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DIGITAL PATHWAYS TO GLOBAL MARKETS:
THE INFLUENCE OF ICTS ON VALUE CHAIN PARTICIPATION

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Abstract:

Although scholars agree that the rise of global value chains appears to have happened alongside the ICT revolution, the empirical evidence documenting the nexus ICTs-participation in the GVC is still very scant. So, the objective of this study is twofold: (i) to examine the effect of ICT on participation in GVC, and (ii) to explore the channels through which ICT influences the integration into the GVC. Data are collected from the WDI of the World Bank and the UNCTAD-EROA for a sample of 217 countries covering the 1996 to 2018 period. A dynamic linear model is estimated using the system GMM estimator. The results strongly show that a greater internet penetration rate and mobile telephone use contribute to more intensive participation in GVC in both Africa and the World. Then, the net impacts computed from the interaction GMM approach show that both internet penetration and mobile phone complements trade to intensify GVC participation in Africa on proportions above the World average. The study calls for a more tailored digital-industrial policy approach that links technology, trade, and investment to foster inclusive GVC participation.

Keywords: ICTs, Global value chain, Dynamic panel, Trade, Foreign investment

1. Introduction

In the contemporary era of globalization, Information and Communication Technologies (ICT) have emerged as powerful catalysts, revolutionizing the way countries operate and engage in the global economy. The fall of commercial barriers which would have made it possible to reinforce integration, accompanied by the progress of ICT, have allowed production to be increasingly unbundled into multiple tasks carried out in different geographic spaces to take advantage of factor costs (Grossman and Rossi Hansberg, 2008; Timmer et al, 2014). These intricate networks of production, distribution, and consumption span across borders, connecting suppliers, manufacturers, and consumers worldwide. The integration of ICTs into various aspects of industries and trade has significantly impacted global value chains (GVC[1]) and, in turn, transformed the dynamics of international trade. The question at the heart of this discourse is, Do ICT spur GVC participation? In other words, do these digital technologies facilitate and encourage more countries to actively engage in GVC? How does this work in Africa compared to the World?

As ICT advance and become more pervasive, they hold the potential to reshape traditional economic structures and redefine the roles of nations and corporations in global trade. This work delves into the role of ICTs in shaping and expanding global value chains, exploring the mechanisms through which ICT use influences participation, and shedding light on the implications for economic growth, development, and equitable distribution of gains in the context of the globalized world.

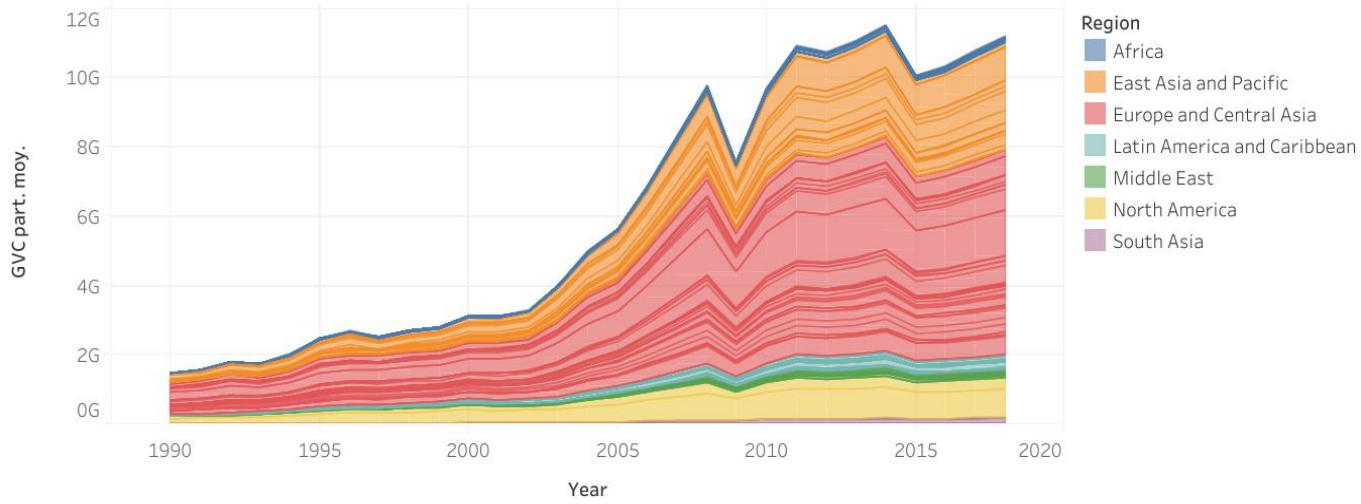
Despite the rather weak empirical evidence, scholars agree on the fact that information and transportation technologies constitute a driving factor in high participation in GVC (Freund and Weinhold, 2002; Clarke and Wallsten, 2006; Foster et al, 2018). A report by the World Bank (2020) demonstrates the developmental benefits of GVCs through productivity gains, higher income per capita and poverty reduction. In this study, we refer to GVC participation as the extent to which countries are interconnected within global production networks, contributing to the production and distribution of goods and services on a global scale. This GVC participation is captured using a measure of the GVC index collected from the UNCTAD-EROA Global Value Chains database.

The first figure depicting trends of GVC participation by region presents intriguing insights into the evolving dynamics of international trade and economic integration. Since the 2000s, it is evident that GVC participation has witnessed a remarkable surge, signifying the increasing interdependence and interconnectedness of economies on a global scale. One prominent observation from the figure is the substantial gap between Europe and Central Asia (ECA) and the rest of the regions. ECA demonstrates a significantly higher level of GVC participation, indicating a robust integration of countries within the region into global production networks. Following closely behind ECA, the East Asia and Pacific (EAP) region also displays a notable lead in GVC participation. This trend is reflective of the region's economic powerhouses, such

[1] A common definition of GVC following Antras (2020), “A global value chain or GVC consists of a series of stages involved in producing a product or service that is sold to consumers, with each stage adding value, and with at least two stages being produced in different countries. A firm participates in a GVC if it produces at least one stage in a GVC" (p. 543).

as China, Japan, and South Korea (refer to the GVC map in appendix Figure A3), which have capitalized on ICT advancements, skilled labor, and favorable trade policies to become key players in global supply chains (Torsekar and VerWey, 2019). However, the most striking aspect of the figure is the comparatively lower GVC participation index for Africa. Despite the rapid growth in GVC participation worldwide, Africa seems to lag behind in fully harnessing its potential within global value chains. Some countries stand out and display the highest levels of integration into the global value chain for the region, such as South Africa, Algeria, Nigeria, Morocco and Egypt, respectively (See the GVC mapping in appendix Figure A3).

