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Digitalization, inter-organizational collaboration, and technology transfer

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Abstract
In this study, we explore the impact of business process digitalization on technology transfer intensity through the mediating mechanism of inter-organizational collaboration. Using data collected from 211 firms in Vietnam, we find that: (1) digitalization positively influences inter-organizational collaboration, (2) inter-organization collaboration positively affects technology transfer intensity, (3) the effect of inter-organizational collaboration on technology transfer intensity is amplified when technology commercialization potential is high, and (4) the effect of digitalization on technology transfer intensity is mediated by inter-organizational collaboration. These findings suggest that technology commercialization potential is a critical moderating factor that needs to be considered in the context of technology transfer, and its interaction with inter-organizational collaboration should be carefully managed to maximize the benefits of technology transfer. The study provides practical implications for technology firms seeking to enhance their technology transfer outcomes.

Keywords Technology transfer · Inter-organizational collaboration · Technology commercialization potential · Digitalization

JEL Classification O32 · M13 · M10

1 Introduction

As organizations seek to improve their operational efficiency and competitive advantage, the digitalization of business processes has become an increasingly popular strategy. The adoption of digital technologies has enabled organizations to streamline their workflows, reduce costs, and enhance their ability to deliver products and services to customers (BarNir et al., 2003; Viriyasitavat et al., 2019; Zahoor et al., 2023). Business process

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digitalization refers to the use of digital technologies to transform traditional business processes and activities (Adomako et al., 2021b; BarNir et al., 2003). It involves the integration of digital technologies into various aspects of business operations, including data collection, analysis, communication, and decision-making. The goal of business process digitalization is to increase efficiency, reduce costs, and enhance the ability of organizations to deliver products and services to customers in a fast and agile manner (Adomako et al., 2021b; Berthon et al., 2008). For example, organizations make use of cloud computing, artificial intelligence, automation, and digital communication tools to streamline workflows and improve business outcomes (Davenport & Ronanki, 2018; Kulkov, 2021). Organizations can stay competitive and adapt to the rapidly changing business environment by adopting business process digitalisation. In addition, when organizations embrace digital technologies and leverage the opportunities they present, they can achieve greater efficiency, agility, innovation, and customer satisfaction, ultimately driving long-term success (Wang & Cen, 2022; Zahoor et al., 2023). Additionally, previous studies have shown that digitalization has brought significant changes to organizations, and those that can adapt to these changes are more likely to improve their performance (Björkdahl, 2020; Martín-Peña et al., 2019) and business model innovation (Mostaghel et al., 2022; Rachinger et al., 2018). For example, digitalization can provide organizations with a competitive advantage by enabling them to be more agile, responsive, and innovative. Thus, business process digitalization is becoming increasingly important in today's digital age, and organizations that fail to embrace may fall behind their competitors.

Although business process digitalization has been conjectured to increase efficiency and productivity by streamlining workflows, reducing errors, and automating repetitive tasks (Martín-Peña et al., 2019; Ritter & Pedersen, 2020), we still do not know its impact on technology transfer intensity. By technology transfer intensity, we refer to the extent to which organizations engage in the transfer of technology or knowledge from one organization to another, or from academia to industry (Castillo et al., 2018). Indeed, technology transfer can take many forms, including licensing agreements, joint ventures, research collaborations, and consulting services. In addition, there are informal channels of technology transfer which to the informal and non-structured ways through which knowledge and technology are shared between individuals, organizations, and communities. These channels often involve interpersonal relationships, collaborations, and informal networks, rather than formal agreements or contracts. Furthermore, although it is appealing to suggest that business process digitalization can increase the intensity of technology transfer, we still do not know the mechanism through which business process digitalization impacts knowledge transfer intensity in organizations.

Thus, the aim of this article is twofold. First, it explores the effect of business process digitalization on technology transfer intensity through the mediating mechanism of inter-organizational collaboration. Second, we investigate the conditions under which intern-organization collaboration improves technology transfer intensity. These aims help us to answer the following research question: how does business process digitalization influence technology transfer intensity? Under what condition does inter-organizational collaboration boost technology transfer intensity?

This article contributes to the literature in several ways. First, it extends to the inter-organizational collaboration literature (e.g., Adomako et al., 2021a; Alexiev et al., 2016; Hardy et al., 2003) by explaining the effect of business process digitalization on inter-organizational collaboration. Although there has been some research on the impact of digitalization on inter-organizational collaboration (Yang et al., 2021), the impact of digitalization on inter-organizational collaboration is not yet fully understood, and there are concerns

that it may have unintended consequences that could negatively affect collaboration (Leão & Silva, 2021). Given these concerns, it is important to investigate the effect of business process digitalization on inter-organizational collaboration to develop a more comprehensive understanding of this relationship. Second, this article contributes to the technology transfer literature (e.g., Bolzani et al., 2021; Pitsakis & Giachetti, 2020; Scarrà & Piccaluga, 2022) by exploring the impact of inter-organizational collaboration and technology transfer intensity. By exploring this relationship, researchers can contribute to developing theories that help explain the mechanisms through which collaboration impacts technology transfer. Thus, our article contributes to theory development by improving our understanding of the factors that influence technology transfer and provides insights into how organizations can better facilitate the transfer of knowledge and technology across organizational boundaries. Third, we extend the digitalization literature (Adomako et al., 2021b; BarNir et al., 2003; Zahoor et al., 2023) by exploring the mechanism through business process digitalization influences technology transfer intensity in organizations. Thus, this article advances our understanding of the mechanisms through which digitalization affects technology transfer. Digitalization is a relatively new phenomenon (Björkdahl, 2020; Menz et al., 2021), and there is still much to learn about how it impacts technology transfer. By investigating this relationship, we add to the existing literature by explaining the mechanisms through which digitalization affects business process digitalization. Finally, this article advances our understanding of the conditions under which inter-organizational collaboration is most effective for technology transfer. Thus, we highlight the impact of technology commercialization potential in the collaboration-technology transfer relationship. This improves our understanding of the effectiveness of collaboration in facilitating technology transfer.

The rest of this article is organized as follows: First, we present the study's theoretical background and derive the hypotheses. Second, we describe the method which includes the sample and data collection process. Third, we present the results of the study. Finally, the findings are discussed regarding the theoretical and practical contributions. This article concludes with the limitations and suggestions for future research trajectories.

