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Abstract

Despite the increasing attention to innovation in emerging markets, there remains a dearth of studies that specifically examine how and when R&D support drives firm-level innovation through digital entrepreneurship. Utilizing time-lag data collected from 212 firms in an emerging market using digital platforms, the study examines the impact of R&D support on product innovation through the mediating role of digital entrepreneurship. Our results indicate a positive intervening role of digital entrepreneurship in R&D support and product innovationrelationship. The findings contribute to the product innovation and digital entrepreneurship literature by highlighting the mechanism through which R&D support yields greater product innovation outcomes.

Keywords: *Digital entrepreneurship; R&D support; digital platform risk; product innovation; innovation ecosystem*

1. Introduction

The growth in digital platforms and related ecosystems is considered crucial in the context of entrepreneurship (Ojala & Lyytinen, 2024; Nambisan and Baron, 2021; Nambisan et al., 2019; Sitaridis and Kitsios, 2024). Digital platforms or digital ecosystems have the potential to help new ventures develop new products and services that add to the existing offerings (Ojala & Lyytinen, 2024; Sitaridis and Kitsios, 2024). Defined as the use of digital technologies, platforms, and innovations to initiate, manage, and scale entrepreneurial activities (Paul et al. 2023), digital entrepreneurship has emerged as a vital pillar in today's knowledge-intensive global economy not only among nations in advanced economies but also in emerging economies (Nambisan, 2017; Nambisan and Baron, 2021). This also entails leveraging digital tools and resources for the creation, development, and operation of new ventures, as well as the enhancement of existing business models. Accordingly, entrepreneurial ventures pursue

market opportunities through the use of digital technologies, digital media, or ICT to help reduce operating works and improve efficiency (Paul et al. 2023).

Despite the theorized and observed importance of digital entrepreneurship (Paul et al. 2023; Sitaridis and Kitsios, 2024), scant research exists to explain the antecedents and outcomes in the context of emerging economies. First, although digitalization of the entrepreneurial processes can help governments and policymakers foster inclusive development (Ghazy et al. 2022), thus far there has been very limited scholarly attention to how and whether R&D support can encourage a shift towards digital entrepreneurship. To this end, the role of R&D support in digital entrepreneurship is not immediately apparent and thus requires further empirical examination.

Addressing this gap is vital given the increasing importance digital entrepreneurship in firms' competitive performance and national development. Second, while digital technology adoption is considered an important step to boost entrepreneurship in developing nations (Soluk et al. 2021), research highlighting the outcomes of digital entrepreneurship is limited (Nambisan, 2017). Hence, it remains unclear how the increasing digital entrepreneurial endeavors manifest in firms' product innovation activities especially in the context of developing economies. Further, we still do not know enough about how digital platform risk moderates the effect of R&D on digital entrepreneurship and the consequential effect on firm product innovation. More specifically, the firm-level conditions under which R&D support is most viable in fostering digital entrepreneurship, and consequently product remain understudied. This research deficit is surprising given that product innovation stems from organizational capability and has the potential to amplify overall organizational performance (Aydin, 2021). Hence, there is a pressing need to delineate more clearly the boundary conditions of the R&D support, digital entrepreneurship, and product innovation linkage.

Against the backdrop, the purpose of this study is to examine the impact of R&D support on product innovation through the mediating mechanism of digital entrepreneurship.

This article offers several contributions to entrepreneurship and innovation literature. First, given the importance of digitalization in entrepreneurship (Tang et al. 2023), there remains limited understanding pertaining to the mediating role digital entrepreneurship on the R&D support- product innovation nexus. Accordingly, this study contributes to the emerging body of research on emerging economies by using data from Ghana to illuminate scholarly understanding of the dynamics of digital entrepreneurship in a resource-constrained and precarious institutional context of an emerging economy. This contribution is vital given that much of what we know about digital entrepreneurship has emerged from firms in stable institutional conditions of advanced economies. In addition, by isolating the crucial role of digital entrepreneurship in R&D support and product innovation linkage, we demonstrate that R&D support alone may not be enough to achieve robust innovation outcomes. Thus, by establishing the mechanism through which R&D support influences product innovation we paint a clearer picture of the intervening mechanism and provide theoretical clarity on how the three variables relate in tandem with one another. In doing so, we extend digital entrepreneurship research (Paul et al. 2023; Nambisan, 2017). Furthermore, drawing on a moderated mediation framework (Preacher et al. 2007), we show that R&D support directly and indirectly (via digital entrepreneurship) affects product innovation and that digital platform risk moderates the indirect effect. By accounting for the moderating effect of digital platform risk on this linkage, we resolve the fundamental question of when R&D support is most effective in facilitating product innovation. Thus, we provide an enriched understanding of the intricate dynamics within the innovation ecosystem (de Vasconcelos Gomes et al. 2021; Shengxi et al. 2024). This insight contributes to existing product innovation literature by highlighting the contextual factors, specifically the level of digital platform risk, that shape the

effectiveness of R&D support in fostering product innovation. This analysis contributes to a more nuanced and context-sensitive theoretical framework for understanding innovation processes within the digital landscape of firms in emerging markets.

2. Theoretical background and hypotheses development

2.1 Digital technologies, R&D and ecosystem dynamics

In the global economy's rapidly evolving landscape, digital technologies are transforming entrepreneurial opportunities (Heeks et al., 2021; Soluk et al. 2021). Digital entrepreneurship—the creation and management of technology-driven businesses—has emerged as a cornerstone for fostering innovation, growth, and societal change (Nambisan et al. 2019). By leveraging digital platforms and tools, entrepreneurs can identify and exploit market opportunities in novel ways (Beliaeva et al. 2019; Giones and Brem, 2017). However, in emerging economies, the potential of digital entrepreneurship is both promising and challenging. Digitalization offers new avenues for previously excluded entrepreneurs (Zhang et al. 2024), yet it also exposes underlying resource and capability inequalities. Significant barriers, such as limited capital, and access to technology, continue to restrict widespread adoption and impact (Dy et al. 2018; Daniels, 2013). Contextual conditions such as institutional norms, culture, and regulatory environments can facilitate or impede entrepreneurial activities in these regions (McAdam et al. 2020).

