International Journal of Business and Economic Affairs (IJBEA)
11(2), 01-14 (2026)
DOI: 10.24088/IJBEA-2026-112001
ISSN: 2519-9986

From Digital Entrepreneurial Orientation to Sustainable Competitive Advantage: The Sequential Roles of Digital Capability and Business Model Innovation

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Abstract: Digital transformation is reshaping entrepreneurial firms by enabling organizations to integrate emerging technologies, access market intelligence, redesign business processes, and respond rapidly to changing competitive conditions. However, the mechanisms through which digital transformation and technological investment translate into disruptive innovation remain insufficiently understood. Building on the dynamic capabilities perspective, this study examines how digital transformation and technological investment contribute to disruptive innovation through digital innovation capability and investigates whether inter-organizational collaboration strengthens this transformation–innovation process. Drawing on data from entrepreneurial firms, the study develops an integrated framework in which digital transformation and technological investment enhance firms' digital innovation capability, which subsequently facilitates disruptive innovation. In addition, inter-organizational collaboration is proposed as a boundary condition that strengthens the effect of digital innovation capability on disruptive innovation by enabling firms to access complementary knowledge, resources, expertise, and market intelligence. The study contributes to the disruptive innovation literature by moving beyond direct-effect explanations and clarifying the capability-building mechanism through which digital transformation and technology-related investments generate disruptive outcomes. The findings are expected to provide important implications for entrepreneurial firms seeking to convert digital resources and collaborative relationships into market-disrupting innovations.

Keywords:Digital transformation, Digital innovation capability, Technological investment, Inter-organizational collaboration, Disruptive innovation, Entrepreneurial firms, Dynamic capabilities.

Received: 03 February 2026 / Accepted: 15 March 2026 / Published: 08 April 2026

INTRODUCTION

The theory of disruptive innovation, originally developed by Christensen in his seminal work "The Innovator's Dilemma" over two decades ago, has been extensively discussed and applied (Bergendal, 2017). Despite the widespread attention, various viewpoints and debates surrounding this research topic persist, leading to a lack of consensus on crucial issues and contributing to confusion rather than clarity in the theory (Lindsay & Hopkins, 2010). The term "disruptive innovation" is often applied loosely to diverse contexts of innovation, leading to ambiguity and misinterpretation (Martínez-Vergara & Valls-Pasola, 2021). Concerns have been raised by Christensen himself regarding the indiscriminate application of the theory in unrelated situations (King & Baatartogtokh, 2015). This state of disorder and fragmentation has led to misunderstandings of disruptive innovation, potentially hindering its further development and application, and risking its transformation into a mere business buzzword (Gibbons, 2015). Thus, it is imperative to precisely define the fundamental concept of the theory and its true implications to rectify past misunderstandings, prevent misuse, and discern the genuine implications of disruptive innovation.

Furthermore, a more general approach towards disruptive innovation is characterized as follows: A new product, deemed the disruptive innovation, initially falls short in performance compared to the existing product's primary dimension valued by mainstream customers. Innovation is widely recognized for its significant impact on economic development and the attainment of sustainable competitive advantage (Hana, 2013). However, it may excel in an

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alternative dimension, potentially opening up a new market or offering advantages such as ease of use or lower cost. Gradually, the disruptive innovation improves on the primary dimension, ultimately capturing the attention of mainstream customers who initially rejected it. Christensen et al. (2013) argue that established businesses often overlook the threat posed by disruptive innovations. They assert that when incumbents are displaced, it is typically by disruptive innovations. Therefore, managers must identify disruptive innovations early on. These works further suggest that to effectively address disruptive innovation, incumbents should pursue it through a separate business unit. This underscores the importance of clear recognition; a firm must be capable of distinguishing between disruptive innovation and its counterpart, sustaining innovation. Anticipating the disruptive potential of innovation holds significant importance for established players in the market, enabling them to avoid detrimental consequences resulting from neglecting disruptive innovations. These adverse outcomes may include a decrease in market share, diminished status, or even the potential for bankruptcy or organizational demise. However, organizational managers often face the challenge of determining whether a particular technology will lead to market disruption or impact their organization. A widely held belief suggests that if managers could identify disruptive innovations before these technologies impact markets, they could take proactive measures to transform potential marketplace disruptions into new opportunities or, at the very least, avert organizational failure (Yu & Hang, 2008).

