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More than money: strategic and operational innovation capabilities to promote technological innovation through crowdfunding

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Abstract

Crowdfunding delivers far more than financial capital when ventures possess the right innovation capabilities. Drawing on the dynamic-capability view, transaction-cost economics, and knowledge-based view, we theorize that *strategic* (dynamic scanning, seizing, and reconfiguring) and *operational* (digitalization, investment, and networking) capabilities jointly propel firms' technological innovation and that this propulsion is channeled through digital-platform trust and crowdfunding. Primary data from 164 technology-oriented start-ups and SMEs were analyzed via partial least-squares structural equation modeling. The results confirm that digitalization, networking, and dynamic capabilities each exert positive direct effects on technological innovation; however, their total impact is significantly amplified when digital trust first converts capabilities into successful crowdfunding campaigns, which in turn finance and legitimize experimentation and learning. Investment capability, in contrast, exhibits no independent effect once strategic and operational capabilities are taken into account, underscoring that money alone is insufficient. The model explains 43% of the variance in digital trust and 69% in technological innovation. The study advances theory by specifying a two-stage capability-trust-crowdfunding pathway that links financial-innovation scholarship with innovation-management research and by demonstrating the complementary roles of strategic sensing-seizing-reconfiguring routines and operational digital and network assets under Industry 4.0 conditions. Practically, the findings advise entrepreneurs to build credible digital-trust architectures and partner networks before they seek crowdfunded capital and guide platform providers and policymakers in designing trust-enhancing mechanisms that translate funding into sustained innovative output in the form of technological learning and its upgrading.

Keywords: Crowdfunding, Innovation capabilities, Entrepreneurial capital, Technological innovation, Industry 4.0

Introduction

The successive shocks of COVID-19 and the continuing geopolitical turbulence in Europe and the Middle East have exposed the fragility of business models and underscored that sustained competitiveness now hinges on rapid and continuous innovation (Adam & Alarifi 2021; Papadopoulos et al. 2020). While large corporations, armed with deep pockets, traditionally spearhead technological breakthroughs, the world's 400 million startups and technology-based SMEs responsible for more than 70% of global employment frequently lack the resources needed to participate fully in this innovation race (Shahbaz et al. 2018). However, their ingenuity was vividly displayed during the pandemic, as resource-constrained ventures developed critical innovations such as ventilators, diagnostic kits, and digital triage tools at unprecedented speeds (Adam & Alarifi 2021). Realizing this latent innovative capacity is therefore critical for addressing future pandemics, natural disasters, and market upheavals.

Crowdfunding has emerged as a pivotal enabler, transforming dispersed microinvestments into substantial R&D financing (Belleflamme et al. 2014; Cumming and Reardon, 2023; Hornuf & Schwiendbacher 2017). Platforms such as Kickstarter and Indiegogo have channelled hundreds of millions of dollars into early-stage technological ventures, demonstrating that beyond financial capital, the right crowd can significantly propel innovation (Belleflamme et al. 2014). Central to crowdfunding's success is trust (Rodriguez-Ricardo et al., 2019). Classically, interpersonal trust remains critical; however, in the digitally mediated context of Web 2.0 and Industry 4.0, digital platform trust rooted in transparency, blockchain immutability, and algorithmic accountability has emerged as a crucial mechanism driving users' interactions and funding intentions (Oesterreich et al. 2024). This digitally grounded trust not only facilitates but also significantly enhances entrepreneurial capabilities and collaborative innovation networks (Shamah & El Sawaby 2014; Mubarak & Petraite 2020).

High-tech startups in emerging economies illustrate the transformative potential of digital platforms. Lithuania's Vinted and Nord Security, both unicorns, leveraged robust digital ecosystems and cross-border crowdfunding to scale rapidly (Cernat 2021; Golić, 2014; Krepsta, 2020; Hafeez et al., 2025). Comparable momentum is evident across Southeast Asia, where Malaysian and Singaporean ventures are increasingly recognized as regional knowledge and innovation hubs (Brail 2020; Shahzad et al., 2025). These firms rely heavily on technological learning "the dynamic process of acquiring technological capability" (Kim 1997, p. 6) to continually upgrade products and processes. Sustained learning has elevated Estonia, Lithuania, and Malaysia from peripheral economies to competitive actors in the electronics, cybersecurity, and fintech sectors (Mubarik et al. 2021; Petraite & Dlugoborskyte 2017; Radosevic et al. 2019). Although financial resources support such activities, recent evidence highlights innovation capabilities particularly dynamic routines and digital competences as stronger determinants of a firm's ability to effectively transform crowdfunding into technological learning and eventually its upgrading (Ghobakhloo et al. 2022; Musiolik et al., 2012; Wen et al. 2018).

The existing studies on technological upgrading have primarily focused on financial aspects, such as foreign direct investment (FDI), and have largely relied on secondary data (Radosevic et al., 2019). Consequently, non-financial capabilities, particularly those examined through primary data, remain largely underexplored. Likewise, what constitutes and enhances the financial mechanism for SMEs and startups also ignored.

Moreover, literature on crowdfunding success have typically emphasized financial literacy and market-oriented skills, often overlooking innovation capabilities fundamental to postfunding technological performance (Belleflamme et al. 2014; Hornuf & Schwiendach 2017). Further the research on trust continues to adopt traditional human-centric approaches, insufficiently addressing how digital technologies such as blockchain, IoT, and big data analytics influence users’ trust intentions on digital crowdfunding platforms (Oesterreich et al. 2024; Mubarak & Petraite 2020). In this context, the present study integrates dynamic capability (DC), transaction-cost economics (TCE), and knowledge-based view (KBV) perspectives to examine how strategic capabilities (such as dynamic scanning, seizing, and reconfiguring) and operational capabilities (including investment, digitalization, networking) interact with digital trust and crowdfunding to foster technological learning to ultimately foster successful technological innovation.

Therefore, this study addresses the following research questions:

- (1) How can crowdfunding-based entrepreneurial finance and technological innovations be simultaneously enhanced?
- (2) How does digital trust enhance crowdfunding and technological innovation?
- (3) How do digitalization, investment, networking capabilities cultivate digital trust that strengthens crowdfunding effectiveness?

Malaysia offers a pertinent empirical setting for this study. Ranking third in Southeast Asia’s startup ecosystem (StartupBlink, 2023), Malaysia actively promotes digitalization and innovation capabilities among local ventures but continues to face investor skepticism rooted in institutional and cultural factors. Thus, digital trust mechanisms could play a decisive role in mobilizing local and international investors for Malaysian high-tech startups.

The remainder of the paper proceeds as follows. First, we discuss the theoretical background and then review the relevant literature, and propose hypotheses linking these constructs with technological learning. Next, we detail our research design, instrument development, sampling, data collection, and analytical methods. The findings are subsequently presented, followed by a discussion of the theoretical and practical implications. Finally, limitations and directions for future research are articulated, followed by concluding remarks.

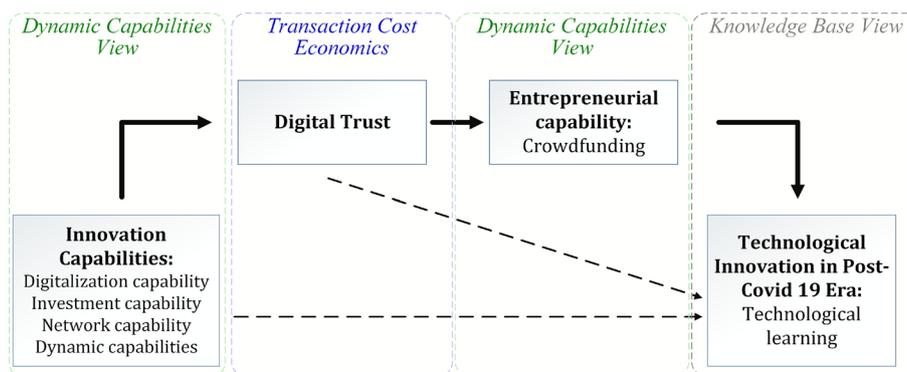


Fig. 1 The research framework

Theoretical exposition and hypothesis development

The research framework of this study posits that firms' strategic and operational innovation capabilities are transformed into technological innovation (by enhancing technological learning) through crowdfunding platforms, which is mediated by digital platform trust. To comprehensively ground our theoretical arguments, we integrate the dynamic capabilities view (DCV), transaction cost economics (TCE), and the knowledge-based view (KBV). Figure 1 illustrates the conceptual framework of this research.