Figure 1: Evolution of GVC participation by region



Source: Author using the UNCTAD-EROA Global Value Chains database.

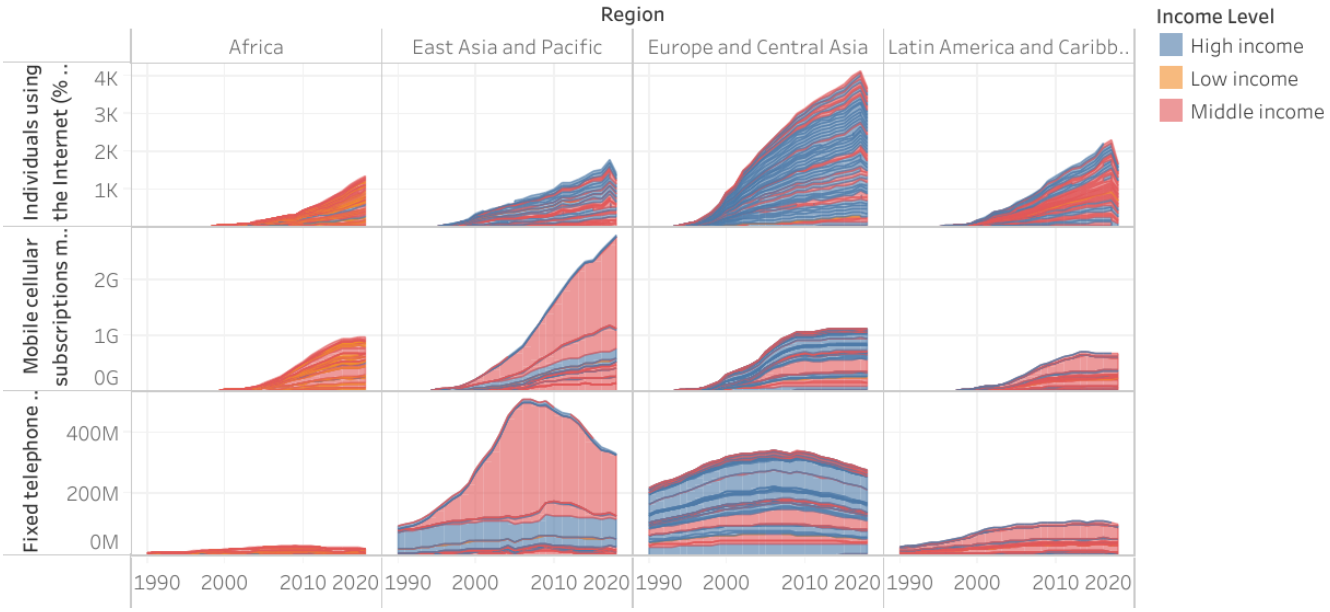
This overall increasing trend of integration into the global value chain is synonymous with an increase in the fragmentation of production. In other words, production, which once took place mostly close to major input suppliers (or consumers in end markets), now increasingly takes place where the necessary skills and materials are readily available at competitive quality and cost. With this fragmentation of production comes new opportunities for developing countries in particular to enter global markets as suppliers of components or services without having to set up the entire value chain. Baldwin (2011) shows that fragmentation affects all stages of the production process of a good including research and development, design, production of intermediate goods, assembly, marketing, and distribution. This great international fragmentation of production, which increased in the 1990s, has contributed positively to the expansion of international trade over the past thirty years. It has been made possible by technological advances, in particular those related to ICT infrastructure, which have considerably reduced barriers to international trade. However, the use of ICT in the majority of developing countries remains very low, particularly in Africa.

Figure 2 depicting the evolution of three dimensions of ICT use, namely internet, mobile phone, and fixed telephone line, across different regions of the world, provides valuable insights into the technological advancements and disparities among these regions. Firstly, it is evident that ECA and East Asia and EAP regions have emerged as dominant players in almost all the three dimensions of ICT. The ECA and EAP regions respectively exhibit impressive

growth rates in internet usage and mobile phone adoption, showcasing their strong embrace of modern technologies and their responsiveness to digital transformation. In contrast, Africa stands out as a region that is still lagging behind in ICT adoption, particularly concerning fixed telephone use. While Africa has shown a steady increase in internet use and mobile phone adoption, the relatively low level of fixed telephone usage has remained stagnant for the past two decades.

Although the continent remains at the bottom of the global rankings table when it comes to developing ICTs and harnessing their potential. The diffusion of ICTs on the continent has greatly accelerated in recent years. According to the GSM Association report (2017) the average annual growth rate of the diffusion of ICT exceeds 6%, with a meteoric rise in mobile telephones (the strongest in the world) which has overwhelmed fixed telephony. The diffusion of ICTs has been accelerated in some places compared to others. Specifically, the increase in internet penetration has been mainly observed in Nigeria, South Africa, Kenya and some North African countries. Also, mobile telephony remains the most widely used technology in Africa (See the ICT mapping in appendix A4 for details).

Figure 2: Trends in three dimensions of ICT by region, and income groups



Source: Author using the WDI of the World Bank database.

This study contributes to the literature on the effect of ICT use on GVC participation in two ways. First, it recognizes that both higher internet penetration and mobile telephone use lead to more intensive participation in GVC, taking into account the endogeneity of ICT use. The results of the dynamic panel depict the coefficients of internet and mobile telephone with positive and significant effects, but the coefficient of the fixed telephone is positive but significant with less specification. Second, it identifies channels through which this effect is accentuated. Cross variables with the three dimensions of ICT are added to the model. The net effects of ICT on participation in GVC are positive and significant from the complementarity between the internet and both trade and foreign direct investment, and the interaction between mobile phones and trade.