The ability to predict disruptive innovations carries significant implications, prompting researchers to explore methods of forecasting disruptions caused by innovations (Wan et al., 2015). However, such studies encounter several common challenges: the ambiguity of defining disruptive innovation, the varying impact of disruptive innovations on different organizations, and the availability of data only after the disruption has occurred (Lyytinen & Rose, 2003; Hynes & Elwell, 2016). These challenges have led researchers to seek clearer and more precise definitions or identification methods for disruptive innovations. The work of Christensen and Bower (1996), which focused on characterizing marketplace disruptions resulting from new technologies, presents an opportunity to define how these technologies drive market changes. This suggests that specific characteristics of technologies contributing to marketplace disruptions could be identified to expand disruptive innovation theory. Despite several attempts to define or identify disruptive innovations from an innovation perspective rather than solely a marketplace perspective, existing definitions have fallen short of specifying innovation characteristics that could clarify the concept of disruptive innovation (Markides, 2006; Schmidt & Druehl, 2008).

Previous research on disruptive innovations has indicated that firms confronted with disruptive innovations must be ready to address their unexpected challenges and opportunities by embracing disruptive business model innovation as disruption typically leads to new product and service offerings (Cozzolino et al., 2018). Furthermore, from an entrepreneurial standpoint, a business model represents the configuration of organizational structures to exploit commercial opportunities that arise from market imperfections (Zott et al., 2010). Moreover, a gradual shift from the old model to the new right business model is often challenging (Bucherer et al., 2012). Businesses are required to explore alternative models to existing business practices and understand how they can fulfill customer needs differently (Nidumolu et al., 2009), making it more crucial for business success than mere product or service innovation. Businesses require strong incentives to drive entrepreneurial activities essential for gaining insights into both technological and market realms in the face of disruption. Entrepreneurs and managers must comprehend the underlying customer needs and assess how competitors are addressing those needs, explore technical and organizational enhancements, make informed predictions about future customer and competitor behaviors as well as costs, and make necessary adjustments to the business model through extensive trial and error learning (Rerup & Feldman, 2011). The main challenges in adopting disruptive lie in understanding how new products and services generate and distribute value across the various actors in a firm's value network, and aligning the incentives of different actors with the new value distribution.

The evolution of businesses through digital transformation is reshaping both technology and business frameworks, presenting both challenges and opportunities for established businesses and new startups, particularly in the realm of disruptive innovations. A significant outcome of this shift, stemming from the Fourth Industrial Revolution (4.0) is the emergence of smart factories. The transition from traditional manufacturing facilities to smart factories begins with the digitization, measurement, and integration of all aspects of production systems. However, the adoption and incorporation of Industry 4.0 technologies (such as advanced robotics, additive manufacturing, augmented reality, simulation, horizontal and vertical system integration, the Industrial Internet of Things (IIoT), cloud computing, cybersecurity, big data, and analytics) within manufacturing enterprises represent a disruptive

innovation that is revolutionizing production methods (Brunelli et al., 2017).

Firm performance theory, or FRM theory, encompasses the use of a balanced assessment, such as the balanced scorecard, as a managerial instrument for guiding the management and execution of strategies grounded in the idea of holistic organizational evaluation. Furthermore, business firms need to cultivate the capacity for learning and the creation of novel resource foundations to navigate beyond the limitations posed by current capabilities, thereby establishing a fresh reservoir of competitive advantages. Additionally, the role of innovation in gaining competitive advantage can't be ignored. The correlation between dynamic capability and innovation capability can catalyze heightened organizational innovation endeavors, ultimately culminating in improved performance. Additionally, fostering a culture of disruptive innovation within the organization can amplify this effect, propelling it toward unprecedented levels of success. In the dynamic landscape of customer demand, firms endeavor to provide inventive ideas and products or services, aiming to generate enhanced value through innovation. An organization's innovation strategy is determined by its existing capacity and knowledge. The dynamic capability and innovation capacities of an organization are closely intertwined with its innovation strategies, all of which rely on internally and externally sourced resources. Therefore, businesses engage in disruptive innovation to gain competitive advantage and to explore new sectors in a market thus boosting performance through innovation.

