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Competition, Digitalization, and Innovation:

Empirical Evidence from Developing and Emerging Economies

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Abstract.

This paper examines the effects of formal and informal competition, as well as adoption of digitalization, on firm-level innovation. Using firm-level data from the World Bank Enterprise Surveys (WBES) covering 160 countries between 2006 and 2024, we estimate extended probit models to address potential endogeneity in the relationship between competition and innovation, applying a set of instrumental variables. The analysis controls for firm heterogeneity by country, region, year, and industry, as well as for firm-specific characteristics and reverse causality. The findings show that digitalization tools are crucial drivers of firm performance across multiple dimensions. Formal competition and informal competition, however, affect innovation differently. Formal competition displays a non-linear relationship with innovation: while moderate competition encourages innovation, intense competition does not. In contrast, informal competition consistently stimulates innovation, likely because it pressures formal firms to adapt and remain competitive. At the regional level, results reveal that formal competition tends to hinder innovation, while informal competition acts as a positive force. Digitalization emerges as a strong and consistent driver of innovation across all regions, particularly in MENA. Based on these results, the paper derives key policy recommendations for innovation strategies, competition policies, and regulatory reforms.

Keywords. Competition, Digitalization, Innovation, Firm performance, Entrepreneurship, Extended probit model

JEL classifications. L22, L86, O30, L26, D22, C25, F65

Declarations

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Availability of data and material. The datasets analysed during the current study are available in Enterprise Surveys, The World Bank, http://www.enterprisesurveys.org

Code availability. Stata is the software used

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1. Introduction

Digitalization has become a key driver of firm performance by enhancing innovation, productivity, and competitiveness (Cusolito et al., 2020; Forman and Van Zeebrroeck, 2019). This makes the adoption of digital technologies in the business environment crucial, especially for developing countries, where firms face structural challenges related to digital infrastructure, institutional quality, and competition (Clarke and Wallsten, 2006). Therefore, the impact of digitalization varies across regions and economic contexts.

Competition is also a key driver for market performance and firm productivity and innovation. The relationship between competition and innovation has been studied using both theoretical and empirical analyses (Grossman and Helpman, 1991; Romer, 1990; Baldwin and Scott, 1987). This study hypothesizes that digitalization and market competition affect firm performance, particularly in terms of innovation. It further suggests that firms in more competitive markets benefit differently from digital adoption, as they are pressured to innovate and optimize operations to maintain market share.

While extensive research has explored the determinants of firm performance and innovation, most studies tend to examine either competition (formal or informal) or digitalization in isolation on single countries, specific regions, or limited timeframes. Few papers have jointly assessed the interplay between formal competition, informal competition, and digitalization on multiple firm outcomes such as innovation across various countries and regions.

This study addresses these gaps by offering the first comprehensive, cross-country analysis covering 160 countries from 2006 to 2024 using firm-level data from the World Bank Enterprise Surveys (WBES). It contributes to the literature by examining how digital adoption tools (like websites and e-payments) and competitive pressures shape firm innovation and performance, while accounting for endogeneity and firm heterogeneity. It also adds to the scarce empirical literature on how informal competition affects firm behavior globally, with a dedicated regional focus on MENA where digital adoption is rapidly expanding.

Moreover, the paper uses the Survey of Enterprises' Digitization (SED) by the Economic Research Forum (ERF), conducted within the framework of the Open Access Micro Data Initiative (OAMDI), covering Egypt, Jordan, and Morocco, along with firm-level data from the World Bank Enterprise Surveys (WBES) across 160 economies between 2006 and 2024. We use these datasets to (i) provide a descriptive evidence on the patterns of formal and informal competition, digitalization, and innovation, and then (ii) empirically examine the effect of competition and digitalization on innovation and other firm performance indicators.

This study aims to fill this gap by analyzing how competition and digitalization drive firm innovation, using firm-level datasets for developing countries. Additionally, it extends previous studies by examining heterogeneous effects across different firm sizes and industries, offering policy insights into how policies can enhance digital infrastructure and competition policies to support growth and innovation. Extended probit model is used to account for the endogeneity problem that may arise when studying the effect of competition on innovation, by using a set of instrumental variables. This paper controls for heterogeneity among firms (by country, region, and industry), firms' characteristics and reverse causality.

The remainder of this paper is structured as follows: Section 2 highlights the theoretical and empirical studies on the effect of competition and digitization on firm performance. Section 3 presents some stylized facts on competition, digitalization and innovation. Section 4 provides the data and methodology used to estimate this relationship. In Section 5, we will present the empirical findings of the paper and some robustness checks. Section 6 concludes and presents some policy implications.

2. Literature review

This part presents briefly the theoretical and empirical literature studying first the effect of competition, followed by the effect of digitilzation on firm performance and innovation.

2.1.Competition and firm performance

The relationship between competition and innovation operates through several counteracting mechanisms. First, some theoretical studies suggest that in highly competitive, firms are driven to innovate in order to gain a competitive edge over their rivals (Aghion et al., 2005). Therefore, intensified product market competition serves as a stimulus for innovation as firms seek to move ahead. However, Schumpeter (1942) argues that in less competitive sectors, increased competition can discourage innovation, particularly among laggard firms, which may prioritize maximizing short-term profits over investing in uncertain and costly innovation activities (Vlachos, 2024; Aghion et al., 2005). Moreover, monopolies and large firms are more likely to invest in R&D because of economies of scale and monopoly profits. Finally, there is a third starand of literature that highlights how the overall intensity of innovation in an economy depends on the relative size of markets, as the incentives and constraints facing firms differ systematically across these market structures, which results in the inverted-U shape of the relationship between competition and innovation (Aghion et al., 2005; Aghion et al., 2015; Nickell, 1996; Vlachos, 2024). As a result, the relationship between competition and innovation remains theoretically and empirically ambiguous (Gilbert, 2006).

A substantial body of research has examined the effect of informal competition on firm performance, particularly on sales, productivity, and job creation. Most studies find negative or insignificant effects. For instance, La Porta and Shleifer (2008) found that informal firms tend to be small and unproductive in African, Asian, and Latin American countries, while Williams and Bezeredi (2018) showed that competition from informal firms reduces formal firms' sales, job creation and productivity. Similarly, Hudson et al. (2012), Beltran (2020), and Amin (2023) confirmed these negative impacts across various developing economies using WBES data.

When it comes to innovation, the evidence is more mixed. Several multi-country studies report a positive relationship, suggesting that informal competition pushes formal firms to innovate in order to defend market share. Farooq et al. (2022), Amin (2021), McCann and Bahl (2017), Ozturk (2023), Dwibedy (2022), and Hlioui et al. (2022) identified this positive effect in diverse regions ranging from developing countries to Eastern Europe and Central Asia.

Most recently, Vlachos (2024) by using WBES data on Greece found that informal competition can have a positive effect on formal firms' innovation decisions, as firms may innovate to maintain their competitive edge. It also explores the relationship between overall and informal competition and innovation in formal firms, while considering the effects of bribery and other relevant variables.

Conversely, some single-country studies and regional analyses suggested that informal competition can have a negative effect on innovation, particularly in contexts prone to imitation or weak regulatory enforcement. For example, Heredia et al. (2017) found a negative impact in several Latin American economies, while Abbas et al. (2022) observed the same in South Asia. Mendi and Costamagna (2017) suggested an inverted-U relationship where innovation increases with informal competition up to a certain point, beyond which it decreases.

However, some other studies focusing on individual countries as in India (Farooq et al., 2019) indicates that informal competition can have a negative effect on product innovation, although it may positively influence process innovation. Similarly, Kouakou (2023) found that in Côte d'Ivoire, the effect of informal competition on formal firms' innovation activities depends on the severity of the competition: less severe competition encourages innovation, while more severe competition discourages it.

