Lee et al., 2020). Therefore, the present study seeks to empirically test a framework that links digital technology scope with different kinds of innovation.

To address these gaps, this research investigates the curvilinear relationship between digital technology scope and different types of innovation i.e. technological and organizational innovation. Drawing on the resource-based view (Barney, 1991), this research argues that digital technology scope will have a non-linear relationship with innovation. In effect, digital technology scope may help firms increase their innovation by increasing their access to information and knowledge (Nambisan et al., 2017; Wan et al., 2023). Yet, excessive reliance on digital technologies may become counterproductive (Usai et al., 2021). This study advances digitalization literature by showing that digital technology scope has positive impacts on innovation but the positive returns decrease after a certain level due to increased coordination and implementation costs. This research addresses an important gap for deeper investigation of the non-linear effects of digital technologies (Dabrowska et al., 2022). Moreover, this study expands existing research on digitalization literature by indicating that digital technology scope has an inverted U-shaped influence on both technological and organizational innovation. The results also indicate that this decreasing effect is more pronounced for organizational innovation. In doing so, this research highlights the differences between innovation types when investigating the non-linear effect of digital technologies. This research tests its hypotheses using data from the Flash Eurobarometer 486 survey with a sample of 15,448 firms.

2. Literature Review

2.1. Innovation

Undertaking innovative activities has been one of the main antecedents of firm performance (Crossan & Apaydin, 2010). The innovation process is continuous and complex, and the literature suggests that there are different antecedents to explain different types of innovation in firms (Barney et al., 2011). The importance of internal knowledge and unique resources has been highlighted to explain innovation potential in firms (Barney, 1991; Grant, 1996). In addition, capabilities, skills, and adaptation to technological changes are also highlighted as the drivers of innovation (Eisenhardt & Martin, 2000). Recently, the usage of digital technologies has been proposed as an important antecedent of innovation (Nambisan et al., 2017; Hassan et al., 2024).

2.2. The Adoption of Digital Technologies

Digital technologies are important to restructure economic and social activities. Some digital technologies can have disruptive impacts while others can have a more incremental impact (Ciarli et al., 2021). Previous studies have suggested that digital technologies are the means to improve firms and produce new goods and services (Ciarli et al., 2021; Hinings et al., 2018; Nambisan et al., 2017). These technologies enable users to formalize, store, and share a huge and diverse amount of information. For instance, big data analytics can enable firms to access wider data and records thereby improving firms' operational efficiency (Toga & Dinov, 2015). In addition, cloud computing and internet of Things increase productivity and reduce production costs (Caputo et al., 2016; Lian et al., 2014). Artificial intelligence can also alter the nature and structure of new products and services by collecting, analyzing, and applying data (Gama & Magistretti, 2025). Overall, digital technologies open up new opportunities for firms by changing value creation mechanisms (Del Giudice et al., 2018; Hanelt et al., 2020; Nambisan et al., 2017). Despite these positive insights, prior research has also discussed that digitalization can have dark implications, such as the complexity and coordination costs of digitalization (Benitez et al., 2022; Hanelt et al., 2020; Sarwar et al., 2024). In particular, implementing multiple digital technologies at the same time can create complexity costs for firms due to their management and implementation difficulties (Brynjolfsson & Mitchell, 2017; Usai et al., 2021). Therefore, the dark side of implementing digital technologies should not be overlooked (Dabrowska et al., 2022).

2.2.1. The Influence of Digital Technology Scope on Innovation

Digital technology scope enables firms to access different knowledge and information by applying a wide range of digital technologies. Digital technologies increase firms' innovation potential through the knowledge dissemination (Wan et al., 2023). Digital technologies could increase the efficiency of firms in storing the required knowledge and information (Gupta & Misra, 2016). These digital technologies can also inform firms about the changes in customer preferences and market demand. Firms can acquire effective information to respond to the market demand of customers (Gomez et al., 2017). Sharing information about such changes in preferences can enable firms to create new products and services (Huenteler et al., 2016).