Inter-organizational collaboration is a key tool for developing disruptive innovation in today's dynamic and complex business environment. Furthermore, collaborative efforts between businesses enable the collective utilization of valuable resources, knowledge, and expertise, therefore, enhancing the potential for disruptive breakthroughs in a market. As highlighted by Ernkvist (2015), such collaborations facilitate access to complementary capabilities and resources that may not be available internally, thereby enhancing the capacity for disruptive innovation. Furthermore, inter-organizational collaboration serves as a catalyst for disruptive innovation by fostering a culture of openness, experimentation, and risk-taking (Mutira et al., 2023). Collaborative ecosystems provide fertile ground for cross-pollination of ideas and perspectives, leading to the generation of novel solutions to complex problems. By engaging in collaborative innovation networks, organizations can tap into a broader innovation ecosystem comprising industry partners, startups, research institutions, and even competitors, thus expanding the scope and scale of disruptive innovation initiatives. This collaborative approach not only accelerates the pace of innovation but also mitigates risks associated with pursuing disruptive ideas in isolation (Moellers et al., 2020; Van de Ven & Ring, 2006). Overall, inter-organizational collaboration plays a pivotal role in driving disruptive innovation by fostering synergy, diversity, and collective intelligence across organizational boundaries. In this study, we aim to explore the interplay of digital transformation, firm performance, and inter-organizational collaboration in the context of disruptive innovation. To address this objective, we systematically developed our study's hypotheses, we empirically analyze 1823 entrepreneurial firms from Malaysia spanning various industries, geographical locations, and sizes.

THEORETICAL BACKGROUND AND HYPOTHESES DEVELOPMENT

Digital Transformation and Disruptive Innovation

Digital Business Transformation is reshaping businesses across all industries by dismantling obstacles between individuals, businesses, and objects. Through the removal of these barriers, new products, services, and more efficient business practices are being developed. The emergence of information and digital technologies, is characterized by the utilization of information and communication technologies (Bonenberg et al., 2018) as well as the proliferation of new digital technologies (Redwood et al., 2017). Furthermore, within business organizations, this type of organizational metamorphosis, facilitated by technology, focuses on leveraging information and digital technologies to influence various aspects of the organization (Constantiou et al., 2023). For instance, organizations integrate emerging technologies such as social media, mobile technologies, the internet of things, cloud technologies, and big data analytics to optimize firm's operations (Bessis & Dobre, 2014). Consequently, these technologies reshape the operational landscape of business entities, generating value and delivering unique experiences to diverse stakeholders involved (Peterson, 2004).

Digital technology plays a pivotal role in supporting firms' innovation endeavors by providing essential technical infrastructure (Nambisan et al., 2019). Moreover, firms enhance their ability to identify emerging opportunities and threats in external environments, enabling them to swiftly allocate resources toward innovative activities (Ireland &

Webb, 2007). Particularly for entrepreneurial firms, digital platforms, and infrastructure serve as facilitators for accessing and leveraging market information. These firms leverage editable and transferable data offered by digital technologies (Chan et al., 2020). Digital transformation enables these entrepreneurial firms to involve consumers in the design, production, distribution, and service processes (Nambisan et al., 2019). In the context of the digital economy, traditional cost-leadership strategies, which prioritize operational cost reduction, are no longer sufficient (Wang et al., 2006). Leveraging digital technologies and embracing digital transformation have become pivotal strategies for entrepreneurial firms to capture market attention and deliver superior services (Cennamo et al., 2020). Despite considerable ongoing efforts in this domain, this study highlights that research conducted in this field remains in its early stages. There are indications of an emerging literature landscape along with a constrained comprehension of the phenomenon. With the pervasive adoption of digital transformation, entrepreneurial firms gain access to vast amounts of market data, enhancing their ability to adapt to evolving environments promptly. This lays a robust foundation for facilitating disruptive innovation. Therefore, we assert that:

$H1$: Digital transformation facilitates disruptive innovation by enabling organizations to leverage digital technologies, platforms, and extensive market data, enhancing adaptability and innovation capabilities.

Inter-organizational Collaboration and Disruptive Innovation

Inter-organizational collaboration has been acknowledged as a crucial factor in complementing internal innovative activities within organizations (Zahoor & Al-Tabbaa, 2020). Existing literature emphasizes that organizations can enhance their innovative capabilities by establishing collaborative relationships with various partners (e.g. suppliers and research institutes) (Tsai, 2009). The benefits of inter-organizational collaboration for enhancing the effectiveness and efficiency of innovation strategies are manifold (Hiidensalo, 2016). Firstly, such collaborations provide access to complementary assets necessary for translating innovation projects into commercial success (Teece, 1986). Secondly, collaborating with other organizations facilitates the transfer of codified and tacit knowledge (Foos et al., 2006). Finally, inter-organizational collaboration helps distribute the costs of research and development (R&D) among multiple parties (Feller et al., 2013).