2.2.Digitalization and firm performance

Across the literature, different studies have found evidence of a positive effect of digitalization on various indicators of firm performance. For instance, Alfaiate (2023) studied Portuguese firms from 2008 to 2021 and found that having a website is strongly associated with higher total factor productivity, while the use of social media is less associated with productivity gains.

Other studies focus on email and internet use. Wu et al. (2003) defined e-business as "the use of Internet technologies to link customers, suppliers, business partners, and employees as e-commerce websites." They examined e-business adoption across industries and found that electronic communication within firms and with customers positively affects performance outcomes. Verma (2024) focused more on digital marketing and online presence in Indian SMEs and found that digital marketing adoption, encompassing website and email use, significantly improves firm performance through increased customer engagement and acquisition.

For the MENA region, Zaki (2023) examined how digitalization is associated with firm performance (such as sales and exports) and labor composition using the ERF 2022 dataset. He found that internet use is associated with higher sales in both Egypt and Jordan, while application listing increases sales only in Egypt. As for exports, the presence of self-managed payment-enabled websites matters in Egypt, whereas internet use shows a positive effect in Jordan.

Moreover, using firm-level data from Jordan, Morocco, and Egypt, Zhu and Luo (2023) found that digital adoption, including e-commerce, websites, and internet use, is linked to higher production, productivity, trade participation, and innovation, though the strength of these associations varies by country and firm characteristics.

To conclude, these studies highlight the positive role of digital tools, particularly websites and internet use, in improving firm performance outcomes.

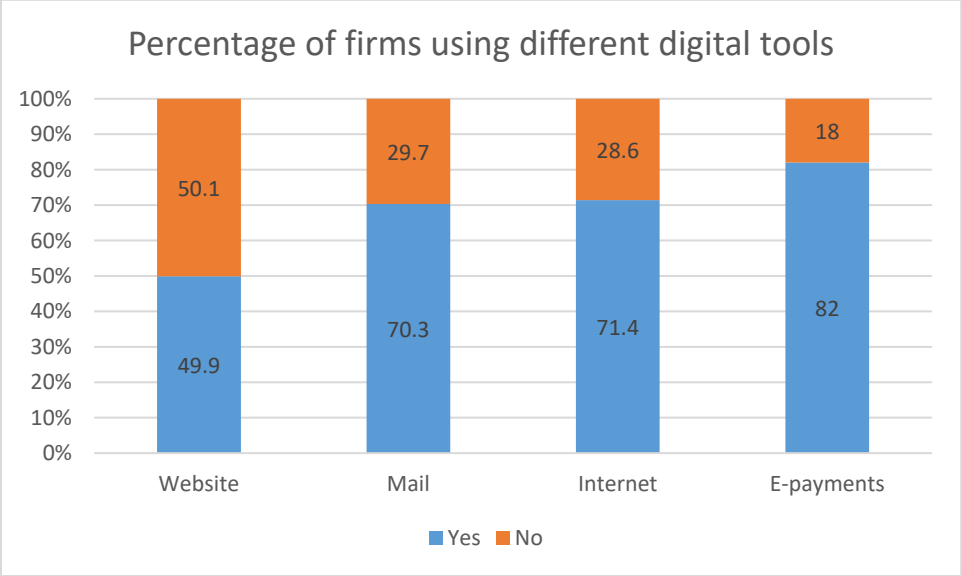
3. Stylized facts

This part presents a set of stylized facts using data visualizations to illustrate the key patterns, relationships, and distributions in the dataset prior to econometric analysis. The aim is to provide an overview of the prevalence of innovation, digitalization and competitive distribution faced by firms in the sample. Firm-level data is obtained from World Bank Enterprise Surveys (WBES) database which offers an extensive array of economic data on more than 225,000 firms in 160 economies during the period between 2006 and 2024.[2]

3.1.Digitilization indicators

Figure 1 shows the adoption rates of various digital tools among firms. E-payments have the highest adoption rate at 82%, followed by Internet use (71.4%) and business email (70.3%). Having a website is the least common digital tool, with only 49.9% of firms maintaining one, suggesting firms prioritize transactional and communication tools over public online presence.

Figure 1. Share of firms using different digital indicators



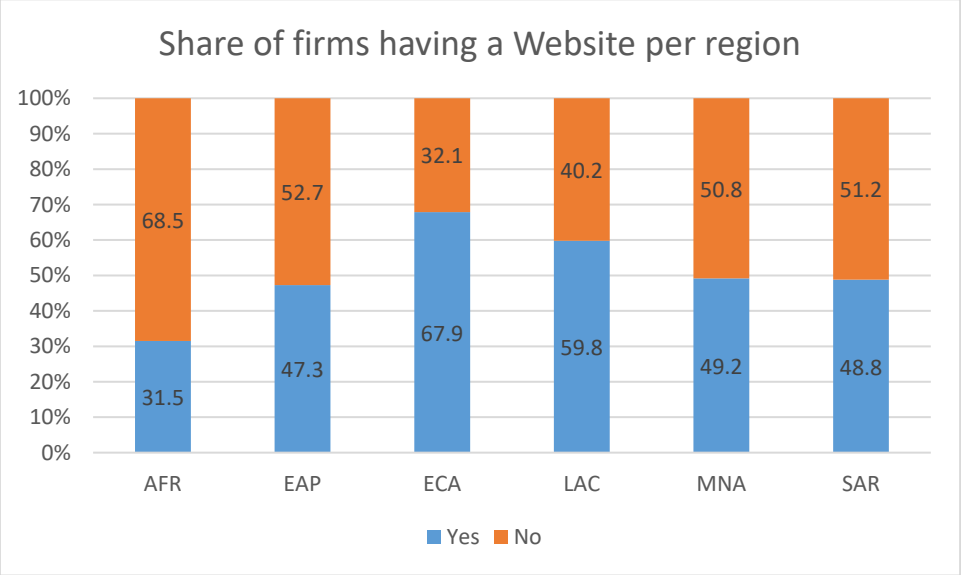
Source: Constructed by the author from WBES (2024)

The graph below in Figure 2 shows the percentage of firms with a website across different regions. Europe and Central Asia (ECA) leads with 67.9% of firms having a website, followed by Latin America and the Caribbean (LAC) at 59.8%. In contrast, Sub-Saharan Africa (AFR) lags significantly with only 31.5%. The Middle East and North Africa (MNA) and South

[2] Table A1 in the Appendix provides a description of the countries, years, and number of firms in the sample.

Asia (SAR) show moderate adoption rates of around 49%, indicating regional disparities in digital presence.

Figure 2. Share of firms having a website per region



Source: Constructed by the author from WBES (2024)

Examining digitalization in selected MENA countries—Egypt, Jordan, and Morocco—using the 2022 ERF digitization survey, Figure 3 illustrates the adoption of various digitalization tools. These tools can be categorized into three groups: Digital Presence & Transactions (internet, website, online sales, online buy, online sell, self-built), Digital Capacity (IT person, digital skills, smartphones), and Digital Outreach (social media, applications).

