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Bringing Rigour and Evidence to Economic Policy Making in Africa

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List of abbreviations and acronyms

AfCFTA	African Continental Free Trade Agreement
GVC	Global Value Chain
IV	Instrumental Variable
LPM	Linear Probability Models
OECD	Organisation for Economic Co-operation and Development
R&D	Research and Development
UNIDO	United Nations Industrial Development Organization
WBES	World Bank Enterprise Survey

Abstract

Firm-level innovation in developing countries is mostly incremental and depends on non-R&D activities. Integration into global production networks is one such activity that could help firms in developing countries to innovate. This is particularly the case since new technologies and foreign knowledge diffuse through inter-firm linkages. This paper examines the relationship between Global Value Chain (GVC) participation and firm innovative capabilities in Africa, utilizing data from the World Bank's Enterprise Survey (WBES). Addressing endogeneity arising from reverse causality, our results show that firms in Africa that engage in GVC activities have a higher likelihood of introducing innovative products onto markets. The results are robust to alternative definition of GVC and innovation variables and identification strategy. Our findings shed light on the mechanisms that make innovation possible within GVC firms, and the implications it has for trade, regional integration, and innovation in Africa.

Key words: *Global value chain; Innovation; Africa.*

JEL classification codes: *F14; O30; N77.*

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1. Introduction

The emergence of global value chains (GVCs) has 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. Akin to this, integration into GVCs has been recognized as an important way for developing countries to acquire new technologies or foreign knowledge. Inter-firm linkages within GVCs are considered key channels for transferring knowledge and promoting innovation (De Marchi et al., 2018). In a seminal paper, Rodrik (2018) argued that GVCs are vehicles for the dissemination of new technologies from developed to developing countries. Access to existing and new technologies lead to the creation of new products and services.[1]

Prior studies have examined the relationship between GVC participation and local innovation capabilities (De Marchi et al., 2018), GVC governance and introduction of new products and processes (Gereffi et al., 2005; Giuliani et al., 2005), and firm innovation and GVC participation (Reddy et al., 2021). The clear evidence coming out of this literature is that the relationship between GVC participation and innovation performance of firms is non-linear. This outcome notwithstanding, the existing literature has provided evidence on the different forms of innovation taking place at the local level, distinguishing among product, process, organizational and market-related inventions for firms participating in GVCs in Latin America and Asia (De Marchi et al., 2018).

In Africa, where few firms participate in GVCs, the existing literature is scarce on three fronts: the characteristic of firms that participate in GVCs and whether these firms self-select into GVCs; whether participating in GVCs lead to innovative learning in firms; and whether firms that participate in GVCs are more innovative and perform better than their counterparts. While some empirical evidence exists, the available literature largely focuses on the determinants of GVCs (Reddy et al., 2021; Dovis & Zaki, 2020). For example, Reddy et al. (2020) find firm innovation as the driver of GVC participation. While it is true that innovation helps firms in developing countries to penetrate international markets by increasing production efficiency and the possibility of product differentiation (Reddy et al., 2021), it is also possible that GVC integration builds the innovative capabilities of firms in developing countries through technology spillovers (De Marchi et al., 2018; Rodrik, 2018).

In this paper, we examine the effect of GVC participation on firm-level innovation in Africa using data from the World Bank's Enterprise Survey (WBES), spanning the period of 2006–2018[2] for 50 African countries. To motivate our empirical analysis,

we argue that, in developing countries, a salient feature of firm-level innovation is that it is incremental in nature and depends largely on non-R&D activities. GVC integration is one such activity that avails opportunity for firms in developing countries to innovate. In fact, foreign knowledge absorption through outright transfer from foreign firms, learning-by-doing, and interaction is observed to be the predominant strategy deployed by GVC firms (Pietrobelli & Rabellotti, 2011). Conceptually, we show that GVC participation could stimulate product and process innovation through the following channels: finer division of labour, availability of a greater variety of inputs, competition, and learning and technology transfer.

Following our conceptual linkage of GVC participation to product and process innovation, which are our two outcome variables, we define product innovation as a binary variable that takes the value 1 if a firm introduces a new product and 0 otherwise. Similarly, process innovation is a binary variable that takes the value 1 if a firm introduces a new process and 0 otherwise. As our main regressor, we define our main GVC participation variable as firms that simultaneously export, import (two-way traders), and have internationally recognized quality certificate. In addition, we test the robustness of our GVC indicator to alternative indicators including two-way traders and two-way traders with foreign ownership. Among other robustness tests, we also address endogeneity issues arising from reverse causality and omitted variable bias by exploring exogenous variations in two external instruments: the decision of a firm to obtain import license and the likelihood of engaging in GVC driven by the average propensity to participate in GVC reported by other firms operating in the same industry, region, and country in the same year. The requisite validity tests all show that our external instruments satisfy the relevance test and over-identification restriction test.

The results provide strong support for our hypothesis. First, the baseline probit and linear probability estimations all show that GVC participation is an important correlate of product and process innovation, implying that GVC participating firms are more likely to introduce new products and processes than non-GVC participating firms. Second, the IV estimation strongly corroborates the results from the probit and linear probability models, indicating a possible causal relationship from GVC participation to product and process innovation in African countries. Finally, these results are robust to alternative definition of GVC and innovation variables and identification strategy that controls for selection bias. In particular, our results hold in qualitative and quantitative terms when we use alternative GVC indicators including two-way traders and two-way traders with foreign ownership. Also, firms can jointly introduce product and process innovation. When we define our outcome variable as such, our main findings still hold, suggesting that GVC participating firms are more likely to jointly introduce new products and processes than non-GVC participating firms.

The rest of this paper is structured as follows. Section 2 discusses the literature on GVCs and innovation. Data and measurement of GVC and innovation variables, and estimation model are discussed in Section 3. Section 4 discusses the results of estimations; while Section 5 presents the concluding remarks.

2. Literature review

GVC and innovation: Conceptual linkages

The idea of innovation is deeply entrenched at the heart of GVCs scholarship, although it is often discussed within the broader narrative of "upgrading". Upgrading here is linked to a combination of making better products, improving processes to make these products, and taking over new functions (Ponte & Ewert, 2009; Lee et al., 2018). Four types of upgrading, including product, process, functional, and inter-sectoral or inter-chain, are often discussed within the GVCs framework (see Humphrey & Schmitz, 2002). The focus of our study is on product and process innovation, which are knitted tightly with the idea of product and process upgrading within the GVCs framework. Descriptively, product (process) innovation refers to improvement of an existing product (process) or the introduction of an entirely new product (process).

The product and process innovation gains associated with GVCs arise through multiple channels, including through finer division of labour, availability of a greater variety of inputs, competition, learning and knowledge/technology transfer, and spillover (Pietrobelli & Rabellotti, 2011; Ndubuisi & Owusu, 2021), which extant studies have shown to be significant predictors of innovation (Fritsch & Slavtchev, 2010; Chen et al., 2017). Beginning with the finer division of labour, the emergence of GVCs has enabled more efficient use of production resources by enabling participating firms to outsource activities for which they have a less comparative advantage and concentrate on core activities where they have a competitive advantage (Ndubuisi & Owusu, 2021). Through such efficient use of limited resources, GVC participating firms extract higher value per input while the specialization in core tasks enable them to invest their resources to build innovation capabilities. As per a greater variety of inputs, integration into GVC enables firms to access a wider variety of sophisticated and competitively priced inputs which can lead to innovation through embodied technology transfer.