R&D initiatives, critical enabler of innovation (Kang and Park, 2012), can help firms overcome structural barriers and create innovative products. Governmental R&D support becomes particularly vital in emerging markets, where firms often lack the resources to pursue innovation independently (Bruton et al. 2010). In the context of emerging ecosystems, where firms face unique uncertainties in the process of accessing resources, a central question

concerns how these dynamics unfold. The innovation ecosystem literature highlights the importance of dynamic capabilities—such as the ability to deploy digital tools effectively—for fostering innovation in complex and evolving environments (Dong, 2019; Nambisan, 2017; Autio et al. 2018). Digital entrepreneurship serves as a dynamic capability, enabling firms to adapt to technological advancements and exploit emerging opportunities (Dong, 2019). However, while the role of digital entrepreneurship has been studied in developed markets, there is limited evidence of how it operates within the unique ecosystems of emerging markets (Soluk et al. 2021).

Emerging economies often face challenges such as inadequate technological infrastructure, underdeveloped financial markets, and a lack of skilled labor (Leong et al. 2022). These constraints not only hinder the adoption of digital technologies but also raise questions about whether findings from developed market studies can be generalized to these contexts.

2.2 R&D support and digital entrepreneurship

Government R&D support refers to the funding, resources, and incentives provided by governments to encourage and support scientific and technological innovation and development (Kang and Park, 2012). This support can come in various forms, such as grants, tax incentives, subsidies, and loans, and can be provided to both private and public organizations, as well as academic institutions and individual researchers. The goal of government R&D support is to drive economic growth, competitiveness, and innovation by fostering the development of new products, technologies, and industries (Adomako et al. 2021a).

R&D support is often driven by governments in terms of providing business support systems to enable them to capitalize on market opportunities. In this study, we contend that R&D support can predict digital entrepreneurship for several reasons. First, given that new

ventures require support, R&D support can provide funding, resources, and tax incentives to encourage individuals and companies to start new digital ventures. This is the case for entrepreneurial ventures as support in R&D can drive technological advancements and innovations that can lead to the creation of new digital products and services (Adomako et al. 2021b). Second, R&D support can be used to build the necessary infrastructure, such as broadband networks and data centers, that is critical for the growth of entrepreneurship (Beliaeva et al. 2019). Third, R&D support received from the government can be used to provide education and training programs that help to develop the skills and knowledge needed for digital entrepreneurship. Through education in digitalization, entrepreneurial ventures build and foster ecosystems that support digital entrepreneurship, such as innovation hubs, accelerators, and incubators. This is predicated on building digital infrastructure and ICT support systems for the development of new ventures. Government support in the form of subsidies, preferential treatments, and favorable treatment provides the support mechanisms for entrepreneurs to mitigate resource and institutional constraints which often impede the development of new ventures (Adomako et al. 2021b). Such support can also foster investments in new technologies as well as entrepreneurship training which can ultimately help improve the performance of their venture. Indeed, government support can serve as a source of legitimacy which helps to improve the competitiveness of new ventures (see Wang et al. 2021). Thus, we suggest that:

H1: R&D support is positively related to digital entrepreneurship.

2.3 Digital entrepreneurship and product innovation

Product innovation refers to the process of creating, developing, and introducing new or improved products into the market (Aydin, 2021; Story et al. 2015). It involves the ideation, design, and commercialization of new products or the improvement of existing products to meet the changing needs and preferences of customers. Product innovation can take many

forms, including incremental improvements to existing products, the development of entirely new products, or the introduction of new features or functions to existing products.

Relatedly, digital entrepreneurship helps innovative new ventures looking to stay ahead of the curve and remain competitive in the market (Sahut et al. 2021; Tang et al. 2023). This can be done through the use of technology and digital platforms to create, design, and launch new products and services that meet the needs and preferences of consumers in the digital marketplace. By blending entrepreneurial processes with digital technologies, entrepreneurs can overcome some of the challenges of starting new businesses by leveraging online platforms for buying and selling goods (Nambisan, 2017; Paul et al., 2023). Some researchers have indicated that digital technologies can fuel innovation among entrepreneurial organizations beyond the boundaries of the industry as well as fast-track new venture formation (Nambisan et al. 2019). Largely due to resource-scarce and institutional constraints in developing economies, digital entrepreneurship has flourished in developing countries (Ngoasong, 2018). It has also provided ample avenues for new ventures to utilize and capture untapped market opportunities for business development (Ngoasong, 2018). The advent of digital technologies has provided means for existing firms to update their business model to better respond to their customers. Such capability and process updating are crucial in maintaining the competitive edge of incumbent ventures.

Further, digital entrepreneurs are often at the forefront of adopting and leveraging new and disruptive technologies (Nambisan, 2017), such as artificial intelligence, blockchain, and the Internet of Things, to create new products and services. In addition, digital entrepreneurs often take a customer-centric approach, using data and analytics to identify unmet needs and opportunities for new product development. The use of digital technologies in entrepreneurship activities is likely to improve the agile development of the venture. For example, digital entrepreneurs often employ agile development methodologies, allowing them

to quickly iterate and improve upon their products based on customer feedback. Finally, digital entrepreneurship is likely to improve product innovation because it often helps ventures leverage network effects to create and scale their products and services, leveraging the power of platforms and ecosystems to reach large audiences and create new opportunities.