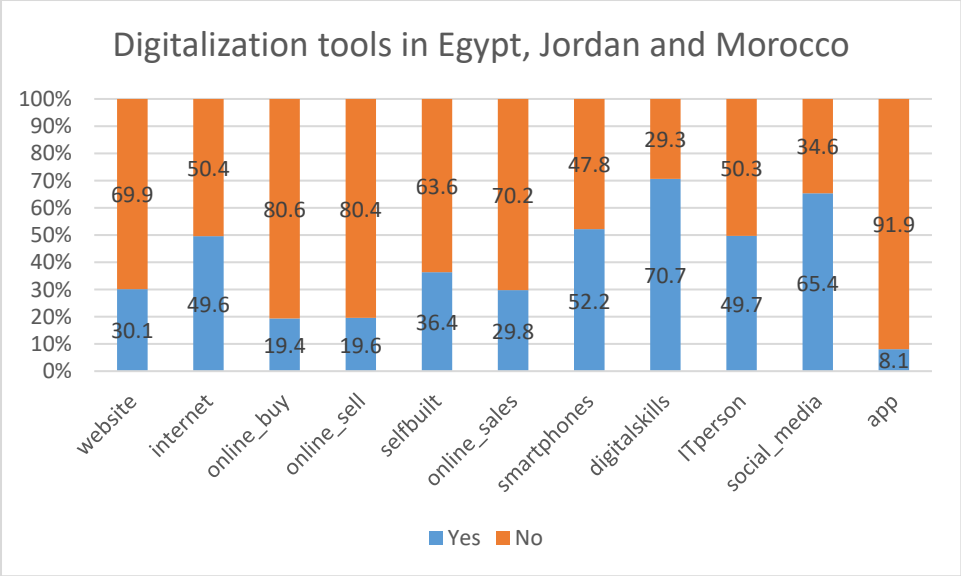
Starting by **Digital Presence & Transactions**, across all the listed digitalization tools, there is a significant share of firms in Egypt, Jordan, and Morocco who do not adopt them. This suggests considerable potential for further digitalization in these countries. Moreover, the adoption distribution rates vary significantly depending on the specific tool. Having a website shows a relatively low adoption rate with only around 30%. However, internet access shows a much higher percentage of firms with around 50%, highlighting its foundational role in any digitalization efforts. The adoption of online buying and online selling is relatively low, with only 20% each, suggesting that traditional methods still dominate over e-commerce methods. Online sales with only 30% reinforce this analysis. Moreover, the share of firms with self-built sales websites is only around 35%.

When it comes to **Digital Capacity**, the percentage of firms where employees use smartphones to conduct online transactions for business shows a significantly higher adoption rate of 52% compared to many other digital tools. This highlights the importance of mobile devices in the digital landscape of these countries. The adoption rate for digital skills (whether digital skills play a role in the decision to appoint managerial staff) is around 30%, indicating a potential skills gap that could hinder digitalization. Moreover, the share of firms with dedicated IT person is around 50%, indicating that not all firms have in-house IT expertise.

Digital Outreach indicators show different distributions. Using social media for business purposes shows a relatively high adoption rate (around 65%), indicating its significant role in business activities in these countries. Finally, the share of firms listed on any app or website (e.g. a food delivery app, Amazon, Jumia) is relatively low with around 10%, suggesting that mobile applications are not yet widely used by these countries.

These stylized facts across many tools highlight a potential digital divide within these countries, where access to and utilization of digital technologies are not universal. The low adoption rates for online buying and selling suggest a significant potential for e-commerce growth in Egypt, Jordan, and Morocco. The moderate adoption of digital skills and the presence of IT persons emphasize the need for investments in digital literacy and IT in to facilitate further digitalization in these MENA countries.

Figure 3. Share of digitalization tools in Egypt, Jordan and Morocco

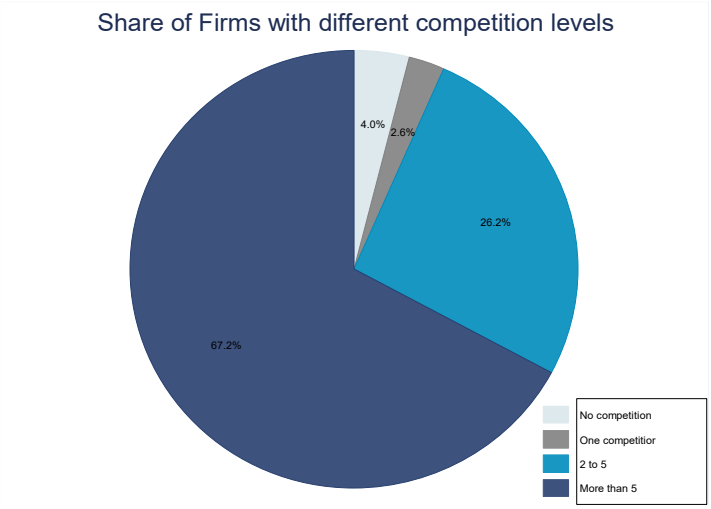


Source: Constructed by the author from ERF digitization survey (2022)

3.2.Formal and Informal Competition indicators

For competition indicators, we will start by the level of formal competition in the market. Figure 4 indicates the distribution of firms based on the number of competitors they face. A very small percentage of firms (4.0%) reported facing no competition. An even smaller fraction of firms (2.6%) indicated having only one competitor. A significant portion of firms (26.2%) reported facing between two and five competitors. The vast majority of firms (67.2%) indicated operating in markets with more than five competitors.

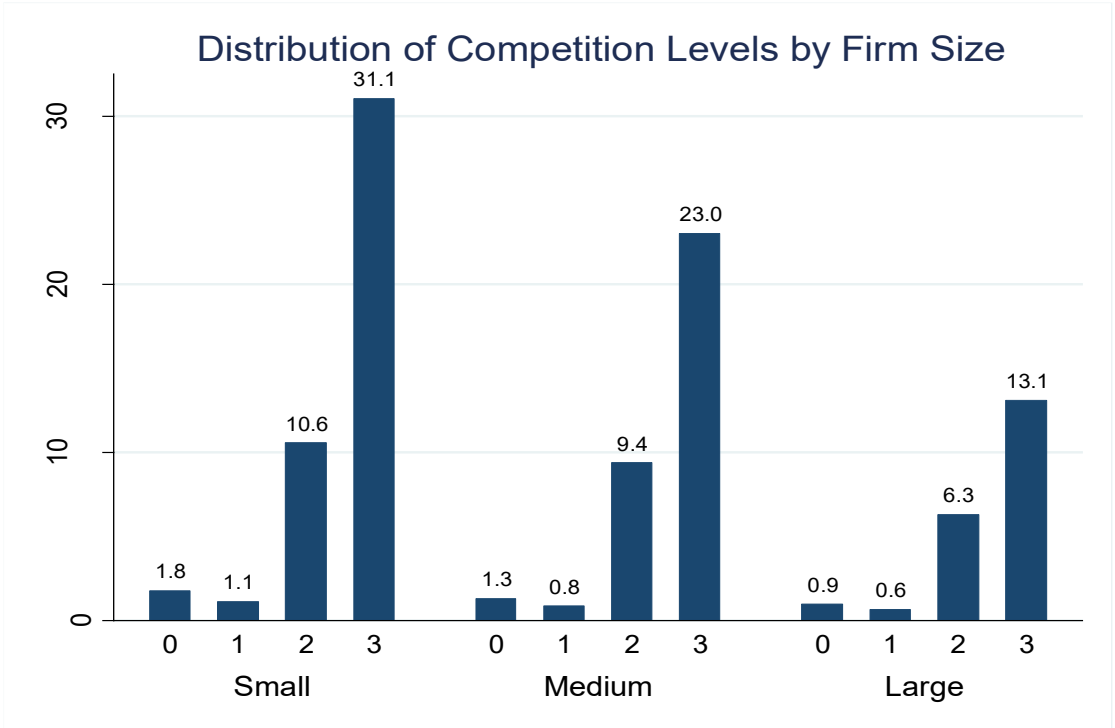
Figure 4. Share of firms per competition level



Source: Constructed by the author from WBES (2024)

Figure 5 shows the Distribution of competition levels by firm size (Small: <20 employees, Medium: 20-99 employees, Large: 100 and over employees). High Competition is common across all firm sizes. However, competition intensity tends to decrease with firm size as the percentage of firms facing "More than 5 Competitors" is highest for small firms (31.1%), followed by medium firms (23.0%), and then large firms (13.1%). This suggests that larger firms might operate in markets with relatively less intense competition, possibly due to factors like market power, economies of scale, or regulatory barriers to entry.