In addition, applying different digital technologies makes firms' internal processes more efficient, such as increased response speed and organizational flexibility, thereby enabling firms to create new innovations. For example, firms implementing robotic technologies into their activities speed up their production time and offer affordable prices to the customers (Blichfeldt & Faullant, 2021). Moreover, cloud computing enables firms to quickly develop and test new products, and make their innovations available to their customers (Boss et al., 2007). Finally, the implementation of digital technologies enriches firms' abilities to gain new external resources. Different digital technologies enable firms to acquire new resources through resource acquisition channels and reduce acquisition costs (Boeker et al., 2021). Identifying potential opportunities and capturing them successfully enhances firms' ability to efficiently follow changes in the market.

Although implementing digital technologies increases innovation, this research argues that increasing numbers of adopted digital technologies have negative consequences for innovation. Integrating a greater number of digital technologies and converting it into innova-

tive outcome is more demanding, complicated, and expensive. Consequently, as the number of adopted digital technologies increases, complexity and coordination costs rise, resulting in fewer innovative outcomes (Brynjolfsson & Mitchell, 2017). The adoption of multiple digital technologies can be challenging because of their complex nature and limited understanding (Benitez et al., 2022; Cenamor et al., 2019). Applying digital technologies requires firms to adjust their culture, work practices, processes, and routines (Garud & Karunakaran, 2018). Firms might need to transform their ways of doing business to be successful in this process of implementation (Eden et al., 2019; Nambisan et al., 2019). The lack of supporting activities and knowledge base to efficiently exploit such digital technologies can increase coordination and complexity costs (Usai et al., 2021). Uncertain outcomes of new digital technologies can increase ambiguity inside organizations. This can result in inefficiencies in organizations and increasing coordination costs.

In addition, in order to benefit from different digital technologies, firms need to invest in other capabilities and skills, which can increase implementation costs. If firms lack such capabilities and skills they can either take longer times to yield or lead to missing returns (Gama & Magistretti, 2025; Wamba et al., 2017). For instance, personnel might not have the knowledge and skills to use the new systems. Leaders need to develop certain skills, such as open communication, understanding technologies, and increasing the acceptance of such technologies by employees, thereby creating a supportive environment (Hanelt et al., 2020; Hwang & Seo, 2025; Solberg et al., 2020). Developing digital leadership skills becomes important to lead the integration processes of these technologies (Benitez et al., 2022). In addition, firms need to develop capabilities in different areas such as operations, customer needs, and innovation (Fitzgerald et al., 2013). Overall, the implementation of new technologies and processes can be costly and take time and increase payback times (Kohtamaki et al., 2020). Therefore, this study proposes that;

Hypothesis 1: Digital technology scope has a negative curvilinear effect on innovation.

2.2.2. Digital Technology Scope and Technological Innovation

Damanpour & Evan (1984: 394) define technological innovation as "the implementation of an idea for a new product or a new service or the introduction of new elements in an organization's production process or service operation." Application of digital technologies enables firms to build a competitive advantage through new resources and capabilities. Firms can create and deliver products and processes by using such technologies and changing their routines and practices. They enable firms to create differentiated and customized products or value-added services (Radicic & Petkovic, 2023). The application of different digital technologies makes firms' internal products and delivery processes more efficient, and enables firms to achieve the highest degree of resource effectiveness (Nambisan et al., 2017). For example, usage of robotics technologies can speed up the manufacturing process and enable firms to offer affordable prices to their customers (Blichfeldt & Faullant, 2021). Digital technologies can also enable firms to have more data from their customers and thereby better predict the changes in preferences. Cloud computing can enable firms to access important information about target customers in order to develop their products or services (Usai et al., 2021). Firms can determine the market potential for new products in several industries by adopting cloud computing technology. In addition, artificial intelligence technology helps firms sense, interpret, and evaluate

information thereby creating novel values (Verganti et al., 2020). Overall, this shows that each digital technology provides different resources and capabilities to firms. Therefore, the adoption of a broad range of digital technologies increases firms' ability to introduce new products and processes (Blichfeldt & Faullant, 2021; Goduscheit & Faullant, 2018).