2 Theoretical background and hypotheses

2.1 Digitalization, technology transfer, and resource dependency theory

Digitalization has become an important strategic imperative for organizations to remain competitive in the fast-paced, technology-driven business environment (Björkdahl, 2020; Ciampi et al., 2022). The literature defines digitalization as the transformation of physical processes, assets, and resources into digital formats through the use of technology (Arslan et al., 2021; Ritter & Pedersen, 2020). This process enables organizations to leverage the power of technology to optimize their operations, enhance productivity, and create new business models. In this article, we focus on business process digitalization which reflects the transformation of traditional, manual, paper-based processes into digital processes using digital technologies (Adomako et al., 2021b; BarNir et al., 2003). This transformation involves the use of technology to automate and streamline business processes, which can lead to increased efficiency, improved customer experiences, and reduced costs.

It has been suggested that business process digitalization has the potential to improve business processes which ultimately can improve firm performance (Martín-Peña et al.,

2019). For example, it has the potential to significantly impact a firm's performance by increasing efficiency, reducing costs, improving customer satisfaction, and creating new revenue streams. Similarly, previous research shows that business process digitalization has important implications for the internationalization of firms (Adomako et al., 2021b). Further, research has demonstrated that firm age and size are important drivers of business process digitalization (BarNir et al., 2003). Thus, digitalization has the potential to significantly impact a firm's activities by increasing efficiency, reducing costs, improving customer satisfaction, and creating new revenue streams.

Despite these insights, questions remain unanswered. Particularly, the utility of Resource Dependency Theory (RDT) (Pfeffer & Salancik, 1978) on the impact of business process digitalization on inter-organization collaboration remains unaddressed. As Pfeffer and Salancik (1978: 1) suggest, "To understand the behavior of an organization you must understand the context of that behavior—that is, the ecology of the organization."

In this study, we suggest that business process digitalization enables organizations to collaborate more effectively and efficiently. We contend that business process digitalization may help break down traditional barriers to facilitate more seamless collaboration. For example, by improving communication, enhancing data sharing, streamlining workflows, and increasing transparency, digitalization can enable organizations to work together more effectively, leading to improved outcomes and better relationships. This is particularly important in today's interconnected business environment, where collaboration and cooperation are increasingly necessary for success.

The RDT suggests that organizations are dependent on external resources to achieve their goals and objectives (Pfeffer & Nowak, 1976; Pfeffer & Salancik, 1978, 2003). The RDT argues that all organizations depend on other organizations for the provision of important resources and this dependence is considered reciprocal. This explains why firms exhibit interdependence by engaging in different kinds of inter-organizational arrangements, such as inter-organization collaboration, and knowledge transfer activities (Pfeffer & Salancik, 1978). Given that an important resource for organizations is technology, depending on other organizations can likely enable them to innovate, compete, and grow. Thus, the applicability of the RDT is justified for the following reasons. First, the RDT can help to explain the significance of technology transfer for organizations. According to resource dependency theory, organizations seek to minimize their dependence on external resources by controlling or acquiring those resources themselves (Drees & Heugens, 2013; Hillman et al., 2009; Pfeffer & Salancik, 1978). In addition, technology transfer may also increase dependence on external sources if the transferred technology or knowledge is critical to the organization's success. Organizations mitigate risks by digitalizing their business process and adopting strategies such as building internal capabilities to maintain and enhance the transferred technology, developing alternative sources of technology or knowledge, and building strong relationships with external partners (Adomako et al., 2021a).

Collectively, the RDT is important for business process digitalization and technology transfer in that technology transfer and digitalization can be significant factors in organizational success. Organizations that effectively manage technology transfer can benefit from the advantages of new technologies and knowledge while reducing their dependence on external sources.

2.2 Business process digitalization and inter-organizational collaboration

This study responds to gaps in the literature about more theory and evidence needed to better understand how business process digitalization affects inter-organizational collaboration. Simply adopting new technologies and digitalization alone may not provide a sustainable competitive advantage for organizations. Instead, organizations must establish processes and structures that allow them to collaborate and perform innovation value chain functions and engage with stakeholders such as customers, suppliers, and clients (Mostaghel et al., 2022). Previous research has defined inter-organizational collaboration by adopting a distinction that reflects the perspectives of innovation as a process (Crossan & Apaydin, 2010). Improving innovativeness, or the ability to introduce new products and services, is crucial for many companies to gain a competitive advantage and promote growth (Gupta et al., 2007). Relatedly, the process of innovation within the boundaries of the organization is a major issue in innovation management, as noted by both researchers and practitioners (Alexiev et al., 2016; Crossan & Apaydin, 2010). Some researchers have examined internal organization-based approaches such as portfolio (Faems et al., 2005) or project-based (Blindenbach-Driessen et al., 2010) approaches, while others have focused on inter-organizational collaboration in developing and commercializing new products and services (Yli-Renko et al., 2001). In this paper, we conceptualize inter-organizational collaboration as a characteristic of the innovation process that relates to the extent to which other organizations take an important part in the innovation process (Alexiev et al., 2016).

Given that business process digitalization involves activities such as gathering competitive intelligence, interacting with channel members, and conducting online commercial transactions, it is likely to facilitate communication and information sharing between organizations, making it easier to collaborate on innovation projects and initiatives. By streamlining processes, organizations can make information more easily accessible to one another and reduce the time and effort required to coordinate efforts. This can help facilitate collaboration by making it easier for organizations to coordinate their efforts and work together towards common goals. In addition, it has been suggested that digitalization can improve transparency in the collaboration process by making information and data more easily accessible to all stakeholders which helps to overcome innovation barriers (Antonioli et al., 2017; Cozza & Zanfei, 2016). This can help reduce misunderstandings and increase trust between organizations. Moreover, business process digitalization is likely to streamline processes and reduce the time and effort required for organizations to coordinate and collaborate. Thus, this can offer increased efficiency and effectiveness in the collaboration process.

Finally, we reason that when business processes are digitalized, it is likely to make it easier to share information and resources among organizations. For instance, cloud-based storage and collaboration tools enable organizations to access and share documents and data seamlessly. This facilitates collaboration, enabling organizations to work together towards a common goal. Relatedly, digital technologies are increasingly important in strategic goals for collaborative innovation partnerships. For example, digital capabilities in M&As involve the utilization of emerging technologies such as artificial intelligence and robotization. Based on the aforementioned discussion, we proposed that:

H1 Business process digitalization has a positive influence on inter-organizational collaboration.