Regarding learning and knowledge/technology transfer or spillover, supply chain linkages intensify contacts between foreign firms and domestic suppliers, and therefore open up conduits of knowledge and know-how spillover, say, through inter-firm personnel face-to-face communication. Outright knowledge transfer may also occur from lead firms to their input suppliers for efficient production of the outsourced input because they will eventually be the consumer of that input. As Baldwin and

Lopez-Gonzalez (2015) put it, "When Toyota makes car parts in Thailand, they do not rely on local know-how; they bring Toyota technology, Toyota management, Toyota logistics and any other bits of know-how needed because the Thai-made parts have to fit seamlessly into the company's production network". Existing studies suggest that these knowledge and technologies emanating outside of the firms' boundary are an important driver of innovation (see Goedhuys, 2007; Pietrobelli & Rabellotti, 2011).

Whereas the foregoing suggests a positive effect of GVCs integration on innovation, extant studies suggest that such gains from GVC may not be automatic especially for non-lead GVC firms Pietrobelli & Rabellotti, 2011). Importantly, such gains may well depend on the nature of the national innovation system as well as the mode of GVCs governance the firm is embedded in. On the one hand, the predominant view is that differences in the national innovation systems in which firms in a local milieu are embedded are as important as those firms' internal tangible and intangible resources in birthing frontier innovation. In this case, a well-functioning national innovation system becomes pivotal in both pooling global lead firms as well as creating the enabling system for knowledge absorption and recombination based on the resulting inter-firm interlinkages and interactions. On the other hand, GVCs governance mode pertains to the power relations among actors involved in a value chain (Lee et al., 2018). It determines upgrading opportunities as it significantly affects the 'how' and 'know-know' a lead firm can transfer as much as the extent those 'know-how' suppliers along the value chain can internalize.[3]

GVC and innovation: Empirical evidence and hypothesis

Although the channels underpinning the relationship between GVCs and innovation is well established, empirical studies focused on the nexus have been limited. Brancati et al. (2017) provide one of the earliest empirical evidence in this regard using a sample of Italian firms. In particular, the study examined the innovation effects of different GVC governance modes in the aftermath of the great recession. They found that, while high-skill relational suppliers display a significant propensity to engage in innovative activities and R&D projects, other modes of GVC participation have no innovation premium compared to domestic companies. Still focused on Italian firms, albeit on only input suppliers, Brancati et al. (2021) examine how value-chain governance affects innovation performance. They found that, while 'modular' value-chain governance is more conducive to innovation for suppliers, especially when these firms have medium capability levels, market-based governance modes appear to strongly reduce the innovativeness of suppliers with low capability. More recently, Delera et al. (2022) use a novel UNIDO database on firms' adoption of different generations of production technology in Ghana, Viet Nam, and Thailand, and found that firms' participation in GVCs is positively associated with the adoption of Industry 4.0 technologies.

In an industry-level study across 25 developed and emerging countries, Piermartini and Rubínová (2021) use patent counts as innovation indicator to test whether GVC spurs innovation through knowledge spillover. Their result shows that it does. A similar

analysis was also conducted by Tajoli and Felice (2018) albeit using country-level data. The study use patent per capital to proxy innovation performance and found that it is positively related to countries' involvement in GVCs. Focusing on China's manufacturing industry, Yang et al. (2020) examined the innovation effects of GVCs along two dimensions—GVC participation and GVC position—as well as how each of these dimensions interacts with industrial agglomeration to determine innovation. As an empirical measure of innovation performance, they employed patent counts per capita. Their results showed that GVC participation has an inverted U-shaped effect on innovation performance, whereas the effect of GVC position on innovation performance is positive. Akin to this, the interaction effect of GVC position and industrial agglomeration positively influence innovation performance, while the interaction effect of GVC participation and industrial agglomeration is negative.

Whereas the above studies have provided important insights on the nature of the relationship they address, they focused largely on developed and emerging economies, and used different input measures of innovation. To date, evidence on how GVC affects innovation in African countries remains scarce. The need to fill this gap cannot be overemphasized since innovation in developing economies is largely incremental and depends more on non-R&D activities. In this regards, foreign knowledge absorption through outright transfer from foreign firms, learning-by-doing, and interaction is more of the predominant strategy (Pietrobelli & Rabellotti, 2011). As GVC has become an important conduit of the latter, it may provide an easier route to African country firms to innovate. The objective of our study is to test this empirically. Along this line, the two hypotheses that guide our study are as follows:

Hypothesis 1: GVC participation raises the probability of introducing new products.

Hypothesis 2: GVC participation raises the probability of introducing new processes.

3. Methodology

Data

We use the World Bank Enterprise Survey (WBES)[4] to analyse the effect of GVC integration on innovation. The WBES are collected and compiled by World Bank through face-to-face interviews with firm managers or owners and collects information on firm characteristics. The number of firms interviewed differs across countries based on the size of the country. Currently, the survey is conducted in 144 countries, covering both the manufacturing and services sector. The survey is believed to provide a national representative firm-level data stratified by size, location, and sector. Following our research objective, we restrict the observation to only firms in African countries. There are only 50 African countries in the sample and the periods covered include 2006, 2007, 2009–2018. It is important noting that the survey is not a repeated cross-sectional, although some firms may be sampled twice or more. Each country also enters the survey in different time periods. Akin to this, each country's survey may be carried out in different periods. Hence, the resulting sample for each country is not available in consecutive years as listed above. Table A1 (in the appendix) shows the description of data availability across the countries.

The two most important variables for our analysis are indicators of firm GVC participation and innovation variables. In line with our research hypotheses, we use two innovation variables: product and process innovation.[5] Our product innovation variable is a binary variable that takes the value 1 if a firm introduces a new product and 0 otherwise. Concurrently, our process innovation variable is a binary variable that takes the value 1 if a firm introduces a new process and 0 otherwise. Concerning firm GVC indicator, extant studies has operationalized it differently. For example, Rigo (2021) identified GVC participating firms as two-ways traders—i.e., firms that jointly export and import, while Del Prete et al. (2017) and Reddy et al. (2021) identified them as internationally trading firms—i.e., firms that have international quality certification are either only importing, exporting or are two-way traders. Dovis and Zaki (2020) identified GVC participating firms as internationally trading firms with foreign ownership, while Baldwin and Yan (2014) defined it as firms that simultaneously import intermediate inputs and exports intermediate or final goods. In this paper, we define GVC participating firms as two-way traders with

internationally recognized quality certificate. However, we shall test the robustness of our GVC indicator to alternative indicators including two-way traders and two-way traders with foreign ownership.

The choice of our preferred GVC indicator is due to data availability and backed by two anecdotal evidences. First, while the data enables us to identify firms that import intermediates, the data do not allow us to distinguish between final and intermediate exports. Second, the restriction to only two-way traders enables us to capture the sequential and back-and-forth aspect of global linkage as well as underscore the characteristic of GVC where firms use imported intermediate to produce goods that are then exported (Balwin & Yan, 2014). Third, GVC-related trade entails higher relationship-specific investments such as in the development and adaptation of products and production to the specific needs of buyers (Antràs & Chor, 2013). Hence, global buyers tend to cherry pick the most capable suppliers to avoid production line delays and quality debasements caused by problems in the supply base. In this case, meeting the quality requirement of global buyers which can be proved through requisite certification becomes integral to participating in GVC. This argument is even more compelling to GVC participating firms in African countries which predominantly specialize in upstream activities where they serve as input suppliers to global lead firms (Ndubuisi & Owusu, 2022b).

Finally, to minimize potential omitted variable bias, it is also important that we control for other variables in our empirical specification. Guided by the literature on the determinants of innovation (see Criscuolo et al., 2010; Goedhuys, 2007; Fritsch & Görg, 2015; Chen et al., 2017), our empirical specification controls for skill intensity, line of credit, R&D investment, age, firm size, and training. The description of these variables, and all other variables employed in our analysis, are presented in Table 1.