Although the positive influence of digital technologies on technological innovation has been proved, this research argues that each type of digital technology has different challenges (Usai et al., 2021); therefore, beyond a certain point, implementing multiple digital technologies can increase negative returns. Complex nature of digital technologies requires firms to often have lengthy, heavy, and costly integration processes (Brynjolfsson & Mitchell, 2017). In addition, these technologies can require different capabilities and competences since each type of technology has a different nature. For instance, each type of technology can require new human skills and competences (Guinan et al., 2019). Implementing artificial intelligence requires firms to have a set of enabling capabilities such as functional competence and cybersecurity management (Gama & Magistretti, 2025). Therefore, the implementation of each technology can be costly, limiting its benefits (Blichfeldt & Faullant, 2021). Therefore, this research proposes that;

Hypothesis 2: Digital technology scope has a negative curvilinear effect on technological innovation.

2.2.3. Digital Technology Scope and Organizational Innovation

Damanpour & Aravind (2011: 429-432) define organizational innovation as "new approaches in knowledge for performing the work of management and new processes that produce changes in the organization's strategy, structure, administrative procedures, and systems." Organizational innovation involves changes in a firm's organizational structures and marketing strategies (Birkinshaw et al., 2008). The application of digital technologies pushes firms to innovate their business models and organizational structures to exploit the opportunities offered by digital changes (Ancillai et al., 2023; Plangger et al., 2022). For instance, digital technologies helps firms develop new forms of business models characterized by decreased reliance on physical elements (Erevelles et al., 2016). Moreover, firms can use data analytics technologies to identify emerging management trends, practices, and processes (Li et al., 2024). Overall, digital technologies enable firms to transform their ways of doing business, such as organizational structure and management approaches.

The adoption of digital technologies also enables firms to access rich data about customers and market. For instance, big data analytics collect and store large amounts of data about customers and their preferences. With such data firms are able to forecast the demand and determine which product, styles, and colours are more acceptable in the market. In addition, artificial intelligence technology offers firms new innovative opportunities to deliver value for their customers (Grewal et al., 2020). The usage of such digital technologies helps firms and managers to understand customers' behaviour and change the way they market to their customers (Davenport et al., 2020; Erevelles et al., 2016; Grewal et al., 2020), thereby increasing marketing innovation (Athaide et al., 2025).

Although the adoption of digital technologies enables firms to introduce innovation in their organizational structures and strategies, firms' transition into new organizational struc-

tures and new management approaches can be challenging when firms trying to adopt a wide range of digital technologies. Organizational innovation is characterized by its complexity, ambiguity, and unknown outcomes (Volberda et al., 2013). Thus, firms can face constraints from their employees and managers when implementing a change in the organizational structures and models (Elbanna & Newman, 2022). Changes in organization structures or undertaking new operational processes increase implementation costs and lead to negative outcomes (Wamba et al., 2017). Therefore, the dark sides of implementing digital technologies can be worsened with the challenging process of organizational innovation. In other words, investment in different digital technologies requires significant organizational transformation. Hence, employees can face uncertainties such as anxiety over role changes, potential job losses, or learning new technologies and potentially leading to significant resistance to these changes (Marsh et al., 2022; Paul et al., 2024). The costs of adopting new technologies exceed their perceived benefits (Hwang & Seo, 2025). Therefore, this study proposes that;

Hypothesis 3: Digital technology scope has a negative curvilinear effect on organizational innovation.