The remaining article is organized into 4 sections; section 2 sets the theoretical framework on the relationship between ICT and GVC participation. Section 3 describes the empirical strategy and the procedure of data collection and sources. Section 4 lays out empirical findings and the results of robustness exercise. Lastly, section 5 gives concluding remarks.

2. Theoretical Background

This study is grounded in the transaction cost theory (Williamson, 1973, 1975, 1979, 1985), which posits that the structure and boundaries of firms and markets are shaped by efforts to minimize the costs of economic exchange—such as searching for information, negotiating contracts, and coordinating activities. In the context of GVC, digital technologies like internet connectivity and mobile communications reduce these transaction costs by enabling faster information flows, improving coordination across borders, and lowering the barriers to participating in international production networks. This section presents the theoretical background underpinning the ICT–GVC nexus, structured into three thematic sub-sections: (1) digital technologies and GVC participation, (2) the mechanisms and context of ICT influence, and (3) the conceptual framework and research hypotheses.

2.1. Digital Technologies and GVC Participation

The adoption of digital technologies has reshaped the organization of production and trade, facilitating countries and firms' integration into international production networks. Recent research underscores how technologies associated with the Fourth Industrial Revolution (Industry 4.0) are reshaping the market dynamics of manufacturing, coordination, and cross-border collaboration (Fedyunina et al, 2024; Dalenogare et al, 2018; Frank et al, 2019). These technologies—including ICTs—reduce transaction costs, enable real-time coordination, and enhance firm-level agility in global production systems (Hallward-Driemeier and Nayyar, 2017).

Micro-level evidence shows that ICT adoption increases firm competitiveness by lowering communication costs and facilitating engagement with foreign suppliers, distributors, and customers (Jean et al, 2010; De Marchi et al, 2018). This results in stronger export capabilities and more active participation in GVCs, particularly among small and medium-sized enterprises (Clarke, 2008; Hagsten and Kotnik, 2017; Gopalan et al, 2022). ICTs enable firms not only to access global markets but also to reposition themselves within the value chain, capturing higher value-added segments through enhanced connectivity and knowledge exchange (Kano et al, 2020).

However, the literature also identifies a duality in the effects of digitalization. While ICTs promote outward orientation, some studies suggest that digitalization could lead to reshoring or reduced international fragmentation (Dachs et al, 2019; Fort, 2017), thus potentially decreasing certain types of GVC involvement.

2.2. Channels of ICT Influence: Trade and FDI

ICTs contribute to GVC participation both directly—by lowering entry barriers and enhancing coordination—and indirectly—by boosting productivity and expanding market access. Two key transmission channels are frequently emphasized in the literature: trade openness and foreign direct investment (FDI).

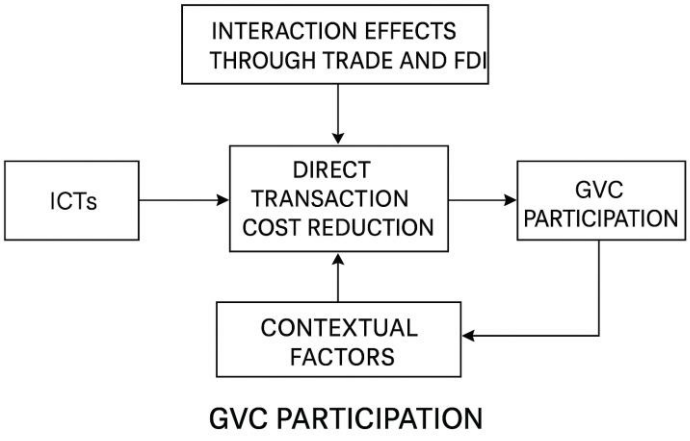
First, ICTs enhance the trade channel by enabling firms to access international markets, communicate with buyers and suppliers, and deliver digital or digitally-enhanced products (Cardona et al, 2013; Cassetta et al, 2020). In trade-intensive economies, ICT adoption tends to produce stronger effects on GVC participation due to greater exposure to global demand and standards.

Second, FDI represents another potential transmission mechanism. Through ICT-enabled communication and knowledge sharing, multinational enterprises may embed local firms into their global supply networks (Jean et al, 2010; Kano et al, 2020). However, the literature also highlights that this channel is contingent on absorptive capacity and complementary institutional support (Heavin and Fitzgerald, 2004; Añón Higón et al, 2025). In low-income regions, such as parts of Africa, the complementarity between FDI and ICT appears weaker, possibly due to mismatched investment priorities or lack of supportive infrastructure (Foster et al, 2018).

2.3 Conceptual Framework and Research Hypotheses

ICT are theorized to reduce information frictions, lower transaction costs, improve coordination across borders, and enable participation in geographically dispersed production systems. These effects can be direct—facilitating firm-level integration into international supply chains—or indirect—operating through enhanced trade flows or improved attractiveness to foreign direct investment (FDI). The conceptual framework of this study builds on these mechanisms and incorporates regional considerations, particularly for Africa, where ICT diffusion patterns differ from global trends (Figure 3).

Figure 3: Conceptual model of ICTs as determinants of GVC participation



Source: Author's own construction.

We posit that ICT adoption—proxied by mobile subscriptions, internet penetration, and fixed-line usage—influences GVC integration through both standalone effects and interaction effects with trade and FDI. The following five hypotheses are formulated to reflect this framework:

H1: Higher levels of ICT adoption significantly increase a country's participation in global value chains (GVCs).

ICTs lower barriers to international production and improve firm connectivity across borders. As digital tools reduce communication costs and enable real-time information exchange, they enhance the capacity of domestic firms to integrate into GVCs—either as suppliers of intermediate goods or as final assemblers. Evidence from international trade and innovation literature (Cassetta et al, 2020; Añón Higón et al, 2025) consistently shows that digitalization increases both the probability and intensity of export participation. At the national level, higher ICT adoption is linked to better infrastructure, improved logistics, and reduced entry costs into international production networks.

H2: The positive effect of ICTs on GVC participation is amplified in economies with greater trade openness.

