

A Matter of Survival: Development Through Innovation

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Abstract This paper examines innovation by emphasizing the role of Global value chains (GVCs) and financial development. Using data from 25,690 firms from the World Bank's Enterprise Surveys (WBES) from 2006 to 2023, extended probit and two-step probit selection models are constructed. The findings show that engaging in GVCs is essential to innovation, with financial development playing a moderating role. Moreover, in addition to participation in GVCs and financial development, human capital is the main driver of innovation. Firm age, top manager experience, firm size, sector of activity, and competition against informal or unregistered firms positively affect a firm's decision to innovate. However, instrumenting the quality of institutions, business environment, and energy constraints, political instability is a key impediment to innovation even if firms join GVCs and have access to finance.

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I. Introduction

One of the most dominant features of the current development process is the fragmentation of production stages into different steps that are achieved sequentially across several national borders (OECD, 2013; Ndubuisi and Owusu, 2023). This singularity is widely known as the global value chain (GVC). Today, it is extremely difficult to talk about development, especially international trade, without talking about global value chains (GVCs). Its development has been amazing over the past decades in all regions of the world (Del Prete et al., 2018; World Bank, 2020; De Melo and Twum, 2021). As defined by Gereffi and Fernandez-stark (2011) and Porter (1985), a value chain demonstrates a system of activities needed to bring a product or service from its conception to end-use and beyond, as well as designing, producing, marketing, delivery, and aftersales support. Beyond the global dispersion of activities among inter-firm networks, GVC is also a collection of intra-sectoral linkages among firms and other sectors that allow

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for the geographical and organizational reconfiguration of global production (Ha, Dung, and Thanh, 2023). Antràs (2019) considers that firms or countries participate in GVCs if they take part in any stage of the production process.

As a key form of the international division of labor and offering a new path toward industrial development, since firms from high-technology countries are combining their firm-specific marketing, technical, and managerial know-how with the low wages in developing countries (Baldwin, 2016), GVCs have become a crucial way to promote the sustainable growth of the world economy. Changes in transportation and communication costs, distribution channels, and the diffusion of information technologies have led many firms to abandon producing services and goods entirely in a single country and within their organizational boundaries. Through outsourcing and offshoring, firms have sliced up their value chains and dispersed activities to locations and actors where production processes can be most efficient, by leveraging resources that are either specific and skilled or economically convenient (Baldwin and Venables, 2013; Ambos et al., 2021; Fischer et al., 2024). Therefore, trade and investments are better organized allowing firms to enter global markets as components or service suppliers, without having to build a product's entire value chain (Dovis and Zaki, 2020).

The emergence of global value chains provides many benefits to both developing and developed countries. Rodrik (2015) and Amador and Cabral (2017) indicate that countries participating in GVCs have opportunities to specialize in core tasks that contribute to growth. Attending to GVCs also helps countries acquire new technologies and foreign knowledge which in turn contributes to the convergence of countries (Danquah, 2018; Pahl and Timmer, 2020; Ndubuisi and Owusu, 2021). The rise of GVCs has also allowed firms in developing countries to access global markets by specializing in specific tasks that form part of a value chain without building an entire domestic industry and capability. Inter-firm networks are key channels for transferring knowledge and promoting innovation (De Marchi et al., 2018). While high value-added activities such as branding, R&D, and design are developed firms' in-house activities, manufacturing and assembling activities are outsourced to labor-intensive locations in developing countries (Coe et al., 2009; Cuervo-Cazurra and Pananond, 2023). Therefore, suppliers from emerging markets can gain knowledge, acquire skills, and upgrade to high value-added activities. This process is undeniably accompanied by higher productivity, wages, employment (Paus, 2012; Pipkin and Fuentes, 2017), industrialization, foreign direct investment, structural transformation, economic development, and quality of living for citizens (Fagerberg et al., 2018; Pleticha, 2021). These insights are not only relevant for developing countries but also constitute an indispensable development paradigm.

Thus, GVCs are seen as vehicles for the dissemination of new technologies from developed to developing countries, and access to these technologies leads to innovation through the creation of new products and services. GVC can, therefore, be considered a strong predictor of

innovation. This is the case for African countries, which have been particularly dynamic in recent years, with trade growth outpacing most economies. This is because many firms serve as key suppliers of raw materials to other firms and can therefore participate in innovation in their countries or other countries. However, this facet of firms in Africa is neglected in theoretical and empirical studies, while this area is said to be the new destination of future offshoring (Baldwin, 2016). Remarkably absent in this literature is the contribution of GVCs to the innovation of firms, particularly those located in Africa. This important research gap needs to be filled, especially when considering the nature of the technology, design, and branding that account for approximately one-third of the production value that is created in GVCs (Pietrobelli and Rabellotti, 2011), the abundance of available resources, and the rise of human capital (Ambos et al., 2021).

Since the beginning of the twentieth century, innovation has been considered the true and indisputable driver of long-term growth (Schumpeter, 1942; Arrow, 1962; Coe and Helpman, 1995; Acemoglu et al., 2012). Innovation can take many forms including new or improved products or processes, and organizational and market-related inventions (De Marchi et al., 2018). At the macro level, innovation generates employment and economic growth, which in turn greatly improve people's lives (Lucas, 1988; Romer, 1990); additionally, at the micro level, innovation plays a major role in firms' productivity growth and competitiveness in the market (Grossman and Helpman, 1990; Aghion et al., 2012). This is where integration into global value chains becomes essential. As innovative activities are costly, numerous firms located in Africa face significant financing challenges. This is where financial development comes into play. This paper examines the effects of GVC participation, financial development, and their interaction on firm-level innovation.

Indeed, the existence of underdeveloped institutions and financial markets, a low level of financial inclusion, and barriers to accessing credit reduce firms' innovative investments and subsequent technological innovation, which hinders countries' economic growth (Brown et al., 2009; Ackigit and Melitz, 2021). In line with this stream of the literature, Savignac (2008), Aghion et al. (2012), Xie et al. (2019), and Fischer et al. (2024) noted that limited financial access, limited financial infrastructure, underdeveloped financial institutions, and markets were major financial constraints for firms, and firms suffering from these constraints were less likely to innovate. In contrast, few studies (Hewitt-Dundas, 2006; Scopelliti et al., 2014; Fernandez, 2017) find that financial development is harmful to innovation because financial constraints act as a stimulus to creativity and innovation. Most of the previous studies have limitations in dealing with the endogeneity problem arising from this relationship, which this paper addresses. A class of literature focusing on integration in GVCs (Gereffi et al., 2005; Brancati et al., 2017) suggests that firms participating in GVCs benefit directly from knowledge transfers or indirectly from technology spillovers through foreign direct investment, licensing from foreign

firms providing access to technology, importing capital goods, importing intermediate goods, and technological upgrading. Accordingly, these firms will increase their competitiveness in the international market and improve their innovative capabilities. Using data from the World Bank Enterprise Surveys (WBES) from 2006-2023 for 51 African countries, this paper investigates the nexus between GVC participation and financial development on the likelihood of innovation.

The main contributions of this study to the literature are as follows: First, the literature on firms participating in GVCs in Africa is scarce. The available literature mainly focuses on the determinants of GVC participation (Dovis and Zaki, 2020; Ha, Dung, and Thanh, 2023) by considering that the innovation of firms enables the penetration of international markets. However, GVC participation also builds the innovative capabilities of firms in developing countries (De Marchi et al., 2018; Reddy et al., 2021) which is missing from empirical studies. This paper therefore provides evidence of this missing link. Second, most studies in both developing and developed countries address the individual effects of GVC participation (Ackigit and Melitz, 2021; Eissa and Zaki, 2023; Ito et al., 2023) and financial development (Aghion et al., 2012; Del Prete et al., 2018; Ajide et al., 2023) on innovation. This paper further explores the interaction effect of the two on innovation. Third, as mentioned earlier, the major limitation of previous work was the use of the classical probit model, which does not solve the endogeneity issue. This paper applies an extended probit model that allows for the use of more than one binary endogenous independent variable (financial development and GVC integration), and the interaction between the endogenous variables, unlike the instrumental variable probit model. Fourth, the paper uses alternative measurements of innovation, GVC, and financial development.

The rest of this paper is organized as follows: Section 2 discusses the theoretical and empirical literature on GVC participation, financial development, and innovation. Section 3 presents the data, measurements, and descriptive statistics on the nexus between GVC integration, financial development, and innovation. Section 3 also describes the estimation strategy. Section 4 analyses and discusses the findings. Section 5 focuses on robustness checks to strengthen the results, and Section 6 concludes the paper.

II. Literature Review

Economic development results from an indispensable process of structural change that shifts labor from low-productivity activities to higher-productivity activities. This 'Successful' structural change is not simple, as it involves climbing the technology ladder by continuously upgrading production structures. This unconditionally requires innovation. Thus, international trade has long been considered a privileged channel of technology transfer. Although traditional trade theories have long focused mainly on trade in final goods (Ricardo, 1817; Heckscher, 1919;

Ohlin, 1933), at the beginning of the twenty-first century, the concept has given way to the idea of trade in tasks (Grossman and Rossi-Hansberg, 2008). The so-called global value chain (GVC) trade differs from traditional trade in terms of hyper-specialization and durable firm-to-firm relationships. This segmentation improves the economy at both the micro and macro levels and results in higher levels of innovation and technological upgrading while attracting additional financial flows. This section discusses the theories and empirical evidence on first the effect of GVC integration on innovation and second the effect of financial development on innovation.