The dynamic capabilities view (DCV), initially articulated by Teece et al. (1997), emphasizes the importance of continuously adapting internal and external competencies to sustain competitive advantage amidst turbulent and rapidly changing environments. This theoretical lens suggests that strategic capabilities sensing emerging opportunities, swiftly seizing market prospects, and dynamically reconfiguring resources are critical for firms, particularly in the context of the COVID-19 pandemic and related disruptive global events (Adam & Alarifi 2021; Papadopoulos et al. 2020; Pavlou & El Sawy 2011; Shahzad et al., 2025). Given the rise of platform-based economies and digitally mediated business models, operational capabilities such as digitalization, networking, and strategic investment are equally vital. Specifically, digitalization capability enables firms to exploit digital technologies effectively, enhancing their interactions with customers, partners, and crowdfunding backers, thereby securing resources critical for innovation. Networking capability further complements these strategic advantages, facilitating collaboration with diverse external stakeholders, such as suppliers, research institutions, and other enterprises (Leckel et al. 2020). Additionally, investment capability, the ability to allocate resources effectively toward tangible and intangible technology assets, is essential to capitalizing on market opportunities (Cavallo et al. 2021; Hafeez et al., 2025a). Collectively, these strategic and operational capabilities constitute the innovation capabilities that empower firms to leverage crowdfunding platforms for technological innovation effectively.

Further supporting our theoretical model is transaction cost economics (TCE), which argues that firms strive to minimize transaction costs and operational uncertainties to enhance overall efficiency (Williamson 1998). Trust, especially digital platform trust, plays a pivotal role in reducing these costs, given that trusted interactions decrease the need to repeatedly validate and reestablish new relationships with crowdfunding investors, suppliers, and innovation partners (Oesterreich et al. 2024). Establishing digital trust is especially critical in crowdfunding contexts, where transactions occur between dispersed and often anonymous stakeholders. Recent studies emphasize that digital trust enabled by transparency, accountability, and technological safeguards such as blockchain effectively reduces the uncertainties inherent in digital financial transactions and entrepreneurial collaborations (Hornuf & Schwenbacher 2017; Mubarak & Petraite 2020). Consequently, digital trust not only curtails transaction costs but also amplifies coinvention opportunities by facilitating more secure, stable, and long-lasting partnerships.

Drawing upon the knowledge-based view (KBV), this research underscores knowledge as a unique strategic asset critical to technological innovation and sustained competitive advantage (Grant 1996). Unlike generic resources, knowledge resides within individuals and manifests as either tacit (experiential, intuitive) or explicit (codified, documented) (Nonaka, 1995; Shahzad et al., 2025). Technological learning, as conceptualized by the KBV, involves firms continually

enhancing their knowledge base concerning technologies, processes, and products (Dodgson 1991; Hafeez et al., 2025a). Given highly disruptive contexts such as pandemics, geopolitical conflicts, and rapid digital transformations, technological learning has become increasingly indispensable for survival and growth. Firms achieve technological learning by effectively absorbing and integrating the external knowledge gained through interactions within crowdfunding platforms and associated innovation ecosystems. Here, digital trust and innovation capabilities critically determine the extent and efficacy of knowledge transfer and cocreation processes. Through trusted crowdfunding platforms, smaller firms can access external knowledge resources, internalize them, and thereby significantly increase their technological learning outcomes (Belleflamme et al. 2014; Cumming and Reardon, 2023; Mubarik et al. 2021).

Therefore, synthesizing the DCV, TCE, and KBV perspectives, we propose that firms' dynamic capabilities (strategic sensing, seizing, and reconfiguring) and operational capabilities (investment, digitalization, networking) directly contribute to technological innovation by enhancing technological learning. Moreover, digital platform trust acts as an essential mediating mechanism that enables firms to effectively utilize crowdfunding platforms to transform their innovation capabilities into tangible innovation outcomes. By clarifying these pathways, this study provides a nuanced and comprehensive theoretical framework for understanding how strategic and operational innovation capabilities, combined with robust digital trust mechanisms, enable SMEs and startups to effectively harness crowdfunding to foster technological innovation amid disruptive challenges.

Figure 2 represents the research model of the study. This model involves 11 direct hypotheses and five mediational hypotheses. The following sections discuss these hypotheses extensively.

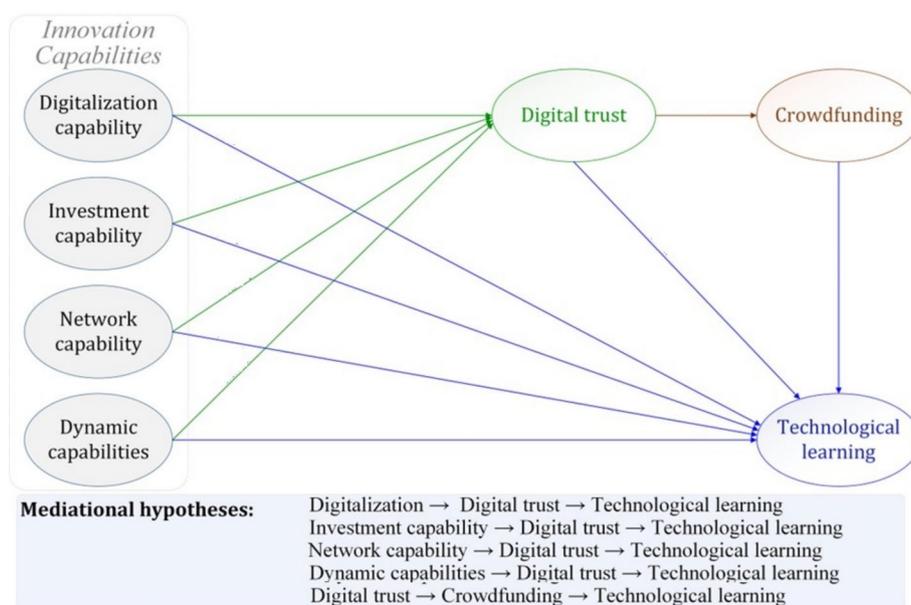


Fig. 2 Research model of the study

Technological learning

Technological learning is conceptualized as an organizational capability through which firms systematically acquire, assimilate, transform, and apply technological knowledge to continuously innovate and respond effectively to environmental shifts and market disruptions (Kim 1999; Lee & Yoon, 2015). This perspective closely aligns with the concept of absorptive capacity, emphasizing a firm's competence in recognizing the value of external technological knowledge, assimilating it, and applying it innovatively (Cohen & Levinthal, 1990; Mubarak & Petraite 2020; Pan et al. 2018). In the context of technology-oriented startups, particularly within disruptive conditions, technological learning is instrumental in ensuring sustainable innovation and competitive advantage.

Crowdfunding platforms facilitate this learning not only by providing financial resources but also by enabling knowledge interactions and the iterative development of products and processes. Carayannis and Alexander (2002) underscore that crowdfunding platforms function as experimental spaces for entrepreneurs to test their technological ideas and continuously refine their innovations, a process termed by Cumming et al. (2022) as "testing the waters". This approach allows firms to align their technological capabilities more closely with evolving market needs, investor feedback, and broader technological developments, significantly enhancing their innovative potential.

In rapidly emerging economies such as Malaysia, technological learning assumes even greater importance, as startups and SMEs must navigate resource constraints while simultaneously upgrading their technological capabilities. Crowdfunding platforms thus emerge as critical enablers by providing access to both financial capital and critical nonfinancial resources, including strategic investment knowledge, robust digital capabilities, effective networking opportunities, and dynamic capabilities. These capabilities are vital for startups to strategically sense market opportunities, seize them effectively, and dynamically reconfigure internal and external resources to sustain technological innovation (Hafeez et al., 2025a; Hafeez et al., 2025b). Therefore, strengthening these innovation capabilities by crowdfunding ecosystems has become a strategic imperative, particularly for coping with ongoing disruptions from events such as COVID-19, geopolitical tensions, and accelerated digital transformation trends (Papadopoulos et al. 2020).

Innovation capabilities

Innovation capabilities are increasingly recognized as essential drivers of technological innovation, organizational adaptability, and sustainable competitiveness, particularly in rapidly evolving and uncertain environments (Freixanet et al. 2020; Saunila 2020). These capabilities can be broadly classified into strategic and operational dimensions (Pavlou & El Sawy 2011). Dynamic capabilities the core of the strategic dimension to address market shifts and technological disruption (Teece et al. 1997; Rajapathirana & Hui 2018). Such dynamic routines enable firms to remain agile and innovative, especially when leveraging the open, rapidly changing environment of digital platforms and crowdfunding ecosystems.