This study argues that the negative impacts of implementing a wide range of digital technologies are more pronounced for organizational innovation than technological innovation. Organizational innovation is more complex due to its relatively abstract and intangible nature, which can make this type of innovation ambiguous. Specifically, with organizational innovation firms try to adopt new ways to organize the work routines, new responsibilities, and decision-making. In addition, this type of innovation is more contingent on internal and external actors (Birkinshaw, 2006). For instance, managers need to put greater emphasis on their employees to be able achieve this transformation. In particular, employees might not have the expertise and knowledge in the area of management innovation. People's lack of understanding in the organization increases when there is uncertainty about the outcome of management innovation. Changing the organizational structures or models and adopting different digital technologies simultaneously can increase the implementation costs, thereby limiting its benefits. Therefore, this study proposes that;

Hypothesis 4: The negative curvilinear effect is more likely to happen for organizational innovation than technological innovation.

3. Methodology

3.1. Sample

This paper uses firm level microdata from the Eurostat Flash Eurobarometer No. 486 on "SMEs, Start-ups, Scale-ups and Entrepreneurship" (European Commission, 2020). This data was collected for the period between 2016 and 2019, and was administered between February and May 2020. Despite its cross-sectional nature, data from these surveys are used for research in academic publications (Arroyabe et al., 2024; Rousseliere et al., 2024; Valero-Gil et al., 2024).

This survey covers different topics, such as challenges of SMEs, digital transformation, sustainability, and innovation. 16,365 telephone interviews were conducted in 39 EU and non-EU countries. The data is dominated by SMEs. There are 15,515 SMEs and 850 large firms in

the collected data. The data covers both manufacturing and service industries. After removing some responses due to missing answers to some of the variables, the final sample consists of 15,448 firms from 16 industries and 39 countries.

3.2. Measures

3.2.1. Dependent Variables

This research has three dependent variables to measure innovation. The first one is *innovation*. Examining different types of innovation together becomes important to fully realize firms' innovation performance (Damanpour & Aravind, 2011). Participants were asked to indicate whether firms introduced i) "a new or significantly improved product or service to the market", ii) "a new or significantly improved production process or method", iii) "a new organization of management or a new business model", iv) "a new way of selling your goods or services", v) "an innovation with an environmental benefit", and vi) "social innovations". Innovation is constructed as a combination of six innovation types, each of which is coded as a binary dummy variable, with 0 introducing no innovation and 1 introducing innovation. Each firm gets a 0 when no innovations are introduced while the firm gets the value of 6, when all innovation types are introduced. Therefore the variable ranges from 0 to 6.

The second one is *technological innovation*. Participants were asked to indicate whether firms introduced "a new or significantly improved product or service to the market" and "a new or significantly improved production process or method" during the last year. It is measured as a dummy variable. The third one is *organizational innovation*. Participants were asked to indicate whether firms introduces "a new organization of management or a new business model" and "a new way of selling your goods or services" during the last year. It is measured as a dummy variable.

3.2.2. Independent Variable

This research captures *digital technology scope*. To do this, the questionnaire asks multiple questions to measure the usage of digital technologies. The question posed is: which of the following digital technologies has your firm adopted? The question contains multiple options: i) artificial intelligence, ii) cloud computing, iii) robotics, iv) smart devices, v) big data analytics, vi) high-speed infrastructure, and vii) blockchain. Digitalization scope is constructed as a combination of the seven digital technologies, each is coded as a binary dummy variable, with 0 representing no technologies and 1 adopting the digital technology. Each firm gets a 0 when no technologies are adopted while the firm gets the value of 7, when all technologies are adopted. Therefore the variable ranges from 0 to 7.