2.3 Inter-organizational collaboration and technology transfer

One of the main objectives of this study was to explain whether inter-organizational collaboration fosters technology transfer intensity among organizations. Previous research has defined technology transfer as "the movement of know-how, technical knowledge, or technology from one organizational setting to another" (Roessner, 1997, p. 1). In large and research-intensive private firms, technology transfer has been used to describe the processes by which ideas, proofs of concept, and prototypes move from research-related to production-related phases of product development. In this study, we define technology transfer as the process of transferring technology and knowledge from one organization to another (Bozeman, 2000; Gubitta et al., 2016). In terms of the intensity of knowledge transfer, we refer to the level of knowledge and technology that is transferred from one entity to another. It typically measures the amount of knowledge or technology transferred as a proportion of the total knowledge or technology available. The intensity of technology can be measured in various ways, such as the number of patents or licenses granted, the amount of research and development funding transferred, the number of collaborations and partnerships formed, or the number of personnel exchanges between organizations (Castillo et al., 2018; SScarrà & Piccaluga, 2022).

Given that a high level of technology transfer intensity is generally seen as beneficial for both the recipient and the provider of knowledge or technology (Brantnell & Baraldi, 2022; Gubitta et al., 2016), we predict that firms are likely to collaborate to improve the intensity of technology transfer. First, inter-organizational collaboration can create opportunities for organizations to exchange knowledge and expertise, which can result in the transfer of technology and new ideas (Fernández-Olmos & Ramírez-Alesón, 2017; Puliga et al., 2023). When organizations collaborate, they often bring different skills, experiences, and perspectives to the table, which can lead to the creation of new technologies and the improvement of existing ones. Second, inter-organizational collaboration improves resource sharing, knowledge, expertise, and technology, which can facilitate technology transfer. For example, the RDT (Pfeffer & Salancik, 1978) highlights the importance of collaboration for organizations to access the resources they need to achieve their goals. In effect, collaboration helps organizations to diversify their resource base and reduce their dependence on any one source. For example, when firms collaborate, it provides them with access to complementary resources and capabilities that they may not have internally (Bäck & Kohtamäki, 2015; Murgia, 2021). This is likely to help organizations access new ideas, technologies, and markets. This in turn can lead to joint research and development projects, joint production, and distribution agreements, and joint marketing efforts. Through collaboration, organizations can share resources and expertise, which can help to reduce the costs and risks associated with technology transfer (Corral de Zubielqui et al., 2019; Xu et al., 2019). Further, inter-organizational can also help to overcome barriers to technology transfer such as intellectual property rights, cultural differences, and lack of trust between organizations. Through collaboration, organizations can develop trust, establish common goals, and negotiate agreements that facilitate technology transfer. In the main, inter-organizational collaboration can be an important strategy for organizations to spur technology transfer. Thus, inter-organizational collaboration shapes the intensity of technology transfer by creating opportunities for knowledge and technology

exchange, overcoming technological barriers, and increasing access to resources and knowledge. The above discussion leads us to suggest that:

H2 Inter-organizational collaboration has a positive influence on technology transfer intensity.

2.4 The moderating role of technology commercialization potential

Assessing a technology's commercialization potential is an important step in determining whether a new technology is worth investing in and developing further. Organizations identify the risks and challenges involved in bringing the technology to market and evaluate the potential rewards and benefits (Mariani et al., 2023; Paluch & Wünderlich, 2016). By technology commercialization potential, we refer to the likelihood that a new technology or innovation can be successfully brought to market and generate revenue (Fini et al., 2009). In this study, we argue that technology commercialization potential would play a significant moderating role in the relationship between inter-organizational collaboration technology transfer intensity. In other words, we suggest that the influence of inter-organization collaboration on technology transfer intensity (i.e., the amount and speed of technology transferred from one organization to another) is greater when the potential for technology commercialization is high.

First, when organizations collaborate they are likely to access complementary resources such as expertise, technology, and funding to facilitate the development and commercialization of technology. With the greater potential for technology commercialization, there may be a greater need for these resources to be combined to successfully bring the technology to market. Second, provided that inter-organizational collaboration is likely to facilitate the sharing of risks and rewards associated with technology development and commercialization (Battistella et al., 2016; Hagedoorn, 1993), it is the case that when the potential for commercialization is high, there may be a greater need for organizations to share the risks associated with bringing the technology to market, such as regulatory hurdles, market uncertainties, and technological challenges (Shaikh & Randhawa, 2022). For example, inter-organization collaboration may facilitate sharing of potential rewards, such as revenue, market share, and reputation when the potential for technology commercialization is high. Third, when technology has high commercialization potential, there is a greater incentive for organizations to collaborate and invest resources in technology transfer efforts. Given that high commercialization potential facilitates significant market demand, and successful commercialization can yield beneficial outcomes (Chen, 2009; Frishammar et al., 2012), organizations may be more willing to collaborate and invest resources to ensure the successful transfer and commercialization of the technology.

Additionally, a high commercialization potential may lead to more focused technology transfer efforts. Organizations may be more selective in identifying potential collaborators and partners and may devote more time and resources to developing and implementing effective technology transfer strategies (Markman et al., 2008; Park & Ryu, 2015). Collectively, the influence of inter-organization collaboration on technology transfer intensity is likely to improve, particularly when the technology being transferred has high commercialization potential. This is because when the potential for technology commercialization is high, inter-organizational collaboration can be particularly

valuable in helping to advance technology development and bring the technology to market. Thus, we suggest that:

H3 The influence of inter-organization collaboration on technology transfer intensity is amplified when technology commercialization potential high.

2.5 The mediating role of inter-organizational collaboration

Premised as a feature of the innovation process, inter-organization collaboration allows organizations to play an important role in innovation activities (Adomako et al., 2021a; Love et al., 2011). These processes can be distributed across the organization and inter-organizational collaboration can be part of these activities to complete the innovation value chain (Alexiev et al., 2016; Love et al., 2011; West & Bogers, 2014). This suggests that inter-organizational collaboration can be used at every stage of the innovation process in an organization, allowing for a broader conceptualization of innovation unbound by formalized R&D processes (Hansen & Birkinshaw, 2007). The outcome of this process is called "firm innovativeness," which refers to a company's ability to create and introduce new products or services. Therefore, in this study, we argue that collaboration between different organizations plays a key role in how the digitalization of business processes affects the intensity of technology transfer. The main argument is that inter-organizational collaboration facilitates knowledge sharing, collaboration, and joint innovation between organizations (Ahmad & Daghfous, 2010; Eriksson et al., 2022; Lahiri et al., 2021) and can serve as a mechanism between business process digitalization and technology transfer intensity. First, in the context of business process digitalization, inter-organizational collaboration can help to identify new opportunities for innovation and promote the adoption of new technologies (Picazo-Vela et al., 2018). For example, organizations that collaborate closely may be more likely to share information about emerging technologies and may be better equipped to evaluate and adopt these technologies quickly.