A. GVC and innovation

From a theoretical perspective, the link between GVC participation and innovation can be explained through fragmentation theory or new trade theory. According to fragmentation theory (Antràs et al., 2017; Tintelnot, 2017), GVCs are designed when production processes are split into multiple stages and dispersed across several countries. This fragmentation occurs only if (1) firms can benefit from lower labor and production costs when fragmented production is located in a new position than when it is in the original position, (2) the costs incurred to link all located production hubs are low, and (3) the costs of establishing the GVC network are low. Therefore, fixed costs and the productivity of suppliers are the ultimate factors that determine the inclusion of countries in GVCs.

According to new trade theory (Melitz, 2003; Helpman et al., 2004), firms' ability to take part in GVCs is based on their heterogeneous nature. In more detail, this theory explains that heterogeneity in terms of firm efficiency and cost minimization drives firm integration in GVCs. This theory asserts that integration into international trade is associated with huge costs and that only highly efficient firms can achieve sufficient profit to cover these costs. Therefore, firms engaged in imports and exports could afford the fixed costs of foreign trade, providing them with an opportunity to perform economies of scale and productivity advantages (Blaum et al., 2018).

Global value chain participation drives economic innovation and upgrading through developing new products and processes or improving existing products and processes to move from low- to high-value-added activities. Following Humphrey and Schmitz (2002) and De Marchi et al. (2018), four types of innovation, namely, product, process, functional or organizational, and inter-sectoral innovation, are dissociated within the GVC framework, but product and process innovation are the most crucial. Accordingly, this study focuses on product and process innovation. Five theoretical linkages, including a finer division of labor, the availability of a greater variety of inputs, competition, learning, knowledge transfer, and spillover, are listed as strong predictors of innovation (Pietrobelli and Rabellotti, 2011; Ndubuisi and Owusu, 2021; Fischer et al., 2024).

First, GVC allows for more efficient use of production resources by enabling firms to outsource activities for which they do not have a comparative advantage (Lileeva and Trefler, 2010; Antràs and Staiger, 2012). They can upgrade their technology and provide competitive products. Therefore, participating in GVCs leads to innovation. Second, exposure to GVCs results in better quality inputs and higher revenues due to specialization in core tasks. This provides productivity gains and resources that could be used to build innovation capabilities (Danquah, 2018). In addition, integration into GVCs grants firms access to a wide variety of sophisticated and competitively priced inputs that drive innovation through embodied technology transfer (Aghion et al., 2012). Third, learning, knowledge/technology transfer, and spillover are the key benefits of GVCs. Technological knowledge is embodied in goods traded across borders, and exporting goods are expected to absorb new knowledge from foreign markets (Coe and Helpman, 1995). Furthermore, learning by exporting seems to occur more when firms exporting to advanced economies (De Loecker, 2007), are involved in knowledge-intensive activities, or export various products to several destinations (Benkovskis et al., 2020).

Furthermore, vertical linkages, such as buyer-supplier relationships, are an important channels of technology spillovers, as downstream firms (buyers) can benefit from logistics, foreign know-how, and technologically advanced or less expensive inputs from their intermediate upstream firms (input suppliers), which improves overall performance (Gereffi and Fernandez-stark, 2011). However, there is a consensus in the literature that innovation through GVCs, especially in developing countries, depends chiefly on the mode of governance or the internal environment based on resources (Krammer et al., 2018; Dovis and Zaki, 2020), the nature of the national innovation system or home institutions (North, 1990; Pipkin and Fuentes, 2017; Kano and Tsang, 2020), and the absorptive capacities of the destination country (Corrado et al., 2013). Although the theoretical channels establishing the relationship between GVCs and innovation are well documented, empirical studies are limited.

Empirically, a comprehensive body of literature explains firms successful at innovating as a benefit of participation in GVCs through modes of governance. Giuliani et al. (2005) examined Latin American countries and found that integrating GVCs and upgrading their technological capabilities are moderated by sectoral characteristics. Although trade in intermediate goods has generated learning and innovation activities, the introduction of new products and processes depends on three modes of governance: network, hierarchy, and quasi hierarchy. A network involves horizontal cooperation, whereas a hierarchy involves vertical cooperation or exchange between downstream users and their suppliers. They concluded that the environment in which firms operate determines upgrading. Similarly, Brancati et al. (2017, 2021), using a sample of Italian firms from 2008 to 2013 with a random effects model, fixed effects estimator, two-step system GMM, and matching technique to address the reverse causality issue, investigated the innovation effects of GVC governance modes after the Great Recession. Their findings showed

that involvement in GVCs increased the propensity to innovate and undertake R&D projects compared with participating in national value chains or stand-alone firms. High-skill relational suppliers are significant, while other modes of GVC participation have no innovation premium compared with domestic companies. They further highlighted that market-based governance modes seem to strongly lessen the innovativeness of suppliers with low capability.

Some studies focusing on developed and emerging countries use industry-level and country-level data, and patent per capita data as a proxy for innovation. Therefore, Tajoli and Felice (2018), Yang et al. (2020), and Piermartini and Rubínová (2021) found that GVC spurs innovation. In addition, GVC contribution has an inverted U-shaped effect on innovation performance, whereas the effect of GVC position is positive. While industrial agglomeration accelerates the GVC position effect, it slows the GVC participation effect. Using the World Bank's Enterprise Surveys, propensity score matching, and difference-in-differences approach, Rigo (2021) examined productivity in participating in global value chains. The results indicated that becoming a two-way trader significantly increased foreign-licensed technology use. Therefore, GVC participation fosters firm performance. Ndubuisi and Owusu (2023), using difference-GMM, added that GVC participation enables technology-lagging countries to become more productive. However, the innovation and catch-up gains from the GVC accrue more strongly to countries that have high human capital stock, well-functioning financial markets, stable macroeconomic conditions, and specialize in downstream activities in the value chain. Eissa and Zaki (2023) examined the association between GVC participation and countries' innovation performance. After constructing a GVC knowledge spillover index with the EORA26 dataset and the R&D of the trade partner, the results established a positive association between GVC and innovation. Furthermore, trade policy, intellectual property rights agreements, and competition policy constitute moderating factors in the nexus between GVC participation and innovation.

Finally, studies on firms' integration in GVCs and innovation are scarce for the African continent (and particularly for Sub-Saharan Africa). For instance, Del Prete et al. (2017) established a link between GVC and productivity for North African manufacturing firms. Identifying GVC firms as traders (exporter-only, importer-only, or two-way traders) with quality certification, they concluded that GVC participation fosters firm performance. Pasquali (2021) used firm-level data from 2006 to 2015 in Kenya to investigate the upgrading of the Kenyan leather sector. The findings indicate that product quality improves when products are exported from the South to the North. Furthermore, participation in GVCs involves not only flows of goods and materials but also intangibles such as information, technology, or managerial knowledge (Antràs, 2020). Recently, Delera et al. (2022) employed a database on firms' adoption of different generations of production technology in Ghana and found that participating in GVCs is positively linked with the adoption of industry technologies. Nevertheless, studies emphasize that firms participating in GVCs need a better financial structure to enable them to access the international market.

Therefore, firms constrained by a lack of financial development are less likely to innovate (Bernard and Jensen, 2004; Bernard et al., 2018; Chatterjee et al., 2023).

B. Financial development and innovation

The theoretical foundations of the relationship between financial development and innovation go back to Schumpeter (1942) and Arrow (1962) before their interaction was endogenized in the endogenous growth model at the macro level (Lucas, 1988; Romer, 1990) and in terms of productivity at the micro level (Grossman and Helpman, 1990; Aghion et al., 2012). Indeed, innovation is the main driver of economic growth. However, innovation requires enormous investments, which can be problematic, especially in underdeveloped capital markets where access to financial resources is challenging for various reasons. On the one hand, as mentioned by Holmstrom (1989), investing in innovation not only necessitates high investments but also involves uncertain outcomes and high risks, as neither the investor nor the firm knows the real value of the investment and whether it will produce high returns. On the other hand, as developed by Arrow (1962), information asymmetry problems between investors and firms may occur once the newly funded technology is successful, or moral hazard issues can lead firms to change ex-post behavior, increasing the risk faced by lenders (Krugman, 2009).

Specifically, in developing countries, access to credit is a necessary condition for stimulating participation in the GVC, as it allows firms to engage in complementary investments that are crucial for innovation. Difficult access to finance leads to high trade costs and discourages innovation. The lack of financial facilities and medium-term financing, rudimentary capital markets, and weak financial intermediation make the regulatory environment predatory, forcing firms to resort to informal financing. This may negatively affect their innovation in global value chains. Since access to credit requires a well-functioning and well-developed financial market, a country's financial development can strongly affect the level of innovation for firms participating in GVCs.

Empirically, some major literature establish that financial development is positively related to innovation. Thus, limited financial access, markets, and institutions are major constraints on innovation. Among the pioneers, Savignac (2008) and Aghion et al. (2012) using data from France between 1993 and 2004, and Ayyagari et al. (2011), relying on WBES data for 47 developing countries from 2002 to 2004, investigated the effect of access to finance on firms' innovation. Employing a probit model, the generalized method of moments (GMM) approach, and a logit model, they concluded that firms facing fewer credit constraints and having access to bank financing innovate the most with extensive R&D investments, especially if they benefit from external sources of finance or foreign currency. They also added that innovation increases with the size of the firm. Similarly, Brown et al. (2009) found that young and innovative firms

in the USA rely mainly on their internal sources of finance since external debt is not easily accessible due to a lack of collateral, uncertain returns, and information problems. Using data from 27 transition countries, Gorodnichenko and Schnitzer (2013) added that firms suffering from a liquidity shock or a high cost of accessing external financing are less likely to innovate or export in the service sector.