3.2.3. Control Variables

A series of variables that impact on innovation are controlled. Specifically, *firm size* is controlled to gauge its impact on innovation (Damanpour, 2010). Firm size is a continuous variable therefore it is measured as the logarithm of the number of employees. Older firms have a greater level of experience which increases innovation abilities of firms (Kotha et al., 2011). Therefore, this research also controls for *firm age*, measured as the logarithm of the number of years the firm has been active. Ownership structure has also been controlled by several varia-

bles. Family-owned firms can invest in innovation since they have high level of resources and low agency costs (Islam et al., 2022). *Family ownership* is measured as a binary variable equal to 1 if the firm is mainly family-owned. *Public ownership* can also enable firms to access more resources and be more risky (Zhou et al., 2017). Public ownership is measured as a binary variable to indicate whether the firm is co-owned by a public entity. *Business group membership* is measured as a binary variable to indicate whether the firm is part of a national or international enterprise group (Kim & Lui, 2015). Venture capitals provide firms access to more information and financial resources, thereby affecting innovation (Dutta & Folta, 2016). It is measured as a binary variable equal to 1 if the firm is co-owned by venture capital firm.

In order to understand international influence, *global value chain participation* is also controlled as a binary variable which gets the value of 1 if the firm is a part of a global value chain. In order to understand firms' innovation abilities, the *patent application* of the firm is controlled as a binary variable which equals to 1 if the firm has a patent or patent application. *Population size weight* is also controlled to account for potential sample bias. Finally, *sixteen sector* and *thirty-nine country* dummies are controlled.

4. Findings

Table 1 contains the means, standard deviations, minimum, and maximum values of variables. Looking at the descriptive statistics, 37% of firms produce technological innovation and 30% of firms implement organizational innovation. The average firm age is 24 years old and a firm has 61 employees on average. 20% of firms are mainly family-owned whereas 3% of firms have public ownership. 8% of firms are a part of national or international business group. 9% of firms have global value chain participation and 6% of them have patent or patent application. Table 2 shows correlations among the variables. The correlations are below 0.6. The results show that the mean variance inflation factor is 2.2 for each model. This suggests that multicollinearity is not a problem in this study (Neter et al., 1989).

Table 1: Descriptive Statistics

Variables	Min.	Max.	Mean	Std. Dev.
Technological innovation	0	1	0.376	0.484
Organizational innovation	0	1	0.304	0.460
Innovation scope	0	6	1.274	1.457
Digital technology scope	0	7	1.454	1.428
Firm size	1	9000	61.07	279.5
Firm age	0	170	24.70	21.45
Family ownership	0	1	0.207	0.405
Public ownership	0	1	0.030	0.172
Business group membership	0	1	0.085	0.279
Venture capital ownership	0	1	0.0127	0.112
Global value chain	0	1	0.0954	0.293
Patent	0	1	0.0691	0.253

Technological innovation and organizational innovation variables have value of zero or one. Therefore, logit regression is the most appropriate econometric technique (Hoetker, 2007). In addition, innovation scope variable ranges from 0 to 6, hence ordered logistic regression is applied (Long & Freese, 2001). Overall, Table 3 summarizes logit and ordered logit regression results. Among the control variables, firm size positively and significantly influences technological, organizational innovation, and innovation scope. Firm age negatively and significantly impact innovation suggesting that younger firms are more likely to be innovative. Family-owned firms are more conducive to innovation whereas public ownership negatively influences innovation. Global value chain participation and patent application positively and significantly affect innovation.

Hypothesis 1 suggests a negative curvilinear effect (inverted U-shaped) of digital technology scope on innovation. Model 2 in Table 3 indicates that digital technology scope has a positive and significant effect on innovation scope ($\beta = 0.6120$, $p < 0.01$) and the coefficient of the squared term is negative and significant ($\beta = -0.0421$, $p < 0.01$). This provides support for hypothesis 1. Hypothesis 2 predicts that digital technology scope has a negative curvilinear effect on technological innovation. Model 4 in Table 3 indicates that digital technology scope has a positive and significant effect on technological innovation ($\beta = 0.4844$, $p < 0.01$) and the coefficient of squared term is negative and significant ($\beta = -0.0335$, $p < 0.01$). This provides support for hypothesis 2. Hypothesis 3 proposes that digital technology scope has a negative curvilinear effect on organizational innovation. Model 6 in Table 3 shows that digital technology scope has a positive and significant effect on organizational innovation ($\beta = 0.5268$, $p < 0.01$) and the coefficient of squared term is negative and significant ($\beta = -0.0545$, $p < 0.01$). This provides support for hypothesis 3.