Second, collaboration can help to facilitate technology transfer between organizations (Geisler & Turchetti, 2015). When firms collaborate, they can identify opportunities for joint ventures or licensing agreements that allow them to share technology and expertise. These partnerships can be particularly effective in industries where research and development costs are high, and where access to specialized expertise is limited (Bellini et al., 2019). For example, digitalization is likely to improve collaboration by providing new tools and platforms for communication and knowledge sharing. Similarly, technology transfer can be facilitated by inter-organizational collaboration, as organizations work together to develop and transfer new technologies.

Third, the mediating role of inter-organizational collaboration can be seen in how it helps to promote technology transfer intensity between organizations that have undergone business process digitalization. By collaborating with other organizations, a firm can access complementary knowledge, expertise, and resources (He et al., 2020; Kohtamäki et al., 2018), which can accelerate the process of innovation and increase the likelihood of successful technology transfer. Overall, inter-organizational collaboration plays a critical role in mediating the relationship between business process digitalization and technology transfer intensity by promoting knowledge exchange, driving innovation, and enabling technology transfer between organizations. By working

together to share knowledge, resources, and expertise, firms can increase the likelihood of successful technology transfer and accelerate the pace of innovation.

H4 Inter-organizational collaboration mediates the relationship between business process digitalization and technology transfer intensity.

3 Method

3.1 Study setting

In this study, we focused on firms in Vietnam to test our hypotheses. Vietnam is a rapidly growing country in Southeast Asia. Small and Medium Enterprises (SMEs) in Vietnam operate within a unique context characterized by various factors. Vietnam has experienced significant economic growth and transitioned into a market-oriented economy, creating opportunities and challenges for SMEs. One important aspect is the government's support for SME development through various policies and initiatives. The Vietnamese government has implemented reforms to promote entrepreneurship, streamline business registration processes, and provide financial support and incentives for SMEs (MoIT, 2021). This support aims to foster innovation, job creation, and economic diversification. However, SMEs in Vietnam also face several challenges. Limited access to finance is a significant hurdle, as banks often prioritize lending to larger enterprises. This makes it challenging for SMEs to secure capital for business growth and expansion. Despite these challenges, SMEs in Vietnam have shown resilience and adaptability. They play a crucial role in employment generation, poverty reduction, and driving economic development at the grassroots level. Efforts are being made to address the challenges faced by SMEs, including the promotion of digitalization and the development of support mechanisms such as business incubators and accelerators. Based on the foregoing discussion, Vietnam is considered an ideal context in Southeast Asia for testing our hypotheses.

3.2 Sample and data collection

Survey-based studies often suffer from small sample sizes and single informants (Adomako et al., 2021a). To address these shortcomings, we collected data at two points in time conducted in 2022 and 2023. First, a questionnaire was sent to chief executive officers (CEOs) measuring business process digitalization, inter-organizational collaboration, and all the control variables. Then, four months later, a questionnaire was sent to a member of the top management team to capture technology transfer intensity and all the control variables.

Before the main survey, we pre-tested the survey instrument with 15 CEOs (excluded from this study). Based on their feedback, we revised the questionnaire to establish the reliability and factor structure of our measures. Using the Vietnam Business Directory, we randomly selected 500 firms operating in Vietnam. The following sampling criteria were met in selecting our sample: (1) firms that were not part of any company group, (2) firms with direct contact details of the CEO or a member of the founding team, (3) firms not employing more than 250 full-time workers, and (4) manufacturing or services firms with productive activities.

Of the 500 firms, 58 were closed or could not be tracked. This resulted in 442 firms. In wave 1, we visited the head offices of the 442 firms with the help of six research assistants recruited for this study. First, in a pen-and-paper survey, data were collected from 266 CEOs. Of the 266 surveys, we discarded 22, resulting in 244 complete surveys. Six months later, in wave 2, we obtained responses from a senior team of the firms that took part in the first wave. This yielded 211 matched surveys from wave 1 and wave 2, constituting a 47.73% response rate. A t-test revealed no significant differences between responding and nonresponding firms in terms of size and age.

Table 1 provides the descriptive statistics of the demographic variables. The sample contained a mean age of 9.53 (s.d. = 8.52) years and the mean size was 13.52 (s.d. = 14.22) full-time employees. Additionally, 60.19% of the firms were service providers, whereas 39.85% were manufacturing firms.

3.3 Measures

Unless otherwise stated, all the multi-item constructs were measured using a seven-point Likert scale ranging from 1 = strongly disagree and 7 = strongly agree. Table 1 presents the measures used in this study.

3.3.1 Business process digitalization

This construct was measured with the scale developed by BarNir et al. (2003). This scale has four dimensions entailing information gathering, marketing, administration, and communication. Three items were used to measure each of the constructs.

Table 1 Demographic and venture characteristics of the sample

Variables	Sub-category	Frequency	%
CEO age	25–30 years	11	5.20%
	31–40 years	78	37.00%
	41–50 years	80	37.91%
	51–60 years	38	18.00%
	> 61 years	4	1.89%
Industry	Service	127	60.19%
	Manufacturing	84	39.81%
Firm age	1–5 years	58	27.48%
	6–10 years	40	18.96%
	11–15 years	52	24.64%
	16–20 years	31	14.70%
	> 20 years	30	14.22%
Firm size	1–9 employees	88	41.70%
	10–20 employees	45	21.32%
	21–30 employees	22	10.44%
	> 30 employees	56	26.54%

$n = 211$. The industry is a dummy variable

3.3.2 Technology commercialization potential

We used 3 items from Fini et al. (2009) to capture technology commercialization potential.

3.3.3 Inter-organizational collaboration

We captured inter-organizational collaboration with a 6-item scale from Alexiev et al., (2016). A sample item is ''in the past three years, to what extent has your organization worked together with other organizations to put new products and services to market''.

3.3.4 Technology transfer intensity

This construct was measured with 5 items from Gopalakrishnan and Santoro (2004). A sample item is ''time spent interacting with university research center personnel specifically for developing and commercializing new technologies''.