Complementing these are operational innovation capabilities, including digitalization, networking, and investment capabilities. Digitalization capability encompasses the effective adoption and integration of digital technologies, thus enabling firms to participate actively in platform economies and to access, share, and process information efficiently (Papadopoulos et al. 2020). Networking capability refers to a firm's proficiency in forming and maintaining strategic relationships with a diverse array of stakeholders suppliers, customers, research institutions, and other firms thereby enhancing collaborative innovation and access to external knowledge (Giudici and Rossi-Lamastra, 2018). Investment capability, meanwhile, is related to the ability to strategically allocate and manage financial resources toward both tangible and intangible technological assets, ensuring that innovative projects are not only initiated but also sustained and brought to fruition (Sun et al. 2020).

Digitalization capability

Industry 4.0-driven digitalization has become a pivotal force in transforming business models, catalyzing innovation, and reshaping the competitive landscape across sectors (Ghobakhloo et al. 2021). In response to heightened environmental turbulence exemplified by the COVID-19 crisis firms have accelerated the digitalization of core processes to boost organizational agility, resilience, and long-term growth (Peppard 2016; Santos et al. 2023). Notably, digitalization has enabled organizations to expand into new markets, enhance customer engagement, automate operations, reduce costs, and achieve significant process efficiency while also improving risk management and supply chain resilience through advanced analytics (Desmet et al. 2015; Fernández-Olano et al. 2015; Kusi-Sarpong et al., 2022).

Digitalization capability refers to a firm's ability to effectively adopt and integrate digital technologies such as big data analytics, blockchain, IoT, and cyber-physical systems into its operations, product development, and market strategies (Mubarak et al. 2021; Ghobakhloo et al. 2022). This capability is increasingly recognized as a central determinant of performance and adaptability, not only at the firm level but also within broader value chains and economies (El-Darwiche et al. 2012; Deloitte Access Economics 2015). Empirical studies consistently show that, compared with their less digitized peers, firms that invest in digital infrastructure and solutions achieve superior growth and operational efficiency (Catlin et al. 2015; Westerman et al. 2012; Mubarak & Petraite 2020).

In the context of crowdfunding, digitalization capability is especially consequential. The adoption of advanced digital solutions enhances platform accessibility, transparency, and efficiency key factors that attract both investors and project initiators (Ghobakhloo et al. 2022). Furthermore, digitalization fosters digital trust, as technological safeguards such as blockchain and real-time analytics promote transparency, reliability, and secure interactions within collaborative networks (Mubarak & Petraite 2020; Oesterreich et al. 2024). As a result, the likelihood of successful funding outcomes and knowledge-sharing interactions is significantly increased.

At the macroeconomic level, digitalization stimulates innovation, supports sustainable production, creates jobs, and enhances governance and public sector efficiency (El-Darwiche et al. 2012; Deloitte Access Economics 2015). These broad benefits have

spurred substantial investments in digital transformation, particularly within innovation-intensive sectors such as fintech (Caldo et al. 2014; Miller & Wong 2016; Weiss & Sachdeva 2016).

Extending this perspective to our study, we argue that digitalization capability not only improves operational performance and network resilience but also strengthens digital trust in crowdfunding platforms. This, in turn, supports more robust technological learning and innovation outcomes among startups and SMEs. Prior research highlights that digitalization directly enhances learning interactions, both within and across firm boundaries (Mubarak & Petraite 2020), suggesting that its effects extend beyond efficiency to encompass knowledge creation and capability upgrading. Accordingly, we formulate the following hypotheses.

H1a. Digitalization improves digital trust in crowdfunding.

H2a. Digitalization positively affects technological learning.

Investment capability

Investment capability represents a critical internal resource for firms seeking to effectively engage with and benefit from crowdfunding platforms, particularly in environments marked by heightened uncertainty and the need for rapid technological learning and upgrading its eventually (Lee et al., 2021; Lu et al. 2020). In the context of this study, investment capability is conceptualized as a firm's competence, knowledge, and foresight to identify, evaluate, and strategically allocate resources toward promising technologies that can be transformed into innovative products or services. This capability extends beyond mere financial acumen to include an understanding of how investments in both tangible and intangible assets support long-term technological advancement.

The strategic importance of investment capability is underscored in the innovation literature, where it is consistently linked to enhanced technological learning and innovation outcomes (Lee and Slater, 2007; Lee et al., 2021; Lall 1994; Radosevic et al. 2019). By enabling firms to make informed decisions about which technologies to acquire and how to deploy them, investment capability acts as a catalyst for upgrading not only the firm's internal processes but also its integration within broader innovation networks and crowdfunding ecosystems. This is particularly vital in the post-COVID-19 landscape, where resource constraints and shifting market dynamics require firms to be highly selective and effective in their investment choices.

Within the crowdfunding context, strong investment capability can also enhance the credibility of a firm's campaigns, signaling to potential backers that the firm possesses the vision and expertise to utilize raised funds effectively (Cumming and Reardon, 2023). This, in turn, fosters greater digital trust among investors, who are more likely to support ventures that demonstrate sound investment logic and technological foresight. The cumulative effect is a more robust crowdfunding mechanism that supports both technological learning and sustained innovation.

Accordingly, we hypothesize that investment capability not only improves digital trust within crowdfunding platforms but also directly and positively influences technological learning among innovative firms. The following hypotheses are therefore proposed:

H1b Investment capability improves digital trust in crowdfunding.

H2b Investment capability positively affects technological learning.

Networking capability

Networking capability is widely recognized as a cornerstone of organizational innovation, enabling firms to harness and exchange both tacit and explicit knowledge through diverse external relationships and collaborative networks (Mubarak et al. 2021). Effective external network management facilitates access to critical resources, expertise, and ideas that may otherwise remain beyond the reach of individual firms, thus accelerating technological innovation and adaptability (Leet et al., 2021; Petraite et al., 2022). As Teece (1996) highlights, cooperative relations ranging from interfirm partnerships to collaborations with research institutions and internal cross-functional teams allow even smaller ventures to marshal resources and capabilities that were once exclusive to large corporations. These collaborative engagements not only stimulate creativity and reduce risk but also improve the pace and quality of innovation outcomes (Powell, 1996).

Within this study, networking capability is defined as the ability of a firm to form, manage, and leverage relationships both within and beyond its organizational boundaries. This encompasses collaboration with suppliers, customers, consultants, research centers, and other key stakeholders, extending across individual, firm, and network levels. In the context of crowdfunding, networking capability is particularly salient, as it expands the scope and frequency of interactions on crowdfunding platforms, thereby broadening access to potential backers, partners, and knowledge sources.

Frequent and high-quality interactions within these digital networks not only support the sharing and acquisition of knowledge but also foster greater digital trust among stakeholders (Mubarak et al., 2020). Enhanced digital trust is, in turn, critical for the success of crowdfunding campaigns, as it reassures investors and collaborators of the venture's credibility and capacity to deliver on its promises. Thus, by strengthening their networking capability, firms can create more vibrant and trustworthy crowdfunding ecosystems, ultimately supporting both technological learning and innovation.

On the basis of these insights, we hypothesize that networking capability improves digital trust within crowdfunding platforms and directly contributes to increased technological learning. Given this background, we propose the following hypotheses.

H1c Networking capability improves digital trust in crowdfunding.

H2C Networking capability positively affects technological learning.

Dynamic capabilities

Dynamic capabilities have emerged as a fundamental source of sustained competitive advantage in today's fast-paced, technology-driven business landscape. At their core, dynamic capabilities refer to an organization's capacity to purposefully sense and seize new opportunities, as well as to reconfigure internal and external resources to effectively navigate technological shifts and market turbulence (Teece et al. 1997; Mubarak & Petraite 2020). This continuous renewal and adaptation of competencies are especially vital as innovation life cycles contract and environmental uncertainty intensifies, requiring firms to operate with greater agility and foresight.