Hypothesis 4 predicts that the inverted U-shaped influence of digital technology scope on innovation is more pronounced for organizational innovation than technological innovation. The coefficients of Models 4 and 6 for technological and organizational innovation suggest that digital technology scope has a higher impact on organizational innovation. In order to test the inverted U-shaped relationship, this study visualizes the curvilinear relationships between digital technology scope and technological innovation, and between digital technology scope and organizational innovation. Figure 1 shows the impact of digital technology scope (*sum_digital/horizontal line*) on technological innovation (*Pr_Tech_Inno/vertical line*). Figure 2 shows the impact of digital technology scope (*sum_digital/horizontal line*) on organizational innovation (*Pr_Organ_Inno/vertical line*). As it is shown in Figure 1, at high levels of digital technology scope (*sum_digital=7*), the effect of digital technology scope on technological innovation starts to slow down whereas Figure 2 depicts that at lower levels of digital technology scope (*sum_digital=5*), the effect of digital technology scope on organizational innovation starts to be negative. Figure 2 clearly shows that the curve reaches its maximum at a digital technology scope value of 5 and then begins to decline. The plots reveal how increasing levels of digital technology scope beyond it resulted in a declining organizational innovation. Therefore, this result provides support for hypothesis 4.

Table 2: Correlation Matrix

Variables	1	2	3	4	5	6	7	8	9	10	11	12	13
1. Technological innovation	1.00												
2. Organizational innovation	0.27*	1.00											
3. Innovation scope	0.70*	0.65*	1.00										
4. Firm size	0.13*	0.09*	0.18*	1.00									
5. Firm age	0.01*	-0.01	0.02*	0.28*	1.00								
6. Family ownership	0.08*	0.06*	0.11*	0.02*	0.11*	1.00							
7. Public ownership	-0.01	0.00	0.02*	0.16*	0.07*	-0.07*	1.00						
8. Group ownership	0.09*	0.07*	0.10*	0.22*	0.05*	0.00	0.00	1.00					
9. Venture capital ownership	0.04*	0.04*	0.06*	0.08*	-0.00	0.01*	0.02*	0.09*	1.00				
10. Global value chain	0.14*	0.11*	0.19*	0.16*	0.03*	0.07*	0.01*	0.27*	0.09*	1.00			
11. Patent	0.19*	0.12*	0.23*	0.15*	0.04*	0.08*	0.00	0.10*	0.03*	0.18*	1.00		
12. Population weight	-0.10*	-0.04*	-0.11*	-0.58*	-0.23*	-0.03*	-0.10*	-0.17*	-0.05*	-0.12*	-0.12*	1.00	
13. Digital technology scope	0.28*	0.23*	0.38*	0.30*	0.06*	0.09*	0.03*	0.17*	0.08*	0.22*	0.21*	-0.15*	1.00

Note: *p<0.05.

Figure 1: The Curvilinear Impact of Digital Technology Scope on Technological Innovation