Trade openness is a key enabler of GVC integration, as it allows firms to source inputs and sell outputs across borders. When coupled with robust ICT infrastructure, trade policies become even more effective in embedding domestic production into international networks. ICTs enhance market access, improve the discoverability of partners, and facilitate compliance with standards and documentation—all critical in cross-border trade. This interaction is supported by literature showing that digital readiness strengthens the impact of trade liberalization on international integration (Luong and Nguyen, 2021; Freund and Weinhold, 2004).

H3: The complementarity between ICT adoption and foreign direct investment (FDI) does not consistently enhance GVC participation in Africa.

FDI is commonly seen as a conduit for technology transfer and GVC entry, but in many African contexts, the complementarities between ICT and FDI are weak or underutilized. The absorptive capacity of local firms, weak institutional frameworks, and insufficient linkages between foreign and domestic firms may dampen the positive spillovers from FDI. Some studies (Foster et al, 2018; Karamujic, 2025) highlight the risk that FDI may remain enclave-oriented, with minimal integration into the local economy—even when ICT infrastructure exists. As such, the expected synergy between ICT and FDI may not hold uniformly, particularly in low-income settings.

H4: The effect of ICTs on GVC participation is more pronounced in African countries compared to the global average.

African countries often leapfrog traditional infrastructure through mobile and internet-based technologies, making the marginal returns to ICT investment particularly high. With mobile penetration often outpacing fixed-line development, ICTs serve as a key enabler of market access and digital inclusion. As noted in recent studies (Añón Higón et al, 2025; Gopalan et al, 2022), the transformational impact of digital tools in Africa is heightened by structural

constraints: where formal trade institutions are weaker, ICTs can substitute by improving transparency, logistics, and business-to-business connectivity.

H5: Among ICT components, internet penetration is the most significant predictor of increased GVC participation.

While ICTs broadly support GVC engagement, internet access in particular provides a dynamic platform for market search, digital trade, customer relationship management, and real-time supply chain coordination. Unlike mobile telephony, which supports voice communication, internet connectivity enables complex interactions including e-commerce, online contracting, and digital service delivery. This aligns with findings from Clarke (2008), Fernandes et al. (2019), and De Marchi et al (2018), who identify internet penetration as a key determinant of export growth and firm internationalization.

3. Empirical strategy

3.1. Method

This work mainly focuses on making an in-depth examination of the relationship between ICTs and participation in the global value chain with data on several countries and covering a large period. At first glance, suppose a non-dynamic linear model which will serve as the basis, with the following form:

$$GVC_{it} = \alpha_i + ICT'_{it}\beta + Z'_{it}\pi + \epsilon_{it} \qquad (1)$$

This equation mainly explains the relationship between the use of information and communication technologies (ICT) and participation in the global value chain (GVC). Z_{it} represents the vector of control variables. A naive estimation of this model is done using the ordinary least squares (OLS) technique. However, it becomes biased when there is any potential problem of autocorrelation or individual heterogeneity. The autocorrelation tests on the variables are carried out as a prelude to the estimation of the model. But the problem of individual heterogeneity remains, and the results are biased when this is not taken into account. Several recent works apply the fixed effects (FE) approach for non-dynamic linear models to take into account the potential problem of individual heterogeneity (Amendolagine et al, 2019; Djoumessi, 2021, 2022).

A non-negligeable difference exists between non-dynamic linear models with fixed effects and random effects. In the first case, the fixed effects are unconstrained. Consequently, they can, implicitly, be correlated with the explanatory variables. In the second case, the random effect is a disturbance without correlation with the explanatory variables. This is a very restrictive assumption (Djoumessi, 2021).

Subsequently, the analysis of the transmission channels through which the use of ICTs affects participation in the global value chain is made adding to the model the cross variables of both trade (Trade) and foreign direct investment (FDI) with the different dimensions of ICTs. The new equation is written as follows:

$$GVC_{it} = \alpha_i + \sum_k \beta_k ICT_{kit} + \sum_k \delta_k (Trade_{kit} \times ICT_{kit}) + \sum_k \delta_k (FDI_{kit} \times ICT_{kit}) + Z'_{it}\pi + v_{it} \quad (2)$$

However, several authors argue about the reversible nature and the potential endogeneity bias of the empirical nexus ICT- integration into the global value chain (Fort, 2016, Gopalan et al, 2022). Hence all the interest in analyzing this relationship in a dynamic linear model considered in a second step. A dynamic linear model is a model in which one or more lags of the dependent variable appear as explanatory variables. The new model is written in the following form:

$$GVC_{it} = \alpha_i + \gamma GVC_{it-1} + ICT'_{it}\beta + Z'_{it}\pi + \varepsilon_{it} \quad (3)$$

GVC_{it-1} represents the principal novelty of this equation, and at the same time the new source of the difficulties associated with the estimation of this type of model. The generalized method of moments (GMM) is an estimation technique very common to this type of model. Originally introduced by Arellano and Bond (1991), the GMM method is based on the orthogonality conditions between the lagged variables and the error term, both in first differences and in level. When the dynamic model is expressed in first differences, the instruments are in level, and vice versa.

There are two variants of the dynamic panel GMM estimator: the first difference GMM estimator and the system GMM estimator. In this work, the choice concerns the GMM estimator in a system which already takes into account the major problems of the GMM estimator in difference. Further, Blundel and Bond (1998) showed using Monte Carlo simulations that the system GMM estimator is more efficient than that in the first differences, the latter gives biased results in finite samples when the instruments are weak. Our system equation takes the following form:

$$\begin{cases} \Delta GVC_{it} = \alpha_i + \gamma \Delta GVC_{it-1} + \Delta ICT'_{it}\beta + \Delta Z'_{it}\pi + \Delta\varepsilon_{it} \\ GVC_{it} = \alpha_i + \gamma GVC_{it-1} + ICT'_{it}\beta + Z'_{it}\pi + \varepsilon_{it} \end{cases} \quad (4)$$

The system GMM estimator of Blundel and Bond (1998) combines first difference equations with level equations. The instruments in the first difference equation are expressed in level, and vice versa. In this specification, we treat ICT variables (internet penetration, mobile subscriptions, and fixed telephone lines), as well as trade openness and FDI, as predetermined[2]. This allows for the possibility of reverse causality—where higher GVC participation may influence future ICT investment or trade exposure. In contrast, GDP, industry value added, technological progress (patent applications), and year dummies are treated as exogenous. For the differenced equation, lagged levels (t−2 or earlier) of the predetermined variables are used as instruments; for the level equation, their lagged first differences are employed. This approach balances consistency and instrument relevance while

[2] Variables are classified as follows for instrument construction in the system GMM framework:

- Predetermined: ICT variables (internet, mobile, fixed lines), trade openness, FDI.
- Exogenous: GDP, industry value added, technological progress (patents), year dummies.