The dynamic capabilities view highlights three key routines: sensing (identifying and interpreting opportunities and threats), seizing (mobilizing resources rapidly to capture value), and reconfiguring (transforming and realigning resources and processes for future success) (Pavlou & El Sawy 2011). As innovation accelerates and market demands evolve, the ability to cycle through these routines determines a firm's capacity to innovate, learn, and thrive under disruptive conditions (Xu et al., 2023). In particular, dynamic capabilities underpin technological learning by enabling firms to absorb, integrate, and apply new knowledge facilitating not only adaptation but also proactive innovation and strategic renewal.

Within the crowdfunding context, dynamic capabilities are especially salient. Crowdfunding platforms offer unique opportunities for rapid access to financial resources, market validation, and knowledge flows, empowering firms to accelerate the development and deployment of technological innovations. Firms with strong dynamic capabilities are better equipped to leverage these platforms, not only by securing funding but also by building digital trust, navigating uncertainties, and orchestrating collaborative networks that support ongoing learning and adaptation.

Therefore, we hypothesize that dynamic capabilities enhance digital trust within crowdfunding environments and directly contribute to firms' technological learning. These relationships are articulated in the following hypotheses:

H1d Dynamic capabilities improve digital trust in crowdfunding.

H2d Dynamic capabilities positively improve technological learning.

Digital trust in crowdfunding platforms

This study conceptualizes "digital platform trust" as a multidimensional construct reflecting both technological and human factors but with a pronounced emphasis on the trust mechanisms embedded within digital platforms. Building on the work of Mubarak and Petraite (2020), who introduced digital trust by combining conventional trust measures with Industry 4.0 technologies, we extend the discussion to fit the distinct context of digital platform-based business models specifically, the multisided platforms and crowdfunding environments central to this research. While previous frameworks addressed trust for firms with both physical and virtual presences, our focus is on the digital-first and digitally intensive nature of platform-based entrepreneurial finance.

Table 1 Differences between digital trust and digital platform trust

Trust typology	Differences			
	Focused Firm types	Presence of firms (Physical/online)	Offerings (products or services)	Measurement levels (Firm/network/platform)
Digital trust	SMEs large firms	Predominantly physical	High-tech products	Firm level network level
Digital platform trust	Startups/SMEs	Predominantly digital/online less Physical	Innovative products services solutions	Network level platform (MSP) level

Table 2 Levels of digital platform trust

Levels	Scope	Sources	Focus of study
Level I digital network	Funding platforms	McKnight et al. (2002); Mubarak and Petraite (2020)	Crowdfunding platforms in the country
Level II actor	Service providers	McKnight et al. (2002); Mubarak and Petraite (2020)	Entrepreneurs
Level III offerings	Products or services	Ba and Pavlou (2002), Lim et al. (2006)	Entrepreneurial projects

A key advancement in our approach is the central role of blockchain technology in enabling digital platform trust. Blockchain, with its inherent properties of immutability, transparency, verifiability, and traceability, fundamentally reduces reliance on traditional human-mediated trust, establishing what is often termed a "trustless" system (Mubarik et al. 2021; Rejeb et al., 2025). By minimizing human intervention, blockchain elevates technological trust and redefines the trust landscape on crowdfunding platforms, ensuring that contractual, ethical, and competent interactions are maintained with minimal subjective bias. However, while the technological dimension of trust is strengthened, our conceptualization acknowledges that human-centric elements such as ethical conduct, reputation, and communication still play an important role, especially in contexts where complete automation is not yet feasible or where regulatory and cultural factors demand human oversight (Söilen & Benhayoun 2021).

This distinction is particularly salient for startups and SMEs seeking funding through crowdfunding platforms. Unlike prior research on digital trust in established manufacturing sectors (Mubarak & Petraite 2020), our focus shifts to platform-level and network-level trust within predominantly digital environments, where the offerings are innovative products, services, or solutions, and interactions are mediated through digital channels. The measurement of trust thus transitions from the firm or network level to the platform level, capturing the unique dynamics of multisided digital platforms. Moreover, in contexts where institutional trust may be undermined by weak digital infrastructure or regulatory challenges such as in countries under scrutiny by the Financial Action Task Force (Amin et al. 2020) robust digital platform trust, anchored in advanced technologies, becomes even more critical for enabling successful crowdfunding outcomes.

In summary, our study defines digital platform trust as confidence fostered through blockchain-enabled mechanisms on digital crowdfunding platforms, ensuring secure, transparent, and ethical interactions among participants. This approach recognizes the

evolving nature of trust in the digital era, balancing the benefits of advanced technology with the enduring relevance of human judgment, particularly for startups and SMEs navigating the complex terrain of digital entrepreneurial finance. These distinctions and the evolution of the digital trust concept are further detailed in Table 1.

Levels of digital platform trust

To comprehensively capture the construct of digital platform trust in crowdfunding environments, this study proposes a multilevel measurement approach, drawing on established frameworks and recent advancements in the literature. Specifically, we build on the dimensions of trust in platforms and service providers as conceptualized by McKnight et al. (2002) while also integrating insights from Ba and Pavlou (2002) and Lim et al. (2006) to assess trust in specific crowdfunding projects. Furthermore, we incorporate the technological facet of trust by considering the role of blockchain technology, as articulated by Han et al. (2024), Mubarak and Petraite (2020) and Hochstein et al. (2023). This approach enables a nuanced assessment of trust at three interconnected levels: the platform level, the actor (service provider) level, and the project (offering) level, as outlined in Table 2.

Table 2 delineates these levels:

- Level I (digital network/platform): This level encompasses trust in the overall crowdfunding platform, reflecting users’ confidence in the platform’s structure, security, governance, and technological backbone.
- Level II (actor/service provider): Here, trust is directed toward the service providers or entrepreneurs who initiate and manage crowdfunding projects on the platform. The focus is on their perceived competence, integrity, and reliability.

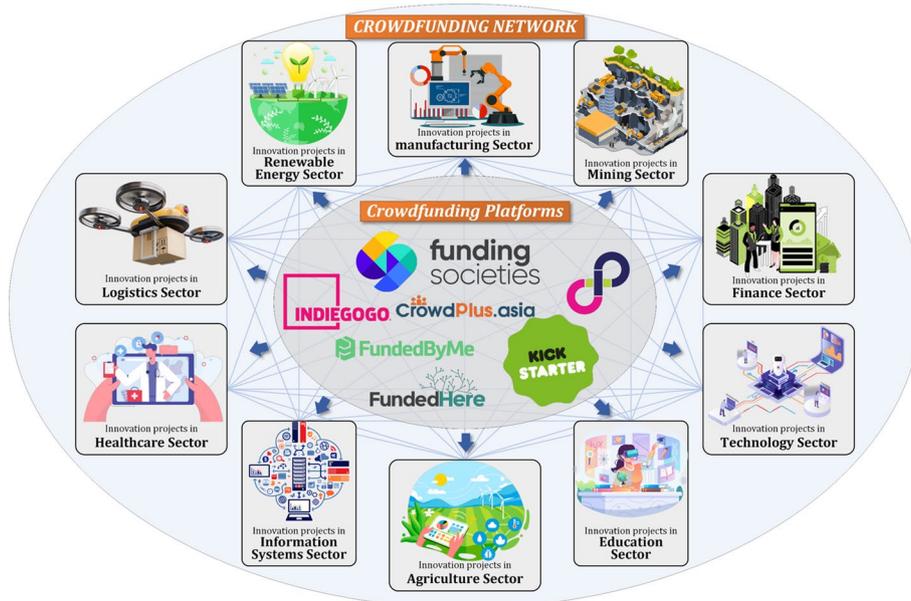


Fig. 3 Digital network for crowdfunding

- Level III (Offerings/Projects): The most granular level evaluates trust in the specific products, services, or innovations being presented by entrepreneurs, reflecting backers' confidence in the feasibility, value, and delivery of the projects.

By structuring digital platform trust across these three tiers, our study offers a holistic and contextually relevant perspective tailored to the unique dynamics of crowdfunding ecosystems. This approach also accommodates the platform's technological infrastructure particularly blockchain integration which enhances transparency, verifiability, and security at each level (Han et al. 2024; Mubarak & Petraite 2020).

While digital platforms span diverse domains such as e-commerce, education, entertainment, and innovation this research specifically targets crowdfunding platforms within Malaysia. At the platform level, we assess trust in the overall crowdfunding environment; at the service provider level, the focus is on entrepreneurs or project creators; and at the project level, trust is evaluated in relation to the specific offerings posted. This layered approach not only distinguishes our conceptualization from prior research that often focused on firm or network levels but also enables a more granular analysis of the mechanisms through which digital trust facilitates crowdfunding success.