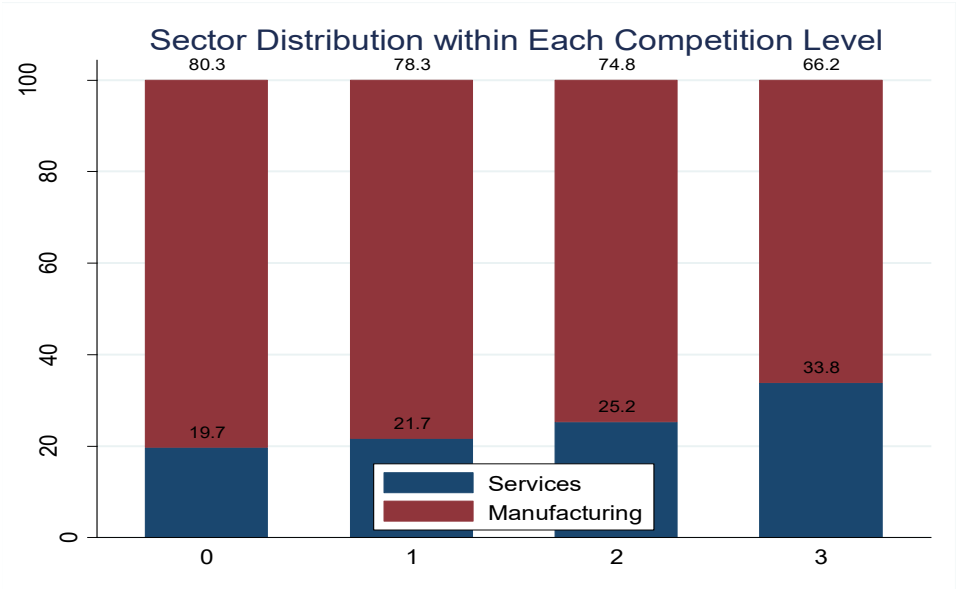
Figure 5. Distribution of competition level per firm size



Source: Constructed by the author from WBES (2024)

In Figure 6, we analyze the Sector Distribution within each Competition Level. We find that highly competitive markets are more likely to have a larger presence of Services firms compared to markets with less competition. While Manufacturing firms still form the majority (66% versus 34%), the gap between the two sectors has narrowed considerably at this highest level of competition. As the level of competition increases, the proportion of Services firms within that competition level also tends to increase.

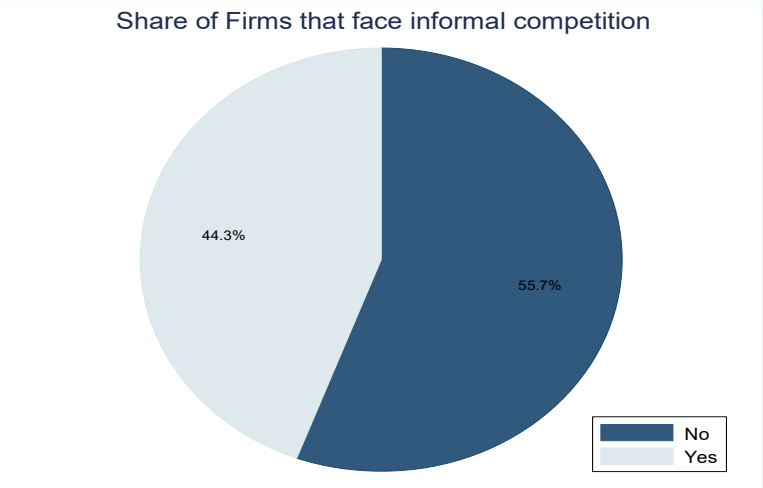
Figure 6. Sector distribution per competition level



Source: Constructed by the author from WBES (2024)

Figure 7 shows the proportion of firms in the sample that reported facing competition from informal businesses. The figure indicates that a slightly larger percentage of firms (55.7%) in the sample do not face informal competition, while a significant portion (44.3%) report experiencing competition from informal businesses. This suggests that informal competition is a notable factor affecting a considerable number of firms in the market.

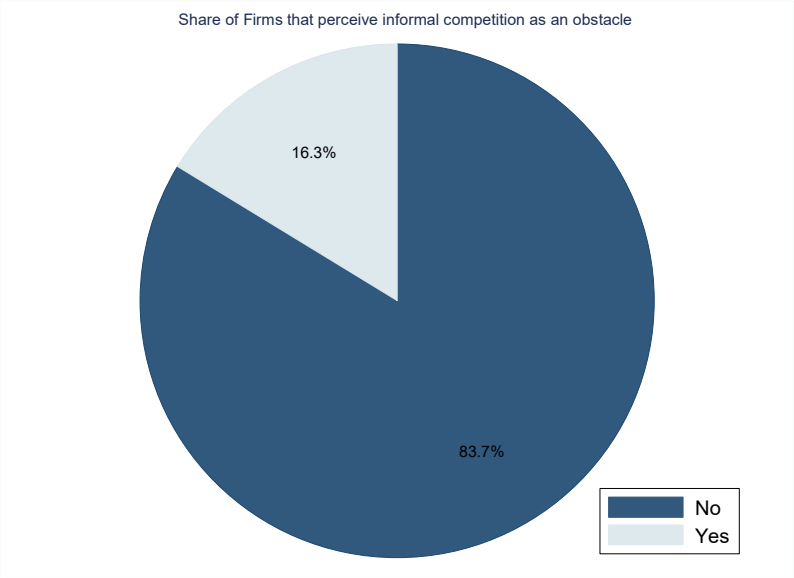
Figure 7. Share of firms facing informal competitors



Source: Constructed by the author from WBES (2024)

However, in Figure 8, we plot the proportion of firms that consider competition from informal businesses to be an obstacle to their operations. This shows that only 18.3% of firms consider informal competition to be an obstacle to their business, while the vast majority, 81.7% of firms, do not perceive it as a significant impediment. This suggests that while informal competition is present as in Figure 8, most firms do not view it as a significant impediment to their operations.