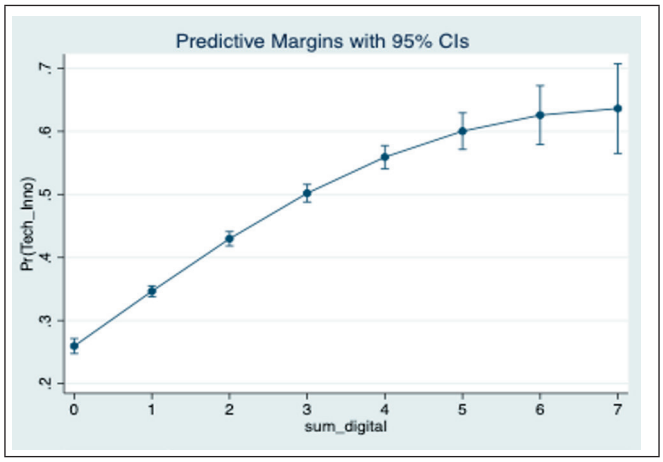
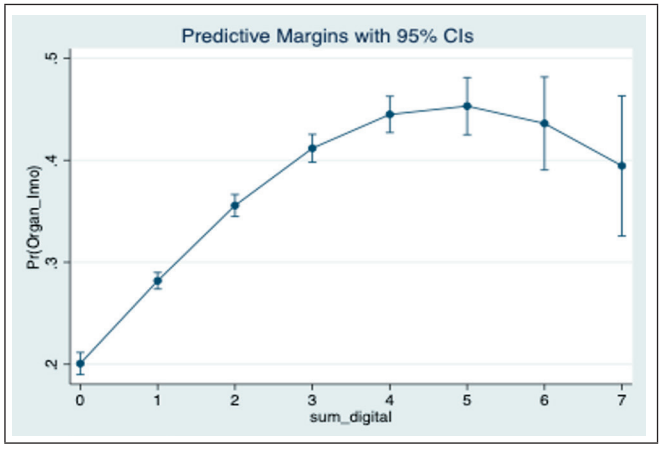


Table 3: Regression Results

Variables	Model 1 DV: Innovation scope	Model 2 DV: Innovation scope	Model 3 DV: Technological Innovation	Model 4 DV: Technological Innovation	Model 5 DV: Organizational Innovation	Model 6 DV: Organizational Innovation
Firm size (logged)	.2288*** (.0140)	.1247*** (.0144)	.1757*** (.0165)	.0880*** (.0173)	.1533*** (.0168)	.0794*** (.0175)
Firm age (logged)	-.1425*** (.0208)	-.1048*** (.0210)	-.1125*** (.0244)	-.0827*** (.0249)	-.1577*** (.0250)	-.1342*** (.0254)
Family ownership	.2228*** (.0389)	.1668*** (.0392)	.1621*** (.0453)	.1221*** (.0463)	.1280*** (.0465)	.0863* (.0472)
Public ownership	-.0172 (.0905)	-.0146 (.0921)	-.2389** (.1123)	-.2412** (.1146)	-.0689 (.1103)	-.0719 (.1121)
Business group membership	.0788 (.0561)	-.0305 (.0566)	.1636** (.0665)	.0916 (.0680)	.1213* (.0664)	.0551 (.0672)
Venture capital ownership	.2948** (.1316)	.2014 (.1329)	.1942 (.1571)	.1315 (.1601)	.3988*** (.1530)	.3467** (.1551)
Global value chain	.5861*** (.0540)	.4285*** (.0546)	.4926*** (.0639)	.3582*** (.0655)	.4176*** (.0631)	.3053*** (.0641)
Patent	.9573*** (.0604)	.7600*** (.0610)	1.053*** (.0758)	.9024*** (.0776)	.4931*** (.0702)	.3594*** (.0715)
Population weight	.0895*** (.0330)	.0838** (.0332)	.1110*** (.0392)	.1110*** (.0400)	.0586 (.0402)	.0589 (.0408)
Digital technology scope		.6120*** (.0288)		.4844*** (.0347)		.5268*** (.0351)
Digital tech. scope squared		-.0421*** (.0058)		-.0335*** (.0071)		-.0545*** (.0069)
Country and industry effects	Incl.	Incl.	Incl.	Incl.	Incl.	Incl.
Number of firms	15448	15448	15448	15448	15448	15448
LR chi squared	2863.93	4121.94	1816.39	2401.57	1253.98	1687.98
Pseudo R-squared	0.0603	0.0868	0.0888	0.1174	0.0661	0.0889
Log likelihood	-22310.4	-21681.4	-9321.7	-9029.2	-8864.5	-8647.5

Note: Standard errors in parentheses; *p<0.1; **p<0.05; ***p<0.01.