Figure 3 further illustrates the digital crowdfunding network, depicting the diversity of projects across categories such as electronics, IT, healthcare, and clean energy. This comprehensive view supports our hypotheses regarding the pivotal role of digital platform trust at multiple levels in enhancing crowdfunding effectiveness and technological innovation.

Against this backdrop, we formulate the following hypotheses.

H3 Digital trust positively improves crowdfunding.

H4 Digital trust positively improves technological learning.

H5a Digital trust positively mediates the relationship between digitalization capability and technological learning.

H5b Digital trust positively mediates the relationship between investment capability and technological learning.

H5c Digital trust positively mediates the relationship between network capability and technological learning.

H5d Digital trust positively mediates the relationship between dynamic capabilities and technological learning.

Crowdfunding

Crowdfunding has emerged as a distinct and powerful offshoot of crowdsourcing, which broadly refers to the practice of sourcing knowledge, ideas, resources, or solutions from large, distributed, and often anonymous groups via digital platforms (Konhäusner et al.

2021). Unlike traditional financing avenues, crowdfunding is fundamentally collaborative and rooted in cocreation: it involves the direct participation of diverse stakeholders including entrepreneurs, investors, and end-users in the generation, refinement, and funding of innovative projects. For startups and technology ventures, crowdfunding is not only a mechanism for capital acquisition but also a dynamic platform for market testing, product validation, and iterative technological learning (Cumming et al. 2022; Carayannis & Alexander 2002). By allowing entrepreneurs to engage with a broad base of supporters, crowdfunding platforms foster feedback loops that enable the continual improvement of products and services in response to rapidly shifting technological and market landscapes.

The digital infrastructure of crowdfunding platforms has led to the creation of vibrant online communities where entrepreneurs and innovators exchange ideas, collaborate on development, and coproduce value (Cumming and Reardon, 2023; Petruzzelli et al. 2019). These platforms serve as critical digital intermediaries, linking creative entrepreneurs with a wide array of potential investors, experts, and early adopters (Rejeb et al., 2025). The strategic importance of crowdfunding has become even more apparent in the wake of the COVID-19 pandemic and ongoing global conflicts, which have underscored the need for rapid, flexible, and decentralized approaches to technological innovation. R&D-intensive startups, often the source of breakthrough innovations, rely heavily on crowdfunding to sustain their activities, address emergent challenges, and build resilience in uncertain environments (Stanko & Henard 2016).

A core determinant of success within crowdfunding ecosystems is trust. While previous studies in entrepreneurial finance have explored the motivations driving crowdfunding participation, recent research has identified trust as even more fundamental: without trust in the platform, the project initiators, the broader digital network, and the motivation to engage and invest quickly erodes (Strohmaier et al. 2019; Moysidou & Hausberg 2020). In digital-first, technologically focused crowdfunding environments, traditional human-centric models of trust are increasingly inadequate (Mubarak & Petraite 2020). Instead, robust models of digital trust encompassing technological safeguards, transparency, data security, and algorithmic integrity are now vital for sustaining engagement and facilitating successful financing for innovation. Addressing these contemporary dimensions and typologies of trust is essential for understanding and enhancing the effectiveness of crowdfunding platforms in supporting entrepreneurial ventures. Therefore, this study hypothesizes the following relationships:

H6 Crowdfunding positively improves technological learning.

H7 Crowdfunding mediates digital trust and technological learning.

Research methodology

This study has applied a quantitative research method following the deductive approach by adopting the positivism research philosophy. In doing so, data collection was performed via a purposive sampling technique. Importantly, survivorship bias was not explicitly accounted for in this study, as the sample was limited to firms that had been

operational for a minimum of five years. This criterion was chosen to ensure that the firms included had sufficient experience and stability to provide meaningful insights into the role of crowdfunding and digital trust in enhancing technological learning. However, this approach may have excluded younger firms or those that did not survive, potentially leading to an overrepresentation of successful outcomes. Our research focuses on Malaysia, a rapidly developing country in the Asia–Pacific region. Following the study of Moysidou and Hausberg (2020), who investigated crowdfunding in the German context, we collected data from Malaysian investors and startups who are well acquainted with crowdfunding platforms and processes. The data are collected through an online survey form sent to the respondents in 2022. After collection, the data are analyzed via the PLS–SEM technique owing to the nature of the investigation, which involves many indicators to predict the model.

Measurement instrument

Instrument development followed a systematic scale-adaptation protocol to ensure conceptual fit with the study’s focus on how Malaysian technology start-ups convert crowdfunding resources and digital trust into technological learning under disruptive conditions. All variables were operationalized with the indicator items rated on a five-point Likert continuum (1 = strongly disagree, 5 = strongly agree). The items were drawn from established scales, reworded for contextual relevance, and then vetted through two rounds of expert review and a pilot test with ten founders to confirm face validity and linguistic clarity.

Crowdfunding is captured as perceived service quality, reflecting user evaluations of platform performance, differentiation, and staff competence. This focus aligns with our interest in crowdfunding not only as a financing mechanism but also as an experiential service that can foster or undermine subsequent learning processes. Digital-platform trust is measured through competence, integrity, and benevolence beliefs three dimensions that recent fintech studies identify as central to investor confidence in blockchain-enabled platforms thereby linking directly to the paper’s theorization of trust as an intangible bridge between resources and learning. Investment capability taps firm knowledge of tangible, intangible, and R&D resource acquisition; networking capability gauges the breadth of relational reach to entrepreneurial peers, research institutions, and key suppliers; and digitalization capability assesses workforce skills,

Table 3 Source of the constructs

Constructs	Number of items	Sources
Crowdfunding	3	Bergmann et al. (2020)
Digital platform trust	4	McKnight et al. (2002); Pavlou and Gefen (2002); Mubarak and Petraite (2020)
Investment capability	3	Flor and Oltra (2005); OECD-Eurostat (1997); Shan and Jolly (2013)
Networking capability	3	Caloghirou et al. (2002); Fernhaber and McDougall (2005); Lefebvre et al. (1993)
Digitalization capability	4	Kotarba (2017); Szymanek, (2015)
Dynamic capabilities	4	Teece et al. (1997); Pavlou and El Sawy (2011)
Technological learning	3	Pan et al. (2018); Petraite et al. (2022); Wei et al. (2020)

cybersecurity readiness, client comfort, and integration with open digital infrastructures. These three capabilities represent the “operational innovation capabilities” that the conceptual model proposes as an antecedent to trust and technological learning.

Dynamic capabilities are operationalized through four items covering sensing, seizing, transforming, and reconfiguring routines, mirroring the microfoundations outlined by Teece (1997) and later empirical treatments. Such behavioral routines are central to our objective of explaining how firms adapt crowdfunding-enabled knowledge flows to turbulent environments. Finally, technological learning is measured via acquisition, exploitation, and proactive search for emerging technologies, directly capturing the outcome the study seeks to explain. Collectively, the instrument provides a parsimonious yet theoretically comprehensive representation of the constructs needed to test the proposed mediation pathways while minimizing respondent burden and maintaining strong psychometric properties. The sources and details of the constructs are given in Table 3.

Respondents’ demographics

A closed-ended questionnaire was used for data collection via online sources. The questionnaire was sent to 391 investors, startups, and tech firms in Malaysia adequately acquainted with crowdfunding platforms and investment processes. As a result, 177 questionnaires were returned, 164 of which were considered for further analysis, excluding 13 that were incomplete. As a result of the analysis, 63% (103) of the respondents were male, and 37% (60) were female. In terms of age, 61% of the respondents were between 31 and 40 years, 22% were between 25 and 30 years, 12% were between 41 and 50 years, and 5% were over 50 years. In terms of qualifications, 66% had bachelor’s degrees, 27% had master’s degrees, and 7% had a Ph.D.

Results

The study applied PLS-SEM to test the direct and mediational hypotheses. For this purpose, SmartPLS 3.3.9 was used (Ringle et al., 2015). In our model, the relationships between all the constructs and their measurement items were constructed reflectively. The PLS-SEM analysis in this study involves the assessment of the measurement models and the structural path model. The measurement model assessment involves evaluating the construct’s reliability and validity as well as discriminant validity. The assessment of the structural model involves evaluating the significance of hypothesized relationships, multicollinearity, and models’ predictive relevance. For this purpose, complete bootstrapping with 5000 subsamples was performed.