In light of the observations that digital technologies are "enablers" of new venture formation (Elia et al. 2020; von Briel et al. 2018), we contend that digital entrepreneurship is likely to generate product innovation, especially in developing countries where firms face resources and capabilities constraints are a force to innovative with less to ensure their long-term survival as a business. Hence:

H2: Digital entrepreneurship is positively related to product innovation.

2.4 The mediating effect of digital entrepreneurship

Based on H1 and H2, we propose that digital entrepreneurship is a mediator between R&D support and product innovation. First, by providing funding, resources, and incentives to digital entrepreneurs, government R&D support can help to foster an environment that is conducive to innovation and creativity. Digital entrepreneurs can then leverage this support to create new products and services, using their expertise, market insights, and technological capabilities to bring these innovations to market. Second, while government R&D support may not directly lead to product innovation, it can play an important role in promoting and supporting the mechanisms that are necessary for innovation to flourish. By investing in digital entrepreneurship, governments can help to build a vibrant and dynamic innovation ecosystem that is better equipped to drive product innovation and bring new products and services to market. Thus, we argue that:

H3: R&D support has an indirect effect on product innovation through digital entrepreneurship.

2.5 The moderating role of digital platform ecosystem risk

Digital platform risk refers to the uncertainties and potential losses that are associated with operating in the digital marketplace (Hein et al. 2020; Kim and Cavusgil, 2020). This can include a variety of different types of risks, such as technological risk, regulatory risk, and cybersecurity risk. Thus, digital platform risk can be a significant barrier to the growth and success of digital entrepreneurship, and it is an important factor to consider when evaluating the potential for product innovation. As observed by Hein and colleagues, a typical digital platform ecosystem encompasses a "platform owner that implements governance mechanisms to facilitate value-creating mechanisms on a digital platform between the platform owner and an ecosystem of autonomous consumers" (Hein et al. 2020, p. 90). Through the process of coordinating the participants such as suppliers, customers, and third-party organizations in the ecosystem, they play a key role in the value creation processes, which can enhance organizations' competitiveness (Hein et al., 2020; Teece, 2018). Indeed, the ecosystem actors and interaction among them can fuel innovation (Nambisan et al. 2019). Given the interdependencies between participants in an ecosystem (Hein et al., 2020; Li et al. 2012), they represent a diverse source of risks such as cyberattacks, which can be difficult to mitigate and can impede the organization's ability to achieve success.

There are two reasons to argue that digital platform risk has a moderating effect on the indirect relationship between R&D support and product innovation. First, when digital platform risk is low, digital entrepreneurs are more likely to take advantage of the opportunities and support provided by government R&D support to create new products and services. This, in turn, can have a greater positive indirect effect on product innovation. Second, a low-risk environment provides digital entrepreneurs with the confidence and security they need to invest their resources and focus their efforts on creating innovative new products. In this environment, government R&D support can play a critical role in providing the necessary resources, funding, and infrastructure to support digital entrepreneurship and drive product innovation.

Conversely, when digital platform risk is high, digital entrepreneurs may be less likely to take advantage of government R&D support due to concerns about the viability of their business and the potential for investment losses. In this scenario, the positive indirect effect of R&D support on product innovation may be limited. Therefore, to maximize the positive indirect effect of R&D support on product innovation through digital entrepreneurship, governments need to reduce digital platform risk and create an environment that is supportive of innovation and entrepreneurship.

H4: R&D support has a greater positive indirect effect on product innovation through digital entrepreneurship when digital platform risk is low.

3. Method

3.1 Study setting-Ghana

Two reasons informed our choice of Ghana as a study context. First, Ghana is considered a ‘‘gateway to Africa’’ in terms of doing business because of its strategic position and rapid economic growth. In addition, Ghana remains the easiest place to do business in West Africa (World Bank, 2022). For example, the country has implemented several policies geared toward boosting entrepreneurial activities. In particular, Ghana has successfully implemented an open market economy for decades. For example, the intraduct of the National Entrepreneurship and Innovation Plan is a major policy initiative to help early-stage ventures to scale up and innovate. Second, Ghana has adopted digitalization as a key strategy to develop a more digitally accessible economy. This strategy is aimed at encouraging transparency and efficiency to drive growth in all aspects of the country’s economy. For example, the widespread adoption of mobile money and digital payment systems has significantly improved the use of digital platforms in Ghana. In addition, several institutions have adopted digital payment platforms to facilitate payment activities.

3.2 Sample and data

We developed our sampling frame from the Ghana National Entrepreneurship and Innovation Plan (NEIP). The NEIP is a government of Ghana policy initiative to boost the entrepreneurial and innovation ecosystem. The NEIP database contained 7500 new firms that have applied to access various funding programs for innovation. In this study, we randomly 1600 firms to participate in our study. Subsequently, we further applied the following sampling technique to select 600 ventures: (1) firms classified as independent with no link to any company group; (2) firms with greater ownership by an entrepreneur or group of entrepreneurs; (3) firms that were using digital platforms such as Airbnb, Amazon, Facebook, etc. to sell or distribute their products/services, (4) firms manufacturing physical products or service providers, (5) firm aged not more than 8 years; and (6) firms with complete information on the founder or group of founders. The 8-year cut-off adopted was in line with prior research that conceptualizes new ventures (Ahsan, et al., 2023).