3.3.5 Control variables

We controlled for several variables that could potentially influence the outcome variable. These are firm age, firm size, industry type, technological turbulence, and technological capability. Firm age was measured as the logarithm transformation of the number of years since the firm was incorporated. Firm size was measured as the logarithm transformation of the number of full-time employees. We adopted four items from Lee & Tang (2018) to capture the degree of technology turbulence. We controlled for service industry and was was measured as follows: 0 = service and 1 = manufacturing. We measure technological capability with 5 items from Zhou & Wu (2010). We asked respondents to compare their firms to major competitors and evaluated their firms' capabilities using five items on a seven-point scale (1 = much worse; 7 = much better).

3.4 Common method variance

We assessed common method variance (CMV) by following two procedures. First, we followed Cote & Buckley (1987) and statistically estimated three competing models (see Table 2). Model 1 is a method-only model where all the indicators are loaded on a single latent factor. Model 2 assessed a trait-only model in which each indicator loaded on its respective latent factor. Finally, we combined the method-only and trait-only models and estimated a method and trait model (Model 3). This model included a common factor that links all the indicators in Model 2. Consequently, we compared all three models and found that Model 2 and Model 3 were better than Model 1. Further, Model 3 was not substantially superior to Model 2. Thus, CMV is not a major concern in our data.

3.5 Measurement model

We used the LISREL 8.71 software to perform a confirmatory factor analysis (CFA) on all the measures. This was done to assess potential problematic indicators. First, we assessed

Table 2 Common method bias nested models

Models	χ^2	df	χ^2/df	RMSEA	TLI	CFI	SRMR
Model 1: Method-only	7026.11	1303	5.39	0.16	0.45	0.39	0.14
Model 2: Trait-only	1409.15	1065	1.32	0.05	0.92	0.93	0.06
Model 3: Method-and-trait	1370.65	989	1.38	0.04	0.93	0.94	0.08

χ^2, Chi-square; df, degrees of freedom; RMSEA, Root mean square error of approximation; TLI, Tucker-Lewis index; CFI, Composite fit index; SRMR, Standardized root mean square residual

Table 3 Constructs, measurement items, and reliability and validity assessment

Item description	Factor loadings
Business process digitalization	
Information gathering: α = 0.83; CR = 0.84; AVE = o.65	
In this firm, we use the Internet to do consumer research (e.g., market, customer)	0.77
We use the Internet for competitive benchmarking	0.80
We use the Internet for general information	0.85
Marketing: α = 0.84; CR = 0.85; AVE = 0.66	
In this firm, we use the Internet to conduct our sales	0.69
We use the Internet to advertise/market our products	0.87
We use the Internet for customer service activities	0.88
Administration: α = 0.91; CR = 0.91; AVE = 0.78	
In this firm, we use the Internet for purchasing activities	0.83
We use the Internet for shipping/distribution	0.90
We use the Internet for general administrative duties	0.93
Communication: α = 0.87; CR = 0.88; AVE = 0.72	
In the firm, we use email to communicate with staff members	0.78
We use email to communicate with our customers	0.88
We use email to communicate with other stakeholders	0.89
Technology commercialization potential: α = 0.88; CR = 0.89; AVE = 0.73	
Availability of technological knowledge	0.80
Previous investments in technology development	0.86
Market demand for commercial exploitation of the technology	0.91
Technology transfer intensity: α = 0.92; CR = 0.92; AVE = 0.70	
Time spent interacting with university research center personnel specifically for developing and commercializing new technologies	0.75
Level of joint decision-making in technological consulting arrangements for developing and commercializing new technologies	0.77
Level of joint decision-making in developing and commercializing new technologies	0.85
Number of personnel exchanges specifically for developing and commercializing new technologies	0.89
Level of participation in research center extension services specifically for developing and commercializing new technologies	0.91
Inter-organizational collaboration: α = 0.91; CR = 0.92; AVE = 0.69	
In the past three years, to what extent has your organization …	
Worked together with other organizations for product and/or service innovations	0.78
Worked together with other organizations to put new products and services to market	0.89
Allied with other organizations to introduce new products and/or services	0.92
Implemented joint promotional activities for new products and/ or services	0.69
Maintained joint distribution and service agreements for new products and services	0.85
Signed contracts with other companies and institutions for product development	0.90
Technological turbulence: α = 0.91; CR = 0.92; AVE = 0.75	
The technology in our industry is changing rapidly	0.81
Technological changes provide substantial opportunities in our industry	0.87
A large number of new product ideas have been possible due to technological breakthroughs in our industry	0.89
It is very difficult to forecast where the technology in this area will be in the next few years	0.90

Table 3 (continued)

Item description	Factor loadings
Technological capability: α = 0.90; CR = 0.91; AVE = 0.69	
Acquiring important technology information	0.83
Identifying new technology opportunities	0.85
Mastering the state-of-art technologies	0.76
Responding to technology changes	0.80
Developing a series of innovations constantly	0.91

item loadings and their related constructs to ensure that the constructs' shared variances are greater than the error terms. The items of the main constructs yielded factor loadings that were well above the recommended threshold value of 0.70 (Bagozzi & Yi, 2012). Second, we established internal consistency by inspecting the composite reliability (CR) of the constructs. As shown in Table 3, the CR of all measures was greater than the suggested threshold value of 0.70 (Hair et al., 2017). Third, a convergent validity test was performed by calculating the average variance extracted (AVE). This was done to examine how well the items explain the variance of the main constructs. The results in Table 3 show that the AVEs of the constructs were greater than the acceptable threshold value of 0.50 (Fornell & Larcker, 1981). The square root of the AVE was calculated to help establish the discriminant validity of the measures. The values were (see Table 4, AVE in the diagonal) larger than the values in the corresponding columns and rows, suggesting that discriminant validity has been established in our measures (Fornell & Larcker, 1981). In addition, the CFA indicates that the factor loadings were as hypothesized and with positive and significant values. This further confirms convergent validity (Bagozzi & Yi, 2012). Overall, the measurement model shows adequate fit (SRMR = 0.07, RMSEA = 0.05; CFI = 0.91, TLI = 0.93, χ^2/df = 2.23) (Hu & Bentler, 1998).