Measurement model assessment

Table 4 lists the results of evaluating the measurement models. This table shows that the Cronbach’s alpha and composite reliability values for all the constructs are above the prescribed threshold of 0.7. Thus, the internal consistency reliability is satisfactory. Since the outer loading values are well above the cutoff value of 0.7, the indicator reliability is also satisfied according to the set threshold. Table 4 shows that the data offer adequate convergent validity since all average variance extracted (AVE) values are above the recommended cutoff value of 0.5 (Hair et al., 2020).

Table 4 Results of evaluation of measurement models

Item	Outer loadings	Cronbach's Alpha	CR	AVE
<i>Crowdfunding</i>		0.794	0.879	0.708
CRWF1	0.835			
CRWF2	0.810			
CRWF3	0.879			
<i>Digital trust</i>		0.812	0.877	0.640
DIGT1	0.805			
DIGT2	0.799			
DIGT3	0.785			
DIGT4	0.810			
<i>Digitalization capability</i>		0.846	0.897	0.685
DigC1	0.823			
DigC2	0.815			
DigC3	0.805			
DigC4	0.866			
<i>Dynamic capability</i>		0.777	0.857	0.600
DynC1	0.807			
DynC2	0.715			
DynC3	0.823			
DynC4	0.748			
<i>Investment capability</i>		0.790	0.877	0.705
InvC1	0.815			
InvC2	0.827			
InvC3	0.874			
<i>Network capability</i>		0.803	0.883	0.716
NetC1	0.850			
NetC2	0.792			
NetC3	0.893			
<i>Technological learning</i>		0.813	0.889	0.728
TECL1	0.858			
TECL2	0.812			
TECL3	0.888			

Table 5 Results of the assessment of the Fornell–Larcker criterion

Variables	CRWF	DIGT	DigC	DynC	InvC	NetC	TECL
Crowdfunding (CRWF)	0.842						
Digital platform trust (DIGT)	0.511	0.800					
Digitalization capability (DigC)	0.553	0.544	0.827				
Dynamic capabilities (DynC)	0.449	0.496	0.404	0.774			
Investment capability (InvC)	-0.067	-0.100	-0.124	-0.005	0.839		
Network capability (NetC)	0.298	0.461	0.355	0.394	-0.025	0.846	
Technological learning (TECL)	0.613	0.678	0.614	0.611	-0.035	0.578	0.853

Furthermore, the Fornell–Larcker criterion and the heterotrait–monotrait (HTMT) approach were used to check discriminant validity. Table 5 presents the results of the discriminant validity assessment via the Fornell–Larcker criterion. This table shows

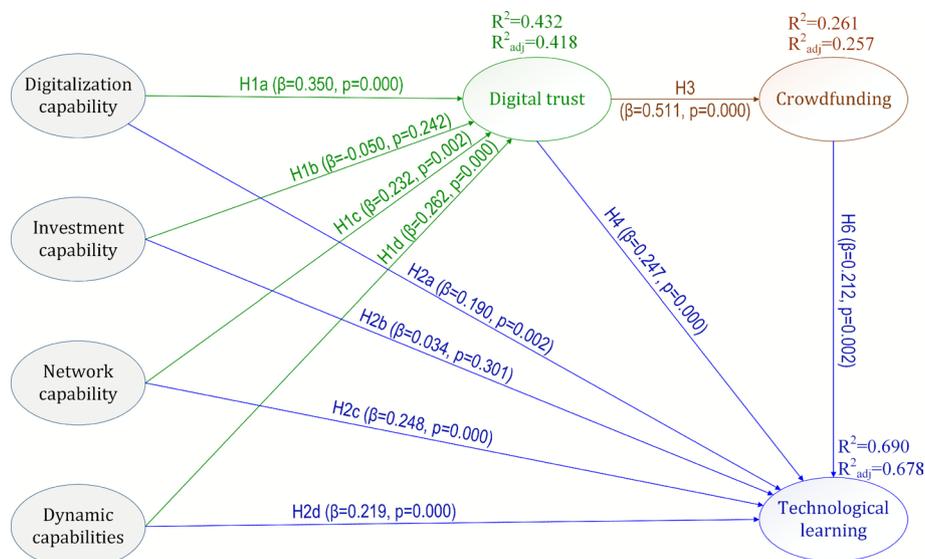


Fig. 4 The structural path model and underlying results

that in all instances, the square rooted values of the AVE in the diagonal are greater than those in the interconstruct correlation, thus confirming the discriminant validity of all the measurement models. In addition, all values in the HTMT matrix are less than 0.85, further confirming the discriminant validity of our study.

Assessment of the structural model

The hypothesized relationships within the structural model were rigorously tested via partial least squares structural equation modeling (PLS-SEM). The initial assessment focused on ensuring the absence of multicollinearity issues, which could undermine the reliability of the results. This was confirmed, as all variance inflation factor (VIF) values remained well below the recommended threshold of 3.3, indicating that the constructs were distinct and that the model did not suffer from collinearity problems. This step was crucial in establishing the validity of the subsequent analysis. The results of the structural model are shown in Fig. 4.

The results of the structural path analysis provided compelling evidence for several key hypotheses. First, digitalization capability, network capability, and dynamic capabilities were all found to have significant positive effects on digital trust ($\beta=0.350, t \text{ value}=4.764$; $\beta=0.232, t \text{ value}=3.306$; $\beta=0.262, t \text{ value}=3.885$, respectively). These findings support hypotheses H1a, H1c, and H1d, underscoring the importance of these capabilities in fostering a trust-rich digital environment. In the context of smaller firms, the ability to digitalize operations, effectively manage networks, and dynamically respond to changes appears to be critical for building the digital trust that underpins successful engagement with digital platforms, including crowdfunding. The positive impact of these capabilities highlights their role not only in operational efficiency but also in establishing a foundation of the trust necessary for digital interactions.

In contrast, investment capability did not exert a significant influence on digital trust ($\beta = -0.050$, t value = 0.701), leading to the rejection of H1b. This result suggests that while financial resources are essential for enabling innovation and scaling operations, they do not inherently contribute to the development of digital trust. Trust, particularly in a digital context, may be more closely tied to how firms manage and implement their digital strategies and interact with their networks rather than merely their financial investment capacities. This finding invites further exploration into the qualitative aspects of trust-building, such as transparency, communication, and digital literacy, which might mediate the relationship between investment capability and digital trust.

Further examination of the model revealed that digitalization capability, network capability, and dynamic capabilities also had significant positive effects on technological learning ($\beta = 0.190$, t value = 2.882; $\beta = 0.248$, t value = 3.474; $\beta = 0.219$, t value = 3.450, respectively), leading to the acceptance of hypotheses H2a, H2c, and H2d. These results suggest that firms with strong digitalization processes, well-managed networks, and the ability to adapt dynamically to changing conditions are better equipped to learn and integrate new technologies. Technological learning, a critical component for maintaining competitive advantage in rapidly evolving markets, appears to be significantly enhanced by these capabilities. This underscores the importance of not only acquiring these capabilities but also continuously developing them to foster an environment conducive to ongoing learning and innovation.

However, investment capability did not significantly impact technological learning ($\beta = 0.034$, t value = 0.522), resulting in the rejection of H2b. This finding indicates that financial investment alone may not directly translate into enhanced technological learning. This suggests that other factors, such as the strategic use of investments, the alignment of financial resources with learning objectives, and the presence of a supportive organizational culture, may play more crucial roles in driving technological learning. This highlights the complex interplay between financial resources and learning outcomes, suggesting that investment capability needs to be complemented by strategic initiatives and managerial practices that prioritize learning and innovation.

The study further confirmed the pivotal role of digital trust in influencing both crowdfunding and technological learning. The significant positive impact of digital trust on crowdfunding ($\beta = 0.511$, t value = 7.675) and technological learning ($\beta = 0.247$, t value = 3.763) led to hypotheses H3 and H4. These findings underscore digital trust as a critical enabler of successful crowdfunding initiatives, as it enhances the credibility and attractiveness of crowdfunding campaigns. Moreover, the positive relationship between digital trust and technological learning highlights how trust in digital platforms can facilitate the exchange of knowledge and the adoption of new technologies. In this context, digital trust emerges not only as a facilitator of financial transactions but also as a driver of learning and innovation, particularly in contexts where technological advancements and digital interactions are key to survival and growth.