Instruments for predetermined variables are constructed using lagged levels (for the differenced equation) and lagged first differences (for the level equation), consistent with system GMM methodology (Roodman, 2009).

controlling for unobserved heterogeneity and persistence in GVC participation. The validity of the selected instruments will be confirmed or invalidated, based on the tests of Hansen and Sargan (Arellano, 2002).

Five main reasons justify the choice of a system GMM strategy: (i) the number of cross-sections ($N_{World} = 217\ or\ N_{Africa} = 53$) is higher than the number of years (T=23) in each time series (T<N); (ii) the GVC variable is persistence because its respective correlation coefficient with its first lag is higher than 0.800, which is the rule of thumb for establishing persistence in a dependent variable; (iii) Our panel data is consistent with the GMM approach and so, it does not eliminate cross-country variations; (iv) it deals with the endogeneity issue by controlling for time-invariant omitted variables and simultaneity; and (v) the approach mitigates potential small sample biases from the difference estimator. This last reason is put forward by Bond et al (2001) to prefer the system GMM estimator proposed by Arellano and Bover (1995) and Blundell and Bond (1998) to the difference estimation by Arellano and Bond (1991).

Then, this work applies a two-step GMM deviations instead of differencing following Roodman's (2009a, 2009b)'s specification, an extension of Arellano and Bover (1995) that restrict overidentification and limits the proliferation of instruments (Love and Zicchino, 2006). The two-step is preferred to the one-step because the latter is based on the homoscedasticity assumption while the former controls for heteroscedasticity (Asongu, 2017).

For the interaction model, it is important to discuss two key aspects of the GMM approach: identification and exclusion restrictions. First, the identification strategy that employs years and time-invariant indicators as strictly exogenous (Roodman, 2009b; Dewan and Ramaprasad, 2014), while this work considers ICT to depict strict exogeneity through the line: the effect of ICT on GVC participation through trade and foreign direct investment. Then, with the exclusion limitations or restrictions, the strictly defined exogenous variables (ICT and time-invariant indicators) have an influence on the GVC participation exclusively through the suspected endogenous variables. The statistical validity of this second key aspect is examined using the Difference in Hansen Test (DHT) for instrument exogeneity. The null hypothesis of the DHT related to instrumental variables (IV) (ICT, year, eq(diff)) should not be rejected for exclusion restrictions assumption to hold.

In the interaction model, the coefficient no longer indicates the average effect of variables as they do in a linear-additive model. Brambor et al (2005) show that interpreting the constitutive elements of interaction terms as unconditional or average effects mislead the implications and propose an alternative as "net effect" or the threshold effect called minimum conditions for desired impacts proposed by Cummins (2000).

3.2. Data collection and sources

Data used in this study come from the World Development Indicators (WDI) of the World Bank and the UNCTAD-EROA Global Value Chains database. The data are collected on a sample of 217 countries covering the 1996 to 2018 period.

In line with other empirical studies on the global value chain (Amendolagine et al, 2019; Belotti et al, 2020; Lim, 2021), the dependent variable GVC participation is proxied by a GVC index provided by the EROA database. For country i at the time t, the estimated value of GVC participation follows the formula (Koopmans et al, 2014):

$$GVC\ participation_{it} = (DVX_{it} + FVA_{it})/Exports_{it} \qquad (5)$$

The indirect Domestic Value Added (DVX) refers to the portion of a country's domestic value that is incorporated into the exports of foreign partners, reflecting how a country's production contributes indirectly to global trade through intermediate goods or services. On the other hand, Foreign Value Added (FVA) represents the foreign content embedded in a country's exports, highlighting the degree to which each country's exports rely on inputs from foreign producers. Together, these concepts help to capture the interconnectedness of global value chains and the extent of cross-border production sharing.

Table 1: Descriptive statistics

Variable	Definition	Obs.	Mean	Std. dev.
Africa				
GVC	Global Value Chain participation	920	12.9362	1.905494
Internet	Internet penetration	1,156	0.409355	2.51603
Mobile	Mobile phone subscriptions	1,132	13.59643	2.827003
Ftelephone	Fixed telephone subscriptions	1,162	11.40689	1.758263
FDI	Foreign Direct Investments	1,097	0.716448	1.416102
GDP	Gross Domestic product	1,168	23.04852	1.568705
Trade	Trade	1,072	4.11442	0.457804
Industry VA	Value-added of industry	1,051	21.61375	1.835004
Technological progress	Technological progress	295	3.301237	2.047134
World				
GVC	Global Value Chain partipation	3,795	14.67378	2.681942
Internet	Internet penetration	4,492	2.042126	2.33178
Mobile	Mobile phone subscriptions	4,554	13.84904	3.02434
Ftelephone	Fixed telephone subscriptions	4,698	12.75067	2.485962
FDI	Foreign Direct Investments	4,076	1.01976	1.394444
GDP	Gross Domestic product	4,623	23.85376	2.346456
Trade	Trade	4,127	4.340372	0.546195
Industry VA	Value-added of industry	4,077	22.60731	2.539538
Technological progress	Technological progress	2,336	5.43204	2.745503

Source: Authors' calculation using WDI and EROA data.