4 Structural model estimation and results

In this study, structural equation modeling (SEM) and the maximum likelihood method were used. The LISREL8.80 software was used to estimate entire nested models. Mean values for the dependent and the moderating variables were created to reduce complexity in the estimation. The averages were computed for each multi-item construct to arrive at composite scores. However, for the dependent variables (inter-organizational collaboration, and technology transfer intensity), we used the full information (entire indicators) method was utilized. Accordingly, the individual measurement items, instead of the mean values were used to estimate the model. Using both averages and a full information approach helps to mitigate potential model under-identification due to inadequate information in the structural model (Hair et al., 2017). Additionally, we followed Cortina et al. (2001) in using moderated structural equation modelling to estimate the hypothesized moderation effect. Based on this procedure, we created the moderating term (i.e., inter-organizational collaboration *X* technology commercialization potential). The constructs involved in the interaction were mean-centered to attenuate multicollinearity concerns. Overall, we estimated five models. The dependent variable in Model 1 is inter-organization collaboration and Model 2 and Model 5 have technology transfer intensity as the dependent variable. Model 1 estimated the effects of business

Table 4 Descriptive statistics and inter-construct correlation (N = 211)

Variables	Means	SD	1	2	3	4	5	6	7	8	9
Firm age (log)	1.21	0.16									
Firm size (log)	1.6	0.37	− 0.11								
Service industry	0.56	0.43	− 0.10	− 0.03							
Technological turbulence	4.85	1.19	− 0.09	− 0.07	0.08	**(0.86)**					
Technological capability	5.86	2.97	0.13	0.14*	0.09	0.17*	**(0.83)**				
Business process digitalization	4.81	1.27	− 0.10	− 0.11	0.14*	0.29**	.28**	**(0.83)**			
Inter-organizational collaboration	5.03	1.28	0.12	− 0.22**	0.11	0.23**	0.15*	0.31**	**(0.83)**		
Technology commercialization potential	4.83	1.25	0.15*	0.12	0.25**	0.14*	0.11	0.12	0.13	**(0.85)**	
Technology transfer intensity	4.92	1.23	− 0.12	0.16*	0.27**	0.34**	0.33**	0.26**	0.25**	0.15*	**(0.83)**

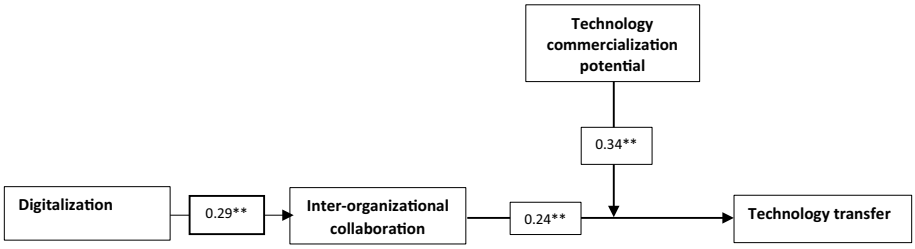

Fig. 1 Path estimates of the entire model as shown by Model 5 in Table 5. Goodness of fit indices: χ^2/d.f. = 1.93; NNFI = 0.93; CFI = 0.94; RMSEA = 0.05

process digitalization on inter-organization collaboration. In Model 2, we estimated the direct effect of business process digitalization on technology transfer intensity. The effect of inter-organization collaboration and the direct effect of the moderating variable (technology transfer potential) were included in Model 3. The interaction effect (inter-organizational collaboration *X* technology transfer potential) was added in Model 4. Following previous studies (see Adomako et al., 2022; Zahoor & Al-Tabbaa, 2021), we estimated Model 5 which consisted of the full structural model. Accordingly, we utilized the single model estimation procedure that included both inter-organizational collaboration and technology transfer intensity as dependent variables. This approach in SEM allowed us to simultaneously estimate both paths. Figure 1 depicts path estimates of the entire structural model with its associated fit indices.

The correlations of the variables are presented in Table 4. We present the results of structural model estimation in Table 5. Hypothesis 1 predicted that business process digitalization would have a positive influence on inter-organizational collaboration. The results in Model 1 show that H1 was supported ($\beta = 0.29$; $t = 3.92$; $p < 0.01$). Hypothesis 2 stated that inter-organizational collaboration would have a positive influence on technology transfer intensity. The results in Model 3 demonstrate that H2 was supported ($\beta = 0.24$; $t = 3.22$; $p < 0.01$). In Hypothesis 3, we proposed that the effect of inter-organization collaboration on technology transfer intensity would be exacerbated when technology commercialization potential is high. The results in Model 4 show that H3 was supported ($\beta = 0.34$; $t = 4.79$; $p < 0.01$).

To investigate the direction of the moderation, we followed recommended procedure (Aiken & West, 1991) and plotted a graph of the moderation at one standard deviation above and below the mean of technology commercialization potential (Fig. 2). The results of the simple slope analysis demonstrated that the effect of inter-organizational collaboration on technology transfer intensity was stronger when technology commercialization potential was high (simple slope = 0.32, $t = 3.72$, $p < 0.01$). Conversely, the slope was weak when technology commercialization potential was low (simple slope = −0.02, $t = -0.10$, $p = > 0.10$).

Finally, in Hypothesis 4, we predicted that inter-organizational collaboration mediates the relationship between business process digitalization and technology transfer intensity. To test the mediation hypothesis (i.e., H4), we followed Hayes & Preacher (2010) and estimated the significance of the indirect effect using the Sobel test and bootstrapping. The results in Table 6 show that the indirect effect was significant (Sobel $z = 2.05$, $p = 0.05$). The results of the Sobel test were confirmed by utilizing the bootstrapping method. Further, we estimated 95% bias-corrected confidence intervals (CI) for indirect effect by bootstrapping 10,000 samples. The results from bias-corrected CI ranged from 0.02 to 0.10, excluding zero in the CI. Since we did not find any zero in the CI, we concluded that the indirect effect is different from zero (Shrout & Bolger, 2002). Therefore, H4 was supported.

Table 5 Results of structural model estimation

	Independent variables			Dependent variables		
	Inter-organizational collaboration	Technology transfer intensity			Inter-organizational collaboration	Technology transfer intensity
	Model 1	Model 2	Model 3	Model 4		Model 5
Control paths						
Firm size (log)	0.11 (1.10)	0.12 (1.18)	0.09 (0.88)	0.03 (0.38)	0.08 (1.23)	0.11 (1.09)
Service industry	0.09 (1.04)	0.26 (2.89)**	0.20(2.71)**	0.18 (2.43)**	0.07 (1.08)	0.23 (2.73)**
Firm age (log)	0.12 (1.14)	− 0.11 (1-.12)	− 0.04 (− 0.53)	− 0.03 (− 0.44)	0.11 (1.11)	− 0.07 (− 0.83)
Technological turbulence	0.20 (2.95)**	0.26 (3.29)**	0.20 (2.93)**	0.19 (2.79)**	0.17 (2.36)**	0.26 (3.28)**
Technological capability	0.14 (1.73)*	0.25 (3.23)**	0.24 (3.17)**	0.22 (2.71)**	0.14 (1.74)*	0.23 (2.99)**
Direct effect paths						
Business process digitalization (BPD)	0.29 (3.92)**	0.24 (2.89)**	0.16 (2.49)*	0.14(1.71)*	0.27 (3.68)**	0.22 (2.79)**
Inter-organizational collaboration (IOC)			0.24 (3.22)**	0.20 (2.89)**		0.22 (3.20)**
Technology commercialization potential (TCP)			0.14 (1.77)*			0.13 (1.66)
Two-way interaction paths						
IOC * TCP				0.25 (2.80)**		0.34 (4.79)**
Goodness of fit indices						
R^2	0.20	0.14	0.16	0.21	0.29	
ΔR^2	–	–	0.04	0.05	0.08	
χ^2/D.F	1.64	1.43	1.42	1.35	1.90	
CFI	0.91	0.90	0.92	0.91	0.91	
NNFI	0.92	0.92	0.93	0.92	0.90	
RMSEA	0.06	0.05	0.04	0.04	0.05	