Empirical model

To investigate whether firm GVC participation has an impact on innovation, we estimate the following equation:

$$Pr(\pi_{kijt} = 1) = \Phi(\alpha + \delta GVC_{kijt} + Z' + \varepsilon_{kijt}) \quad (1)$$

Where: the subscripts *k*, *i*, *j*, and *t* denote firm, industry, country, and year. π is a binary variable, which depending on the estimated equation can be either product or process innovation. δ_0 is the intercept, while *Z*' is a vector of control variables as described in the previous section. It also includes full sets of industry, country, and year dummies. ε_{kijt} is the error term and is robust to heteroscedasticity. GVC_{kijt} is an indicator variable that takes a value of 1 if a firm participates in GVC and 0 otherwise. Hence, δ is the parameter of interest. Consistent with Section 2, we expect it to be positive and statistically significant in all regressions.

Table 1: Definition and summary statistics

Variable	Definition and measurement	Obs.	Mean	Std. dev.	Min	Max
GVC1	Dummy variable that takes the value 1 if the firm is a two-way trader with internationally recognized certificate; and 0 otherwise.	19,794	0.12	0.32	0.00	1.00
GVC2	Dummy variable that takes the value 1 if the firm is a two-way trade; and 0 otherwise.	19,794	0.12	0.32	0.00	1.00
GVC3	Dummy variable that takes the value 1 if the firm is a two-way trader and has a foreign ownership at least 10%; and 0 otherwise.	19,794	0.04	0.19	0.00	1.00
Process innovation	Dummy variable that takes the value 1 if the firm introduced a new process over the last three years; and 0 otherwise.	19,794	0.44	0.50	0.00	1.00
Product innovation	Dummy variable that takes the value 1 if the firm introduced a new or significantly improved good or service over the last three years; and 0 otherwise.	19,794	0.40	0.49	0.00	1.00
Innovation 1	Dummy variable that takes the value of 1 if a firm simultaneously introduce new product and process; and 0 otherwise.	19,794	0.31	0.46	0.00	1.00
Innovation 2	Dummy variable that takes the value 2 if a firm simultaneously introduce new product and process, 1 if it either introduce only new product or process, and 0 otherwise.	19,794	0.83	0.87	0.00	2.00
R&D	A dummy variable equal to 1 if the firm spent on research and development (excluding market research) during the last fiscal year.	19,794	0.17	0.38	0.00	1.00
Log Sale	Log of total sales plus 1	16,828	15.88	3.07	0.00	29.53
Training	Dummy variable that takes the value 1 if the firm has a formal training programmes for permanent, full-time employees in last fiscal year.	19,794	0.25	0.43	0.00	1.00
Credit Line	A dummy variable that takes the value of 1 if establishment has a line of credit or loan from a financial institution; and 0 otherwise.	19,153	0.21	0.41	0.00	1.00
Skill intensity	The share of non-production workers over total workers.	19,489	0.12	0.20	0.00	10.00
Import license	Dummy variable that takes the value of 1 if firm has import license; and 0 otherwise.					
Log Age	A continuous variable defined as the total number of years a firm has been in operation, constructed as the natural logarithm of the total number of years plus 1.	19,377	2.55	0.88	0.00	7.58
Size	Dummy variable that takes the value of 1 if medium and large enterprise; and 0 if otherwise	19,794	0.85	0.36	0.00	1.00
Others GVC1 propensity	Predicted propensity to participate in GVC1 reported by other firms operating in the same industry, region, and country in the same year.	15,247	4.62	4.84	0.00	27.26
Others GVC2 propensity	Predicted propensity to participate in GVC2 reported by other firms operating in the same industry, region, and country in the same year.	15,255	4.75	5.02	0.00	28.83
Others GVC3 propensity	Predicted propensity to participate in GVC3 reported by other firms operating in the same industry, region, and country in the same year.	13,024	1.76	2.12	0.00	16.90

Three econometric issues arise in estimating Equation 1. First, we have a binary dependent variable. We address this by estimating both probit and linear probability models (LPM). Second, there may be endogeneity issue arising largely for omitted variable bias, measurement error, and reverse causality. We expect problems arising from confounding factors to be ameliorated due to the number of firm characteristics as well as industry, country, and year fixed effects we control. We also address issues related to measurement errors in GVC as we conduct robustness checks using alternative GVC indicators. Nevertheless, we acknowledge these approaches may be insufficient and therefore adopt an instrumental variable (IV) technique. Akin to this, the IV technique enables us address potential reverse causality as innovating firms may have a higher propensity to engage in GVC. As a successful implementation of IV technique requires valid instrument(s), we propose two external instruments: i) import license—a dummy variable that takes the value of 1 if a firm has import license and 0 otherwise; and ii) the average propensity to participate in GVC reported by other firms operating in the same industry, region, and country in the same year.

The motivation to use import license as instrument for GVC draws from our initial argument regarding the sequential nature of GVC activities. Along this line, obtaining import license becomes a necessary condition to engage in GVC. Conversely, similar argument does not hold for innovation. Concerning the second instrument, we argue that the propensity of engaging in GVC by other firms in the same industry, region, and country reflect a multitude of factors that affect the decision of a firm to engage in GVC. Hence, they should be strongly correlated with the individual firm decision to participate in GVC. As is conventional in the literature, we shall test for the validity of both instruments using the requisite tests. Finally, the third econometric issue we envisage draws from the fact that the decision to innovate and participate in GVC may be jointly determined, leading to the errors of innovation and GVC to be correlated. Whereas such econometric issue deserves a simultaneous equation modelling, our empirical modelling face the additional issue that GVC would become an endogenous regressor for the innovation variable. To address this concern, we shall also estimate a recursive bivariate probit model which is best suited for this approach.

4. Results and discussion

This section presents and discusses the estimation results analysing the innovation effect of African firms' global value chain participation. The section proceeds in three steps. First, it presents the baseline results explaining the effect of GVC on innovation. The second presents the results of the robustness check of the baseline results, while the third section presents the extended results.

Baseline results

Table 2 presents the baseline regression results on the innovation effect of firm GVC participation, proxied as two-way traders with internationally recognized quality certification. Results presented in the table are achieved using the probit model (PM). Columns (1)-(3) show the regression results for the process innovation, while columns (4)-(6) show the regression results for the product innovation. Columns (1) and (4) show the regression results without year, industry, and country fixed-effects. Columns (2) and (5) show the regression results when we control for year fixed-effects. Columns (3) and (6) are our main results, and show the result when we control for year, industry, and country fixed-effects. Across all the columns in the table, the estimated coefficient of GVC participation is positive and statistically significant at conventional significance levels, suggesting that GVC participating firms are more likely to introduce new products and processes than non-GVC participating firms. Hence, the results confirm our first and second hypothesis as stated in Section 2. Numerous factors could explain the positive relationship between GVC and innovation. Among others, this include learning, technology spillovers, or outright technology transfer that occurs in value chains (Pietrobelli & Rabellotti, 2011; Pietrobelli et al., 2018), which studies have shown to be important determinants of innovation (Goedhuys, 2007; Fritsch & Slavtchev, 2010; Chen et al., 2017).

Overall, our baseline results are consistent with extant literature suggesting a positive effect of GVC on innovation (Tajoli & Felice, 2018; Piermartini & Rubínová, 2021; Yang et al., 2020). In particular, our results contribute to this literature by providing the first firm-level evidence on Africa, and more generally in developing countries. Further, our result that two-way traders with quality certification are more innovative is consistent with the broader GVC literature suggesting that quality certification is an indicator of capability and a consequent driver of upgrading in GVC (e.g., Kaplinsky

et al., 2011; Kummitz et al., 2017; Kaplinsky & Moris, 2018). Indeed, innovation as an aspect of upgrading goes beyond improvement in total factor productivity that may be driven by higher price-adjusted quality associated with the imports of high-tech inputs that are accessed through integration into GVC. Firms must possess the capability to exploit the knowledge embodied in such inputs, which is a crucial aspect for and driver of innovation. Our result that two-way traders with capability, captured by quality certification, lay credence to this view.