Then as independent variables, the main interest variable is ICT operationalized using three variables: (i) Mobile cellular subscriptions, which refers to all subscriptions to a mobile cell

that offers voice communications; (ii) Fixed telephone subscriptions, which include all active fixed telephone line; and (iii) The internet, which represents the share of the population using internet. These indicators are drawn from the WDI and follow standard definitions by the International Telecommunication Union (ITU). Mobile cellular subscriptions capture the extent of mobile access in a country and reflect widespread adoption of voice and SMS-enabled connectivity. Internet usage is measured as the share of the population actively using the internet. Fixed telephone subscriptions are included to reflect legacy infrastructure and allow comparisons across ICT technologies. These variables together capture the communications infrastructure dimension of ICT, which is directly relevant to GVC participation. Several empirical studies measured ICT adoption with the same dimensions (Avom et al, 2020; Djoumessi and Eyike Mbongo, 2021). The literature most of the time shows the positive effect of the internet on trade services (Freund and Weinhold, 2002; Yushkova, 2013), economic growth (Steinmueller, 2011; Keller, 2004; Henry et al, 2009), labour productivity (Van Ark et al, 2008; Strauss and Samkharadze, 2011; Timmer et al, 2011). It is expected a positive significant impact on the three dimensions of ICT on participation in GVC. While computing infrastructure is undeniably part of the broader ICT ecosystem, our conceptual and empirical focus centers on the connectivity and information exchange functions of ICT that directly support cross-border integration. Communications infrastructure better captures these dimensions, particularly in the context of GVC participation, which relies heavily on network access and real-time coordination across geographically dispersed actors.

To ensure robust estimation of the relationship between ICTs and GVC participation, we include a carefully selected set of control variables based on theoretical relevance and empirical precedent in the literature on international trade, economic development, and digitalization (Amador and Cabral, 2017; Grundke et al, 2017; Añón Higón et al, 2025). First, we control for GDP (in logs), which captures the overall level of economic activity and market size. Larger economies are more likely to participate in GVCs due to economies of scale, better infrastructure, and higher institutional capacity. Second, we include trade openness (total trade as a percentage of GDP), which is widely recognized as a key enabler of GVC integration. More open economies tend to engage more actively in intermediate goods trade and offshoring. Third, we control for foreign direct investment (FDI) inflows, as FDI often facilitates GVC integration by embedding domestic firms into multinational production networks and transferring knowledge and technology (Jean et al, 2010; Kano et al, 2020).

We also include industry value-added (as a share of GDP) to account for the relative size and development of the industrial sector, which is the core arena for GVC-related activities, especially in manufacturing. Countries with stronger industrial bases are more likely to participate in production sharing arrangements. In addition, technological progress is proxied by patent applications or similar indicators, following the innovation–GVC literature (Reddy et al, 2021), to capture a country's capacity to generate or absorb innovations relevant to international production. These variables jointly control for structural, institutional, and productivity-related factors that are theoretically linked to both ICT adoption and GVC participation, thereby reducing the risk of omitted variable bias and improving causal identification. Details on statistics of these variables are resented in table 1.

4. Results and discussion

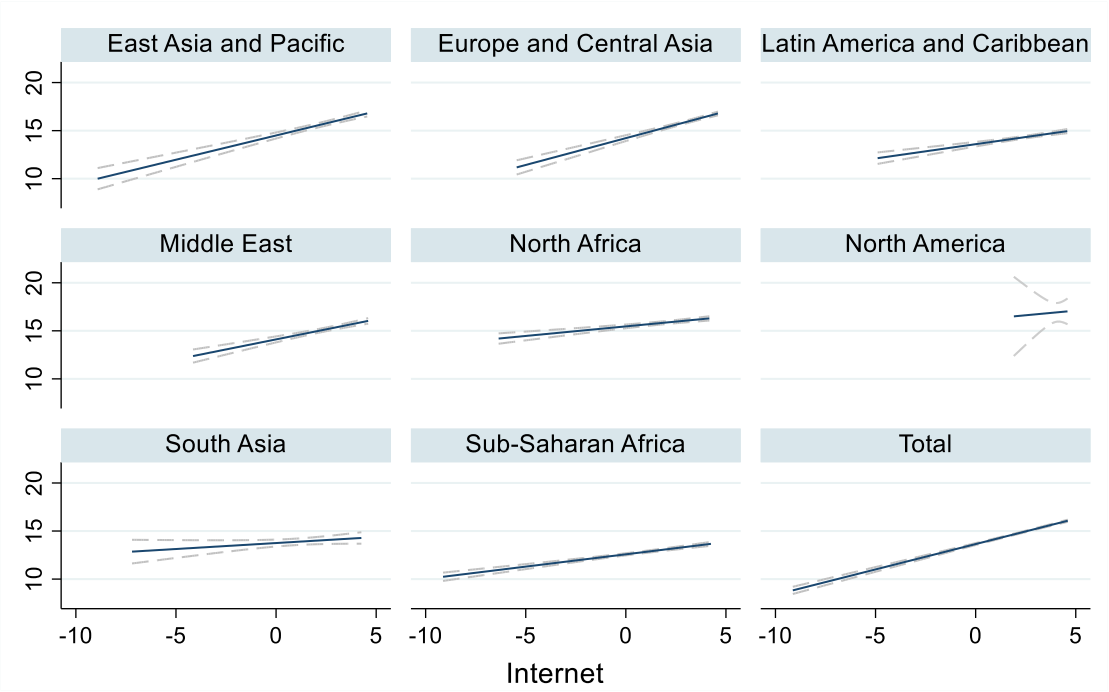
4.1. Baseline results

The baseline regression of the impact of ICT use on participation in GVC is done through the FE approach and the results are shown in Table 2. Although ICT infrastructure is typically deployed in parallel—enabling mobile, internet, and fixed-line connectivity simultaneously—we estimate the effects of each ICT component in separate models to address multicollinearity concerns and to isolate their individual contributions. As shown in Appendix Table A4, the inclusion of ICT variables increases the R^2 from 0.752 to 0.813 in a standard OLS model—a gain of around 6 percentage points. This demonstrates the incremental contribution of ICTs to explaining GVC participation, beyond structural controls. In the full model with fixed effects, R^2 rises to 0.997, but this should be interpreted cautiously due to the inclusion of country and year dummies.