N = 211; Critical values of the t distribution for α = 0.05 and α = 0.01 (two-tailed test) are * = 1.96, and ** = 2.58, respectively (t-values are reported in parentheses)

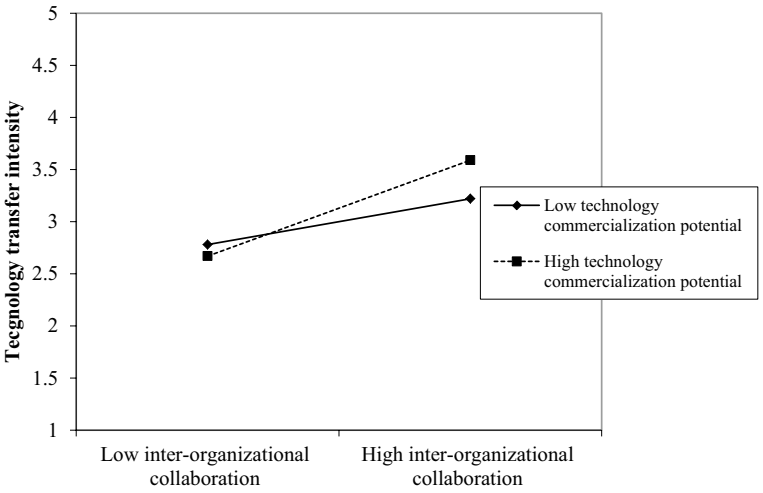

Fig. 2 Interaction of inter-organizational collaboration and technology commercialization potential on technology transfer intensity

Table 6 Indirect effect and significance using the normal distribution

	Value	SE	z	*p*
Sobel	0.04	0.03	2.05	0.05
Bootstrap results for the indirect effect	Effect	SE	LL 95% CI	UL 95% CI
	0.04	0.03	0.02	0.11

N = 211. Bootstrap sample size = 10,000. *$p < 0.05$; **$p < 0.01$

5 Discussion and implications

This study builds upon the RDT (Pfeffer & Salancik, 1978) and examines the influence of business process digitalization on technology transfer intensity through inter-organizational collaboration. The study's first finding emphasizes the importance of digitalization in improving technology transfer activities such as licensing, joint ventures, collaborations, and partnerships. Our study argues that business process digitalization improves efficiency, reduced costs, data accuracy, and enhances customer experience (Adomako et al., 2021b; BarNir et al., 2003) which is a valuable source of freeing up resources to focus on more strategic activities, such as inter-organizational collaboration. The second finding suggests that the more collaborative activities with other firms, the more technology transfer activities it pursues. The third finding reveals the mechanism of how digitalization affects technology transfer intensity through the mediating mechanism of inter-organizational collaboration. Additionally, the study hypothesizes and tests the role of technology commercialization potential as a moderator of the relationship between inter-organizational collaboration and technology transfer intensity. The study suggests that if the potential for commercializing a new technology is high, organizations may be more willing to collaborate to transfer the technology as this may be seen as a valuable opportunity to generate

revenue and create value. Overall, this study has important implications for both theory and practice.

5.1 Theoretical implications

Our results add to the current body of knowledge in three primary areas. First, by examining the effect of business process digitalization on technology transfer, this study sheds light on how digitalization can impact the transfer of technology within an organization or between organizations. Previous studies have shown that the adoption of digital technologies improves workflows, and reduces costs (BarNir et al., 2003; Viriyasitavat et al., 2019; Zahoor et al., 2023). Despite this insight, the body of research is limited regarding how digital technology impacts the process of sharing knowledge among organizations. Our theoretical model helps offer a new theoretical framework that incorporates the role of digitalization in technology transfer, highlighting how digitalization can either facilitate the transfer of technology.

Second, our findings extend the technology transfer literature (e.g., Ashari et al., 2023; Guerrero & Urbano, 2019; Hayter et al., 2020) by offering insights into the mechanisms that underlie the relationship between digitalization and technology transfer, which can further enhance our understanding of the digitalization phenomenon and its implications for organizations. Thus, we advance our knowledge of the impact of digitalization on organizational processes and provide a foundation for future research in this area.

Third, previous studies have emphasized the importance of digitalization for inter-organization collaboration (Adomako et al., 2021a; Alexiev et al., 2016; Bstieler et al., 2017; Sun & Cao, 2015), but they have not empirically investigated its role in inter-organizational collaboration. the success of new ventures. In contrast, we build on the growing body of research that views business process digitalization as the use of digital technologies to streamline and automate business processes, increase efficiency, reduce costs, and improve customer experiences (e.g., Adomako et al., 2021b; BarNir et al., 2003). By doing so, we aim to fill this gap in the literature by examining the explicit connection between business process digitalization and inter-organization collaboration. Since the impact of digitalization on inter-organizational collaboration is not well understood, we improve our understanding of the relationship between these two constructs.

Finally, our study contributes to the technology transfer literature (Botchie et al., 2022; Hayter et al., 2020) by investigating how technology commercialization potential impacts the relationship between inter-organizational collaboration and technology transfer intensity. While inter-organizational collaboration can lead to success in technology transfer, it may not be sufficient on its own. Although it is intuitively appealing to suggest that collaborating organizations may have complementary resources and expertise that can facilitate the transfer of technology, there has been little exploration of how technology commercialization potential can enhance the effectiveness of inter-organizational collaboration in driving technology transfer intensity. Technology commercialization potential (Fini et al., 2009; Frishammar et al., 2012) offers a promising framework for understanding the impact of conditions through which inter-organizational collaboration influences technology transfer intensity. However, the inter-organizational collaboration literature (Adomako et al., 2021a; Alexiev et al., 2016; Kusa et al., 2023) has yet to fully consider the role of technology commercialization potential in conditioning the effect of inter-organizational collaboration on technology transfer intensity. Our research addresses this gap by demonstrating

that collaborating organizations with stronger technology commercialization potential are more likely to improve their effort, resources, and activities in transferring technology from one organization to another. This finding is particularly relevant for firms operating in emerging societies, where weak institutional environments and market uncertainty can pose significant challenges (Anokhin et al., 2011; Oxley, 1999; Swinnen & Kuijpers, 2019).