Chundakkadan and Sasidharan (2019), Pahl and Timmer (2020), Ndubuisi and Owusu (2023), and Elshaarawy and Ezzat (2023), using WBES data and performing difference-GMM, extended probit and instrumental variable probit analyses, found that financial constraints impede firms' innovation level. The level of financial development of countries matters enormously. They established that the effects of access to finance and the financial market outweigh the positive effects of GVC participation on innovation. This implies that firms facing joint financial constraints while participating in GVCs have a lower probability of innovation. Whereas the above studies have provided significant insights, they focused mainly on developed and emerging economies. Studies on African countries are rare. Adopting a probit model, Abor et al. (2014) examined how access to bank financing affects firms' export activities in Ghana. The analysis emphasized that access to finance is critical for covering the high fixed costs of exporting, international marketing, and branding and meeting the higher quality standards required for overseas markets. Therefore, older firms that are larger and more productive, and have better access to bank financing are more likely to enter the export market. Similarly, Ayalew and Xianzhi (2020), using 11 African countries and a recursive bivariate probit model, found that underdeveloped financial markets and small banking systems adversely affect a firm's decision to engage in innovative activities and decrease the likelihood of product and process innovation. They also highlighted that this negative outcome prevails more in younger, manufacturing, micro, and small firms than in older ones, services, medium, and large enterprises.

While many studies support the negative effect of financial barriers on innovation, limited work shows the existence of a positive relationship depending on the indicators of financial development used (Mohnen and Röller, 2005; Lööf and Heshmati, 2006) and not accounting for the endogeneity issue (Savignac, 2008; Chundakkadan and Sasidharan, 2019). In addition to these factors, Hewitt-Dundas (2006), drawing on longitudinal data, demonstrates that innovation is an evolutionary process in which the constraints on innovation differ for small and larger firms. A clear understanding of the factors that constrain innovation activity directly impacts the probability of innovating and the degree of innovation success. She found that financial constraints improve innovation since firms suffering from financial constraints, due to an early investment in product development, will try to overcome this problem by implementing new business strategies. This view is also shared by Fernandez (2017). By analyzing WBES data for Latin American countries from 2006 to 2010 and performing a logit model, she found that financial barriers, including firm age, size, and source of finance, were the key drivers

of innovation.

This study fills the gap in the above literature by focusing on African economies and examining the individual effects of GVC participation and financial barriers and their interaction on innovation. As GVCs are critical for development, African countries can benefit from them to spur their innovation. Many African countries have underdeveloped financial systems, and their effects on innovation can be drastic.

III. Methodology

A. Variables

This paper uses a sample of 25,690 firms from the World Bank's Enterprise Surveys (WBES) from 2006 to 2023 for 51 African countries. The WBES database covers a broad range of topics that help us understand the business environment of countries, including regulation and taxes, corruption, access to finance, innovation and technology, infrastructure, trade, management practices, labor force details, firms' greatest obstacles, performance measures, informality, female participation, and firm characteristics. The sampling methodology of the WBES involves stratified random sampling by firm size, business sector, and geographic region. Firms are split according to the number of employees. Small firms have fewer than twenty employees, medium-sized firms hire between 20 and 99 employees, and large firms have more than 100 employees. In this study, the data were harmonized using the global questionnaire to facilitate analysis. The data cover both the manufacturing and services sectors. Table A1 in the online Appendix shows the description of the data in the sample across countries.

Previous studies (De Marchi et al., 2018; Reddy et al., 2021; Elshaarawy and Ezzat, 2023) have measured innovation as the ability of a firm to introduce new products or services in the market. Therefore, a binary variable is used taking the value 1 for firms that introduced a new product or service in the market and 0 for firms with no innovation. However, taking into account recent developments in the nature of innovation (Ambos et al., 2021; Ito et al., 2023; Fischer et al., 2024), this study includes a second innovation variable (process innovation). This variable takes the value 1 for firms that introduce a new process and 0 otherwise. Regardless of GVC participation, several approaches are highlighted. Del Prete et al. (2017) and Reddy et al. (2021) identify GVC firms as traders (importer-only, exporter-only, or two-way traders) with international quality certification. However, this definition is general and involves traditional trade activities. Therefore, for Rigo (2021), the condition sine qua non to participate in GVCs is to be a two-way trader because it includes all firms with internationally fragmented production processes. This definition is in line with the recent macro literature (Bernard et al. 2018;

Benkovskis et al., 2020), as importing and exporting at the same time have economic implications that are qualitatively distinct from being engaged in only one activity.

Nevertheless, considering four dimensions (import status, export status, international quality certification, and foreign ownership), DAVIS and ZAKI (2020) suggest that this latter definition is the least strict. The second and third levels cover firms that are two-way traders and have either international quality certification or a share of their capital owned by a foreign firm. The fourth level is the strictest level surrounding all four dimensions, namely importing, exporting, having a quality certification, and foreign ownership. Following DAVIS and ZAKI (2020) and ELSHAARAWY and EZZAT (2023), this paper uses four dummy variables to measure the four degrees of participation in the GVC; accordingly, the fourth degree is the preferred form, as it represents the maximum level of participation.

In line with the findings of previous studies (Ayyagari et al., 2011; Aghion et al., 2012; Elshaarawy and Ezzat, 2023), access to credit is used as the main variable of financial development. In this study, we construct this variable based on information provided by firms during the survey. Indeed, during the survey, firms were divided into four groups: those that did not need credit because they had enough capital (credit unconstrained); those that applied for a loan and obtained it (lower or maybe credit constrained); those that applied for a loan but were rejected due to lack of working capital or an outstanding bank loan (partially credit constrained); and those that cannot simply benefit from credit (fully credit constrained). A binary variable taking the value 1 if the firm has access to credit and 0 if the firm does not have access to credit is created to capture one dimension of financial development (access). The value 1 reflects the first two groups and the value 0 represents the last two groups. Moreover, a second binary variable is constructed as an alternative indicator of financial development to measure financial system depth which is another dimension. This binary variable is equal to 1 if the firm has access to both domestic and foreign funds and 0 otherwise.

B. Instrumental variables

According to the literature, to address potential endogeneity arising from reverse causality issues, several variables are added to the analysis. In line with Pipkin and Fuentes (2017), Chundakkadan and Sasidharan (2019), Oudgou (2021), Rigo (2021), and Eissa and Zaki (2023), there is a need to control for the endogeneity embedded in the relationship between innovation and GVC participation. Undeniably, these studies highlight the existence of reverse causality to the extent that a positive shock to innovation outcomes in a country can accelerate foreign markets' penetration improving GVC integration. Therefore, we include four instruments in this study to address this endogeneity issue: a first dummy variable of 1 if the firm observes business licensing and permits as the biggest obstacle, and 0 otherwise; a second dummy variable

of 1 if the firm sees customs and trade regulations as the biggest obstacle, and 0 otherwise; a third dummy variable of 1 if the firm perceives tax administration as the biggest obstacle, and 0 otherwise; and a fourth dummy variable of 1 if the firm perceives transportation as the biggest obstacle, and 0 otherwise. These instruments were chosen on the basis of past studies showing that they are directly correlated with GVC participation, as a firm joining the international market and attending to the GVC is directly impacted by the business licensing and permit system or customs and trade regulations, taxes and transportation costs. In addition, they satisfy the exclusion restriction hypothesis since they do not directly affect innovation, unless they do so through GVC participation.

Endogeneity may also exist between innovation and financial development. According to Gorodnichenko and Schnitzer (2013), Ayalew and Xianzhi (2019), Piermartini and Rubínová (2021), Pahl and Timmer (2020), and Ndubuisi and Owusu (2023), a country that concentrates innovation inevitably attracts massive foreign capital, which in turn is beneficial to financial system development. To ensure that reverse causality is carefully considered, three instruments are employed. The first dummy variable is 1 if the firm has an overdraft facility and 0 otherwise. Overdrafts are granted only when the bank has sufficient reserves. The particularity of overdrafts is that banks cover firms' transactions even though they do not have the necessary funds. These transactions, which are even more risky than the loans granted due to the absence of collateral, are therefore highly correlated with the development of the financial system, and more generally, with economic development. According to Savignac (2008) and Elshaarawy and Ezzat (2023), the exogeneity condition is proven by the fact that since it is difficult for financial institutions to deliver loans to firms for innovation financing, providing overdrafts to finance their innovation is even more difficult. The second potential valid instrument represents the percentage of financial losses in transit due to disorder, theft, crime, and corruption. The last instrument is the percentage of financial losses that resulted from power outages. The last two variables are computed based on total annual sales and capture exogenous shocks to firms' cash flows that are lost; thus, they do not benefit the financial system. Accordingly, they directly affect financial development but they do not directly impact innovation (Del Prete et al., 2018; Ha et al., 2023).

C. Control variables

To minimize potential endogeneity arising from omitted variable bias, a vector of control variables is included, inspired and guided by the literature on the drivers of innovation (Pipkin and Fuentes, 2017; Pleticha, 2021; Ambos et al., 2021; Ajide et al., 2023; Ito et al., 2023; Fischer et al., 2024): firm size, age, competition against unregistered or informal firms, human capital, top manager experience, and political instability. Table 1 shows the variable definitions and descriptive statistics.