Table 2: GVC and innovation: Baseline results (probit model)

Dependent Variables→	(1)	(2)	(3)	(4)	(5)	(6)
	Process Innovation			Product Innovation		
GVC1	0.0876**	0.0979***	0.0865**	0.0899***	0.0715**	0.1114***
	(0.0344)	(0.0357)	(0.0381)	(0.0336)	(0.0341)	(0.0360)
Log Age	0.1497***	0.2078***	0.0654	0.0805*	0.0914**	0.1002**
	(0.0460)	(0.0486)	(0.0523)	(0.0458)	(0.0466)	(0.0504)
Log Age-squared	-0.0433***	-0.0394***	-0.0136	-0.0259***	-0.0172*	-0.0166
	(0.0095)	(0.0101)	(0.0107)	(0.0094)	(0.0096)	(0.0103)
Size	0.2744***	0.1752***	0.0206	0.1662***	0.0883***	-0.0592
	(0.0335)	(0.0356)	(0.0400)	(0.0329)	(0.0335)	(0.0377)
Credit Line	0.1998***	0.1736***	0.1752***	0.1618***	0.1534***	0.1976***
	(0.0265)	(0.0282)	(0.0306)	(0.0261)	(0.0269)	(0.0290)
R&D	1.0302***	0.9659***	0.9001***	0.8858***	0.8284***	0.7300***
	(0.0310)	(0.0325)	(0.0347)	(0.0295)	(0.0302)	(0.0316)
Log Sale	0.0464***	0.0633***	0.0489***	0.0339***	0.0415***	0.0304***
	(0.0038)	(0.0042)	(0.0064)	(0.0038)	(0.0039)	(0.0060)
Training	0.4355***	0.5053***	0.4262***	0.4344***	0.4538***	0.4075***
	(0.0254)	(0.0273)	(0.0285)	(0.0250)	(0.0256)	(0.0268)
Skill Intensity	0.0589	0.1597**	0.0616	-0.0361	0.0344	0.0571
	(0.0520)	(0.0623)	(0.0643)	(0.0514)	(0.0513)	(0.0615)
Constant	-1.5541***	-1.5438***	-0.4939	-1.2752***	-1.3657***	-0.5222*
	(0.0880)	(0.0972)	(0.3140)	(0.0874)	(0.0920)	(0.2741)
Observations	16,154	16,154	16,154	16,249	16,249	16,249
Year FE	NO	YES	YES	NO	YES	YES
Industry FE	NO	NO	YES	NO	NO	YES
Country FE	NO	NO	YES	NO	NO	YES

Notes: GVC1 is defined as two-way traders with internationally recognized quality certificate. Robust standard errors are in parentheses. *** p<0.01, ** p<0.05, * p<0.1.

Table 3: GVC and innovation: IV estimation

Dependent Variables →	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	IV-LPM			IV-Probit	IV-LPM			IV-Probit
	Process Innovation				Product Innovation			
	Panel A: Second Stage Regression							
GVC1	0.6930***	0.3190**	0.4843***	1.5967***	0.6837***	0.3522**	0.5204***	1.5194***
	(0.1625)	(0.1394)	(0.1066)	(0.2680)	(0.1641)	(0.1453)	(0.1108)	(0.2556)
Log Age	0.0395**	0.0320*	0.0370**	0.1140**	0.0500***	0.0444***	0.0492***	0.1407***
	(0.0180)	(0.0163)	(0.0168)	(0.0525)	(0.0180)	(0.0169)	(0.0174)	(0.0500)
Log Age-squared	-0.0088**	-0.0065*	-0.0076**	-0.0225**	-0.0095**	-0.0079**	-0.0089**	-0.0251**
	(0.0037)	(0.0033)	(0.0034)	(0.0109)	(0.0037)	(0.0035)	(0.0036)	(0.0103)
Size	0.1169***	0.0576**	0.0836***	0.2550***	0.0915***	0.0397	0.0666***	0.1770***
	(0.0285)	(0.0247)	(0.0205)	(0.0573)	(0.0293)	(0.0261)	(0.0217)	(0.0570)
Credit Line	0.0285**	0.0386***	0.0333***	0.1048***	0.0431***	0.0526***	0.0473***	0.1321***
	(0.0113)	(0.0103)	(0.0103)	(0.0341)	(0.0117)	(0.0109)	(0.0109)	(0.0328)
R&D	0.2363***	0.2525***	0.2450***	0.7237***	0.2230***	0.2361***	0.2283***	0.5844***
	(0.0131)	(0.0115)	(0.0113)	(0.0612)	(0.0141)	(0.0128)	(0.0125)	(0.0504)
Log Sale	0.0043	0.0105***	0.0080***	0.0209**	-0.0001	0.0050*	0.0025	0.0058
	(0.0032)	(0.0029)	(0.0025)	(0.0088)	(0.0033)	(0.0030)	(0.0027)	(0.0078)
Training	0.0957***	0.1096***	0.1027***	0.3107***	0.1092***	0.1233***	0.1163***	0.3091***
	(0.0115)	(0.0104)	(0.0100)	(0.0407)	(0.0121)	(0.0113)	(0.0109)	(0.0375)
Skill Intensity	0.0323	0.0287	0.0329	0.1089*	0.0331	0.0287	0.0331	0.0982
	(0.0221)	(0.0205)	(0.0212)	(0.0642)	(0.0224)	(0.0209)	(0.0217)	(0.0618)
Constant	0.2934***	0.2661***	0.2739***	-0.4091	0.2707***	0.2554***	0.2625***	-0.4399
	(0.0824)	(0.0729)	(0.0767)	(0.3037)	(0.0871)	(0.0800)	(0.0835)	(0.2682)

continued next page

Table 3 Continued

Dependent Variables →	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	IV-LPM			IV-Probit	IV-LPM			IV-Probit
	Process Innovation				Product Innovation			
Country FE	YES	YES	YES	YES	YES	YES	YES	YES
Observations	16,154	15,477	15,477	15,424	16,249	15,584	15,584	15,584
R-squared	0.1517	0.2887	0.2402		0.0554	0.1758	0.1219	
	Panel B: First Stage Regression							
Dependent Variable→	GVC participation							
Import License	0.0839***		0.0816***	0.0843***	0.0853***		0.0824***	0.0859***
	(0.0102)		(0.0104)	(0.0095)	(0.0102)		(0.0104)	(0.0096)
Others GVC propensity		0.0074***	0.0070***	0.0066***		0.0075***	0.0071***	0.0067***
		(0.0008)	(0.0008)	(0.0008)		(0.0008)	(0.0008)	(0.0008)
Year FE	YES	YES	YES	YES	YES	YES	YES	YES
Industry FE	YES	YES	YES	YES	YES	YES	YES	YES
Country FE	YES	YES	YES	YES	YES	YES	YES	YES
Cragg-Donald Wald F statistic	106.41	99.03	97.35		110.02	100.7	99.22	
Kleibergen-Paap rk LM statistic	65.95	78.22	137.89		68.32	80.08	141.05	
Kleibergen-Paap Wald rk F statistic	67.53	79.83	71.8		69.96	81.68	73.41	
Hansen J Statistic		2.548				2.396		
Hansen J Statistic (p-value)	0.11				0.12			

Notes: GVC1 is defined as two-way traders with internationally recognized quality certificates. First Stage outcome variable is GVC1.
Robust standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1.