Figure 8. Share of firms that perceive informal competition as an obstacle

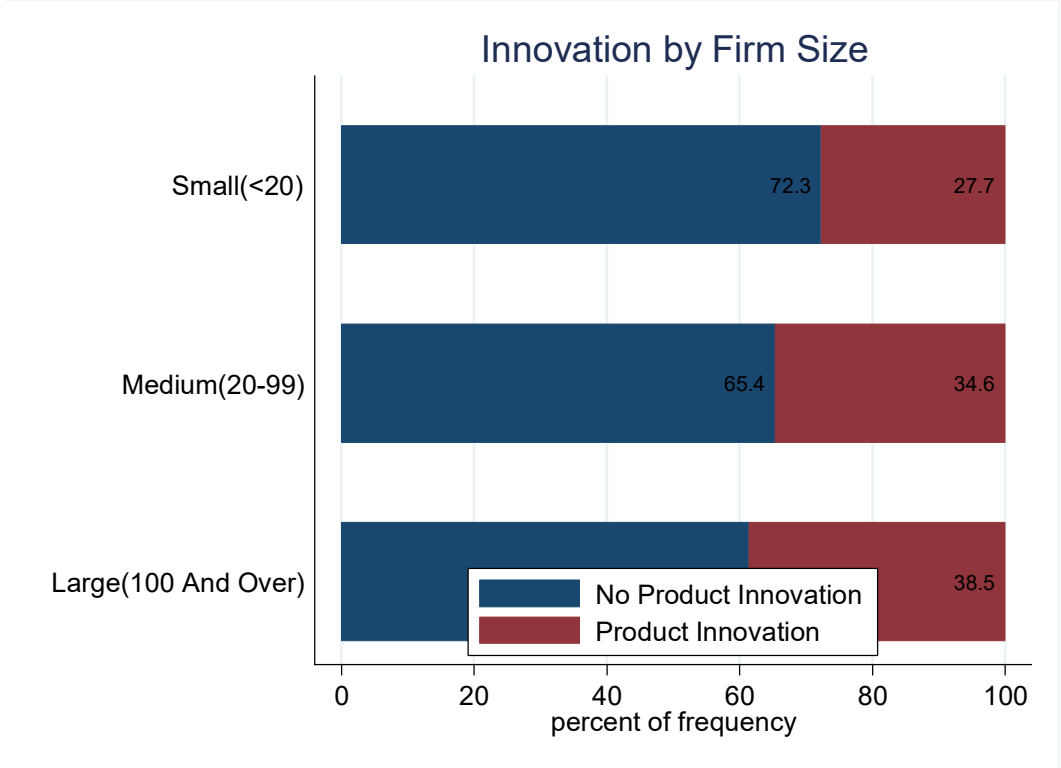


Source: Constructed by the author from WBES (2024)

3.3.Innovation indicators

Figure 9 displays the percentage of firms engaging in product innovation versus those that do not, by firm size. This indicates a positive correlation between firm size and the likelihood of engaging in product innovation. As firm size increases from small (28%) to medium (34%) to large (38%), the percentage of firms undertaking product innovation also increases. This suggests that larger firms, possibly due to better access to finance, are more likely to introduce new products compared to smaller firms. On the other hand, small firms appear to face more constraints that lead to lower rates of product innovation.

Figure 9. Share of firms by innovation status



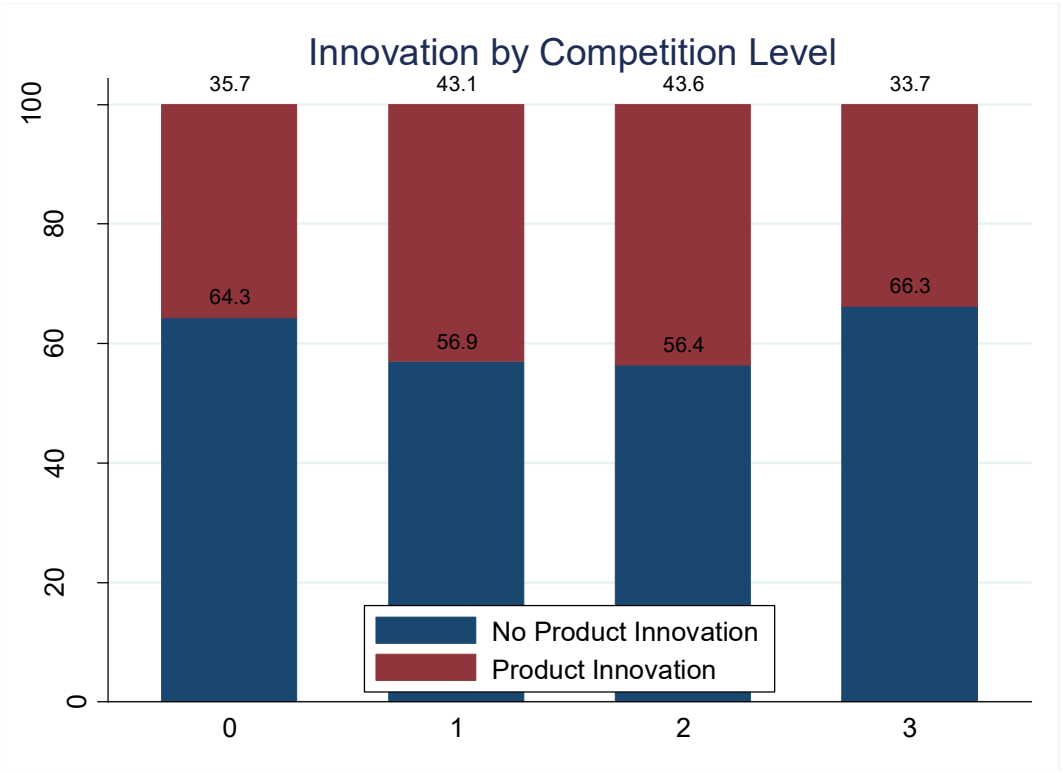
Source: Constructed by the author from WBES (2024)

Figure 10 shows the percentage of firms engaging in product innovation versus those with no product innovation across different levels of competition. The relationship between the level of competition and product innovation is not strictly linear in this data. Interestingly, the highest level of competition (more than 5 competitors) shows the lowest rate of product innovation (33.7%).

However, the highest rates of product innovation are observed at competition levels 1 (one competitor, 43.1%) and 2 (2 to 5 competitors, 43.6%). Thus, the presence of a few competitors could drive the need for differentiation through new products. Firms with no competition show a moderate level of product innovation (35.7%), higher than the highest competition level but lower than the moderate competition levels.

Hence, product innovation is most prevalent when firms face a moderate level of competition. Both very low and very high levels of competition appear to be associated with lower rates of product innovation in this dataset.

Figure 10. Innovation by competition level



Source: Constructed by the author from WBES (2024)

To conclude, our descriptive analysis suggests a nuanced relationship between digitalization, competition and innovative activity. In the following section, we will develop our empirical model, which will aim to formally test some of the relationships suggested by these initial descriptive analyses and statistics.

4. Methodology and analysis

To estimate the effect of competition and digitilzation on the probability of innovation, we have to address the possible endogeneity problem that may result from reverse causality problem between innovation and competition. While competition may affect innovation, innovation itself can change the level of competition. For example, a firm that introduces a new product or technology may gain market power, reducing competition in its sector. Aghion et al. (2005) highlight that the relationship between competition and innovation is complex, and they deal with endogeneity by using instrumental variables.

The model for innovation will be estimated by using an extended probit model that accounts for possible endogeneity of competition and financial access. One of the advantages

of the extended probit model is that it can include more than one endogenous variable while dealing with binary endogenous regressors. To test this effect, we estimate the following equations:

We will estimate first the effect of digitalization on innovation:

$$Y_{ijc} = \alpha_0 + \alpha_1 D_{ijc} + \alpha_2 X_{ijc} + \delta_c + \delta_j + \delta_t + \mu_{ijc} \quad (1)$$

Then, we will test the effect of both competition and digitalization on innovation:

$$Y_{ijc} = \beta_0 + \beta_1 C_{ijc} + \beta_2 D_{ijc} + \beta_3 X_{ijc} + \delta_c + \delta_j + \delta_t + \mu_{ijc} \quad (2)$$

Where i, j and c are firm, sector and country respectively. Y_{ijc} is the dependent variable. To measure **Innovation**, we use two dummy variables: the first dummy equals 1 if during the last three years, this establishment has introduced new or improved products or services, zero otherwise. The second variable equals 1 if this establishment spent on research and development activities, either in-house or contracted with other companies, excluding market research surveys, zero otherwise.

The first main independent variable D_{ijc} is **Digitalization**. We use different indicators to measure digitalization at the firm level. We construct four dummy variables to measure whether the firm has its own website, if the establishment has high-speed internet connection, and if the firm currently communicates with clients and suppliers by E-Mail. We also measure if the establishment received or made payments using e-payments to reflect digital adoption in financial transactions, which is a key aspect of how firms digitize their operations. E-payments use is often used as a proxy for Digital financial inclusion. We also construct a **digitalization index** if the firm uses email and has its own website that varies from 0 to 1 to reflect the level of digitalization[3] of the establishment.