Table 1. Variable Definitions and Summary Statistics

Variable	Definition	Obs.	Mean	SD	Min	Max
Innovation						
Product or service	A dummy variable being 1 if the firm introduces a new product or service during the last 3 years; and 0 otherwise.	25690	0.26	0.44	0	1
Process	A dummy variable being 1 if the firm introduces a new process during the last 3 years; and 0 otherwise.	25690	0.22	0.41	0	1
R&D	A dummy variable being 1 if the firm spent on research and development, excluding market research surveys during the last fiscal year; and 0 otherwise.	25690	0.17	0.38	0	1
GVC						
Two-way	A dummy variable being 1 if the firm is a two-way trader; and 0 otherwise.	25690	0.13		0	1
Two-way certification	A dummy variable being 1 if the firm is a two-way trader with an international quality certification; and 0 otherwise.	23800	0.10	0.34	0	1
Two-way foreign	A dummy variable being 1 if the firm is a two-way trader with a foreign ownership; and 0 otherwise.	23400	0.05	0.22	0	1
Two-way full	A dummy variable being 1 if the firm is a two-way trader with quality certification and foreign ownership; and 0 otherwise.	23080	0.02	0.14	0	1
Financial development						
Access	A dummy variable being 1 if the firm has access to credit; and 0 otherwise.	23218	0.61	0.49	0	1
Depth	A dummy variable being 1 if the firm has access to both domestic and foreign capital markets; and 0 otherwise.	23016	0.29	0.45	0	1
Instruments						
Business licensing and permits barriers	A dummy variable being 1 if the firm perceives business licensing and permit as the major obstacle; and 0 otherwise.	25690	0.33	0.17	0	1
Customs and trade barriers	A dummy variable being 1 if the firm perceives customs and trade regulations as the major obstacle; and 0 otherwise.	25690	0.25	0.22	0	1
Tax barrier	A dummy variable being 1 if the firm perceives tax administration as the biggest obstacle; and 0 otherwise.	25690	0.19	0.19	0	1
Transportation barrier	A dummy variable being 1 if the firm perceives transportation as the biggest obstacle; and 0 otherwise.	25690	0.29	0.14	0	1
Overdrafts	A dummy variable being 1 if the firm receives an overdraft facility; and 0 otherwise.	25101	0.24	0.43	0	1
Transit losses	A continuous variable representing the percentage of financial losses in transit due to disorder, theft, crime, and corruption	25306	0.07	0.25	0	0.14
Power outages losses	A continuous variable illustrating the percentage of financial losses resulting from power outages	25420	0.09	0.28	0	0.19

Table 1. Continued

Variable	Definition	Obs.	Mean	SD	Min	Max
Controls						
Size	A categorical variable being 0 for Small (5-19), 1 for medium (20-99), and 2 for large size (more than 100).	25690	0.54	0.49	0	2
Age	A continuous variable representing the total number of years the firm	25690	17	1.23	0	51
Informality	A dummy variable being 1 if the firm competes against unregistered or informal firms; and 0 otherwise.	24115	0.53	0.50	0	1
Manager experience	A continuous variable illustrating the number of years of the top manager's experience working in the firm's sector.	25205	18	1.56	0	35
Human capital	A continuous variable illustrating the percentage of skilled workers.	25318	0.70	0.46	0	0.98
Political instability	A dummy variable being 1 if political instability is the major obstacle; and 0 otherwise.	25690	0.09	0.28	0	1
Sector	A categorical variable being 2 for manufacturing, 1 for services, and 0 for the retail sector.	25690	1.27	0.73	0	2
Region	A dummy variable being 1 for Sub-Saharan Africa (SSA); and 0 for North Africa (NA).	25690	0.90	0.29	0	1

(Source) Computed by the author using data from the WBES.

D. Stylized facts

This section provides a view of the data related to the variables of interest. Figure 1 compares innovation, GVC participation, and the level of financial development between Sub-Saharan Africa and North Africa. Regarding innovation, it is obvious that innovation pathways are stronger in Sub-Saharan Africa than in North Africa, whether concerning the introduction of new products, new processes, or R&D expenditure. This is because more than 70% of the firms are located in SSA. In contrast, in terms of participation in the GVC, North Africa occupies the dominant position, which is mainly attributed to its developed production systems and strong integration into the global economy. In addition, this region is characterized by a high level of industrialization, more effective institutions, better transportation networks, and more adequate infrastructure than Sub-Saharan Africa. As the definition of GVC becomes stricter, the share of participating firms decreases, with North Africa remaining the lead in GVC integration. This analysis is consistent when comparing the number of firms with access to credit or access to domestic and foreign capital in the two regions. Both access and depth show that financial development is greater in North Africa.

Figure 1. Innovation, GVC participation, and financial development by region

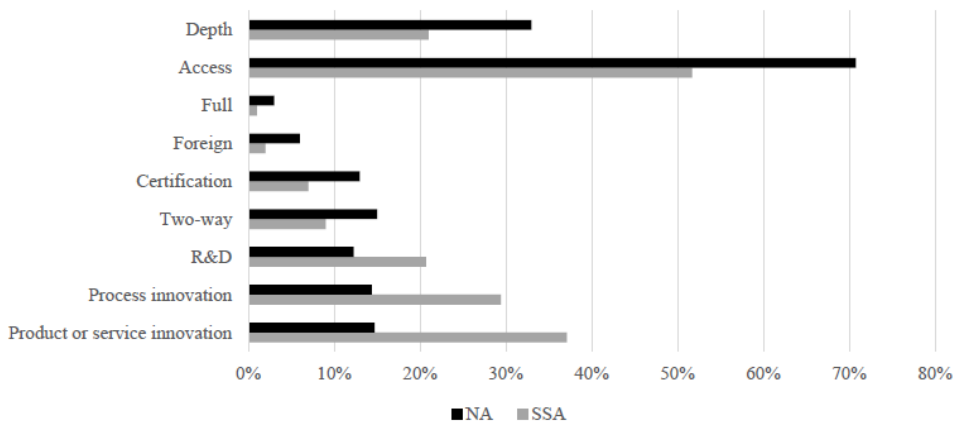


Figure 2 depicts the level of innovation, GVC participation, and financial development according to firm size. Indeed, innovation, participation in GVC, and finance are not accessible for all because they involve high transaction costs and high productivity to compete with global markets. Large firms participate more in global value chains than do medium-sized and small firms because they are better able to bear the fixed costs of importing and exporting, international marketing and branding, and practice more offshoring and outsourcing. Similarly, large firms can easily access financial resources because they exploit economies of scale and have enough collateral. This is not the case for small and medium-sized firms, which accumulate fewer

profits and physical assets. From the above, it is evident that innovation is more prevalent in large firms. The latter are more inclined to innovate, unlike small firms, which can face crucial internal and external challenges.

Figure 2. Innovation, GVC participation, and financial development by firm size

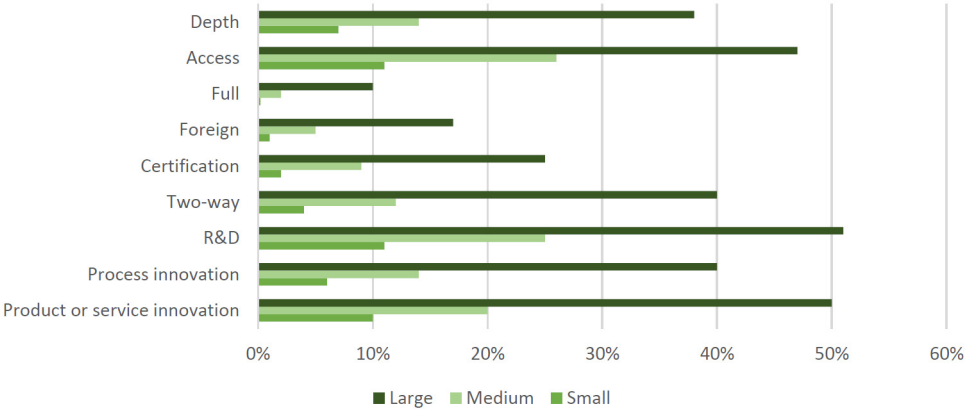


Figure 3 shows that as integration into global value chains increases, product innovation, process innovation, and R&D spending increase. For firms introducing new products or services, only 19% belong to those not participating in global value chains, 48% are two-way traders, 51% are two-way traders with international certification, 53% are two-way traders with foreign ownership, and 84% belong to those reaching the maximum level of participation in GVC. This trend is also consistent with process innovation and R&D investments. The more firms progress in integrating into the global value chain, the higher the number of firms that innovate.