Robustness checks

In this section, we subject the baseline results to a number of robustness checks. First, while we estimate a fixed-effect probit model in the baseline analysis, the results may be biased due to incidental parameter problem that is common when the maximum likelihood estimator is used to estimate nonlinear panel data models with fixed effects. To this end, we re-estimate results reported in Table 2 using the linear probability model (LPM). The results for this exercise are reported in Table A2 (in the appendix). As Table A2 shows, the LPM results are largely consistent with the baseline results, suggesting GVC participating firms are more innovative than non-GVC firms. Second, as discussed in Section 3, the GVC indicator may be endogenous. Among others, this may be due to cofounding factors and reverse causality. We address this concern by implementing the instrumental variable approach, employing two external instruments: import license and the average propensity to participate in GVC reported by other firms operating in the same industry, region, and country in the same year. The motivations for employing these two instruments are as discussed in Section 3. Because there is still no standardized statistical test for testing the validity of external instruments when the structural model is nonlinear, our IV-estimation focuses on the IV-LPM. For completeness, however, we also present the results using IV-Probit model.

Table 3 reports the IV estimation results. Columns (1)-(4) show the results when the outcome variable is process innovation, while columns (5)-(8) show the results when the outcome variable is product innovation. Panel A shows the second stage of both the IV-LPM and IV-Probit model, while Panel B shows their respective first stage regression results. Across all columns in Panel A, the estimated coefficient of GVC is positive and statistically significant. Hence, the results are consistent with the baseline results. Regarding the appropriateness of the employed instrument, as expected, the first stage regression results (i.e., Panel B) show that the estimated coefficients of import license and the propensity to participate in GVC by other firms are consistently positive and statistically significant at all conventional significance levels. More importantly, the Kleibergen-Paap F statistic as reported in the lower part of the panel are all above 10, which is a rule-of-thumb to determine the relevance of an external instrument. Hence, the chosen external instruments are relevant in explaining whether a firm participate in GVC. Regarding the over-identification restriction test, the Hasen J-statistic are statistically insignificant as reported in the lower part of the panel, implying that at least one of the instruments are exogenous in explaining a firm's GVC participation. Put together, the results from the first-stage regression indicate the external instruments are valid. In which case, we are confident in the second stage results suggesting that GVC participating firms are more likely to introduce new products and processes than non-GVC participating firms.

Table 4: GVC and innovation: Recursive bi-probit model

Dependent Variables→	**(1)**	**(2)**
	Process Innovation	**Product Innovation**
GVC1	0.3865***	0.5140***
	(0.1485)	(0.1394)
Log Age	0.0652	0.1001**
	(0.0521)	(0.0500)
Log Age-squared	-0.0135	-0.0165
	(0.0107)	(0.0102)
Size	0.0227	-0.0551
	(0.0398)	(0.0374)
Credit Line	0.1731***	0.1938***
	(0.0304)	(0.0288)
R&D	0.8934***	0.7205***
	(0.0350)	(0.0319)
Log Sale	0.0485***	0.0298***
	(0.0064)	(0.0059)
Training	0.4238***	0.4038***
	(0.0285)	(0.0267)
Skill Intensity	0.0626	0.0576
	(0.0640)	(0.0610)
Constant	-0.1654**	-0.2239***
	(0.0806)	(0.0771)
Constant	-0.5387*	-0.5833**
	(0.3151)	(0.2739)
Year FE	YES	YES
Industry FE	YES	YES
Country FE	YES	YES
atanrho	-0.1654**	-0.2239***
	(0.0806)	(0.0771)
Wald test of rho	4.21488	8.43785
Wald test of rho (p-value)	0.0401	0.0037
Observations	16,154	16,249

Notes: GVC1 is defined as two-way traders with internationally recognized quality certificates. Robust standard errors are in parentheses. *** p<0.01, ** p<0.05, * p<0.1.

As noted in Section 3, while our paper focuses on the innovation effect of GVC participation, it may well be that a firm's decision to innovate occurs jointly with the decision to participate in GVC. In this case, a simultaneity modelling may be more appropriate. We check whether employing such approach changes our baseline results, by employing the recursive bi-probit model since one of the outcome variables—i.e., GVC indicator—is an endogenous regressor in one of the simultaneous regression—i.e., innovation equation. Table 4 presents the results for innovation equation from the recursive bi-probit model. An important condition to retain the models, as in our case, is that the errors from both the innovation and GVC models are significantly correlated. As shown in towards the last rows of Table 4, the atanrho is consistently significant across the columns at conventional significance levels, implying that the error terms of the GVC equation and those of the reported innovation equations are correlated. This is further corroborated by the statistical significance of Wald test as reported in the second to the last row in the table. Hence, the adoption of the model is appropriate. Nevertheless, a look at the GVC indicators across the two columns shows they are both positive and statistically significant at all conventional significance levels. Hence, while the adoption of the model is deemed appropriate, its adoption does not change the baseline result, suggesting that GVC participating firms are more likely to introduce new products and processes than non-GVC participating firms.

Table 5 show the regression results when we employ alternative GVC indicators. In particular, columns (1) and (2) show the results for two-way traders, while columns (3) and (4) show the results for two-way traders with foreign ownership structure as proxies for GVC participation, respectively. Across all the columns, the estimated coefficients of the respective GVC indicator remains positive and statistically significant at all conventional levels, suggesting that GVC participating firms are more likely to introduce new products and processes than non-GVC participating firms. Hence, our results are not driven by our choice of GVC indicator. Our result that two-way traders with foreign ownership structure drive innovation is consistent with the empirical literature. Dovis and Zaki (2020) argue that foreign ownership and quality certification can be both substitutes and complements. In our case, the analysis suggests foreign ownership and quality certification are substitutes since firms that are two-way traders and have both measures of integration are not likely to innovate more than others. It is also the case that, among GVC firms, foreign firms have more access to intermediate materials and achieve lower fixed costs (Halpern et al., 2015; Lu et al., 2019) and are less credit constraint because of support from their home companies (Feenstra et al., 2014). In which case being foreign avails such firms better opportunities to attract better-skilled workers and bear the enormous cost associated with innovation. It also suffices noting that such firms are also often knitted tightly with the lead firm through vertical integration, in which case they become knowledge-generating hubs and are more likely to generate innovations that are novel in and outside their local milieu (Ambos et al., 2006; Phene & Almeida, 2008; Marin & Bell, 2010).

Finally, while Table 5 shows the results obtained using the probit model, Table A3 (in the appendix) shows the results from the LPM.

Table 5: GVC and innovation: Alternative firm GVC participating measures (probit model)

Dependent Variables→	(1)	(2)	(3)	(4)
	Process Innovation	Product Innovation	Process Innovation	Product Innovation
GVC2	0.0967***	0.1163***		
	(0.0375)	(0.0354)		
GVC3			0.1354**	0.1658***
			(0.0606)	(0.0578)
Log Age	0.0660	0.1012**	0.0722	0.1202**
	(0.0520)	(0.0503)	(0.0524)	(0.0508)
Log Age-squared	-0.0138	-0.0166	-0.0146	-0.0206**
	(0.0106)	(0.0102)	(0.0107)	(0.0103)
Size	0.0261	-0.0545	0.0232	-0.0592
	(0.0396)	(0.0373)	(0.0396)	(0.0373)
Credit Line	0.1730***	0.1939***	0.1709***	0.2009***
	(0.0304)	(0.0288)	(0.0306)	(0.0289)
R&D	0.8959***	0.7306***	0.8967***	0.7326***
	(0.0344)	(0.0313)	(0.0346)	(0.0316)
Log Sale	0.0487***	0.0304***	0.0482***	0.0310***
	(0.0063)	(0.0059)	(0.0064)	(0.0060)
Training	0.4329***	0.4045***	0.4243***	0.4029***
	(0.0283)	(0.0266)	(0.0285)	(0.0268)
Skill Intensity	0.0551	0.0478	0.0544	0.0607
	(0.0641)	(0.0614)	(0.0643)	(0.0616)
Constant	-0.4714	-0.5605**	-0.4736	-0.5909**
	(0.3110)	(0.2721)	(0.3120)	(0.2730)
Year FE	YES	YES	YES	YES
Industry FE	YES	YES	YES	YES
Country FE	YES	YES	YES	YES
Observations	16,322	16,476	16,129	16,278

Notes: GVC2 is defined as two-way traders, while GVC3 is defined as two-way traders with foreign ownership structure. Robust standard errors are in parentheses. *** p<0.01, ** p<0.05, * p<0.1.