Data were collected in three waves within eight months. Each wave took approximately two months. In the first wave (t1), we gather information on R&D support and digital platform risk from the founder/entrepreneur of each venture. The questionnaire was delivered using a face-to-face data collection approach. We received a total of 239 out of the 600 questionnaires delivered. Four weeks later, in wave 2, (t2), we reconducted the 239 entrepreneurs/founders who took part in t1 to solicit information on digital platform risk. We received a total of 230 surveys. The nine entrepreneurs/founders who did not return the questionnaire cited several reasons such as limited time to complete the survey. In wave 3 (t3), we contacted a team member of the venture to access the firm innovation construct. Using the same approach as t1 and t2, we obtained a total of 212 complete matched surveys from three waves. This represents a 35.33% effective response rate (i.e. [212/600] x 100).

The informant competency of each respondent was captured using the procedure suggested by Morgan et al. (2004). Accordingly, the respondents were asked to report (1) their knowledge about the questions; (2) information accuracy; and (3) their level of confidence in providing answers. This information was received on a seven-point Likert scale (1 = strongly disagree; 7 = strongly agree). A mean score of 6.09 (SD=1.14) for issues related to respondents' knowledge issues, 6.23 (SD=1.13) on how accurate the responses are, and 5.54 (SD=1.12) for respondents' confidence in proving the questions were recorded. This suggests that the respondents were competent in providing answers to the questions.

The characteristics of the sample are presented in Table 1. The average age of the firms was 6 years and employed 16 full-time employees. The firms operate mainly in agro-processing (30.19%), transportation services (7.07%), textile/garment manufacturing 20.28%), financial services (16.50%), craft and artisans (15.07%) and water and soft drinks processing (10.86%) industries. This indicates 76.42% are manufacturers of physical goods whilst 23.58% are service providers.

To assess non-response bias, respondents and non-respondents were compared (Armstrong and Overton, 1977) in terms of firm size, firm age, entrepreneurs' age, and industry. The information on non-respondents was obtained from the NEIP's database. Pearson's chi-square test was used to assess whether there were differences between the two groups (Greenwood and Nikulin 1996). Since no significant differences were found, it was concluded that the respondents did not differ from the non-respondents; suggesting the findings reported in this study are not influenced by non-response bias.

3.3 Measures

Unless otherwise indicated, we measured all the multi-item constructs on a seven-point Likert with anchors ranging from 1=strongly disagree to 7=strongly agree. The items used to measure the constructs are presented in Table 2.

R&D support. A firm's involvement in R&D funding was measured using government grants as a proxy investment (Adomako et al., 2021b; Kang and Park, 2012). We followed the same approach to assess R&D support as follows: 1= the firm received government grants for its projects in a particular year and 0=otherwise.

Digital platform risk. We measured digital platform risk with seven items from Kim, and Cavusgil (2020). The items reflect opportunistic behaviors and uncertainty in the use of the digital platform ecosystem in the exchange relationship.

Digital entrepreneurship. We developed and used a new survey instrument for digital entrepreneurship, consistent with the original theoretical study (Hull et al. 2007) and subsequent related studies (e.g., McAdam et al. 2020; Hair et al. 2012). The specific items are tied to the dimensions along which Hull et al. (2007) suggested that the degree of digital entrepreneurship could vary.

Product innovation. In this study, we used two types of product innovation (novelty and intensity) to measure the overall product innovation (Story et al. 2015). product innovation novelty reflects the degree of radicalness, creativity, and inventiveness of the firm's products/services. Three items from Story et al. (2015) were used to capture product innovation novelty. Product innovation intensity highlights the number of new products a firm introduces to its target market relative to its competitors. We used three items from Story et al. (2015). Following previous studies (e.g., Lee et al. 2014), we treated product innovation as a formative construct. Accordingly, we used a single score for the reflective measure of product innovation intensity by obtaining the average score for product innovation intensity. We used the same approach to obtain the product innovation novelty score. The average score for the novelty and intensity scores represents the overall product innovation construct.

Control variables. We controlled for R&D expenditure, industry type, firm age, firm size, and environmental dynamism. R&D expenditure was measured as the logarithm

transformation annual total R&D expenses. Industry type was a dummy variable as was assessed as 0=services and 1=manufacturing. Firm age was assessed as the logarithm transformation of the number of years since the formation of the business. We measured firm size as the logarithm transformation of the number of full-time employees. Finally, we measured environmental dynamism with three items from Miller and Friesen (1982).

Table 1. Characteristics of the ample

		Number of samples	%
Firm age (in years)	<3	69	32.55
	3–8	143	67.45
Firm size (employees)	<5	38	17.93
	5–10	67	31.60
	11–15	56	26.42
	16–20	22	10.37
	>20	29	13.68
Industry type			
	Agro-processing	64	30.19
	Textiles and garments	43	20.28
	Financial services	35	16.50
	Crafts and artisans	32	15.09
	Water and soft drinks processing	23	10.86
	Transportation	15	7.08
Sales (in millions)	<3	102	48.11
	3–8	38	17.92
	8–15	43	20.29
	>15	29	13.68

4. Analyses

4.1 Common method variance

Although we used a time-lag design and conducted multiple waves of data collection from multiple respondents, we cannot entirely rule out potential common method variance (CMV) from the findings. As such, we followed conventional practices to assess the magnitude of CMV (Podsakoff et al. 2003). First, we employed Harman's one-factor test (Podsakoff et al.,

2003). The results of this test show that the largest component that explained the variance was 27.22%. This result demonstrates that no single factor accounted for the majority of the covariance that emerged. Second, we performed a confirmatory factor analysis (CFA) by arguing that a single factor describes the variables used in this study. Accordingly, we linked all the items that measure the dependent variable and independent variable to a single factor. The proposed CFA model did not yield an adequate fit for the data (χ^2/d.f = 4.33, RMSEA =0.15, CFI = 0.55, Tucker-Lewis index [TLI] = 0.39). Third, we utilized the single factor-common-method-factor technique suggested by Podsakoff et al. (2003) to assess CMV. The results of the test (χ^2/d.f = 2.33, RMSEA =0.11, CFI = 0.66, TLI = 0.70) poorly fit the data than the proposed model (Table 3). Collectively, these results indicate that CMV was not a major concern in our empirical findings.