Figure 3. GVC participation by innovation

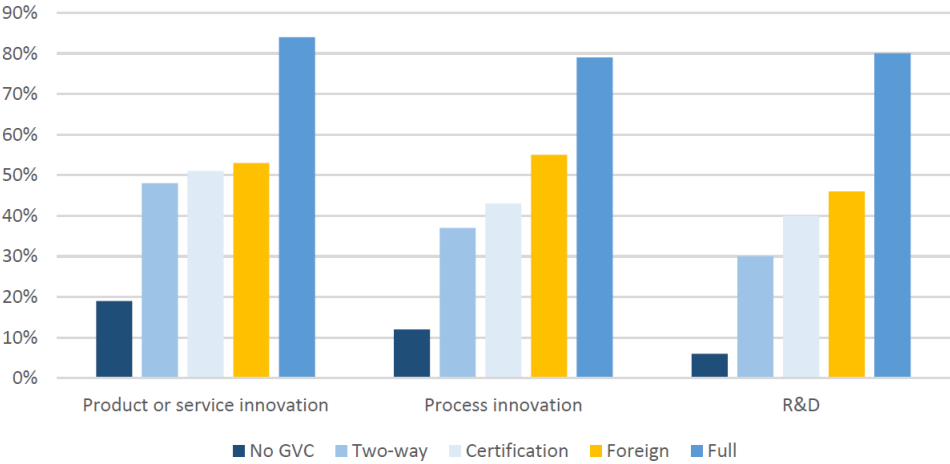
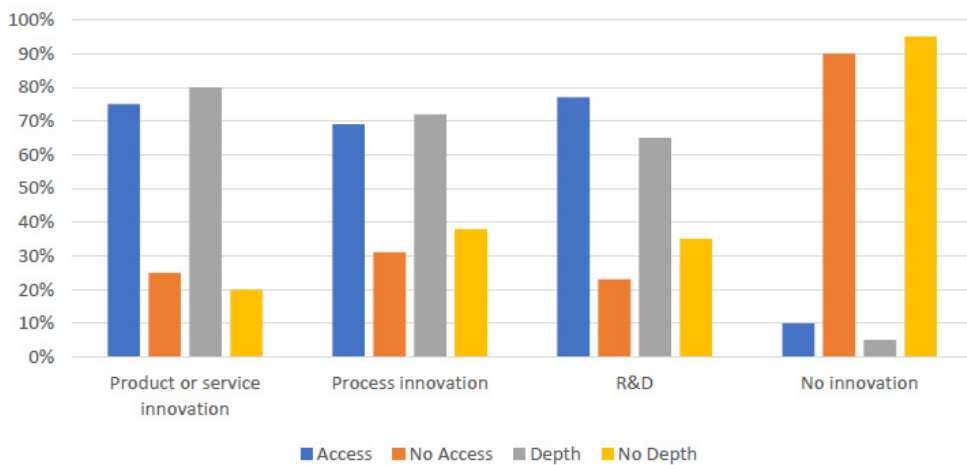


Figure 4 reports the level of financial indicators based on the type of innovation. Firms that have access to credit achieve more product innovation (75%), process innovation (69%), and R&D expenditure (77%) than firms that do not have access to credit (25%, 31%, and 23%, respectively). It emerges that 90% of firms that do not innovate do not have access to credit. The same analysis is observed for depth, where firms with access to capital markets innovate at least twice as much as firms that do not have access to capital markets. The financial system is therefore decisive for innovation.

Figure 4. Financial development by innovation



E. Empirical model

In the literature, several models have been used to examine innovation. Among the most important varieties of approaches are propensity score matching (Rigo, 2021), GMM (Ayyagari et al., 2011), difference-in-differences and difference-GMM (Brancati et al., 2017; Brancati et al., 2021; Ndubuisi and Owusu, 2023), logit (Fernandez, 2017), probit and linear probability (Abor et al., 2014), and recursive bivariate probit (Savignac, 2008; Ayalew and Xianzhi, 2020) methods. Since, in this study, the dependent variable is binary, with reverse causality between the variables of interest, the methods above are biased. In addition, the instrumental variable probit does not consider more than one binary endogenous independent variable or the interaction between the endogenous variables. Therefore, to investigate the effects of GVC participation and financial development on innovation, the extended probit model is used.

As mentioned by Elshaarawy and Ezzat (2023) and Ito et al. (2023), the extended model addresses two key issues. First, the endogeneity issue results from the two-reverse causality between GVC participation and innovation, and between financial development and innovation. Indeed, the extended probit model can include more than one endogenous variable and accounts

for the endogeneity of both GVC participation and financial development, unlike the standard probit model. Since the two endogenous independent variables are dummies, it also allows the use of binary endogenous regressors, unlike the instrumental variable probit. Second, firms can self-select to join GVCs, as only more innovative firms can afford the costs of integration in GVCs. Therefore, possible self-selection is another issue. Since the decision to innovate and to participate in GVCs may be jointly determined, simultaneous equation modeling would have been needed, but the additional endogeneity between innovation and GVC participation would make the bivariate probit the most desirable. However, the second endogeneity with financial development and the interaction of endogenous covariates leads to the extended probit for consistent and unbiased estimators.

Therefore, the effect of GVC on innovation is specified as follows:

$$Innovation_{i,k,t} = \alpha_0 + \alpha_1 GVC_{i,k,t}(H_{i,k,t}) + \alpha_2 X_{i,k,t} + \gamma_k + \gamma_s + \gamma_t + \epsilon_{i,k,t} \quad (1)$$

where i, k , and t denote the firm, country, and time, respectively. γ_k , γ_s , and γ_t are the country, industry, and year fixed effects, respectively. $X_{i,k,t}$ is a vector of control variables including firm size, age, competition against unregistered or informal firms, human capital, top manager experience, and political instability. $Innovation_{i,k,t}$ refers to the product or service and process innovation level. $GVC_{i,k,t}$ represents the four degrees of participation in the GVC; the existence of reverse causality between innovation and GVC integration is addressed by four instruments. $H_{i,k,t}$ is a vector of instruments including business licensing and permits as the greatest obstacle, customs and trade regulations as the greatest obstacle, tax administration as the greatest obstacle, and transportation as the greatest obstacle. We assume that these instruments are directly correlated with GVC participation and satisfy the exclusion restriction with innovation. The relevance of these instruments is tested through the Sargan test. As displayed in Table 2, the instruments are valid because they are exogenous and overidentified for the four degrees of GVC integration.

Table 2. GVC Endogeneity Test

	Under identification test		Endogeneity test		Sargan test	
	Ho: IV not correlated with GVC		Ho: exogenous Variables		Ho: valid instruments	
	F stat	Prob	F stat	Prob	F stat	Prob
Two-way	97.254	0.000	18.432	0.000	0.510	0.636
Two-way certification	73.781	0.000	24.117	0.000	0.324	0.438
Two-way foreign	66.991	0.000	29.940	0.000	0.229	0.412
Two-way full	52.773	0.000	34.672	0.000	0.101	0.333

Instruments: Business licensing; customs & trade regulations; tax administration; transportation.

The effect of financial development on innovation is estimated as follows:

$$Innovation_{i,k,t} = \beta_0 + \beta_1 Findev_{i,k,t}(N_{i,k,t}) + \beta_2 X_{i,k,t} + \gamma_k + \gamma_s + \gamma_t + \vartheta_{i,k,t} \quad (2)$$

where $Findev_{i,k,t}$ refers to financial development, either depth or access. $N_{i,k,t}$ is added to address the reverse causality between financial development and innovation. It includes a vector of instruments such as overdraft facilities, the percentage of financial losses in transit due to disorder, theft, crime, and corruption, and the percentage of financial losses from power outages. Table 3 highlights that the instruments are exogenous and overidentified for the two financial development variables.

Table 3. Financial Development Endogeneity Test

	Under identification test		Endogeneity test		Sargan test	
	Ho: IV not correlated with GVC		Ho: exogenous Variables		Ho: valid instruments	
	F stat	Prob	F stat	Prob	F stat	Prob
Access	106.211	0.000	77.054	0.000	0.832	0.271
Depth	88.909	0.000	55.342	0.000	1.011	0.794

Instruments: Overdraft facility; financial losses in transit; financial losses from power outages.

The effects of financial development and GVC on innovation are specified as follows:

$$Innovation_{i,k,t} = \tau_0 + \tau_1 GVC_{i,k,t}(H_{i,k,t}) + \tau_2 Findev_{i,k,t}(N_{i,k,t}) + \tau_3 Findev_{i,k,t} \times GVC_{i,k,t}(H_{i,k,t} \times N_{i,k,t}) + \tau_4 X_{i,k,t} + \gamma_k + \gamma_s + \gamma_t + \mu_{i,k,t} \quad (3)$$

The three models control for firm heterogeneity in terms of year, country, and sector. To test the robustness of the above results, we check the sensitivity of our analysis to four GVC indicators and two financial development levels. Furthermore, we performed a multicollinearity test for Model (3) by computing the variance inflation factor (VIF) for each independent variable. Two interpretations of the VIF in the literature are provided. The first strand of literature considers a VIF less than 5 as a low correlation, between 5 and 10 as a moderate correlation, and greater than 10 as a high, not tolerable correlation. However, these thresholds are criticized for being too high. Therefore, a second strand states that above 1.5, multicollinearity exists and that beyond 3, multicollinearity is no longer weak and must be corrected. In this study, we consider the second definition, which is the strictest. In addition, we test whether the results hold if the innovation variable changes by using research and development spending (R&D), excluding a market research survey. Indeed, this variable is a proxy of innovation to the extent

that R&D expenditures precede innovation. Finally, we test the robustness of the findings using an alternative method, namely, the Heckprobit. Due to the possible self-selection issue, it is necessary to regress a two-step probit selection model. Indeed, firms may decide to participate in GVCs or to mobilize financial capital because they can innovate. There is then self-selection. To address this, we follow the approach of Reddy et al. (2021) by using firm size as an exclusion restriction.

IV. Results and Discussion

The specific effects of GVC participation and financial development on innovation paths are displayed in Table 4. The first eight columns present the results of the level of participation of GVCs in innovation (product and process), whereas the last four columns show the results of the two dimensions of financial development on innovation (product and process). The correlation between the errors of each GVC and the innovation equation on the one hand and between the errors of financial development and the innovation equation on the other hand, is significant for all the models. This confirms the endogeneity issue assumed at the beginning. Therefore, the extended probit model is valid since the endogenous regressors have been instrumented. Furthermore, all the results remain robust to the inclusion of control variables and without significant differences for process innovation or product or service innovation.

The first interest variable, participation in global value chains, has positive and significant coefficients on both forms of innovation. This means that firms joining the GVC as two-way traders, two-way traders with quality certification, two-way traders with foreign ownership, and two-way traders with quality certification and foreign ownership see their likelihood of innovating new products and new processes increase. Compared with the other variable coefficients in the eight models, the findings also suggest that innovations are driven mainly by participation in GVCs. Moreover, the higher the level of participation is, the more powerful the innovation. For instance, from the least strict (two-way) participation to the strictest one (two-way full), the probability of introducing a new product or service increases from 0.712 to 0.883, while for a new process, the probability increases from 0.649 to 0.799. These results show that in the context of Africa, participation in global value chains is crucial to innovation.