However, despite the potential benefits, not all collaborations are successful (Pekar & Allio, 1994). Furthermore, reasons for alliance failure include unintended knowledge spillovers (Shu et al., 2014). Nevertheless, prior research has demonstrated that inter-organizational collaboration positively influences the innovative performance of firms (Hernandez-Espallardo et al., 2018). Furthermore, innovations not only reshape internal management within organizations but also influence operational norms across the entire industry (Clohessy & Acton, 2019). Alterations in the industry's prevailing technological framework and competitive landscape can lead stakeholders to struggle to adapt to disruptive innovation initiatives (Spencer & Kirchhoff, 2006). Moreover, to ensure the successful implementation of disruptive innovation within their organizations, entrepreneurial firms must seek coordination and cooperation among stakeholders (Bolz, 2020). Collaborating across organizations helps reduce the costs associated with implementing innovative activities, such as promoting new products and changing business models. Additionally, it enables entrepreneurial firms to access accurate market information from various sources at a reduced expense (Cohen & Winn, 2007). This collaboration provides essential market feedback for implementing disruptive innovation and enhances the efficiency of innovation initiatives. Moreover, inter-organizational collaboration can alleviate external constraints on implementing disruptive innovation. Therefore, we propose that:

$H2$: Inter-organizational collaboration positively impacts the successful implementation of disruptive innovation in entrepreneurial firms.

Technological Investment and Disruptive Innovation

Technological investment is a pivotal driver of disruptive innovation within business firms. Through resource allocation towards technological advancements, firms can enhance their innovative capabilities, leading to the development of groundbreaking products, services, or business models that disrupt existing markets (Bergek et al., 2013). Moreover, technological investment enables firms to stay ahead of the curve in rapidly evolving industries, fostering a culture of continuous improvement and adaptation to changing market dynamics (Mızrak, 2024). Furthermore, firms that strategically invest in technology are better positioned to drive disruptive innovation, gain competitive advantage, and shape the future of their industries (Christensen et al., 2018).

Businesses that excel in performance may find it easier to access capital for further investments and innovations

(Teece, 2010). Additionally, prior investments in technology and innovation could enhance a firm's absorptive capacity (Cohen & Levinthal, 1990), and increase the availability of complementary resources such as skilled labor (Acemoglu, 2002). Consequently, there may exist a positive feedback loop between technology investments, performance, investment opportunities, and innovation potentials. Furthermore, business intelligence and information technology play crucial roles in enhancing firms' performance (Ping et al., 2018). Leveraging information technology capabilities enables firms to swiftly respond to evolving business environments, directly impacting firms' innovative capabilities (Sambamurthy et al., 2003). Effective information management fosters flexibility and facilitates adaptive decision-making, ultimately contributing to organizational success (Abubakar et al., 2019).

Technology plays a critical role in enabling and enhancing firms' performance. Moreover, establishing a collaborative and strategic relationship between business and technology is essential for fostering a firm's ability to innovate. Technology significantly contributes to improving business firms' performance amid challenges posed by digital economics, digital transformation, evolving customer preferences, and market demands. Additionally, businesses must innovate and adapt to achieve cost savings and operational efficiencies. In today's dynamic business landscape, the interconnectedness of technology and business is imperative for organizational success (Melville et al., 2004).

$H3$: Technology investments positively impact firms' performance and innovation potentials (Disruptive Innovation), while leveraging information technology enhances firms' creativity and operational efficiencies.