Figure 2: The Curvilinear Impact of Digital Technology Scope on Organizational Innovation



5. Discussion

Existing studies have highlighted the importance of adopting digital technologies across industries to achieve competitive advantage (Nambisan et al., 2019). Different digital technologies such as robotics, additive manufacturing, big data analytics, the cloud, and the internet of things change firms' routines and practices to create and deliver new products and services (Ciarli et al., 2021; Piening & Salge, 2015). These technologies provide important knowledge and information which enable firms to introduce new combinations of knowledge. For instance, big data supports firms to acquire knowledge about customer behaviours. Internet of things increases the productivity and reduces production costs through interconnected devices and machines. Cloud computing reduces costs and increases operational advantages for firms innovation processes. Overall, digital technologies can lower transactions and production costs, thereby leading to increase in innovative outcomes (Mithas & Rust, 2016; Tsou & Chen, 2023).

However, it is important to recognize the dark sides of digitalization since the implication of digital technologies is not always easy (Brynjolfsson & Mitchell, 2017; Elbanna & Newman, 2022; Kohtamaki et al., 2020; Ruiz-Alba et al., 2020). For example, the integration of new digital technologies into firms' activities can be heavy and costly. In addition, integration of new digital technologies might force firms to change their routines and capabilities. This can require firms to undertake radical organizational transformation which can be difficult to implement. Moreover, the implementation of new digital technologies can require new human skills and competences, which require further training and coaching. These show that firms can struggle with the deployment of digital technologies (Kohtamaki et al., 2020; Usai et al., 2021). The difficulty of implementation can increase especially firms try to implement a wide range of digital technologies (Blichfeldt & Faullant, 2021; Sinha et al., 2025). Therefore, it is important to explore digital technology scope to understand the negative impacts digital technologies have on innovation. First of all, this study investigates the impact of digital technology scope on innovation. Moreover, this study makes a differentiation between technological and organizational innovation, and investigates how the impact of digital technology scope varies depending on different types of innovation.

The results indicate that applying a wide range of digital technologies increases innovation, but beyond a certain point, the positive influence on innovation declines. The results also indicate that the usage of digital technologies has a positive influence on technological and organizational innovation but beyond a certain point, the positive impacts decrease. More importantly, the results suggest that this inverted U-shaped effect is pronounced for organizational innovation than technological innovation.

This paper advances digitalization literature by showing the negative impacts digital technologies have (Blichfeldt & Faullant, 2021). Existing literature has neglected to examine negative effects of digitalization on innovation (Usai et al., 2021). This study shows that firms experience some difficulties when implementing a wide range of digital technologies. This paper also advances digitalization literature by highlighting the differences between technological and organizational innovation when investigating the influence of digital technologies on innovation. Existing literature has focused on technological innovation but neglected the aspect of organizational innovation (Athaide et al., 2025). This study highlights that the negative returns from implementing a wide range of digital technologies are more likely to occur for organizational innovation.

This study has some limitations that future research can consider when investigating the impact of digital technologies. This study focuses on digital technology scope. It would be interesting to investigate the depth of digital technologies, meaning how deeply firms use such technologies. Due to data limitations, this study is cross-sectional. Future studies using a longitudinal data would further advance this topic. Finally, this study does not look at the differences between countries. In particular, future studies investigating this topic from the perspective of emerging economies would be helpful. Despite these limitations, this study finds out important insights which help to advance the existing literature on digital technologies and innovation.

Conflicts of Interest

The author declares no conflicts of interest.

Ethics of Approval

No specific ethical approval was necessary for the study.

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