Our findings are in line with Tajoli and Felice (2018), Yang et al. (2020), and Piermartini and Rubínová (2021), who found that GVC spurs innovation. As mentioned by Baldwin (2016), GVC leads to a finer division of labor combined with lower wages in developing countries, which decreases trade costs and improves overall performance. Gereffi and Fernandez-stark (2011) also highlighted that firms attending GVCs benefit from foreign know-how and technological progress, helping them upgrade their products and processes. Our second interest

variable, financial development, has a positive and significant effect on innovation, with a greater impact on financial depth when innovation concerns both the product and the process. This finding shows that access to and depth of the financial system play key roles in innovation. This result underlines that firms that have access to credit innovate more than firms that do not have access to credit. More importantly, the findings show that innovation is even greater for firms that have access to both domestic and foreign capital markets. Therefore, financial development matters in innovation.

Our analysis supports that of Abor et al. (2014), who found that access to finance is crucial for firms to cover fixed export costs, international marketing and branding, and to meet the higher quality standards required for overseas markets. Furthermore, Brown et al. (2009), Aghion et al. (2012), and Ayalew and Xianzhi (2020) found that underdeveloped financial markets and small banking systems adversely affect a firm's decision to engage in innovative activities and decrease its likelihood of engaging in product and process innovation. Underdeveloped financial markets are not conducive to product or process innovation. They argued that the high level of risk in export and import activities, uncertain returns, information asymmetry problems, and moral hazard behavior make underdeveloped financial markets even more fragile, leading institutions and banks to demand high collateral, which excludes the majority of firms requiring R&D expenditures to stimulate innovation. The greater effects of GVCs and financial development on product or service innovation compared to process innovation can be explained by the fact that process innovation is more complex and involves more resources and know-how, often beyond the reach of many African countries. This leads many firms to focus on new products or services, while imitating new processes from developed countries.

All the control variables have a significant effect on innovation, regardless of the form of participation in the global value chain and the level of financial development. Firm age and top manager experience positively influence the likelihood of innovating. These findings underscore the importance of knowledge and accumulated experience over time for innovation. With several years, firms accumulate more experience, enough resources and build trade networks that amplify their know-how and learning by doing, which strengthens their involvement in GVCs and their financial profit. All this leads to better innovations. Fernandez (2017) established similar results for Latin American countries.

Firm size and competition against informal or unregistered firms positively affect a firm's decision to innovate. One of the characteristics of African economies is the persistence of unregistered or informal firms. Thus, competing against the practices of these firms is not only costly but also risky if all these efforts are not productive. Therefore, the higher the number of informal or unregistered firms is, the greater the incentive for formal firms to innovate. The competitive environment then constitutes intense pressure for formal firms to surpass informal and unregistered firms, as noted by Ndubuisi and Owusu (2021) and Elshaarawy and Ezzat

(2023). Not surprisingly, firm size increases the effects of financial development and participation in GVCs on innovation, with a notable magnitude for large firms. Although medium-sized firms experience more innovation than small firms, large firms stand out. The coefficients associated with large firms are above most of the other controls. This clearly shows that innovation increases with the size of the firm (Ayyagari et al., 2011; De Marchi et al., 2018).

In addition, innovation is affected by the sector. Indeed, the manufacturing and services sectors generate more innovation than does the retail sector. This analysis is explained by the fact that manufacturing and services require more investment and structural transformation inducing spillover effects in other subsectors.

Our findings are consistent with those of Pipkin and Fuentes (2017) and Pleticha (2021). The estimation results are also consistent with the literature, as an increase in human capital increases the likelihood that firms innovate. Past studies (Coe et al., 2009; Cuervo-Cazurra and Pananond, 2023) have shown that firms are outsourcing and offshoring labor-intensive activities to developing countries where human capital is less costly. On the other hand, an improvement in human capital is associated with more efficient production processes (Baldwin and Venables, 2013). In addition, an increase in human capital increases both the probability of participating in GVCs and wages (Brancati et al., 2017; Ambos et al., 2021). In all cases, firms are encouraged to innovate. Given the coefficients, the findings of this study reveal that apart from participation in GVCs and financial development, human capital is the main driver of innovation. This result reinforces the findings of Antràs (2020) and Ndubuisi and Owusu (2023).

Notably, the estimates indicate that political instability is a key impediment to innovation even if firms join GVCs and have access to finance. The magnitude of the coefficient surpasses that of all the control variables, including firm size and human capital. This evidence shows that the business environment plays a decisive role in the success of innovation. Even when large firms with years of experience integrate GVCs, have sufficient financial resources, and adequate human capital, they may not achieve innovation if political stability is missing. Participation in GVCs and financial development are therefore not guarantees of innovation. This interesting result echoes that of Del Prete et al. (2017). Finally, Table 4 points out that participation in global value chains enhances innovation more for Sub-Saharan African countries, while financial development improves innovation more for North Africa.

Table 5 extends the analysis by including the interaction term between financial development and GVC participation. Since, in Table 4 product and process innovation show similar results, a single variable is considered. Thus, Table 5 combines product or service innovation and process innovation. Indeed, we construct a binary variable taking the value 1 if the firm simultaneously introduces a new product and process and 0 otherwise. The correlation between the errors is significant for all the equations, stressing the presence of endogeneity between the regressors and innovation. This finding confirms the validity of the extended probit model. The first four

Table 4. GVC Participation and Financial Development Effects on Innovation

	Product or Service Innovation (PSI)						Process Innovation (PI)			PSI			PI		
	GVC Participation						Financial development			Financial development			Financial development		
	Two-way certification	Two-way foreign	Two-way full	Two-way certification	Two-way foreign	Two-way full	Access	Depth	Access	Depth	Access	Depth	Access	Depth	
GVC Participation	0.712*** (0.123)	0.746*** (0.129)	0.778*** (0.117)	0.833*** (0.133)	0.649*** (0.101)	0.674*** (0.107)	0.676*** (0.110)	0.799*** (0.105)	0.640*** (0.100)	0.720*** (0.150)	0.604*** (0.114)	0.694*** (0.146)			
Financial development															
Age	0.208*** (0.085)	0.210*** (0.087)	0.208*** (0.088)	0.211*** (0.081)	0.215*** (0.067)	0.215*** (0.069)	0.212*** (0.089)	0.214*** (0.086)	0.203*** (0.083)	0.203*** (0.080)	0.205*** (0.084)	0.205*** (0.082)			
Informality	0.153*** (0.060)	0.153*** (0.061)	0.155*** (0.064)	0.153*** (0.062)	0.157*** (0.065)	0.154*** (0.063)	0.154*** (0.066)	0.152*** (0.068)	0.160*** (0.050)	0.162*** (0.051)	0.164*** (0.052)	0.165*** (0.054)			
Manager experience	0.128* (0.093)	0.124* (0.094)	0.127* (0.093)	0.125* (0.095)	0.131* (0.097)	0.132* (0.097)	0.134* (0.096)	0.130* (0.098)	0.122** (0.058)	0.122** (0.057)	0.120** (0.053)	0.121** (0.055)			
Human capital	0.380** (0.160)	0.381** (0.163)	0.383** (0.166)	0.382** (0.167)	0.385** (0.151)	0.386** (0.155)	0.389** (0.156)	0.387** (0.158)	0.392** (0.135)	0.394** (0.137)	0.396** (0.159)	0.397** (0.161)			
Political instability	-0.410** (0.200)	-0.400** (0.190)	-0.405** (0.199)	-0.402** (0.195)	-0.404** (0.192)	-0.412** (0.194)	-0.416** (0.191)	-0.407** (0.193)	-0.420** (0.202)	-0.424** (0.201)	-0.428** (0.204)	-0.430** (0.206)			
Large	0.302*** (0.071)	0.304*** (0.073)	0.305*** (0.072)	0.301*** (0.070)	0.311*** (0.091)	0.313*** (0.090)	0.312*** (0.092)	0.310*** (0.074)	0.338*** (0.076)	0.339*** (0.078)	0.341*** (0.077)	0.344*** (0.079)			
Medium	0.126*** (0.032)	0.126*** (0.032)	0.126*** (0.032)	0.104*** (0.035)	0.136*** (0.048)	0.145*** (0.040)	0.144*** (0.038)	0.143*** (0.037)	0.140*** (0.031)	0.138*** (0.049)	0.139*** (0.033)	0.141*** (0.034)			
Region	0.027* (0.020)	0.027* (0.020)	0.027* (0.020)	0.027* (0.020)	0.029* (0.022)	0.028* (0.023)	0.028* (0.023)	0.029* (0.021)	-0.039* (0.025)	-0.036* (0.021)	-0.030* (0.019)	-0.026* (0.017)			
Manufacturing	0.224** (0.102)	0.225** (0.106)	0.230** (0.108)	0.233** (0.112)	0.231** (0.103)	0.234*** (0.043)	0.235*** (0.044)	0.235*** (0.044)	0.243** (0.119)	0.248** (0.116)	0.240** (0.115)	0.241** (0.118)			
Services	0.221*** (0.056)	0.222*** (0.059)	0.227*** (0.075)	0.223*** (0.099)	0.220*** (0.041)	0.228** (0.111)	0.226** (0.109)	0.232** (0.113)	0.239*** (0.042)	0.238*** (0.046)	0.236*** (0.045)	0.237*** (0.047)			
ecorr (GVC, innovation)	0.170*** (0.010)	0.177*** (0.013)	0.182*** (0.015)	0.179*** (0.011)	0.188*** (0.017)	0.181*** (0.024)	0.185*** (0.012)	0.183*** (0.014)							
ecorr (finance, innovation)									0.330*** (0.018)	0.318*** (0.016)	0.340*** (0.009)	0.328*** (0.007)			
Observations	25404	25610	23330	23050	25300	23500	23208	23036	23110	23014	23067	23010			

Robust standard errors in parentheses clustered by firm. All regressions control for country and year-fixed effects. For the equations instrumenting the endogenous regressors, explanatory variables are the exogenous variables plus the respective instruments. ecorr, the estimates of the correlation between the errors of each innovation equation and each GVC or each financial development endogenous regressor. ***p < 0.01, **p < 0.05, *p < 0.1.

columns examine the effects of GVC participation levels, combined with access to credit as a proxy for financial development, on the likelihood of product and process innovation. The last four columns perform the same analysis considering financial depth.