The results are line with those of the probit model and the baseline results. Table A4 (in the appendix) also report the IV estimation results for alternative GVC indicators. The results are also in line with the baseline results. Finally, Table A5 (in the appendix) reports the recursive bi-probit model for the alterative GVC indicators. Again, the results are in line with the baseline results. The exception to this is column (3) where the estimated coefficient of GVC3 although remains positive becomes statistically insignificant. However, a look at the atanrho and the Wald test in that column show they are both statistically insignificant suggesting that the recursive bi-probit model

is not appropriate for that model. In this case, the corresponding results reported Table 5 take precedence.

Table 6: GVC and innovation: Alternative outcome variable

Dependent Variables→	(1)	(2)	(3)	(4)
	Probit	LPM	Oprobit	OLS
	Innovation 1	Innovation 1	Innovation 2	Innovation 2
GVC1	0.0816**	0.0137	0.1038***	0.0499***
	(0.0383)	(0.0109)	(0.0327)	(0.0189)
Log Age	0.0564	0.0143	0.0896*	0.0535**
	(0.0545)	(0.0136)	(0.0458)	(0.0257)
Log Age-squared	-0.0088	-0.0024	-0.0165*	-0.0101*
	(0.0111)	(0.0028)	(0.0094)	(0.0052)
Size	-0.0116	0.0032	-0.0164	0.0003
	(0.0408)	(0.0107)	(0.0343)	(0.0189)
Credit Line	0.1750***	0.0484***	0.1979***	0.1126***
	(0.0307)	(0.0088)	(0.0260)	(0.0153)
R&D	0.8167***	0.2732***	0.8420***	0.5208***
	(0.0319)	(0.0105)	(0.0285)	(0.0165)
Log Sale	0.0350***	0.0095***	0.0411***	0.0243***
	(0.0064)	(0.0018)	(0.0056)	(0.0032)
Training	0.4467***	0.1300***	0.4408***	0.2595***
	(0.0282)	(0.0086)	(0.0244)	(0.0146)
Skill Intensity	0.0946	0.0242	0.0649	0.0331
	(0.0644)	(0.0181)	(0.0594)	(0.0336)
/cut1			0.1562	
			(0.2571)	
/cut2			0.9304***	
			(0.2572)	
Constant	-0.6721**	0.2085***		0.5115***
	(0.3338)	(0.0636)		(0.1218)
Year FE	YES	YES	YES	YES
Industry FE	YES	YES	YES	YES
Country FE	YES	YES	YES	YES
Observations	16,082	16,135	16,135	16,135
R-squared		0.2729		0.3330

Notes: GVC1 is defined as two-way traders, while GVC3 is defined as two-way traders with foreign ownership structure. Innovation 1 is a binary variable that takes the value of 1 if a firm simultaneously introduce new product and process, and 0 otherwise. Innovation 2 is a categorical variable that takes the value 2 if a firm simultaneously introduce new product and process, 1 if it either introduce only new product or process, and 0 otherwise. Column (1) is estimated using Probit Model, column (2) is estimated using Linear Probabilty Model (LPM), column (3) is estimated using Ordered Probit Model (OProbit), while column (4) is estimated using Ordinary Least Square (OLS). Robust standard errors are in parentheses. *** p<0.01, ** p<0.05, * p<0.1.

Extended analysis

So far, our analysis have considered separately product and process innovation although firms may do both simultaneously. Are GVC participating firms more likely to jointly introduce both types of innovation than non-GVC participating firms? To address this question, we compute two additional innovation indicators: i) a variable that takes the value of 1 if a firm simultaneously introduce new product and process, and 0 otherwise. We call this innovation 1; and ii) a variable that takes the value 2 if a firm simultaneously introduce new product and process, 1 if it either introduce only new product or process, and 0 otherwise. We call this innovation 2. Table 6 presents the results when we use these new indicators in empirical analysis. Columns (1) and (2) show the regression results using innovation 1 as the outcome variable, while columns (3) and (4) show the regression results using innovation 2 as the outcome variable. Across the columns, the estimated coefficient of GVC remains positive. With the exception of column 2 where it is not statistically significant, it is statistically significant at conventional significance levels in the remaining three columns. In Table A6 (in the appendix), we present results from similar analysis when we use alternative GVC indicators. In all cases, we find a positive and statistically significant effect of GVC on the new innovation indicators. Hence, this new pieces of evidence lead to the further conclusion that GVC participating firms are more likely to jointly introduce new products and processes than non-GVC participating firms. As introducing one innovation—i.e., either product or process innovation—is easier than jointly introducing both types of innovation even though the later strategy may be more rewarding, the results reported in Table 6 highlights the innovation importance GVC integration holds for firms in Africa.

5. Conclusion

The fragmentation of production stages across national borders by multinational enterprises in pursuit of cost efficiency and economies of scale provides enormous opportunities for developed and developing countries. In this paper, we focused on one of such opportunities—innovation—that has recently gained prominence in the empirical literature. The existing empirical literature suggests that innovation has a positive effect on global value chain (GVC) participation. However, the effect of GVC participation on firm innovation performance remains unexplored in Africa. This paper adds to this literature by investigating the relationship between GVC participation and the likelihood of African firms to introduce innovation. Using data from the World Bank's Enterprise Surveys (WBES) and estimating a probit, IV, and bi-variate recursive probit models, our results suggest that GVC participation affects the likelihood of African firm's innovativeness. The IV estimation shows that GVC participation is a key driver of products and process innovation in Africa. These results are robust to alternative definition of GVC and innovation variables.

The above findings have important policy implications in Africa, and also contribute to the body of knowledge on firm-level trade-innovation literature in Africa. The main finding, that GVC firms that have quality standards and a degree of foreign ownership generate innovation, provide key policy levers that could be developed and used to incentivize firms to improve standards and acquire international quality certification, foreign collaborations, and foreign investments. The role of the African Continental Free Trade Agreement (AfCFTA) in forging foreign collaborations that are mutually beneficial to the innovation activities of African firms cannot be overemphasized. The AfCFTA also has a major role to play in developing and harmonizing trade and quality standards and systems across all member countries, in the bid to improve intra-African trade and Africa's share in global trade.

Given that the WBES is cross-sectional, an extension of our paper would be to develop and use panel data as it becomes available. The use of panel data would allow one to examine the dynamic effects of GVC participation on innovation performance in Africa. This paper provides broad regional findings and patterns. However, there are country-specific idiosyncrasies that may lead to heterogeneous country-specific effects such that these findings cannot be generalized. Our findings can motivate studies that focus on country-specific cases.

Notes

1. This can be described as innovation based on the Oslo Manual (see OECD/Eurostat, 2018).

2. In 2008, survey data was not available for all countries in our sample (see Table A1 in the appendix).

3. For more on governance mode, see Gereffi et al. (2005).

4. Kindly refer to http://www.enterprisesurveys.org

5. In the extended analysis, however, we shall construct and use two additional innovation variables: i) a variable that takes the value of 1 if a firm simultaneously do product and process innovation, and 0 otherwise; and ii) a variable that takes the value 2 if a firm simultaneously do product and process innovation, 1 if a firm either do product or process innovation, and 0 otherwise.