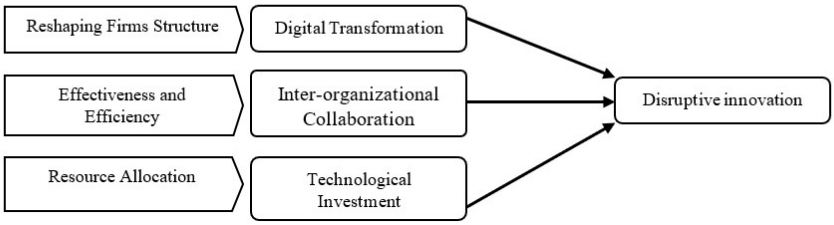


Figure 1: Research Model

METHODOLOGY

The study utilizes an empirical research approach with a quantitative methodology, employing statistical data analysis to comprehend and elucidate relationships. Initially, a research framework is constructed and then tested empirically using a standardized questionnaire, followed by statistical examination through regression and correlation analysis. The initial sample comprised 2,235 firms from Malaysia, selected systematically. Data collection commenced in January 2022 and concluded in December 2023 via an online quantitative survey distributed to firms. Respondents included chief executive officers and other high-level managers in strategy-related fields, ensuring anonymity and aggregated data usage. Among the 2,235 entrepreneurial firms we discarded 412 firms' responses due to incomplete or non-satisfactory responses that completed the online survey, the majority were from the Technology industry. We sourced scale items for digital transformation from the work of Vaska et al. (2021) and Ziyadin et al. (2020); inter-organizational collaboration scale items from the work of Zahoor and Al-Tabbaa (2020) and Saukko et al. (2020); technological investment scale items from the work of Ganda (2019) and Shahzad et al. (2021); and disruptive innovation scale from the work of Si and Chen (2020) and Kivimaa et al. (2021). The responses were assessed using a seven-point Likert scale, ranging from 1 (strongly disagree) to 7 (strongly agree). Confirmatory factor analysis (CFA) was utilized to evaluate the appropriateness of our model. The standardized loadings of all items on their respective constructs, in conjunction with the fit indices Chi-Square ($\chi^2 = 300$, df $= 150$, $\chi^2/\text{df} = 2.00$, IFI $= .90$, TLI $= .88$, CFI $= .92$, and RMSEA $= .07$) indicated that the proposed model demonstrated a strong fit with the data.

RESULTS AND DISCUSSION

Table 1: Model fit

	Variables	R Square	SRMR
Hypothesis 1	Digital Transformation	0.789	0.091
Hypothesis 2	Inter-organizational Collaboration	0.762	0.090
Hypothesis 3	Technological Investment	0.745	0.088

DV- Disruptive innovation

Table 1 depicts model fit statistics for three hypotheses: digital transformation, inter-organizational collaboration, and technological investment. High R Square values (0.745 to 0.789) indicate substantial variance explanation by independent variables. Low SRMR values (0.088 to 0.091) suggest a good fit between observed data and the model. Overall, the model aligns well with data on these variables.

Table 2: Factor Loading, Construct Reliability, and Validity

Variables	**Loadings**	**CA**	**CR**	**AVE**
Digital Transformation (items)		0.876	0.921	0.734
DT1	0.672			
DT2	0.790			
DT3	0.618			
DT4	0.628			
DT5	0.745			
DT6	0.687			
DT7	0.672			
DT8	0.678			
DT9	0.702			
Inter-organizational Collaboration (items)		0.852	0.872	0.723
IOC1	0.709			
IOC2	0.623			
IOC3	0.665			
IOC4	0.687			
IOC5	0.716			
IOC6	0.671			
IOC7	0.683			
IOC8	0.611			
IOC9	0.732			
IOC10	0.784			
Technological Investment (items)		0.901	0.832	0.772
TV1	0.704			
TV2	0.734			
TV3	0.756			
TV4	0.612			
TV5	0.698			
TV6	0.708			
TV7	0.712			
Disruptive Innovation (Items)		0.923	0.871	0.769
DI1	0.736			
DI2	0.768			
DI3	0.672			
DI4	0.712			
DI5	0.684			
DI6	0.769			

DT-Digital Transformation; IOC- Inter-organizational Collaboration; TI- Technological Investment; DI- Disruptive Innovation.
Note: CA, Cronbach's Alpha; CR, composite reliability; AVE, average variance extracted.

Table 2 depicts key measures of construct reliability and validity. The factor loading values are notably high for all items within each variable, ranging from 0.612 to 0.901. Construct reliability, as measured by Cronbach's Alpha

(CA) and composite reliability (CR), is also strong across all variables, with values exceeding the recommended threshold of 0.7. Additionally, the average variance extracted (AVE) values for each construct are satisfactory, surpassing the acceptable threshold of 0.5. These findings collectively indicate strong internal consistency and validity of the measurement model, affirming the reliability of the data and the suitability of the constructs for further analysis.