4.2 Validity, and reliability assessment

In this study, we utilize the LISREL 9.1 statistical package to assess reliability and validity (see Table 2). The reliability assessment shows that Cronbach's alpha values for all the constructs exceeded the suggested threshold value of 0.70. This suggests adequate reliability (Cronbach, 1951). Additionally, the CFA models demonstrated sufficient fit between the hypothesized measurement model and the observed data (χ^2/d.f = 2.19; RMSEA = 0.06; NNFI = 0.93; TLI = 0.94; CFI = 0.92). In addition, as shown in Table 2, the composite reliability (CR) values were significantly larger than 0.60, the level considered as evidence for convergent validity (Bagozzi and Yi, 2012). Moreover, all the factor loadings exceeded the recommended value of 0.70, providing evidence of convergent validity (Fornell and Larcker, 1981). Further, we compared a four-factor model with different models to assess the discriminant validity of the constructs. The results in Table 3 indicate an adequate fit of the four-factor model. Thus, we find support for the discriminant validity of our constructs. Finally, we find that no correlation

was greater than the square root of the average variance extracted (AVE) for each construct. This provides further support for the discriminant validity of our constructs.

Table 2: Constructs, reliability, and validity

Details of measurement items	Factor loading	Cronbach's α	CR	AVE
Digital entrepreneurship (new scale)		0.91	0.92	0.70
Please indicate your level of agreement with these statements related to your current venture				
Our firm's advertising and marketing are done entirely or mostly using a digital platform	0.89			
Our firm is a digital business	0.87			
Our firm's products or services are generally on a digital platform or online	0.79			
Our firm does all or most of its business digital platform, not in person	0.80			
Most of the work done at my firm is done over digital platforms or the Internet	0.83			
Digital platform risk (Kim & Cavusgil, 2020)		0.90	0.90	0.70
Please indicate your level of agreement with these statements on your perception of threat and risk in subscribing to a digital platform ecosystem:				
There is considerable risk involved in participating in this digital platform	0.78			
There is a high potential for loss involved in participating in this digital platform	0.82			
My decision to participate in a digital platform is risky	0.85			
Participating in this digital platform may disrupt our export marketing operations	0.88			
Participating in this digital platform may strain my relationships with our current customers	0.86			
Participating in this digital platform may strain my relationships with our current distributors	0.90			
Participating in this digital platform may allow competitors to exploit our private information (such as price)	0.77			
Product innovation intensity (Story, Boso, & Cadogan, 2015).		0.84	0.85	0.66
On average, each year we introduce more new products/services in our target markets than our key target market competitors	0.75			
Industry experts would say that we are more prolific when it comes to introducing new products/ services in our target markets	0.89			
Our key target market competitors cannot keep up with the rate at which we introduce new products/services in our target markets	0.79			
Product innovation novelty (Story, Boso, & Cadogan, 2015).		0.89	0.90	0.76
Relative to our main competitors, the products/services we offer in our target market(s) are radical	0.89			
Relative to our main competitors, the products/services we offer in our target market(s) are creative	0.88			
Relative to our main competitors, the products/services we offer in our target market(s) are inventive	0.86			
Environmental dynamism (Miller & Friesen 1982)		0.86	0.87	0.70
Competitors are constantly trying out new competitive strategies	0.77			
Customer needs and demands are changing rapidly in our industry	0.87			
New markets are emerging for products and services in our industry	0.88			

Note: AVE=average variance extracted; CR=composite reliability

Table 3. Results of the CFA model comparisons

CFA model	χ^2	Df	χ^2/df	*p*-value	RMSEA	SRMR	NNFI	CFI
Hypothesized four-factor model (digent, digplat, dynm, inno_intens+inno_novel)	1451.44	968	1.49	0.00	0.06	0.07	0.92	0.93
Three-factor model (digent+digplat, dynm, inno_intens+inno_novel)	2293.09	682	3.36	0.00	0.10	0.09	0.60	0.67
One-factor model (digent+digplat+dynm+inno_intens+inno_novel)	2499.28	693	3.60	0.00	0.12	0.11	0.57	0.59

Note digent=digital entrepreneurship; digiplat=digital platform risk; dynm=environmental dynamism; inno_intens= product innovation intensity; inno_novel= product innovation novelty.
***p<0.001

Table 4. Descriptive statistics and correlation among key variables

Variables	Mean	s.d.	1	2	3	4	5	6	7	8
1. R&D expenditure‡	2.78	0.71	1.00							
2. Industry ‴	--	--	-0.24**	1.00						
3. Firm age‡	2.07	0.82	-0.09	-0.07	1.00					
4. Firm size‡	2.91	0.96	-0.10	-0.06	-0.06	1.00				
5. Environmental dynamism	4.38	1.16	0.09	-0.07	0.05	0.13*	1.00			
6. R&D support	0.49	0.42	0.20**	0.17*	-0.05	-0.22**	0.22**	1.00		
7. Digital entrepreneurship	4.79	1.19	0.08	0.12	-0.08	-0.30**	0.09	0.42**	1.00	
8. Digital platform risk	5.01	1.02	-0.08	-0.03	-0.11	-0.21**	0.07	-0.19**	-0.34**	1.00
9. Product innovation	5.14	1.11	0.27**	0.11	-0.16*	-0.17*	0.19*	0.59**	0.37**	-0.29**

Note. n = 212. *p< 0.05; **p < 0.01; SD = standard deviation; ‴ dummy variables; ‡ natural logarithm

4.3 Hypothesis testing

Table 4 provides details of the descriptive and correlations of the variables. Before testing the hypotheses, the variables involved in the interaction were mean-centered to correct multicollinearity (Aiken and West, 1991). The variance inflation factor (VIF) test shows that the largest VIF value was 2.36, which was well below the recommended threshold value of 10 (Neter et al. 1996). This indicates that multicollinearity is not a major concern in our analyses. In addition, the data were scrutinized for potential violations related to normality and outliers. Our checks revealed no significant violations in the data. Thus, we concluded that the data were useable for regression analysis.