Our second main independent variable C_{ijc} is **Competition**. We use different indicators to reflect formal competition. We start by a categorical variable that reflects the degree of competition in the market. This variable varies from zero with no competition at all, 1 with only one competitor in the market, 2 if we have from 2 to 5 competitors and 3 if we have more than 5 competitors in the market. To ensure the robustness of our results, we use also the total number of competitors in the market. We also consider the **Informal competition** measured as dummy variable equal to 1 if this establishment competes against unregistered or informal establishments, zero otherwise. We also use as robustness check another proxy for informal competition, we construct a dummy variable that reflect the degree at which **practices of competitors in the informal sector are** an obstacle to the current operations of this establishment. This variable takes the value of 1 if the establishment perceives it a s a very severe or major obstacle, zero otherwise (no obstacle, minor or moderate).

[3] We only include Website and email in the index due to many missed data for the two other variables that reflect digitalization, namely, epayments and Internet.

Then, we use a vector of firm-level control variables X_{ijc}, namely we use firm size, age, GVC participation, ownership status, total sales, financial access, manager gender and manager experience.

To measure GVC participation, we use three dummy varibles: a dummy equals one if firms export and import simultaneously (two-way trader), as well as if the firm has an international quality certification, and finally if a share of their capital is owned by a foreign firm (Dovis and Zaki, 2020).

Then, for financial access proxies, we follow Kuntchev et al. (2013) and Elshawrawy and Ezzat (2023) and construct four major groups[4] to measure the degree by which firms are credit constrained during the fiscal year whether it is Not Credit Constrained (NCC), Maybe Credit Constrained (MCC), Partially Credit Constrained (PCC) and Fully Credit Constrained (FCC). We then construct a binary variable taking the value of 1 if the firm is FCC or PCC, and the value of 0 if it is MCC or NCC.

Other control variables are inlcuded as firm size (small, medium or large), firm age in years, manger experience in years, female manger dummy that takes 1 if the manager is female, Sole that takes 1 if the leagl staurs of the firm is sole proprietorship (Not a partnership or shareholding company), Informal payment measured as percent of total annual sales paid in informal payments.

According to the literature, reverse causality may exist between competition and innovation. It can also exist between financial access and innovation. Therefore, instrumental variable approach is used. To solve the expected endogeneity problem in our model and to ensure our results are robust, we use a set of instrumental variables. For competition, we calculate the pproportion of firms in the country-sector group excluding the firm in question that face competition in the market (as an instrument for competition) or that report competing against informal firms (instrument for informal competition). (Amin, 2021; Brancati et al., 2024; Vlachos, 2024)

For financial access, the instruments used are Overdraft facility[5] that takes value 1 if the firm have an overdraft facility, 0 otherwise; and the percentage value of products lost in transit due to theft. It is considered as valid instrument because it represents an unexpected and exogenous shock to firms' cash flows and internal funds (Ayalew and Xianzhi, 2019). By testing for the validity of the instruments, the different instruments are exogenous and valid.

[4] Not Credit Constrained (NCC): firms that rely on either external or internal sources of finance and that did not apply for a loan as they have enough capital and do not need one. Maybe Credit Constrained (MCC): firms relying on external sources of finance for working capital and/or investment and/or have an outstanding bank loan, and that applied for a loan. Partially Credit Constrained (PCC): firms using external sources of finance for working capital and/or investment and/or have an outstanding bank loan, and that did not apply for a loan for reasons other than having enough capital, or it may have applied for a loan, but it was rejected. Fully Credit Constrained (FCC): firms that did not use external sources of finance for both working capital and investments, and that did not apply for a loan, or applied for a loan but it was rejected, and that do not have an outstanding loan.

[5] An overdraft facility has been widely used in the literature as an instrument for financial access since it is considered as a short-term loan that can never be offered to firms to finance their innovative investments, hence it does not affect innovation.directly (Elsharawy and Ezzat, 2023; Chundakkadan and Sasidharan, 2019; Oudgou, 2021).

δ_j, δ_i and δ_t are the sector, country and year fixed effect respectively to control for country, sector and time unobservables, and μ_{ijc} is the error term.

5. Empirical findings and discussions

This part shows the results of the effects of digitilzation with different proxies on innovation and those of formal amd informal competition on innovation. The model is then extended by examining the effect for different regions.

5.1.The effect of different proxies of digitalization on innovation

In Table 1, we test first the effect of different proxies of digitalization on innovation by using a probit model. From Columns (1) to (4), we test the individual digitalization channels by testing the effect of having a website, an email, internet connection, and e-payment indicator separately. We find that firms with a **website** are more likely to introduce a new product. The effect is large and highly significant, showing that the online presence of a firm via a website facilitates innovation, through improved customer engagement or market access. Use of **email** for communication increases significantly the probability of innovation, as email use could enhance efficiency and connectivity within and outside the firm. **Internet** connections lead also to an increase in the probability of innovation. This implies that connectivity plays a central role in facilitating information access, networking, and process improvement which facilitates the innovation process. Finally, **e-payment** indicators measuring the ability to make/receive electronic payments increase innovation probability significantly, which reflects better financial infrastructure and lower transaction costs. The **composite digital index** in column (6) shows a robust and significant effect: firms with higher levels of digital adoption are more likely to introduce a new product, suggesting strong additive benefits of digitalization.

Across all specifications (cols. 1–6)[6], the positive and significant coefficients of digitalization proxies show a consistent pattern: digital adoption strongly affects innovation. The effect remains large and significant even after controlling for multiple firm-level characteristics and fixed effects.

For the effect of different control variables on innovation, we find that GVC participation reflected by export and import status in Two-way variables is consistently significant and positive, indicating that firms engaged in both importing and exporting are significantly more likely to innovate. This supports the idea that international exposure fosters knowledge spillovers, competitive pressure, and process improvements that lead to innovation. Foreign ownership has a low or insignificant effect on innovation. However, quality certification has a strong positive effect in all specifications, reflecting structured process and access to higher-standard markets, which affects innovation positively.

For firm size effect, medium firms show a modest but significant positive impact in some specifications, while in others the effect is insignificant, suggesting heterogeneity in

[6] The number of observations varies between columns. Column (1) uses the full sample, while others use smaller subsets due to variable availability. The consistency in coefficients across samples supports the robustness of the results.

innovation capacity among mid-sized firms. Large firms demonstrate a more significant positive effect in some specifications. This supports the idea that larger firms may have more resources to invest in R&D or product development.

The result also shows that older firms and sole proprietorships are generally less likely to innovate, possibly due to limited financial capacity, lack of resources and risk aversion possibility in older firms. When we consider firm size in terms of sales, we find a consistently positive and significant effect on innovation. Managerial experience & female manager are both are positive and significant in most specifications, suggesting that experienced and diverse leadership may enhance innovation decisions.

These results strongly support the hypothesis that digitalization enhances firm innovation. Both individual and composite proxies of digital adoption have a positive effect on product innovation. The findings remain robust across different model specifications and control variables. These results emphasize the importance of promoting digital tools adoption, especially in small and medium enterprises (SMEs), as a channel for fostering innovation.