Table 3: Discriminant Validity (Fornell and Larcker)

	1	2	3	4
01. Digital Transformation	0.845			
02. Inter-organizational Collaboration	0.523	0.832		
03. Technological Investment	0.762	0.376	0.879	
04. Disruptive Innovation	0.751	0.438	0.621	0.875

Table 3 depicts the discriminant validity using the Fornell and Larcker criterion. The values in the diagonal cells (1, 2, and 3) are higher than the corresponding off-diagonal values, indicating that each variable's AVE is greater than its correlations with other variables. This demonstrates adequate discriminant validity among the variables, suggesting that they measure distinct constructs and are not highly correlated with each other, supporting the validity of the measurement model.

Table 4: Discriminant Validity (Heterotrait-Monotrait Ratio)

	1	2	3	4
01. Digital Transformation	0.731			
02. Inter-organizational Collaboration	0.365	0.787		
03. Technological Investment	0.548	0.651	0.765	
04. Disruptive Innovation	0.463	0.572	0.634	0.771

Table 4 depicts the discriminant validity results using the Heterotrait-Monotrait (HTMT). The values in the diagonal cells (1, 2, and 3) represent the HTMT Ratio for each variable, while the off-diagonal values show the pairwise HTMT Ratios between variables. According to the HTMT Ratio criterion, discriminant validity is established when the HTMT Ratios are below the threshold of 1.0. In this table, all the diagonal and off-diagonal values are below 1.0, indicating good discriminant validity. This suggests that the variables are measuring distinct constructs, supporting the validity of the measurement model.

Table 5: Regression Results 95% confidence intervals

Paths	Coefficient	Std. Error	*p*-value
DT $\rightarrow$ DI	0.783	0.032	0.000
IOC $\rightarrow$ DI	0.681	0.049	0.000
TI $\rightarrow$ DI	0.824	0.078	0.000
Model Summary	R = .845(84.5%)	Std. Error = 1.126	

Significance levels: ***p< .001; *p< .05; DT-Digital Transformation; IOC- Inter-organizational Collaboration; TI- Technological Investment; DI- Disruptive Innovation. All individual standardized regression weights are reported.

Table 5 provides empirical support for the hypotheses related to the influence of digital transformation, inter-organizational collaboration, and technology investments on disruptive innovation in entrepreneurial firms. Firstly, consistent with Hypothesis 1, the coefficient estimate for the path from Digital Transformation (DT) to Disruptive Innovation (DI) is 0.783, with a standard error of 0.032 and a highly significant p-value of 0.000. This suggests that

digital transformation facilitates disruptive innovation by enabling business firms to leverage digital technologies, platforms, and extensive market data, thereby enhancing their adaptability and innovation capabilities. Moreover, the cross-level interaction plots showing the association between digital transformation and disruptive innovation are shown in Figure 2. Furthermore, these results are well supported by previous theoretical and empirical studies (e.g., Al-Edenat, 2023; Vaska et al., 2021; Wu & Li, 2024). Similarly, supporting Hypothesis 2, the coefficient estimate for the path from Inter-organizational Collaboration (IOC) to Disruptive Innovation (DI) is 0.681, with a standard error of 0.049 and a significant p-value of 0.000. This indicates that inter-organizational collaboration positively impacts the successful implementation of disruptive innovation in entrepreneurial firms. Moreover, the cross-level interaction plots showing the association between Inter-organizational collaboration and disruptive innovation are shown in Figure 3. Moreover, these results are well supported by previous theoretical and empirical studies (e.g., Greco et al., 2022; Zhou et al., 2022). Furthermore, in line with Hypothesis 3, the coefficient estimate for the path from Technological Investment (TI) to Disruptive Innovation (DI) is 0.824, with a standard error of 0.078 and a highly significant p-value of 0.000. This supports the notion that technology investments positively influence firms' performance and innovation potentials, particularly in enhancing creativity and operational efficiencies through the leverage of information technology. Moreover, the cross-level interaction plots showing the association between Technological Investment and disruptive innovation are shown in Figure 4. Moreover, these results are well supported by previous theoretical and empirical studies (e.g., da Costa Nogami & Veloso, 2017; Suh et al., 2010). In summary, the regression analysis provides robust evidence for the hypothesized relationships, contributing to our understanding of the factors driving disruptive innovation in entrepreneurial contexts.