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Appendix

Table A1: Time dimension for which surveys are available

Countries	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
Angola	X				X								
Benin				X							X		
Botswana	X				X								
Burkina Faso				X									
Burundi	X								X				
Cameroon				X							X		
Cape Verde				X									
Central African Republic						X							
Chad				X									X
Congo				X									
Côte d'Ivoire				X							X		
DRC	X				X			X					
Djibouti								X					
Egypt								X			X		
Eritrea				X									
Ethiopia						X				X			
Gabon				X									
Gambia	X												
Ghana		X						X					
Guinea	X										X		

continued next page

Table A1 Continued

Countries	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
Guinea Bissau	X												
Kenya		X						X					
Lesotho				X							X		
Liberia				X								X	
Madagascar				X				X					
Malawi				X					X				
Mali		X			X						X		
Mauritania	X								X				
Mauritius				X									
Morocco								X					
Mozambique		X											
Namibia	X								X				
Niger				X								X	
Nigeria		X							X				
Rwanda	X					X							
Samoa				X									
Senegal		X							X				
Sierra Leone				X								X	
South Africa		X											
South Sudan									X				
Sri Lanka						X							
Sudan									X				

continued next page

Table A1 Continued

Countries	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
Swaziland	X										X		
Tanzania	X							X					
Togo				X							X		
Tunisia								X					
Uganda	X							X					
Zambia		X							X				
Zimbabwe						X							

Table A2: GVC and innovation: LPM

	(1)	(2)	(3)	(4)	(5)	(6)
	Process Innovation			Product Innovation		
GVC1	0.0312***	0.0261**	0.0181*	0.0316***	0.0225*	0.0310***
	(0.0119)	(0.0108)	(0.0107)	(0.0119)	(0.0117)	(0.0116)
Log Age	0.0478***	0.0668***	0.0200	0.0268*	0.0306**	0.0317**
	(0.0152)	(0.0143)	(0.0149)	(0.0153)	(0.0152)	(0.0155)
Log Age-squared	-0.0140***	-0.0124***	-0.0045	-0.0087***	-0.0057*	-0.0054*
	(0.0031)	(0.0029)	(0.0030)	(0.0031)	(0.0031)	(0.0031)
Size	0.0951***	0.0567***	0.0109	0.0583***	0.0297***	-0.0126
	(0.0112)	(0.0102)	(0.0107)	(0.0113)	(0.0110)	(0.0116)
Credit Line	0.0694***	0.0525***	0.0494***	0.0570***	0.0518***	0.0630***
	(0.0093)	(0.0088)	(0.0088)	(0.0093)	(0.0093)	(0.0094)
R&D	0.3673***	0.3083***	0.2672***	0.3296***	0.3011***	0.2537***
	(0.0096)	(0.0090)	(0.0093)	(0.0102)	(0.0103)	(0.0104)
Log Sale	0.0164***	0.0196***	0.0147***	0.0119***	0.0138***	0.0098***
	(0.0013)	(0.0012)	(0.0018)	(0.0013)	(0.0013)	(0.0019)
Training	0.1559***	0.1554***	0.1230***	0.1584***	0.1583***	0.1354***
	(0.0091)	(0.0084)	(0.0083)	(0.0092)	(0.0091)	(0.0091)
Skill Intensity	0.0201	0.0516***	0.0169	-0.0119	0.0123	0.0174
	(0.0183)	(0.0200)	(0.0191)	(0.0167)	(0.0171)	(0.0194)
Constant	-0.0531*	0.0163	0.2652***	0.0397	0.0279	0.2478***
	(0.0296)	(0.0294)	(0.0684)	(0.0300)	(0.0307)	(0.0760)
Year FE	YES	YES	YES	YES	YES	YES
Industry FE	YES	YES	YES	YES	YES	YES
Country FE	YES	YES	YES	YES	YES	YES
Observations	16,154	16,154	16,154	16,249	16,249	16,249
R-squared	0.1478	0.2655	0.3204	0.1246	0.1670	0.2182

Notes: GVC1 is defined as two-way traders with internationally recognized quality certificates. Robust standard errors are in parentheses. *** p<0.01, ** p<0.05, * p<0.1.

Table A3: GVC and innovation: Alternative firm GVC participating measures (LPM)

	(1)	(2)	(3)	(4)
	Process Innovation	**Product Innovation**	**Process Innovation**	**Product Innovation**
GVC2	0.0219**	0.0327***		
	(0.0105)	(0.0114)		
GVC3			0.0378**	0.0545***
			(0.0169)	(0.0189)
Log Age	0.0203	0.0321**	0.0226	0.0382**
	(0.0148)	(0.0155)	(0.0149)	(0.0156)
Log Age-squared	-0.0045	-0.0054*	-0.0049	-0.0067**
	(0.0030)	(0.0031)	(0.0030)	(0.0032)
Size	0.0124	-0.0114	0.0122	-0.0120
	(0.0106)	(0.0115)	(0.0106)	(0.0115)
Credit Line	0.0487***	0.0620***	0.0478***	0.0640***
	(0.0088)	(0.0093)	(0.0088)	(0.0094)
R&D	0.2657***	0.2542***	0.2658***	0.2542***
	(0.0092)	(0.0103)	(0.0093)	(0.0104)
Log Sale	0.0146***	0.0098***	0.0144***	0.0100***
	(0.0018)	(0.0019)	(0.0018)	(0.0019)
Training	0.1246***	0.1345***	0.1219***	0.1337***
	(0.0082)	(0.0090)	(0.0083)	(0.0091)
Skill Intensity	0.0148	0.0149	0.0149	0.0189
	(0.0188)	(0.0192)	(0.0190)	(0.0196)
Constant	0.2712***	0.2354***	0.2709***	0.2260***
	(0.0679)	(0.0755)	(0.0682)	(0.0759)
Year FE	YES	YES	YES	YES
Industry FE	YES	YES	YES	YES
Country FE	YES	YES	YES	YES
Observations	16,375	16,476	16,182	16,278
R-squared	0.3211	0.2170	0.3201	0.2169

Notes: GVC2 is defined as two-way traders, while GVC3 is defined as two-way traders with foreign ownership structure. Robust standard errors are in parentheses. *** p<0.01, ** p<0.05, * p<0.1.

Table A4: GVC and innovation: Alternative firm GVC participating measures (IV estimation)

Dependent Variable→	(1)	(2)	(6)	(7)
	IV-LPM	IV-Probit	IV-LPM	IV-Probit
	Process Innovation		Product Innovation	
	Panel A: Second Stage Regression			
GVC_ind1	0.4845***	1.6027***		
	(0.1056)	(0.2624)		
GVC_ind3			0.8327***	2.3518***
			(0.1875)	(0.4458)
Log Age	0.0361**	0.1102**	0.0635***	0.1815***
	(0.0167)	(0.0521)	(0.0199)	(0.0559)
Log Age-squared	-0.0073**	-0.0212**	-0.0100**	-0.0281**
	(0.0034)	(0.0108)	(0.0040)	(0.0115)
Size	0.0834***	0.2557***	0.0423**	0.0995**
	(0.0202)	(0.0561)	(0.0180)	(0.0496)
Credit Line	0.0316***	0.0991***	0.0606***	0.1678***
	(0.0103)	(0.0340)	(0.0114)	(0.0331)
R&D	0.2418***	0.7129***	0.2378***	0.6084***
	(0.0113)	(0.0616)	(0.0126)	(0.0515)
Log Sale	0.0074***	0.0191**	0.0036	0.0083
	(0.0026)	(0.0089)	(0.0030)	(0.0089)
Training	0.1036***	0.3136***	0.1190***	0.3126***
	(0.0100)	(0.0409)	(0.0113)	(0.0390)
Skill Intensity	0.0305	0.1022	0.0245	0.0705
	(0.0209)	(0.0638)	(0.0224)	(0.0625)
Constant	0.2923***	-0.3459	0.2248**	-0.5471*
	(0.0762)	(0.3012)	(0.0884)	(0.2807)
Observations	15,699	15,646	13,347	13,347
R-squared	0.2404		0.1046	
Year FE	YES	YES	YES	YES
Industry FE	YES	YES	YES	YES
Country FE	YES	YES	YES	YES

continued next page

Table A4 Continued

Dependent Variable→	(1)	(2)	(6)	(7)
	IV-LPM	IV-Probit	IV-LPM	IV-Probit
	Process Innovation		Product Innovation	
Import License	0.0835***	0.0855***	0.0208***	0.0263***
	(0.0104)	(0.0096)	(0.0079)	(0.0072)
Others GVC propensity	0.0067***	0.0064***	0.0171***	0.0167***
	(0.0008)	(0.0008)	(0.0019)	(0.0020)
Year FE	YES	YES	YES	YES
Industry FE	YES	YES	YES	YES
Country FE	YES	YES	YES	YES
Cragg-Donald Wald F statistic	97.48		81.956	
Kleibergen-Paap rk LM statistic	136.35		89.78	
Kleibergen-Paap Wald rk F statistic	71.25		46.89	
Hansen J Statistic	1.501		5.201	
Hansen J Statistic (p-value)	0.22		0.023	

Notes: GVC2 is defined as two-way traders, while GVC3 is defined as two-way traders with foreign ownership structure. Robust standard errors are in parentheses. *** p<0.01, ** p<0.05, * p<0.1.