The mediation analysis provided additional insights into the mechanisms through which digital trust and crowdfunding influence technological learning. The results revealed that digital trust significantly mediates the relationships between digitalization capability, network capability, and dynamic capabilities with technological learning

Table 6 The HTMT matrix

Variables	CRWF	DIGT	DigC	DynC	InvC	NetC	TECL
Crowdfunding (CRFW)							
Digital platform trust (DIGT)	0.626						
Digitalization capability (DigC)	0.679	0.653					
Dynamic capabilities (DynC)	0.570	0.620	0.499				
Investment capability (InvC)	0.099	0.124	0.150	0.127			
Network capability (NetC)	0.352	0.560	0.420	0.489	0.070		
Technological learning (TECL)	0.759	0.835	0.733	0.767	0.056	0.701	

Table 7 Results of the evaluation of the structural model

Hypotheses	Path coefficient	t value	p value	VIF	Status
Digitalization capability → digital trust	0.350	4.764	0.000	1.286	Accepted
Investment capability → digital trust	-0.050	0.701	0.242	1.018	Rejected
Network capability → digital trust	0.232	3.306	0.001	1.252	Accepted
Dynamic capabilities → digital trust	0.262	3.885	0.000	1.311	Accepted
Digital trust → crowdfunding	0.511	7.675	0.000	1.000	Accepted
Crowdfunding → technological learning	0.212	2.948	0.002	1.658	Accepted
Digitalization capability → digital trust → technological learning	0.086	3.144	0.001	-	Accepted
Investment capability → digital trust → technological learning	-0.012	0.638	0.262	-	Rejected
Network capability → digital trust → technological learning	0.057	2.430	0.004	-	Accepted
Dynamic capability → digital trust → technological learning	0.065	2.572	0.005	-	Accepted
Digital trust → crowdfunding → technological learning	0.108	2.753	0.003	-	Accepted
Digital trust → technological learning	0.247	3.763	0.000	1.845	Accepted
Digitalization capability → technological learning	0.190	2.882	0.002	1.709	Accepted
Investment capability → technological learning	0.034	0.522	0.301	1.023	Rejected
Network capability → technological learning	0.248	3.474	0.000	1.347	Accepted
Dynamic capabilities → technological learning	0.219	3.450	0.000	1.497	Accepted

($\beta=0.086$, $t\ value=3.144$; $\beta=0.057$, $t\ value=2.430$; $\beta=0.065$, $t\ value=2.572$, respectively). These findings support hypotheses H5a, H5c, and H5d, illustrating that digital trust amplifies the positive effects of these capabilities on technological learning. This suggests that digital trust not only directly impacts technological learning but also strengthens the influence of key innovation capabilities on learning outcomes. By fostering a trustworthy digital environment, firms can more effectively leverage their digitalization processes, networks, and dynamic adaptability to enhance their technological learning.

However, digital trust did not mediate the relationship between investment capability and technological learning ($\beta=-0.012$, $t\ value=0.638$), leading to the rejection of H5b. This outcome further emphasizes the notion that investment capability alone does not drive learning outcomes through trust mechanisms. This may indicate that other factors, such as how investments are utilized or the strategic alignment of financial resources with digital initiatives, play a more significant role in facilitating technological learning.

This finding suggests that the pathway from investment capability to technological learning is complex and may require more than just financial resources to yield significant learning benefits Table 6.

Finally, the mediation analysis also revealed that crowdfunding partially mediates the relationship between digital trust and technological learning ($\beta=0.108$, t value = 2.753), supporting H7. This suggests that crowdfunding serves as a mechanism through which the trust established in digital platforms can be translated into enhanced technological learning. Crowdfunding not only provides financial resources but also creates opportunities for firms to engage with a broader audience, receive feedback, and learn from the process of bringing a product or idea to the market. This finding highlights the dual role of crowdfunding as both a financial tool and a learning platform, particularly in environments where innovation and technological advancement are critical. The detailed results of the hypotheses are shown in Table 7.

The overall predictive power of the model was demonstrated by the R^2 values, which indicated that the model explained 43.2% of the variance in digital trust ($R^2=0.432$), 26.1% of the variance in crowdfunding ($R^2=0.261$), and a substantial 69% of the variance in technological learning ($R^2=0.690$). These results suggest that the model effectively captures the key drivers of these outcomes. Additionally, the Stone–Geisser's Q^2 values (0.176 for crowdfunding, 0.266 for digital trust, and 0.485 for technological learning) confirmed the model's predictive relevance, indicating that the endogenous variables are well explained by the model. This robust predictive power reinforces the model's utility in understanding the complex relationships between innovation capabilities, digital trust, crowdfunding, and technological learning in the context of smaller firms facing disruptive situations.

Discussion

The findings of this study offer critical insights into how innovation capabilities, digital trust, and crowdfunding collectively drive technological learning for SMEs, particularly in volatile and disruptive environments. Our results reaffirm the centrality of innovation capabilities including dynamic, digitalization, and networking capabilities in fostering organizational learning and resilience. This aligns with prior scholarship underscoring that firms equipped with robust innovation capabilities are better positioned to recognize, assimilate, and exploit emerging opportunities especially vital during crises such as the COVID-19 pandemic and periods of geopolitical instability (Ganguly et al., 2019; Wei et al. 2020; Papadopoulos et al. 2020; Ghobakhloo et al. 2022). These firms can adapt their strategies and processes more effectively, enabling them to sustain technological innovation in the face of external shocks and market uncertainty (Malik et al., 2024; Rejeb et al., 2025; Wang et al., 2008).

A key contribution of this study is its identification of digital trust as a pivotal mediating mechanism that amplifies the effects of innovation capabilities on technological learning. Echoing Mubarak and Petraite (2020) and recent work by Oesterreich et al. (2024), our findings indicate that digital trust not only facilitates knowledge sharing and collaboration in digital innovation networks but also strengthens firms' ability to translate capabilities into concrete learning outcomes. For practitioners, this highlights the

importance of investing not only in technological assets but also in the relational and technological mechanisms such as secure digital infrastructures, transparent processes, and reputation systems that foster digital trust within and across organizational boundaries (Allison et al., 2015).

The study also underscores the distinctive roles of digitalization and networking capabilities. Consistent with the findings of Kim et al. (2019), Shan and Jolly (2013), and Bouwman et al. (2019), these capabilities emerged as significant drivers of technological learning, both directly and via their influence on digital trust. Digitalization capability enhances the ability to access, process, and share information efficiently, whereas networking capability extends firms' reach to critical external resources and collaborative opportunities (Chi et al., 2018). In contrast, our findings challenge the traditional view drawn from Lee and Slater (2007) and Lall (1994) that investment capability is a core enabler of digital trust and learning. Our data suggest that while investment in technology is necessary, it is not sufficient to engender the trust or learning required for sustained innovation. Instead, elements such as strategic alignment, effective governance, and supportive institutional environments may play a more crucial role in nurturing trust within digital and crowdfunding ecosystems (Barbi & Mattioli 2019; Kusi-Sarpong et al., 2022; Hornuf & Schwiendbacher 2017).

Another important insight from our research is the critical role of digital trust in driving successful crowdfunding outcomes. Our findings support the arguments of Estrin et al. (2022), Eigenstetter (2020), and Belleflamme et al. (2014), who demonstrated that digital trust bolstered by dynamic, digitalization, and networking capabilities increases the likelihood of crowdfunding success, which in turn enhances firms' capacity for technological learning and innovation. However, the lack of a significant link between investment capability and digital trust in our model indicates that financial investment alone does not guarantee the credibility or confidence required to attract backers and partners. Rather, policy frameworks and institutional trust such as clear regulations, government oversight, and platform accreditation may be decisive in certain contexts (Moysidou & Hausberg 2020).

Our results further highlight the transformative potential of crowdfunding in enabling technological learning among SMEs and startups. In contrast to some recent studies (Eldridge et al. 2021; Hervé & Schwiendbacher 2019), which question the impact of crowdfunding on learning, our findings suggest that, when embedded within an ecosystem characterized by strong digital trust and innovation capabilities, crowdfunding serves not only as a financing tool but also as a platform for collaborative experimentation and iterative learning (Block et al., 2023; Cumming et al. 2022; Strohmaier et al. 2019). These discrepancies may arise from differences in context, sectoral focus, or the maturity of crowdfunding ecosystems across studies. Our results highlight the importance of digital trust and innovation capability as critical conditions for unlocking the full learning potential of crowdfunding platforms.