As for the dimensions of ICT, the positive and significant effects of both internet and mobile phone on GVC participation both in Africa and the World suggest that these ICT dimensions play a crucial role in fostering global economic integration. The widespread use of the internet and mobile phones enables seamless communication, access to global markets, and efficient coordination among GVC participants, promoting higher participation and value addition. These results are in a similar vein to Gopalan et al (2022), which find a positive and significant impact of high-speed internet on GVC participation. Also, Clarke and Wallsten (2006) find that greater use of the internet in developing countries increases exports to countries with a high rate of internet penetration. Later, the fitted plots of the ICT effect on participation in GVC help to draw these results. Figure 4 depicts the increasing trend of the relationship between internet penetration and GVC participation in all sub-regions (see figures A1 and A2 in the appendix for the plots with mobile phone and fixed telephone).

The negative and nonsignificant effect of fixed telephone on GVC participation in Africa and the negative and significant effect in the World indicate a shift away from traditional landline communication in favor of more advanced ICT technologies. This result should be interpreted cautiously. Fixed telephone infrastructure represents a legacy technology that has become less relevant to modern trade and production coordination. As illustrated in Figure 2, there has been a marked decline in the use of fixed telephone lines globally since the early 2000s, a trend observed across all world regions. In many countries, particularly in the Global South, digital development has bypassed fixed-line infrastructure in favor of mobile and broadband technologies, which are more scalable and adaptable to GVC needs. Thus, higher fixed-line density may reflect a technological lag or investment inertia, rather than effective digital readiness. This suggests that fixed telephony is no longer a suitable proxy for ICT in the context of global production integration and should be interpreted accordingly.

Figure 4: Fitted plot of Internet use with GVC participation, by region



Source: Authors using WDI and EROA data.

As regards the control variables, the surprising negative and significant effect of FDI inflows on GVC participation in both Africa and the World raises interesting questions. One possible explanation could be that FDI inflows are not necessarily linked to GVC participation but are directed towards other economic activities, potentially creating crowding-out effects, where local firms face increased competition from foreign companies, leading to reduced opportunities for GVC integration. Indeed, it is not recommended to draw any conclusion at this stage of the analysis.

The strong positive and significant effects of trade, GDP, and industry value-added on GVC participation in both Africa and the World align with conventional economic theory. Higher trade volumes, well performing industry, and vibrant overall economic activity are indicative of increased participation in global supply chains, as they offer favorable market conditions and a broader range of production inputs. Then, the positive and significant effect of technological progress on GVC participation in the World across the three specifications highlights the importance of embracing technological advancements for global economic integration. However, the mixed results in Africa suggest that the relationship between technological progress and GVC participation may vary depending on the extent of technology diffusion.

Table 2: Fixed effects estimates of ICT on GVC participation

	Africa			World		
VARIABLES	**(1)**	**(2)**	**(3)**	**(4)**	**(5)**	**(6)**
Internet	0.0510***			0.0235***		
	(0.0144)			(0.00476)		
Mobile		0.0400***			0.0147***	
		(0.0107)			(0.00417)	
Fixed telephone			-0.0362			-0.0316***
			(0.0225)			(0.0107)
FDI	-0.0486***	-0.0482***	-0.0490***	-0.0184***	-0.0204***	-0.0168***
	(0.0109)	(0.0109)	(0.0113)	(0.00380)	(0.00385)	(0.00380)
trade	0.152***	0.127***	-0.0979*	0.192***	0.205***	0.208***
	(0.0471)	(0.0463)	(0.0512)	(0.0210)	(0.0210)	(0.0209)
GDP	1.318***	1.270***	1.378***	0.585***	0.580***	0.670***
	(0.181)	(0.182)	(0.187)	(0.0560)	(0.0566)	(0.0557)
Industry VA	0.395***	0.392***	0.411***	0.0778**	0.0886**	0.0805**
	(0.100)	(0.0997)	(0.104)	(0.0387)	(0.0388)	(0.0387)
Technological progress	0.0092*	0.00977	-0.00878	-0.0171***	0.0138**	0.0150***
	(0.0128)	(0.0127)	(0.0133)	(0.00537)	(0.00541)	(0.00537)
Constant	-7.554***	-7.133***	-9.813***	-3.219***	-4.336***	-3.076***
	(2.341)	(2.342)	(2.893)	(0.678)	(0.662)	(0.816)
Country & Year FE	Yes	Yes	Yes	Yes	Yes	Yes
F-test	1510.22***	1591.63***	1524.09***	4465.9***	4406.68***	4437.49***
Observations	222	222	221	1,856	1,872	1,870
R-squared	0.998	0.998	0.998	0.997	0.997	0.997

Robust standard errors in parentheses; *** p<0.01, ** p<0.05, * p<0.1. Source: Authors' calculation using WDI and EROA data.

The baseline results established it is now important to focus on addressing the endogeneity issues highlighted in the empirical strategy. As mentioned, the relationship between ICT and participation in global value chains might suffer from potential reverse causality where it is rather an integration into GVC that drive the adoption of ICT. To address this concern, a dynamic linear model as specified in equation 3 is estimated using the system GMM estimator. Furthermore, we reserve interaction modeling for the dynamic panel system estimations, where endogeneity and time dependence are better addressed.

4.2. ICTs effects on GVC participation: results with the system GMM estimator

Table 3 depicts the results of the dynamic panel model on the relationship between ICT and participation in GVC in Africa and the World. The results of the Hansen and Difference-in-Hansen tests support the validity of our instruments, as p-values are above conventional thresholds, suggesting that the instrument set is not overfitting the endogenous variables. The novelty is the new variable lag of the dependent variable that shows a positive and significant effect on its growth. There is a slight change in the results of the effect of ICT. Only internet and mobile telephone are observed to have a significant increasing contribution to the integration into GVA both in Africa and the World. These findings confirm Hypothesis 1 *(H1): Higher levels of ICT adoption significantly increase a country's participation in global value chains (GVCs)*. This confirms the central role of modern ICT infrastructure—particularly mobile and internet technologies—in facilitating firm-level coordination, cross-border connectivity, and access to international production networks.

The coefficients of fixed telephone are positive but statistically insignificant. This aligns with the notion that fixed telephony, as a legacy technology, no longer plays a central role in digital trade or production coordination, and supports the view that not all ICT components are equally relevant for modern GVC engagement.