Table 1. Probit model for the effect of digitilization on innovation (New product)

	(1)	(2)	(3)	(4)	(5)	(6)
VARIABLES	Innovation (New Product)					
Website	0.354***				0.304***	
	(0.0153)				(0.0444)	
Mail		0.329***			0.236***	
		(0.0322)			(0.0526)	
Internet			0.347***		0.189***	
			(0.0456)		(0.0453)	
Epayment				0.204***		
				(0.0453)		
Digital Index						0.553***
						(0.0362)
Two-way	0.259***	0.230***	0.236***	0.236***	0.216***	0.208***
	(0.0191)	(0.0258)	(0.0333)	(0.0445)	(0.0338)	(0.0262)
Foreign Ownership	0.0380	0.0503*	0.0421	0.0147	0.0463	0.0492*
	(0.0235)	(0.0297)	(0.0333)	(0.0466)	(0.0331)	(0.0299)
Quality Certification	0.160***	0.219***	0.136***	0.198***	0.0941***	0.171***
	(0.0164)	(0.0237)	(0.0301)	(0.0347)	(0.0352)	(0.0227)
Sole	-0.0561***	-0.0402*	-0.0435	-0.0503	-0.0232	-0.0204
	(0.0176)	(0.0211)	(0.0382)	(0.0349)	(0.0397)	(0.0214)
Age (log)	-0.0357***	0.0105	-0.0680**	-0.0363	-0.0801**	0.00382
	(0.0135)	(0.0212)	(0.0310)	(0.0301)	(0.0313)	(0.0201)
Sales (log)	0.0204***	0.0231***	0.0454***	0.0245***	0.0312***	0.0147**
	(0.00780)	(0.00671)	(0.00839)	(0.00882)	(0.00805)	(0.00695)
Manager Experience	0.00261***	0.00259***	0.00443***	0.00195	0.00465***	0.00270***
	(0.000681)	(0.000743)	(0.00128)	(0.00170)	(0.00130)	(0.000739)
Female Manager	0.0771***	0.0730**	0.0183	0.0745**	0.0297	0.0727***
	(0.0179)	(0.0295)	(0.0368)	(0.0305)	(0.0359)	(0.0277)
Medium Size	0.0462***	0.0763***	0.0381	0.0176	0.0125	0.0537***
	(0.0149)	(0.0167)	(0.0281)	(0.0352)	(0.0269)	(0.0163)
Large Size	0.0445*	0.132***	0.0828*	0.0182	0.0519	0.0912***

	(0.0262)	(0.0281)	(0.0487)	(0.0547)	(0.0472)	(0.0266)
Observations	134,720	60,920	20,148	20,811	20,102	60,842

Notes: (i) Each column represents an individual regression, (ii) *** p<0.01, ** p<0.05, * p<0.1, (iii) Robust standard errors in parentheses. Standard errors are clustered by country, (iv) All regressions include country, region, industry, and year fixed effects, (v) Constant terms are not reported.

5.2.The effect of competition and digitalization on innovation

In this subsection, we will test the effect of competition, along with digitization on innovation. Therefore, we estimate this model by using an extend probit model that accounts for the possible endogeneity problem between competition, financial access and innovation, by using a set of valid instruments in Table 2 and Table 3. We use different proxied for competition in these tables to ensure the robsutness of our results.

We find a negative and statistically significant effect of **the number of formal competitors** in the market and the probability to innovate across various specifications. This suggests that firms operating in more intensely competitive markets are less likely to introduce new products or spend in R&D. This finding goes well with the Schumpeterian view that intense competition may discourage innovation by reducing the expected benefits of innovation, possibly due to profit erosion or innovation being less rewarding in highly competitive markets.

Interestingly, the **categorical competition variable** shows a positive but only marginally significant effect of one competitor in the market compared to no competitor, suggesting a weak relationship. 2–5 competitors category shows a highly significant effect of moderate competition on innovation. Finally, the category of more than five competitors has no clear effect. Innovation does not increase further beyond 5 competitors. This detailed result supports the inverted-U hypothesis where there is a non-linear relationship between competition and innovation (Aghion et al., 2005). Innovation increases with moderate competition but decreases with high competition. Moderate competition encourages innovation to maintain their market share in this competitive market, but very high or very low competition levels dampen it.

Conversely, **informal competition** has a strong and positive effect on innovation. Firms facing competition from unregistered or informal enterprises are more likely to innovate. This could be considered as a defensive strategy to stay competitive and maintain market share against informal firms that may offer lower prices. Innovation is also a tool to distinguish their products through quality and reputation.

A negative and significant coefficient of **credit-constrained variable** suggests that firms with limited access to finance are less likely to innovate. This is consistent with the theoretical literature, which argues that innovative activities are cost-intensive and require stable financing sources.

Table 2. Extended Probit model for the effect of competition and digitilization on innovation (New Product) by using Number of competitiors as proxy of competition.

	(1)	(2)	(3)	(4)
VARIABLES	Innovation (New Product)			

Number of Competitors (log)	-0.0203***	-0.0228***	-0.0184***	-0.0234***
	(0.00145)	(0.00149)	(0.00423)	(0.00165)
Informal Competition		0.233***	0.198***	0.236***
		(0.0162)	(0.0482)	(0.0180)
Website	0.307***	0.294***		0.301***
	(0.0174)	(0.0178)		(0.0197)
Digital Index			0.410***	
			(0.0708)	
Credit Constrainted	-0.0276	-0.0340**	-0.0587	-0.0224
	(0.0169)	(0.0173)	(0.0468)	(0.0192)
Two-way	0.289***	0.293***	0.413***	0.280***
	(0.0197)	(0.0201)	(0.0695)	(0.0221)
Foreign Ownership	0.0788***	0.0982***	-0.0223	0.0988***
	(0.0245)	(0.0250)	(0.0776)	(0.0275)
Quality Certification	0.155***	0.162***	0.154**	0.147***
	(0.0191)	(0.0195)	(0.0664)	(0.0214)
Sole	-0.0513***	-0.0537***	-0.0417	-0.0720***
	(0.0199)	(0.0203)	(0.0548)	(0.0226)
Age (log)	0.0193	0.0138	0.0390	0.000157
	(0.0141)	(0.0143)	(0.0551)	(0.0156)
Sales (log)	0.0139***	0.0175***	0.0193	0.0149**
	(0.00534)	(0.00548)	(0.0149)	(0.00610)
Manager Experience	0.000489	0.000337	0.00472**	0.000276
	(0.000695)	(0.000708)	(0.00209)	(0.000778)
Female Manager	0.0987***	0.0905***	0.163***	0.0907***
	(0.0192)	(0.0196)	(0.0588)	(0.0217)
Informal_Payment				-0.000596
				(0.00114)
Medium Size	0.0186	0.0238	0.0284	0.0278
	(0.0185)	(0.0188)	(0.0561)	(0.0208)
Large Size	-0.0236	-0.0125	-0.000156	0.0147
	(0.0282)	(0.0288)	(0.0845)	(0.0317)
Observations	49,962	48,409	4,962	40,911

Notes: (i) Each column represents an individual regression, (ii) *** p<0.01, ** p<0.05, * p<0.1, (iii) Robust standard errors in parentheses. Standard errors are clustered by country, (iv) All regressions include country, region, industry, and year fixed effects, (v) Constant terms are not reported. (vi) The estimates of the correlation between the errors are significantly different from 0, so the model suffers from endogeneity problem.

Table 3. Extended Probit model for the effect of competition and digitilization on innovation (New Product) by using levels of competitions as proxy of competition.