Table 6: Pearson Correlation

	DT	IOC	TI	Decision-Making Processes (DMP)
DT-Digital Transformation	1			
IOC- Inter-organizational Collaboration	.762**	1		
TI- Technological Investment	.823**	.847**	1	
DI- Disruptive Innovation	.716**	.651**	.871**	1
	** Correlation is significant at the 0.01 level (2-tailed). N = 1823			

DT-Digital Transformation; IOC- Inter-organizational Collaboration; TI- Technological Investment; DI- Disruptive Innovation

Table 6 depicts strong positive correlations between various factors within the context of digital transformation (DT), inter-organizational collaboration (IOC), technological investment (TI), and disruptive innovation (DI). Specifically, significant correlations are observed between DT and IOC ($r = .762$, $p < .01$), DT and TI ($r = .823$, $p < .01$), TI and IOC ($r = .847$, $p < .01$), as well as TI and DI ($r = .871$, $p < .01$). Additionally, strong correlations are found between DI and DT ($r = .716$, $p < .01$), DI and IOC ($r = .651$, $p < .01$), highlighting the interplay between disruptive innovation and other factors in the digital transformation landscape. These findings underscore the interconnectedness of digital transformation initiatives, inter-organizational collaboration, technological investment, and their impact on decision-making processes within organizations.

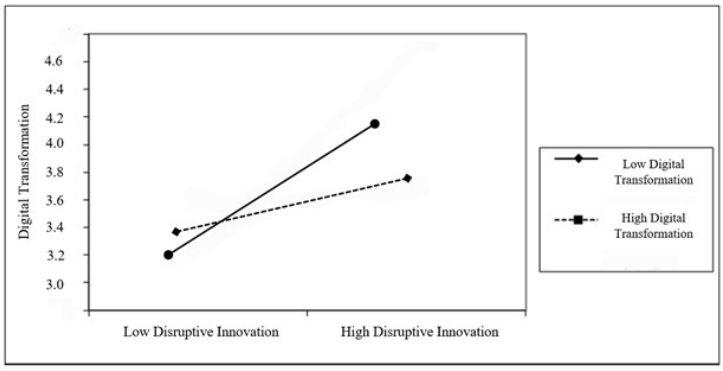


Figure 2: Cross-level interaction plots – Digital Transformation and Disruptive Innovation

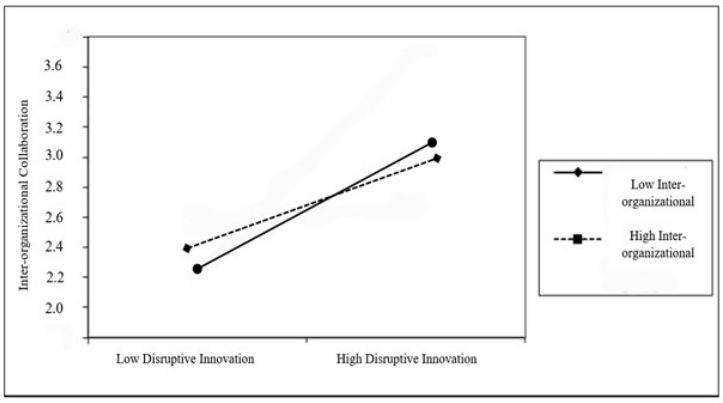


Figure 3: Cross-level interaction plots – Inter-organizational Collaboration and Disruptive Innovation

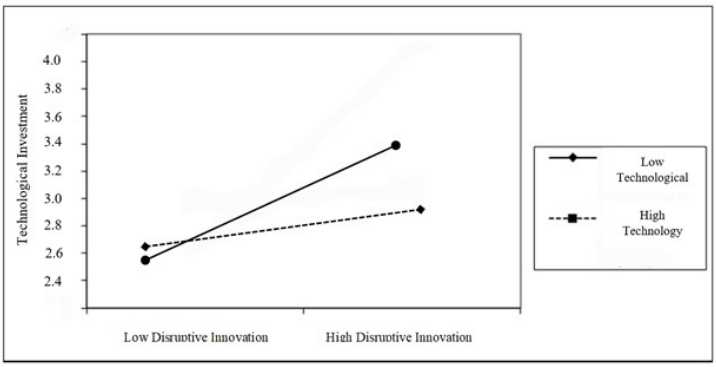


Figure 4: Cross-level interaction plots – Technological Investment and Disruptive Innovation