From a policy and managerial perspective, these insights stress the necessity of fostering digital trust through investments in digital infrastructure, transparent processes, and effective governance (Hornuf & Schwiendbacher 2017; Oesterreich et al. 2024). In markets such as Malaysia, institutional trust reinforced by government regulation and platform oversight serves as a vital catalyst, ensuring the integrity of crowdfunding activities and amplifying the positive effects of digitalization and trust-building measures (StartupBlink, 2023). Policymakers can draw valuable lessons from these findings to design strategies that further

strengthen crowdfunding ecosystems, facilitate the mobilization of capital, and accelerate the technological upgrading of firms. In summary, this study advances the conversation on entrepreneurial finance and innovation management by demonstrating the synergistic interplay among innovation capabilities, digital trust, and crowdfunding in driving technological learning. Future research should further unpack the boundary conditions such as the industry context, regulatory environment, and platform maturity that shape these relationships and explore how digital trust can be strategically cultivated to support sustainable innovation and resilience in SMEs and startups (Papadopoulos et al. 2020).

Implications of the study

The present study advances the literature on crowdfunding, digital trust, and innovation management by elucidating the interplay between innovation capabilities and digital trust in fostering technological learning and innovation, especially for startups and SMEs. These findings have important implications for both research and practice.

On the practical side, the results clearly highlight the pivotal role of digital trust as an enabler of successful crowdfunding and subsequent technological innovation. For practitioners, building and maintaining digital trust should be a strategic priority requiring transparent communication, robust cybersecurity measures, and clear, reliable processes for engaging investors and stakeholders. Firms can achieve this by investing in secure technology infrastructure, enhancing data protection, and maintaining open channels for feedback and communication with both backers and platform operators (Cumming and Reardon, 2023).

The study further demonstrates the necessity for firms to actively develop core innovation capabilities namely, digitalization, networking, and dynamic capabilities to strengthen both their digital trust and their innovation outcomes. This calls for targeted investment in digital infrastructure, the cultivation of strategic partnerships, and the fostering of an organizational culture that supports experimentation, continuous learning, and agile responses to change (Ghobakhloo et al. 2022). Crowdfunding platforms, for their part, should adopt proactive measures to promote digital trust, including user-friendly interface design, rigorous security protocols, and transparent disclosure practices, as well as providing educational resources that empower users particularly startups and SMEs to make informed funding and innovation decisions.

A notable recommendation from the study is the integration of blockchain technology into crowdfunding platforms. As demonstrated by Gada et al. (2021), incidences of fraud and information asymmetry remain persistent challenges in crowdfunding, often undermining trust and deterring potential backers. By leveraging blockchain's decentralized, immutable ledger, platforms can dramatically enhance the transparency, security, and auditability of transactions (Kusi-Sarpong et al., 2022). Beyond regulatory compliance, this technological shift would offer a powerful safeguard against fraudulent activity and position platforms as credible partners for both entrepreneurs and investors. Industry collaboration and regulatory support are recommended to accelerate blockchain adoption, accompanied by educational initiatives to familiarize users with its benefits and use cases.

On the theoretical side, this research also contributes by empirically unpacking the relationships between innovation capabilities, digital trust, crowdfunding, and technological innovation. By drawing on and integrating the dynamic capability view (DCV), transaction cost economics (TCE), and knowledge-based view (KBV), this study provides a robust and holistic framework for understanding the mechanisms underlying successful crowdfunding initiatives and technological innovation in entrepreneurial settings. This integrative approach advances the literature by illustrating how dynamic, digitalization, networking, and investment capabilities interact with digital trust to drive innovation outcomes, thus bridging the domains of innovation management and financial innovation.

Importantly, the study extends the dialog on digital trust by highlighting its critical role not just as a byproduct of innovation and investment but also as an active mediating mechanism that amplifies the value of innovation capabilities in the context of digital crowdfunding platforms (Oesterreich et al. 2024; Mubarak & Petraite 2020; Han et al. 2024). To the best of our knowledge, this work is among the few to operationalize and empirically validate a comprehensive, multitheoretical model of technological innovation in the crowdfunding landscape.

Conclusion

The onset of the fourth industrial revolution has intensified the imperative for continuous technological innovation, a need made even more pressing by the disruptions caused by the COVID-19 pandemic and ongoing global volatility. While large corporations have traditionally led the charge in technological development, the critical role of startups and SMEs as engines of innovation has become increasingly apparent. Despite their agility and creative potential, these smaller firms are frequently hampered by limited access to resources and funding. Our study demonstrates that enhancing crowdfunding mechanisms offers a promising solution to these challenges, enabling startups and SMEs to access the capital and collaborative networks essential for technological advancement.

Drawing on data from 164 participants with direct experience in crowdfunding, this research systematically examined the interplay between innovation capabilities (including digitalization, investment, networking, and dynamic capabilities), digital trust, and technological learning. The findings reveal that digitalization, networking, and dynamic capabilities significantly bolster digital trust, which in turn acts as a critical conduit for technological learning and innovation. Importantly, the study confirms that digital trust mediates the relationship between innovation capabilities and technological learning, whereas crowdfunding further mediates the impact of digital trust on technological innovation outcomes.

These results underscore the necessity for firms to go beyond simply acquiring financial resources; it is equally vital to cultivate digital trust with stakeholders and foster an environment that encourages knowledge sharing and collaboration. By strategically investing in digital infrastructure, strengthening networking ties, and continuously developing dynamic capabilities, firms can unlock the full potential of crowdfunding to drive sustained technological learning and innovation. Enhancing these soft capabilities is essential not only for securing entrepreneurial finance but also for ensuring long-term

competitiveness and resilience in an era defined by rapid technological and market changes.

Limitations and future research directions

The study acknowledges its limitations and proposes the directions for future research in the following ways.

First, the generalizability of our findings is constrained by the exclusive focus on Malaysian startups and technology-based SMEs. Although these firms are essential drivers of economic growth and innovation in the region, caution is warranted when extending these results to organizations in other countries or regions with differing socioeconomic, cultural, and regulatory environments. Future research should therefore replicate and extend this study across diverse geographic and institutional contexts to validate and enrich the findings. Second, the cross-sectional nature of the data limits our ability to make strong causal inferences regarding the relationships among innovation capabilities, digital trust, crowdfunding, and technological learning. While our results provide robust evidence of associations, longitudinal or panel data would be instrumental in capturing the dynamics and potential feedback effects of these relationships over time. Future studies employing longitudinal designs could better elucidate causal pathways and the evolution of digital trust and innovation outcomes within firms.

Third, the relatively modest sample size and the purposive sampling strategy may limit the representativeness of the findings. Although care was taken to ensure a diverse sample of technology-based startups and SMEs, larger and more randomly selected samples would enhance the robustness and breadth of the conclusions. Relatedly, the focus on firms operating for at least five years introduces the risk of survivorship bias, potentially overlooking the experiences of younger or failed ventures. Incorporating younger firms, as well as those that have exited the market, would provide a more nuanced and complete understanding of the challenges and opportunities associated with crowdfunding and digital trust in fostering technological learning. Furthermore, this study concentrated on startups and SMEs in the technology sector, which may restrict the applicability of the results to firms in other industries. Future research could examine whether and how the relationships among innovation capabilities, digital trust, and crowdfunding vary across sectors such as manufacturing, healthcare, creative industries, or services, thus broadening the study's relevance. Finally, while our framework draws on the dynamic capability view, transaction cost economics, and knowledge-based view, there may be value in exploring alternative or complementary theoretical lenses such as institutional theory, social capital theory, or resource orchestration perspectives to further deepen and contextualize our understanding of the mechanisms influencing crowdfunding success and technological innovation in entrepreneurial settings.

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During the preparation of this work, the author(s) used ChatGPT for language editing of the manuscript. After using this tool/service, the author(s) reviewed and edited the content as needed and take(s) full responsibility for the content of the publication.

Author contributions

M.S. contributed to paper Ideation, literature review, write-up, methodology, results, discussion, implications, and overall paper framing. M. P. contributed to Ideation, discussion, writeup, and validation. M.F.M. contributed to paper Ideation, literature review, write-up, discussion and overall paper framing. M.G. contributed to Methodology, data analysis and results. A.R. contributed to Ideation, review, write-up, and discussion.

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Data availability

The data cannot be shared due to confidentiality agreements.

Declarations**Competing interests**

The authors declare that they have no competing interests.

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