The outcomes show that firms that succeed in introducing a new product and a new process simultaneously have the same features as firms that succeed in achieving one or the other innovation. The outcomes are similar to those in Table 4 for all the variables. The individual effects of GVCs and financial development are positive and significant, with a greater magnitude for GVCs. This confirms that in Africa, financial development does not take precedence over global value chains. Otherwise, participation in GVCs is more important for innovation compared to financial development. This conclusion contrasts with those of Gorodnichenko and Schnitzer (2013), Pahl and Timmer (2020), and Elshaarawy and Ezzat (2023) who found that financial development is more imperative for innovation than participation in GVCs. These results can be explained by the sample which was composed mainly of developed and emerging countries, which was not the case in our study.

On the other hand, our results corroborate the previous work of Baldwin (2016), Del Prete et al. (2017), and Ayalew and Xianzhi (2020), who noted that in recent years, Africa has become a privileged destination in international trade, with trade growth outpacing that of most economies. Integrating GVC is therefore essential for African economies, with financial development playing a moderating role. Indeed, the interactions between GVC and financial development show higher positive and significant coefficients. This means that in Africa, the likelihood of introducing new products and processes is fundamentally driven by GVCs. However, when financial facilities accompany this integration, innovation becomes stronger. Nevertheless, African countries must pay attention to the growing political instability, which is seriously hampering innovation. When considering both participation in GVCs and financial development, North Africa leads innovation.

Table 5. *GVC Participation and Financial Development Interaction Effects on Innovation*

	Product or service and Process Innovation (PPI)							
	Access				Depth			
	Two-way	Two-way certification	Two-way foreign	Two-way full	Two-way	Two-way certification	Two-way foreign	Two-way full
GVC Participation	0.700*** (0.244)	0.723*** (0.247)	0.715*** (0.245)	0.780*** (0.264)	0.810*** (0.270)	0.829*** (0.277)	0.835** (0.273)	0.870*** (0.280)
Financial development	0.609*** (0.209)	0.617*** (0.213)	0.628*** (0.207)	0.634*** (0.218)	0.622*** (0.216)	0.650*** (0.198)	0.651*** (0.197)	0.669*** (0.189)
GVC*Financ Development	0.905*** (0.303)	0.913*** (0.300)	0.919*** (0.305)	0.920*** (0.309)	0.910*** (0.308)	0.917*** (0.306)	0.922*** (0.317)	0.930*** (0.314)
Age	0.242** (0.103)	0.249** (0.104)	0.250** (0.105)	0.252** (0.107)	0.246** (0.109)	0.251** (0.110)	0.253** (0.112)	0.254** (0.114)
Informality	0.200*** (0.050)	0.202*** (0.051)	0.204*** (0.053)	0.204*** (0.054)	0.206*** (0.052)	0.210*** (0.055)	0.212*** (0.057)	0.219*** (0.058)

Table 5. Continued

	Product or service and Process Innovation (PPI)							
	Access				Depth			
	Two-way	Two-way certification	Two-way foreign	Two-way full	Two-way	Two-way certification	Two-way foreign	Two-way full
Manager experience	0.182* (0.120)	0.181* (0.121)	0.177* (0.123)	0.179* (0.124)	0.185* (0.125)	0.175* (0.127)	0.176* (0.119)	0.178* (0.118)
Human capital	0.384*** (0.033)	0.388*** (0.030)	0.390*** (0.031)	0.395*** (0.034)	0.391*** (0.036)	0.393*** (0.038)	0.398*** (0.037)	0.399*** (0.039)
Political instability	-0.406** (0.196)	-0.408** (0.168)	-0.403** (0.169)	-0.409** (0.142)	-0.411** (0.147)	-0.414** (0.217)	-0.413** (0.148)	-0.415** (0.149)
Large	0.307*** (0.042)	0.315*** (0.046)	0.316*** (0.044)	0.319*** (0.040)	0.323*** (0.047)	0.325*** (0.043)	0.327*** (0.048)	0.326*** (0.049)
Medium	0.180** (0.090)	0.184** (0.092)	0.187** (0.093)	0.186** (0.095)	0.171** (0.088)	0.172** (0.089)	0.174** (0.082)	0.173** (0.085)
Region	-0.035** (0.014)	-0.035** (0.014)	-0.035** (0.014)	-0.035** (0.014)	-0.041** (0.017)	-0.041** (0.017)	-0.041** (0.017)	-0.041** (0.017)
Manufacturing	0.272** (0.132)	0.274** (0.130)	0.276** (0.131)	0.275** (0.134)	0.273** (0.136)	0.278** (0.135)	0.279** (0.133)	0.283** (0.139)
Services	0.256*** (0.070)	0.257*** (0.073)	0.256*** (0.077)	0.258*** (0.074)	0.260*** (0.071)	0.260*** (0.075)	0.262*** (0.078)	0.261*** (0.079)
Ecorr	0.320*** (0.000)	0.329*** (0.000)	0.334*** (0.000)	0.337*** (0.000)	0.321*** (0.000)	0.332*** (0.000)	0.335*** (0.000)	0.336*** (0.000)
Observations	23215	23215	23215	23070	23014	23014	23014	23014

Robust standard errors in parentheses clustered by firm. All regressions control for country and year-fixed effects. For the equations instrumenting the endogenous regressors, the explanatory variables are the exogenous variables plus the respective interaction instruments. ecorr, the estimates of the correlation between the errors of the innovation equation and GVC and financial development endogenous regressors. ***p < 0.01, **p < 0.05, *p < 0.1.

V. Robustness Checks

The findings presented in Table 4 do not reveal any significant differences in product or service innovation or process innovation when participation in GVCs is measured by two-way traders, two-way traders with quality certification, two-way traders with foreign ownership, or two-way traders with quality certification and foreign ownership. Moreover, the findings for product or service innovation and process innovation are not significantly different whether financial development is measured by access or depth. It can be concluded that the analyses are not sensitive to alternative indicators of financial development and GVC integration. The outcomes are also consistent with those of Table 5 when financial development and GVC interactions are included and both innovations are combined. The comprehensive model depicted in Table 5 is robust to all the indicators. Table 6 shows the multicollinearity test results. All the calculated values are less than 1.5. Consequently, there is no multicollinearity. The coefficients estimated in Table 5 are not very sensitive to small changes in the model.

Table 6. *Variance Inflation Factor*

Variable	Product or service and Process Innovation (PPI)							
	Access				Depth			
	Two-way	Two-way certification	Two-way foreign	Two-way full	Two-way	Two-way certification	Two-way foreign	Two-way full
GVC	1.04	1.06	1.06	1.05	1.05	1.05	1.03	1.03
Fin.Dev	1.10	1.10	1.10	1.10	1.10	1.10	1.10	1.10
GVC*Fin.Dev	1.07	1.07	1.07	1.08	1.06	1.09	1.09	1.08
Age	1.14	1.14	1.14	1.14	1.14	1.14	1.14	1.14
Informality	1.17	1.11	1.11	1.16	1.16	1.16	1.17	1.13
Manager Exp	1.02	1.02	1.02	1.02	1.02	1.02	1.02	1.02
Human capital	1.12	1.18	1.15	1.03	1.11	1.18	1.16	1.16
Pol. instability	1.01	1.01	1.01	1.01	1.01	1.01	1.01	1.01
Large	1.22	1.24	1.25	1.24	1.21	1.21	1.21	1.22
Medium	1.26	1.23	1.24	1.25	1.15	1.04	1.07	1.09
Region	1.30	1.29	1.19	1.20	1.19	1.19	1.08	1.19
Manufacturing	1.34	1.12	1.26	1.09	1.36	1.26	1.28	1.34
Services	1.09	1.13	1.22	1.19	1.17	1.31	1.15	1.20

We also test whether the findings in Table 5 still hold when a firm’s R&D investments are used as an alternative proxy of innovation (Table 7). All the results are still robust. The variables of interest such as financial development and GVC participation remain positive and significant. The coefficients associated with the interaction between GVC integration and financial development still show the largest effects. This underlines that firms that engage in GVCs and do not face financial barriers realize the most investments in R&D, which is consistent with high product and process innovations. Similarly, political instability impedes R&D investments. R&D expenditures are more extensive in Sub-Saharan Africa than in North Africa, as many firms are located there.