	(1)	(2)	(3)	(4)
VARIABLES	Innovation (New Product)			

Competition Level=1	0.0806*	0.0874*	0.0732*	0.0655
	(0.0430)	(0.0511)	(0.0464)	(0.0552)
Competition Level=2	0.129***	0.126***	0.108***	0.0980***
	(0.0298)	(0.0350)	(0.0323)	(0.0380)
Competition Level=3	-0.00194	0.00929	-0.0174	-0.0138
	(0.0291)	(0.0340)	(0.0316)	(0.0370)
Informal Competition	0.253***	0.226***	0.268***	0.235***
	(0.0118)	(0.0142)	(0.0128)	(0.0154)
Website	0.378***			0.297***
	(0.0127)			(0.0166)
Credit Constrainted		-0.0454***		-0.0236
		(0.0150)		(0.0162)
Two-way			0.310***	0.293***
			(0.0152)	(0.0189)
Foreign Ownership			0.0502**	0.101***
			(0.0198)	(0.0236)
Quality Certification			0.177***	0.163***
			(0.0150)	(0.0185)
Sole			-0.0854***	-0.0447**
			(0.0163)	(0.0192)
Age (log)			0.0159	0.0140
			(0.0113)	(0.0136)
Sales (log)			0.0329***	0.0195***
			(0.00428)	(0.00518)
Manager Experience			0.000432	0.000763
			(0.000540)	(0.000659)
Female Manager			0.0725***	0.0868***
			(0.0157)	(0.0186)
Medium Size	0.141***	0.121***	0.0582***	0.0297*
	(0.0122)	(0.0146)	(0.0149)	(0.0178)
Large Size	0.261***	0.218***	0.0514**	-0.0136
	(0.0147)	(0.0183)	(0.0223)	(0.0273)
Observations	81,162	59,735	70,784	52,730

Notes: (i) Each column represents an individual regression, (ii) *** p<0.01, ** p<0.05, * p<0.1, (iii) Robust standard errors in parentheses. Standard errors are clustered by country, (iv) All regressions include country, region, industry, and year fixed effects, (v) Constant terms are not reported. (vi) The estimates of the correlation between the errors are significantly different from 0, so the model suffers from endogeneity problem.

5.3.Effect of compeetition and digitilzation by region

In East Asia and the Pacific (EAP), innovation is primarily driven by digital adoption, exposure to informal competition, and global integration through trade. Conversely, increased formal competition appears to discourage innovation, possibly due to reduced margins or limited strategic space for firms to differentiate.

In Europe and Central Asia (ECA), digitalization exerts a strong positive influence on innovation, making it one of the leading drivers in the region. Innovation is also boosted by global value chain (GVC) participation and adherence to quality standards, although credit constraints and high competition negatively affect firm-level innovation.

In Latin America and the Caribbean (LAC), informal competition emerges as the strongest driver of innovation, followed by global trade participation. Digital tools like websites have a positive but comparatively modest effect. Access to finance does not appear to be a major constraint to innovation in this region.

In the Middle East and North Africa (MENA), digitalization plays the most critical role, with the highest coefficient for digitalization across all regions. Innovation in MENA is also stimulated by GVC participation and quality certification. However, limited access to credit and a negative relationship with formal competition remain significant barriers.

Overall, results consistently show that formal competition tends to discourage innovation. Informal competition acts as a positive stimulus, likely due to pressure on formal firms to adapt and survive. Digitalization is a strong and robust driver of innovation across all regions, especially in MENA. Credit constraints have mixed effects, with negative or insignificant influence depending on the region. Participation in global trade (GVC) is a consistently strong driver of innovation.

Table 4. Extended Probit model for the effect of competition and digitalization by region.

	(1)	(2)	(3)	(4)
	EAP	ECA	LAC	MENA
VARIABLES	Innovation (New Product)			
Number of Competitors (log)	-0.0246***	-0.0247***	-0.0208***	-0.0147***
	(0.00403)	(0.00209)	(0.00500)	(0.00524)
Informal Competition	0.231***	0.209***	0.388***	0.295***
	(0.0429)	(0.0238)	(0.0588)	(0.0515)
Website	0.310***	0.321***	0.205***	0.470***
	(0.0456)	(0.0267)	(0.0645)	(0.0555)
Credit Constrainted	-0.0300	-0.0612**	0.0796	-0.101*
	(0.0456)	(0.0267)	(0.0548)	(0.0576)
Two-way	0.169**	0.301***	0.280***	0.397***
	(0.0674)	(0.0264)	(0.0798)	(0.0643)
Foreign Ownership	0.0270	0.176***	0.107	-0.0756
	(0.0649)	(0.0349)	(0.0982)	(0.100)
Quality Certification	0.131**	0.179***	0.135*	0.302***
	(0.0603)	(0.0254)	(0.0801)	(0.0661)
Sole	-0.0810	-0.0458	-0.0638	-0.152***
	(0.0505)	(0.0351)	(0.0757)	(0.0580)
Age (log)	0.0688	0.00529	0.0461	-0.0761
	(0.0422)	(0.0197)	(0.0496)	(0.0521)
Sales (log)	0.0330**	0.0145	0.0390**	0.00688
	(0.0130)	(0.00894)	(0.0191)	(0.0183)
Manager Experience	0.00395*	-0.00175*	-0.00264	0.00663***
	(0.00207)	(0.000976)	(0.00230)	(0.00243)
Female Manager	0.156***	0.0579**	0.146**	-0.0216
	(0.0440)	(0.0274)	(0.0675)	(0.121)
Medium Size	0.0821	0.0198	-0.0977	-0.0411
	(0.0500)	(0.0269)	(0.0686)	(0.0647)
Large Size	-0.0913	0.00481	-0.0314	-0.0189
	(0.0769)	(0.0425)	(0.102)	(0.0965)

Observations	6,525	20,978	2,958	6,556

Notes: (i) Each column represents an individual regression, (ii) *** p<0.01, ** p<0.05, * p<0.1, (iii) Robust standard errors in parentheses. Standard errors are clustered by country, (iv) All regressions include country, region, industry, and year fixed effects, (v) Constant terms are not reported. (vi) The estimates of the correlation between the errors are significantly different from 0, so the model suffers from endogeneity problem.

5.4.Robustness checks

This section tests whether the results of different estimations still hold after the robustness checks. We re-estimate Table 1 of the effect of different digitlization indicators on innovation by using R&D expenditures as another proxy of innovation in Table A.2. and the results are still robust. We do the same for Table 2 and test the effect of competition on R&D rather than product innovation in Table A.3. and our results are still robust.

We also consider our results on formal and informal competition. For formal competition, we use as a proxy for competition a categorical variable that reflects the level of competition and we find interesting results as shown in Table 3 that confirm our results and fragment the effect into different competition levels.

For informal competition, we also use as a proxy a dummy variable that reflects the degree at which practices of competitors in the informal sector are perceived as an obstacle to the current operations of this establishment. Results are reported in Table A.4. and they are still robsut.

6. Conclusion and Policy implications

Our model analyze how formal and informal competition in the market, as well as digitalization adoption affect firm performance, mainly in terms of innovation, by using WBES database.

Our main findings from Table 1 emphasize the important role of digitalization in enhancing firm-level innovation. Firms with access to digital tools such as websites, email communication, internet connectivity, and electronic payment systems are significantly more likely to innovate by introducing new products, or spending in R&D, specifically in MENA region as shown in Table 4. The channels through which this effect can be explained are that digital tools lower information and transaction costs, improve access to different markets, and enhance internal efficiency. Therefore, targeted policies including digital skill-building programs, facilitating access to digital infrastructure and affordable digital services should be a key priority for policymakers in developing economies.

The findings on formal and informal competition in Table 2 and Table 3 show an important and interesting result. Moderate formal competition stimulates innovation; however intensive competition may discourage firms from undertaking innovations activities as they are costly and risky. As a result, competition policies should be careful to avoid excessive competition in sectors with low margins for innovation.

Moreover, the positive role of informal competition on innovation shows the importance of formalization policies and fair competition policies. This can reduce unfair practices and keep the innovative incentives that informal competition seems to trigger.

Additionally, addressing financial constraints through more inclusive financial systems and tailored funding mechanisms is essential, as limited access to finance was shown to hinder innovation. Moreover, enhancing firms' integration into GVCs would open new opportunities for innovation across the region.

Finally, this study help to contribute to the development of competition policies, digitalization strategies and regulatory frameworks that may help to foster innovation and growth.

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