The hierarchical regression analysis was utilized in testing the hypotheses. However, the moderated mediation analysis was performed using the Process macro advanced by (Hayes, 2013). The results of the regression analysis are presented in Table 5. The dependent variable in Models 1-4 is digital entrepreneurship. Model 1 tests the control variables. In Model 2, we added R&D support as the independent variable. The results in Model 2 show that R&D support has a significant influence on digital entrepreneurship ($\beta = 0.26$, $p < 0.01$). This result provides support for H1. Digital platform risk was included in Model 3 and the influence of R&D support on digital entrepreneurship remained positive and significant ($\beta = 0.24$, $p < 0.01$). The interaction term between R&D support and digital platform risk (R&D support x DPR) was added in Model 4 and the interaction term is negative and significant ($\beta = -0.15$, $p < 0.05$), suggesting that digital platform risk negatively moderates the relationship between R&D support and digital entrepreneurship. The direction of the moderation was investigated by following Aiken and West (1991) in plotting a graph of the moderation at one standard deviation above and below the mean of digital platform risk (see Figure 1).

The simple slope test shows that the influence of R&D support on digital entrepreneurship was stronger when digital platform risk was low (simple slope = 0.30, t = 3.71, p < 0.01). However, the slope was weak when digital platform risk was high (simple slope = −0.01, t = −0.10, p = *n.s.*).

Table 5: Regression results

	Models 1–4: Digital entrepreneurship				**Models 5–8: Firm innovation**			
Control variables	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6	Model 7	Model 8
R&D expenditure‡	0.08	0.08	0.07	0.06	0.15*	0.15*	0.13*	0.13*
Industry ‴	0.11	0.10	0.11	0.11	0.05	0.05	0.04	0.04
Firm age‡	-0.06	-0.05	-0.05	-0.04	0.14*	0.13*	0.13*	0.12
Firm size‡	-0.19**	-0.18**	-0.16*	-0.15*	-0.14*	-0.13*	-0.13	-0.13
Environmental dynamism	0.11	0.10	0.09	0.08	0.14*	0.14*	0.15*	0.15*
Independent variable								
R&D support		0.26**	0.24**	.26**		0.35**	0.32**	0.02
Moderator								
Digital platform risk (DPR)			-0.09	-0.09	-0.08	-0.08	-0.08	-0.07
Interaction								
R&D support * DPR				-0.15*				-0.17**
Mediator								
Digital entrepreneurship							0.34**	0.34**
Model fit statistics								
F-ratio	1.49	3.60**	4.11***	3.11**	2.12*	3.78**	5.92**	6.36**
R^2	0.13	0.20	0.24	0.30	0.11	0.17	0.25	0.29
ΔR^2	-	0.07	0.04	0.06	-	0.05	0.08	0.04
Largest VIF	2.19	1.99	2.17	2.16	2.22	2.36	1.55	1.59

N = 212; * p < 0.05; ** p < 0.01; Standardized coefficients are shown.

Table 6: Indirect effect and significance using the normal distribution

	Value	**SE**	**z**	**p**
Sobel	0.04	0.03	2.03	0.05
Bootstrap results for the indirect effect	Effect	SE	LL 95% CI	UL 95% CI
	0.04	0.03	0.02	0.10

N = 212. Bootstrap sample size = 10000. * p < 0.05. ** p < 0.01.

In Models 5-8. The dependent variable is product innovation. The results in Models 5-8 H4b. In testing the mediation hypothesis, we employed the approach suggested by Zhao et al. (2010). First, the independent variable should have a significant effect on the mediating variable. The results in Model 2 show that R&D intensity significantly influences digital entrepreneurship ($\beta = 0.26$, $p < 0.01$). Second, the mediating variable should have a significant effect on the dependent variable. The results in Model 7 confirm indicate that digital entrepreneurship significantly influences firm innovation ($\beta = 0.34$, $p < 0.01$). To confirm the indirect effect of R&D support on product innovation through digital entrepreneurship, we used Hayes and Preacher's (2010) approach by testing the significance of the indirect effect using the Sobel test and bootstrapping (see Table 6). The results of this test indicate that the indirect effect of R&D support is significant (Sobel $z = 2.03$, $p = 0.05$). The results of the Sobel test confirmed the bootstrapping method. Accordingly, we estimated 95% bias-corrected confidence intervals (CI) for indirect effect using 10,000 bootstrapping samples. The bias-corrected confidence intervals ranged from -0.10 to -0.02. These values exclude zero in the confidence intervals, thus supporting H2.

Third, the influence of the independent variable on the dependent variable should be nonsignificant or weaker when the mediating variable is added to the regression equation. The results in Model 8 show that when R&D support and firm innovation were added to the regression equation, the effect of digital entrepreneurship on firm innovation was positive and significant ($\beta = 0.34$, $p < 0.01$). In addition, the effect of R&D support on firm innovation is nonsignificant ($\beta = 0.2$, $p > 0.10$). These results demonstrate that digital entre

preneurship mediates the relationship between product innovation. Thus, H3 is supported.