Table 7. *GVC Participation and Financial Development Interaction Effects on R&D*

	R&D investment							
	Access				Depth			
	Two-way	Two-way certification	Two-way foreign	Two-way full	Two-way	Two-way certification	Two-way foreign	Two-way full
GVC Participation	0.690*** (0.238)	0.712*** (0.240)	0.704*** (0.220)	0.777*** (0.223)	0.800*** (0.274)	0.816*** (0.275)	0.823** (0.278)	0.853*** (0.241)
Financial development	0.600*** (0.218)	0.605*** (0.219)	0.614*** (0.197)	0.625*** (0.215)	0.615*** (0.214)	0.642*** (0.200)	0.640*** (0.195)	0.658*** (0.205)
GVC*Financ Development	0.900*** (0.288)	0.907*** (0.290)	0.912*** (0.289)	0.916*** (0.291)	0.904*** (0.295)	0.911*** (0.299)	0.918*** (0.297)	0.928*** (0.282)
Age	0.222** (0.092)	0.228** (0.096)	0.232** (0.094)	0.233** (0.090)	0.224** (0.093)	0.230** (0.095)	0.234** (0.098)	0.236** (0.099)

Table 7. Continued

	R&D investment							
	Access				Depth			
	Two-way	Two-way certification	Two-way foreign	Two-way full	Two-way	Two-way certification	Two-way foreign	Two-way full
Informality	0.197*** (0.039)	0.198*** (0.037)	0.201*** (0.030)	0.202*** (0.032)	0.204*** (0.031)	0.206*** (0.033)	0.209*** (0.034)	0.217*** (0.036)
Manager experience	0.161* (0.116)	0.160* (0.106)	0.154* (0.117)	0.162* (0.124)	0.163* (0.102)	0.152* (0.115)	0.155* (0.113)	0.158* (0.111)
Human capital	0.361*** (0.020)	0.369*** (0.022)	0.370*** (0.023)	0.373*** (0.025)	0.371*** (0.021)	0.375*** (0.024)	0.378*** (0.027)	0.380*** (0.029)
Political instability	-0.400** (0.194)	-0.402** (0.167)	-0.404** (0.153)	-0.405** (0.141)	-0.408** (0.144)	-0.410** (0.212)	-0.409** (0.146)	-0.412** (0.142)
Large	0.287*** (0.040)	0.293*** (0.043)	0.294*** (0.042)	0.296*** (0.041)	0.303*** (0.045)	0.304*** (0.046)	0.308*** (0.048)	0.310*** (0.047)
Medium	0.165** (0.085)	0.168** (0.087)	0.173** (0.088)	0.172** (0.089)	0.157** (0.083)	0.156** (0.081)	0.151** (0.086)	0.159** (0.080)
Region	0.038*** (0.010)	0.038*** (0.010)	0.038*** (0.010)	0.038*** (0.010)	0.044*** (0.014)	0.044*** (0.014)	0.044*** (0.014)	0.044*** (0.014)
Manufacturing	0.260** (0.122)	0.262** (0.120)	0.263** (0.121)	0.266** (0.123)	0.261** (0.125)	0.268** (0.124)	0.270** (0.127)	0.272** (0.129)
Services	0.246*** (0.065)	0.248*** (0.069)	0.242*** (0.072)	0.250*** (0.067)	0.252*** (0.066)	0.253*** (0.070)	0.255*** (0.074)	0.257*** (0.075)
Ecorr	0.140*** (0.000)	0.164*** (0.000)	0.166*** (0.000)	0.180*** (0.000)	0.203*** (0.000)	0.211*** (0.000)	0.231*** (0.000)	0.281*** (0.000)
Observations	23208	23208	23208	23066	23012	23012	23012	23012

Robust standard errors in parentheses clustered by firm. All regressions control for country and year-fixed effects. For the equations instrumenting the endogenous regressors, the explanatory variables are the exogenous variables plus the respective interaction instruments. ecorr, the estimates of the correlation between the errors of the innovation equation and GVC and financial development endogenous regressors. ***p < 0.01, **p < 0.05, *p < 0.1.

Finally, this study checks whether the findings remain unchanged if an alternative method is used. By performing the Heckprobit test to address the potential self-selection issue, the inverse Mills ratio was found to be significant, suggesting that positive selection prevailed. After addressing selection bias and endogeneity, the results in Table 8 show that the findings are still valid.

Table 8. Heckprobit Results on Innovation

	Product or service and Process Innovation (PPI)							
	Access				Depth			
	Two-way	Two-way certification	Two-way foreign	Two-way full	Two-way	Two-way certification	Two-way foreign	Two-way full
GVC Participation	0.698*** (0.203)	0.721*** (0.207)	0.713*** (0.218)	0.777*** (0.227)	0.807*** (0.212)	0.825*** (0.214)	0.830** (0.216)	0.874*** (0.224)
Financial development	0.607*** (0.222)	0.620*** (0.200)	0.624*** (0.211)	0.631*** (0.208)	0.612*** (0.217)	0.653*** (0.205)	0.655*** (0.196)	0.666*** (0.192)
GVC*Financ Development	0.909*** (0.292)	0.918*** (0.294)	0.923*** (0.295)	0.927*** (0.290)	0.914*** (0.298)	0.919*** (0.302)	0.925*** (0.306)	0.932*** (0.305)

Table 8. Continued

	Product or service and Process Innovation (PPI)							
	Access				Depth			
	Two-way	Two-way certification	Two-way foreign	Two-way full	Two-way	Two-way certification	Two-way foreign	Two-way full
Age	0.239* (0.168)	0.242* (0.146)	0.244* (0.147)	0.247* (0.142)	0.241* (0.148)	0.248* (0.157)	0.250* (0.154)	0.252* (0.150)
Informality	0.206** (0.101)	0.206** (0.103)	0.206** (0.103)	0.206** (0.100)	0.219** (0.108)	0.219** (0.107)	0.213** (0.105)	0.213** (0.105)
Manager experience	0.180* (0.132)	0.183* (0.131)	0.170* (0.134)	0.177* (0.130)	0.182* (0.137)	0.174* (0.128)	0.181* (0.126)	0.185* (0.121)
Human capital	0.380*** (0.110)	0.382*** (0.112)	0.384*** (0.115)	0.385*** (0.117)	0.390*** (0.119)	0.392*** (0.097)	0.394*** (0.099)	0.395*** (0.095)
Political instability	-0.414** (0.202)	-0.416** (0.204)	-0.422** (0.209)	-0.424** (0.201)	-0.417** (0.197)	-0.420** (0.198)	-0.426** (0.194)	-0.435** (0.199)
Region	-0.030** (0.012)	-0.031*** (0.012)	-0.036** (0.011)	-0.036** (0.016)	-0.039** (0.015)	-0.039** (0.015)	-0.038** (0.019)	-0.038** (0.019)
Manufacturing	0.280*** (0.062)	0.282*** (0.063)	0.281*** (0.065)	0.286*** (0.066)	0.289*** (0.069)	0.287*** (0.072)	0.272*** (0.061)	0.278*** (0.064)
Services	0.254*** (0.048)	0.255*** (0.046)	0.251*** (0.051)	0.259*** (0.054)	0.253*** (0.050)	0.256*** (0.056)	0.258*** (0.058)	0.264*** (0.049)
Inverse Mills Ratio	0.140*** (0.010)	0.144*** (0.009)	0.151*** (0.017)	0.160*** (0.006)	0.220*** (0.000)	0.228*** (0.000)	0.234*** (0.000)	0.249*** (0.000)
Observations	23008	23008	23008	23008	23002	23002	23002	23002

Robust standard errors in parentheses clustered by firm. All regressions control for country and year fixed-effects. Instruments for GVCs are included. ***p < 0.01, **p < 0.05, *p < 0.1.

VI. Conclusion

This paper examines innovation in Africa by emphasizing the role of GVCs and financial development. Using data from 25,690 firms from the World Bank's Enterprise Surveys (WBES) from 2006 to 2023, 51 African countries were investigated. Performing the extended probit model and the two-step probit selection model, this study sheds more light on the literature on innovation in developing countries, where evidence is lacking. Furthermore, this paper aims to overcome the limitations of previous studies in addressing endogeneity issues and sample selection bias. Using alternative measures of innovation, financial development, GVC integration, and including control variables, several key results are established.

Participation in global value chains is crucial to innovation. Joining GVCs as two-way traders, two-way traders with quality certification, two-way traders with foreign ownership, and two-way traders with quality certification and foreign ownership drive product and process innovation and R&D investments. These effects are stimulated by financial development, with the magnitude of financial depth being higher compared to financial access. Interestingly, the interaction effect shows that engaging in GVCs is more essential for innovation than financial development,

which plays a moderating role. Moreover, the findings show that in addition to participation in GVCs and financial development, human capital is the main driver of innovation. Firm age, top manager experience, firm size, sector of activity, and competition against informal or unregistered firms positively affect a firm's decision to innovate. Notably, the findings highlight that political instability is a key impediment to innovation even if firms join GVCs and have access to finance.

As policy recommendations, Africa must strengthen regional cooperation agreements to further stabilize the region, which is plagued by high instability. It is also important to improve the quality of institutions to ensure that the mandates of leaders are respected. For better political stability, governments must respect their commitment to the population. This must be accompanied by an evaluation of all members of the government according to the terms of their mandate. All these measures will contribute to strengthening the credibility of institutions and political stability, which will improve the business environment and reduce the risks and uncertainties that hamper innovation. It is all the more relevant as many regions become increasingly fragile. Governments should provide incentives to firms for engaging in GVCs by removing business licensing, permits, customs, and trade barriers. These policies must also be accompanied by tax incentives and investments in transport and energy infrastructure. These investments help reduce indirect costs and financial losses for firms, which increases their integration in GVCs and therefore innovation. There is no doubt that these measures will strengthen financial development.

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