Table A5: GVC and innovation: Alternative firm GVC participating measures (recursive bi-probit model)

Variables	(1)	(2)	(3)	(4)
	Process Innovation	Product Innovation	Process Innovation	Product Innovation
GVC2	0.3280**	0.4946***		
	(0.1449)	(0.1360)		
GVC3			0.0773	0.5185**
			(0.3469)	(0.2450)
Log Age	0.0661	0.1015**	0.0721	0.1216**
	(0.0519)	(0.0499)	(0.0524)	(0.0507)
Log Age-squared	-0.0138	-0.0166	-0.0146	-0.0209**
	(0.0106)	(0.0102)	(0.0107)	(0.0103)
Size	0.0277	-0.0507	0.0230	-0.0578
	(0.0395)	(0.0370)	(0.0396)	(0.0373)
Credit Line	0.1713***	0.1904***	0.1710***	0.1999***
	(0.0303)	(0.0286)	(0.0306)	(0.0289)
R&D	0.8912***	0.7216***	0.8968***	0.7294***
	(0.0346)	(0.0316)	(0.0346)	(0.0317)
Log Sale	0.0484***	0.0298***	0.0482***	0.0309***
	(0.0063)	(0.0059)	(0.0064)	(0.0059)
Training	0.4314***	0.4010***	0.4241***	0.4025***
	(0.0283)	(0.0265)	(0.0285)	(0.0267)
Skill Intensity	0.0558	0.0483	0.0542	0.0612
	(0.0639)	(0.0610)	(0.0643)	(0.0615)
Constant	-0.5068	-0.6187**	-0.4693	-0.6139**
	(0.3121)	(0.2718)	(0.3127)	(0.2730)
Year FE	YES	YES	YES	YES
Industry FE	YES	YES	YES	YES
Country FE	YES	YES	YES	YES
Atanrho	-0.1274	-0.2108***	0.0275	-0.1695
	(0.0779)	(0.0750)	(0.1589)	(0.1135)
Wald test of rho	2.67601	7.89551	0.030031	2.2309
Wald test of rho (p-value)	0.1019	0.005	0.8624	0.1353
Observations	16,375	16,476	16,182	16,278

Notes: GVC2 is defined as two-way traders, while GVC3 is defined as two-way traders with foreign ownership structure. Robust standard errors are in parentheses. *** p<0.01, ** p<0.05, * p<0.1.

Table A6: GVC and innovation: Alternative outcome variable and GVC indicators

Variables	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	Probit	LPM	Oprobit	OLS	Probit	LPM	Oprobit	OLS
	Innovation 1	Innovation 1	Innovation 2	Innovation 2	Innovation 1	Innovation 1	Innovation 2	Innovation 2
GVC2	0.0957**	0.0178*	0.1124***	0.0553***				
	(0.0376)	(0.0107)	(0.0322)	(0.0186)				
GVC3					0.1202**	0.0340*	0.1565***	0.0905***
					(0.0598)	(0.0180)	(0.0515)	(0.0300)
Log Age	0.0666	0.0168	0.0899**	0.0539**	0.0798	0.0204	0.1026**	0.0616**
	(0.0544)	(0.0136)	(0.0456)	(0.0257)	(0.0550)	(0.0137)	(0.0460)	(0.0258)
Log Age-squared	-0.0104	-0.0028	-0.0164*	-0.0102**	-0.0132	-0.0036	-0.0190**	-0.0117**
	(0.0111)	(0.0028)	(0.0093)	(0.0052)	(0.0112)	(0.0028)	(0.0094)	(0.0052)
Size	-0.0077	0.0042	-0.0108	0.0029	-0.0118	0.0042	-0.0183	0.0009
	(0.0404)	(0.0106)	(0.0340)	(0.0187)	(0.0405)	(0.0106)	(0.0340)	(0.0187)
Credit Line	0.1737***	0.0483***	0.1957***	0.1115***	0.1754***	0.0484***	0.1978***	0.1125***
	(0.0305)	(0.0087)	(0.0259)	(0.0152)	(0.0307)	(0.0088)	(0.0260)	(0.0153)
R&D	0.8130***	0.2726***	0.8393***	0.5193***	0.8112***	0.2711***	0.8405***	0.5194***
	(0.0316)	(0.0104)	(0.0282)	(0.0163)	(0.0319)	(0.0105)	(0.0285)	(0.0165)
Log Sale	0.0340***	0.0093***	0.0408***	0.0241***	0.0344***	0.0093***	0.0408***	0.0241***
	(0.0063)	(0.0018)	(0.0055)	(0.0031)	(0.0064)	(0.0018)	(0.0055)	(0.0032)
Training	0.4480***	0.1303***	0.4417***	0.2602***	0.4457***	0.1291***	0.4363***	0.2567***
	(0.0280)	(0.0085)	(0.0242)	(0.0145)	(0.0282)	(0.0086)	(0.0243)	(0.0146)
Skill Intensity	0.0823	0.0212	0.0552	0.0282	0.0916	0.0238	0.0618	0.0323
	(0.0645)	(0.0179)	(0.0589)	(0.0331)	(0.0645)	(0.0182)	(0.0594)	(0.0337)

continued next page

Table A6 Continued

Variables	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	Probit	LPM	Oprobit	OLS	Probit	LPM	Oprobit	OLS
	Innovation 1	Innovation 1	Innovation 2	Innovation 2	Innovation 1	Innovation 1	Innovation 2	Innovation 2
/cut2			0.9442***				0.9532***	
			(0.2555)				(0.2559)	
Constant	-0.6411*	0.2102***		0.5068***	-0.6688**	0.2065***		0.5016***
	(0.3292)	(0.0632)		(0.1211)	(0.3322)	(0.0634)		(0.1216)
Year FE	YES	YES	YES	YES	YES	YES	YES	YES
Industry FE	YES	YES	YES	YES	YES	YES	YES	YES
Country FE	YES	YES	YES	YES	YES	YES	YES	YES
Observations	16,299	16,352	16,352	16,352	16,106	16,159	16,159	16,159
R-squared		0.2724		0.3324		0.2713		0.3315

Notes: GVC2 is defined as two-way traders, while GVC3 is defined as two-way traders with foreign ownership structure. Innovation 1 is a binary variable that takes the value of 1 if a firm simultaneously introduce new product and process, and 0 otherwise. Innovation 2 is a categorical variable that takes the value 2 if a firm simultaneously introduce new product and process, 1 if it either introduce only new product or process, and 0 otherwise. Columns (1) and (5) are estimated using Probit Model, columns (2) and (6) are estimated using Linear Probability Model (LPM), columns (3) and (7) are estimated using Ordered Probit Model (OProbit), while columns (4) and (8) are estimated using Ordinary Least Square (OLS). Robust standard errors are in parentheses. *** p<0.01, ** p<0.05, * p<0.1.

Mission

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