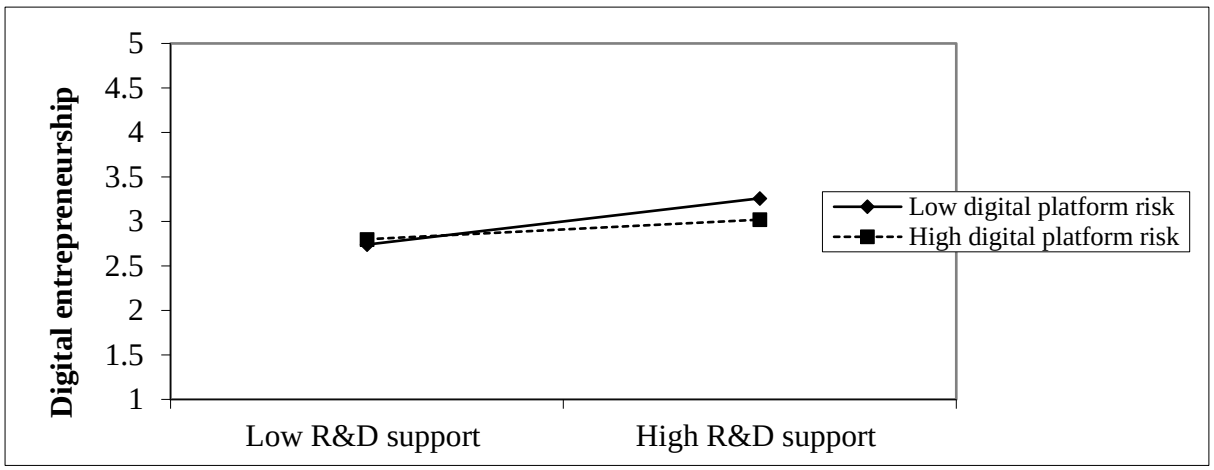
Table 7. Moderated mediation results for firm innovation across levels of digital platform risk

	Product innovation				
Moderator	Level	Conditional indirect effect	SE	LL 95% CI	UL 95% CI
Digital platform risk	Low (-1.09)	−0.05	0.04	− 0.11	− 0.02
	High (1.09)	− 0.00	0.03	-0.04	0.07

N = 212; The results are based on 10,000 bootstrap samples

In testing H4, we used the PROCESS macro (Preacher et al. 2007) and estimated the conditional indirect effect of R&D support on product innovation through digital entrepreneurship (see Table 7). Accordingly, we set digital platform risk at high and low levels at one standard deviation above and below the mean score of digital platform risk. Our results demonstrate that the indirect effect of R&D support on product innovation through digital entrepreneurship was conditional on levels of digital platform risk. The results show that the indirect effect was stronger (-0.05) and significant at a low level of digital platform risk (confidence interval ranged from −0.11 to − 0.02). However, the indirect effect was weaker at -0.00 and significant at a high level of digital platform risk (confidence interval raged from -04 to 0.07). These results provide support for H4.

Figure 1. Interaction of R&D support and digital platform risk on digital entrepreneurship



5. Discussion and conclusion

Building on the product innovation literature (Bustinza et al. 2019; Cai et al. 2019; Story et al. 2015), this study examines how R&D support influences product innovation through the mediating mechanism of digital entrepreneurship. In particular, our first finding (i.e., R&D support is positively related to digital entrepreneurship) shows the importance of the previously underexplored R&D support in explaining digital entrepreneurship. The second finding (i.e., digital entrepreneurship is positively related to product innovation) reveals that firms engaged in digital entrepreneurship are likely to bring into market product innovations. Third, our analyses revealed that digital entrepreneurship mediates the relationship between R&D support and product innovation. This finding highlights the mechanism through which R&D support affects product innovation. Finally, we find that digital platform risk negatively moderates the relationship between R&D support and product innovation mediated by digital entrepreneurship. This finding suggests that digital platform risk serves as a buffer to mitigate the impact of R&D support on product innovation through digital entrepreneurship. Overall, our findings have several implications for theory and practice.

5.1 Theoretical implications

Prior studies argue that understanding digital technology is important in innovation activities outside of high-tech industries (Karimi and Walter, 2021). This is because digital technology is ubiquitous with low barriers to entry and can fundamentally change outcomes and processes (McAdam and Crowley, 2020). Thus, our study contributes to understanding the impact of digital technologies in innovation ecosystems as a key source of competitive advantage. Our empirical evidence suggests that firms that engage in digital entrepreneurship are likely to spur the creation of new products.

Additionally, our findings contribute to the product innovation literature (Adomako et al., 2024) by suggesting that digital entrepreneurship has an intervening effect on the relationship between R&D and product innovation. Recent studies have argued different mechanisms that can explain the mixed findings that have characterized the effect of R&D on product innovation (e.g., Hejj et al. 2020). The advancement of digital technology to facilitate unprecedented opportunities and collaborations can help explain the variations in R&D effectiveness in product innovation.

Despite the surge in research on digital technologies and the closely related field of digital entrepreneurship, we still have a limited understanding of its in R&D support and innovation literature. Thus, our moderated mediation analysis also provides a nuanced perspective to explain the mixed effects of R&D on product innovation. The study deepens understanding of how different mechanisms emanating from digital technologies combine to explain the effectiveness of R&D support in an innovation ecosystem.

Further, we show that digital platform risk as a moderator helps explain variations in a firm's effectiveness in transforming R&D support into digital entrepreneurship. The result of the moderating effect was negative such that the effectiveness of R&D support is attenuated when the level of digital platform risk is amplified. Thus, with this finding, we add new insights to prior research that has examined how R&D support influences firm outcomes (e.g., Sonmez Cakir et al. 2024; Hejj et al. 2020; Lin, Lee & Hung, 2006).