DISCUSSION

The impact of digital transformation, inter-organizational collaboration, and technology investments on disruptive innovation within entrepreneurial firms is a crucial area of study in contemporary business research. Digital transformation plays a significant role in enhancing firms' adaptability and innovation capabilities, as supported by prior studies (Fan et al., 2022; Liu et al., 2021; Putritamara et al., 2023). The integration of digital technologies and the utilization of extensive market data enable businesses to pivot quickly, respond to market demands, and innovate more effectively. This ability to leverage digital tools and platforms not only enhances operational efficiencies but also fosters a culture of innovation within entrepreneurial firms, positioning them to drive disruptive changes within their industries. Similarly, the association between inter-organizational collaboration (IOC) and disruptive innovation (DI) underscores the importance of collaborative efforts among businesses. Research by Hynes and Elwell (2016) and van den Broek and van Veenstra (2018) supports the notion that collaborative ventures positively influence disruptive innovation in entrepreneurial firms. By collaborating with external partners, such as suppliers, customers, and even competitors, firms gain access to diverse resources, expertise, and perspectives. This collaborative ecosystem facilitates knowledge sharing, co-creation, and the pooling of resources, ultimately enabling entrepreneurial firms to develop and implement disruptive innovations that can reshape markets and challenge established industry norms. Furthermore, the positive relationship between technological investment (TI) and disruptive innovation (DI) highlights the crucial role of technology in driving innovation within entrepreneurial firms. Studies by Majumdar et al. (2018) and Palmié et al. (2020) emphasize that technology investments, particularly in information technology, contribute significantly to enhancing firms' performance and innovation potentials. By investing in advanced technologies, such as artificial intelligence, machine learning, and data analytics, entrepreneurial firms can unlock new opportunities, streamline operations, and develop innovative products or services that disrupt traditional market dynamics. This underscores the importance of strategic investment in technology as a key driver of disruptive innovation within entrepreneurial contexts. To conclude, the interplay between digital transformation, inter-organizational collaboration, and technological investment significantly influences disruptive

innovation within entrepreneurial firms. By leveraging digital tools, engaging in collaborative partnerships, and strategically investing in technology, entrepreneurial firms can enhance their adaptability, foster innovation, and drive disruptive changes that challenge industry norms and reshape markets. This highlights the importance of embracing these factors as essential components of an effective innovation strategy for entrepreneurial success in today's dynamic business landscape.

THEORETICAL CONTRIBUTION

The study's findings on digital transformation, inter-organizational collaboration, and technology investments carry important theoretical implications for innovation management and entrepreneurship. Firstly, they highlight that digital transformation goes beyond technology adoption, playing a key role in enhancing firms' adaptability and innovation capabilities. This sheds light on how organizational behavior is shaped by digital transformation, impacting strategic decision-making. Secondly, the emphasis on collaboration challenges traditional competition dynamics, emphasizing the value of partnerships in driving innovation. This suggests that fostering collaborative ecosystems is essential for promoting a culture of innovation and achieving breakthroughs. Lastly, the positive link between technological investments and disruptive innovation underscores technology's role as a vital innovation enabler. This underscores the importance of strategic technology investments for gaining a competitive edge and driving industry changes. Overall, these implications deepen our understanding of how digital transformation, collaboration, and technology investments shape innovation processes in entrepreneurial firms, setting the stage for future research in this field.

FUTURE RESEARCH DIRECTION

The study's findings on digital transformation, inter-organizational collaboration, and technology investments open up avenues for future research in innovation management and entrepreneurship. Firstly, there's a need to explore how specific digital technologies and organizational culture interact to influence firms' adaptability and innovation capabilities. Secondly, further investigation into collaborative partnerships, like strategic alliances and open innovation initiatives, is warranted to understand their role in driving disruptive innovation. This includes identifying effective strategies to overcome collaboration challenges such as trust-building and knowledge-sharing. Thirdly, longitudinal studies are necessary to assess the long-term impact of technological investments on innovation outcomes and how firms can manage associated risks. Overall, future research can deepen our understanding of how these factors interact to shape disruptive innovation, offering valuable insights for both academics and practitioners aiming to foster innovation in entrepreneurial settings.

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