5.2 Practical implications

Not only is this study valuable in theory, but it also has practical implications. The findings of this study can offer guidance to managers on how to improve their technology transfer performance by utilizing business process digitalization through inter-organizational collaboration. As more and more companies adopt digital technologies (Iyanna et al., 2022; Yang et al., 2023; Zahoor et al., 2023), managers need to understand how this affects their business processes. Additionally, our findings could help managers identify areas for technological improvement. Thus, by investigating the relationship between digitalization and technology transfer intensity, managers may be able to identify areas where their company could benefit from the additional technological investment (Fan et al., 2023; Sabherwal et al., 2019). This is likely to help managers to be better equipped to manage the adoption of new technologies within their organization and to leverage knowledge and technology from external sources. Further, our finding that inter-organizational collaboration positively influences technology transfer intensity is important for managing their intellectual property portfolio. For example, given that technology transfer often involves sharing intellectual property (Siegel et al., 2023; Suh & Oh, 2015), which can be a sensitive issue, managers can develop strategies for managing intellectual property through inter-organizational collaboration. Finally, we managers can develop a technology transfer strategy that considers the findings from this research. They can use this information to identify the types of collaborations that are most effective, the factors that facilitate technology transfer, and the best practices for managing intellectual property.

6 Limitations and future research direction

Our study has yielded significant findings that expand the technology transfer literature in terms of understanding how and when digitalization influences firms from engaging in technology transfer activities. However, despite these valuable theoretical contributions, the study has certain limitations that suggest areas for future research.

First, while there is a general understanding that a firm's digital strategy plays a significant role in its technology transfer activities (Björkdahl, 2020; Ciampi et al., 2022), there are still gaps in knowledge regarding the effects of important cultural orientations (Hofstede, 2001) on a firm's technology transfer activities. Due to the objectives of our paper and the need for a parsimonious model, we were unable to investigate the potential influence of national cultural factors, which are widely regarded as important determinants of managerial strategic behaviors, on firms' strategic orientation (Abbasi et al., 2021; Kedia & Bhagat, 1988). For example, to what extent do cultural dimensions like long-term orientation and uncertainty avoidance (Hofstede, 2001) impact firms' technology adoption and technology transfer activities? Therefore, future research that explores the influence

of national cultural orientations on the technology transfer behavior of developing country firms can provide a more nuanced understanding of the key drivers of firms' technology transfer intensity. Additionally, although we control for technological capability in our model, we envisage innovation as a critical driver of technology transfer activities (Hayter et al., 2020; Yun et al., 2018), particularly among technology firms. Therefore, we recommend that future researchers incorporate high technology vs low technology into their analytical models to better explain how these factors explain variations in firms' technology transfer activities. In addition, future research could extend the literature by examining the extent to which firms' innovativeness and technological competence moderate the relationship between digitalization and technology transfer intensity.

Second, emerging economies have weaker institutional frameworks compared to developed markets (Gao et al., 2017; Ge et al., 2019). However, there are subtle differences within these economic groups. The study's findings were based on data set from Vietnam, a leading developing nation in South East Asia, but these findings may not apply to all organizations due to the significant variations across emerging economies. This is because although there have been improvements in political and institutional reforms in the emerging countries, some South Eastern economies still lag in terms of democratic institutional reforms. Additionally, since there are marked structural differences between developed and emerging economies (Gammeltoft et al., 2010), a larger and more diverse sample of organizational actors from both developed and emerging nations would allow for a more comprehensive comparative analysis.

Third, despite utilizing a strong data collection strategy, which involved collecting data from multiple sources, this study has certain limitations. First, the variables were not manipulated, nor was a random assignment strategy employed, which could have strengthened the ability to make causal claims (Barnes et al., 2015). To address this limitation, future studies should obtain multiple data from the same sample over time using a longitudinal design. This is likely to improve our confidence in making causal claims. Moreover, although we used tame-lag data collected from multiple respondents, we acknowledge that using data from a cross-sectional survey to measure both an independent and dependent variable could lead to common method bias (Podsakoff et al., 2012). However, we have taken several measures to minimize this risk, and our tests for common method bias show no indication of any issues.

Fourth, previous research has extensively explored the factors that influence technology transfer, highlighting a diverse range of factors that encompass resources and capabilities (Lin, 2003; Lindelöf & Löfsten, 2004). Resource-related factors encompass tangible assets, such as financial resources, physical infrastructure, and technological expertise, which enable organizations to invest in and support technology transfer initiatives. On the other hand, capability-related factors involve the organization's internal competencies, such as research and development capabilities, absorptive capacity, technological learning, and innovation capabilities. These capabilities enable organizations to effectively absorb, adapt, and apply transferred technology to their context. The interplay of resources and capabilities contributes to the overall success and effectiveness of technology transfer, facilitating knowledge sharing, collaboration, and the adoption of new technologies across industries and organizations. However, since we did not have data to control resource-related factors, our findings are limited to these factors. Future research should control for firm resources such as slack.

Finally, the study's focus on SMEs raises concerns about its generalizability, and future studies may focus on large firms to confirm the results. Moreover, the study is based on data from one developing economy, Vietnam, and may not apply to other emerging

economies due to the unique environmental context of Vietnam. Future studies can be conducted using a multi-country setting to capture the different contextual idiosyncrasies.

7 Conclusion

Despite the foregoing limitations, our analysis of a sample of 211 Vietnamese firms shows that the digitalization of business practices plays a significant role in the degree of technology transfer intensity through inter-organizational collaboration. In addition, our findings demonstrate that the impact of inter-organization collaboration on technology transfer intensity is amplified when technology commercialization potential is high. Overall, the results of our study contribute to the literature on technology transfer by providing a clearer understanding of how and when digitalization and inter-organizational collaboration can affect the extent of technology transfer intensity in emerging markets.

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Declarations

Conflict of interest The authors have no conflict of interest.

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