Finally, our finding regarding the positive relationship between R&D support and digital entrepreneurship contributes to our understanding of the importance of R&D to digital ecosystems. For example, several studies have largely focused on how digital ecosystems stimulate and create new ventures (e.g., Nambisan, 2017, von Briel et al., 2018). However, little research has focused on R&D support. Our findings suggest that both digital platform risk and non-digital (e.g., R&D support) influence digitally enabled entrepreneurial activities. This

finding contributes to the digitalization literature by identifying R&D support as a non-digital factor, especially for explaining digital entrepreneurship.

5.2 Practical implications

Beyond the theoretical implications, this study has implications for managers and policymakers too. First, governments can focus R&D support on fostering digital entrepreneurship by leveraging programs and initiatives that support digital entrepreneurship. Second, digital entrepreneurs can leverage R&D support to drive innovation. For example, digital entrepreneurs can use the funding, resources, and support provided by government R&D support to develop new products and services and bring these innovations to market. Further, by driving product innovation, digital entrepreneurship can lead to the creation of new products and services that improve the quality of life for individuals and communities. Third, the ability to create the condition for digital entrepreneurship requires collective efforts from the government and other stakeholders towards removing regulatory and structural obstacles to ease the processes of starting new ventures. There is also a need for governments to direct resources towards alerting the general public of the opportunities offered by digital technologies and governments' digital skill formation schemes to help them take advantage of business formations. Government investments in the training and development of entrepreneurs could go a long way in incentivizing the growth of digital entrepreneurship.

Moreover, the result suggests that digital entrepreneurship is a crucial mechanism of the relationship between R&D support and product innovation. Thus, entrepreneurial managers are advised to prioritize digital entrepreneurship by investing and integrating digital technologies/tools into their operational routines when implementing innovation as R&D support alone may be inadequate to achieve robust innovation outcomes.

Additionally, the finding that the indirect impact of R&D support on product innovation is contingent on the level of digital platform risk implies that R&D support may not

always be beneficial to digital entrepreneurship and product innovation. Thus, the results shed new light on the condition under which R&D support is most or less effective in influencing product innovation through digital entrepreneurship. With this insight, managers can nurture an enabling environment to boost the overall effect of R&D support on digital entrepreneurship and product innovation by implementing judicious measures to minimize digital platform risk.

Further, our paper underscores the importance of R&D support for product innovation through digital entrepreneurship in the context of an emerging economy. Given that institutional frameworks for innovation are weaker within emerging economies (Amankwah-Amoah and Adomako, 2021b), firms could draw on digital ecosystems to optimize innovation and other firm-level outcomes as it can help firms overcome institutional impediments. Thus, managers can capitalize on digitally driven opportunities to improve firm performance in emerging economies characterized by weak institutional structures. For example, managers can exploit digital technologies, platforms, and infrastructures to enhance firm processes such as absorptive capacity and customer feedback to advance innovation and subsequently overall firm performance. Finally, our findings have important implications for governments, digital entrepreneurs, and society as a whole. By directing R&D support towards programs and initiatives that support digital entrepreneurship, governments can help to create a more favorable environment for innovation and creativity, which can drive economic growth, improve quality of life, and create new opportunities for digital entrepreneurs.

6. Limitations and future research trajectories

There are several limitations associated with this study that indicate useful avenues for future research. First, we focus on new ventures which offer limited insight into old and large corporations. It would be useful for future studies to seek samples from mature and large firms as well as government-owned enterprises to help highlight the influence of digital R&D support on product innovation. Second, the focus on a single country in West Africa makes it difficult

to extend the findings beyond the current setting. Future research could seek samples from other West African nations such as Nigeria, Senegal and Togo. By comparing insights from these countries with Ghana, it would help to shed further light on the generalizability of the findings. Third, although we adopted a time-lag design and conducted multiple waves of data collection to examine the conflated effect of R&D support, digital platform risk, and digital entrepreneurship on product innovation, the data were cross-sectional. Since change is constant for all firms, corresponding effects may also be revealed over time. Therefore, future research should adopt a longitudinal focus involving panel data collection to examine the real-time effects of R&D support, digital entrepreneurship, and the firm's level of product innovation. Furthermore, in this study, we have focused only on the impact of government R&D support on product innovation through digital entrepreneurship. However, the antecedents of digital entrepreneurship and product innovation are far-reaching and multi-faceted. We encourage future studies to extend the scope of this study by examining other aspects such as corporate culture and national culture on the adoption of digital entrepreneurship.

Moreover, our paper considered only the contingency effect of digital platform risk. However, the exact nature and strength of the relationship between R&D support and product innovation through digital entrepreneurship can vary depending on various factors such as the type of support provided, the stage of the start-up, and the competitiveness of the industry. Thus, future research should contribute to the contingency perspective within the field of innovation (Heij et al 2020) by examining the moderating effect of other factors such as knowledge integration, industry conditions, stage of start-up, human resource slack and absorptive capacity on both the direct and indirect effects of R&D support on product innovation.

Additionally, our paper measured product innovation as a formative construct using intensity and novelty. We encourage future research to extend the current model by examining

how digital entrepreneurship affects incremental and radical innovation separately. This could help to isolate the unique effect of digital entrepreneurship on the different elements of product innovation and by so doing help to advance the theoretical conversation on the underlying structures of product innovation.

Despite these limitations, this study provides unique insights into how digital technologies serving as both a moderator and a mediator influence a firm's effectiveness at transforming R&D support into product innovation. Overall, we believe that as a field of research, innovation can benefit from this study as it provides a richer understanding of the applicability of digital technologies in emerging economies where the level of e-readiness is usually low.

Conflict of interest statement

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