In terms of the impact of control variables in this more robust approach, the FDI shows a mixed effect on GVC participation. Globally, the positive and significant effect of FDI on GVC participation suggest that any increase in foreign investment inflows fosters international integration. However, the counterintuitive results are still observed in the case of Africa. Further research is needed to explore this unexpected finding. Then, the coefficients of trade depict a strong positive and significant effect on participation in GVC for all specifications. Similar results are found for the industry value-added and technological progress but only at the World level. In Africa, the effect of industry value-added is positive and significant in the second and third model, and the technological progress, which was depicting a significant effect in one model for the baseline result, has positive but nonsignificant influence in GVC participation.

Table 3: Results of the system GMM regression

	Africa			World		
VARIABLES	**(1)**	**(2)**	**(3)**	**(4)**	**(5)**	**(6)**
L.GVC	0.864***	0.838***	0.877***	0.777***	0.827***	0.869***
	(0.0527)	(0.0722)	(0.0653)	(0.0293)	(0.0318)	(0.0243)
Internet	0.00628**			0.0440***		
	(0.0178)			(0.0104)		
Mobile		0.00233***			0.0303***	
		(0.0141)			(0.0115)	
Fixed telephone			0.0218			0.0260
			(0.0346)			(0.0232)
FDI	-0.0425	-0.0553*	-0.0670	0.0333	0.0302*	0.0480**
	(0.0588)	(0.0316)	(0.0519)	(0.0207)	(0.0203)	(0.0208)
Trade	0.229**	0.283***	0.274**	0.227***	0.224***	0.237***
	(0.147)	(0.120)	(0.148)	(0.0719)	(0.0728)	(0.0672)
Industry VA	0.136	0.139*	0.125**	0.131**	0.0927*	0.0612
	(0.0881)	(0.0748)	(0.0563)	(0.0525)	(0.0556)	(0.0519)
Technological progress	0.0578	0.0712	0.0293	0.0998***	0.0948***	0.0636***
	(0.0409)	(0.0578)	(0.0344)	(0.0284)	(0.0262)	(0.0239)
Constant	-2.192	-2.216	-2.474**	-1.186	-1.371	-1.096
	(1.926)	(1.580)	(0.984)	(0.995)	(1.133)	(1.026)
AR(1)	0.009	0.010	0.009	0.000	0.000	0.001
AR(2)	0.525	0.694	0.626	0.134	0.118	0.156
Sargan OIR	0.001	0.009	0.000	0.001	0.001	0.001
Hansen OIR	0.788	1.000	0.848	1.000	1.000	1.000
DHT for instruments						
(a) instruments for levels						
H excluding group	0.210	0.410	0.981	0.554	0.573	0.566
Dif (null, H=exogenous)	0.988	0.707	0.133	1.000	1.000	1.000
(b) IV (year, ICT, eq(diff))						
H excluding group	0.386	0.630	0.182	0.964	0.924	0.951
Dif (null, H=exogenous)	0.962	0.967	0.980	1.000	1.000	1.000
Wald test	3.5e+05***	8.5e+05***	3.5e+05***	3.9e+07***	5.2e+07***	6.1e+07***
Instruments	19	19	19	101	102	103
Observations	215	215	214	1,787	1,802	1,798
Number of countries	22	22	21	122	122	121

Robust standard errors in parentheses; *** p<0.01, ** p<0.05, * p<0.1. DHT: Difference in Hansen Test for Exogeneity of Instruments Subsets. Dif: Difference. OIR: Overidentifying Restrictions Test.
Source: Authors' calculation using WDI and EROA data.

4.3. Results of the interaction GMM model

This sub-section aims to check the assumption that trade and foreign direct investment driven by greater information and communication technologies adoption mainly contribute to participation in global value chains. For that purpose, the cross variables between the three dimensions of ICTS and both trade and FDI are added to the dynamic panel model. The results of the dynamic panel using the system GMM estimator are presented in table 3.

Table 4: Results of the system GMM of the interaction model

	Africa			World		
VARIABLES	**(1)**	**(2)**	**(3)**	**(4)**	**(5)**	**(6)**
L.GVC	0.977***	0.931***	0.906***	0.796***	0.838***	0.891***
	(0.108)	(0.0394)	(0.0684)	(0.0225)	(0.0245)	(0.0260)
Internet	**0.387****			**0.0390*****		
	(0.392)			(0.0929)		
Mobile		**0.334*****			**0.329*****	
		(0.203)			(0.126)	
Fixedtelephone			-0.552			-0.654
			(0.645)			(0.215)
FDI#Internet	-0.0109*			0.00911**		
	(0.0111)			(0.0104)		
Trade#Internet	**0.0102****			**0.00175*****		
	(0.0989)			(0.0242)		
FDI#Mobile		-0.0280			0.0217	
		(0.00880)			(0.0121)	
Trade#Mobile		**0.00856*****			**0.00892*****	
		(0.0516)			(0.0312)	
FDI#Fixedtelephone			-0.0209			0.00254
			(0.0262)			(0.0153)
Trade#Fixedtelephone			0.141			**0.0170*****
			(0.161)			(0.0521)
FDI	-0.0260	0.409**	0.240	-0.0198	0.358*	-0.0246
	(0.0315)	(0.138)	(0.350)	(0.0373)	(0.195)	(0.228)
Trade	**0.490*****	**0.230****	-0.623	**0.204****	**0.140*****	**0.083****
	(0.261)	(0.835)	(2.090)	(0.0933)	(0.497)	(0.747)
Industry VA	0.0386	0.0864**	0.0664*	0.156***	0.109***	0.0644
	(0.129)	(0.0553)	(0.0591)	(0.0267)	(0.0381)	(0.0561)
Technological progress	0.0160	0.0412	0.0459	0.0566***	0.0631***	0.0174
	(0.0409)	(0.0316)	(0.0499)	(0.0149)	(0.0172)	(0.0231)
Constant	-2.437	3.750	6.084	-1.723***	3.729	8.039**
	(2.188)	(3.874)	(8.668)	(0.586)	(2.368)	(3.465)
Net effects						
FDI	n.a	n.a	n.a	n.a	n.a	n.a
Trade	**0.494**	**0.346**	n.a	**0.205**	**0.262**	**n.a**
AR(1)	0.009	0.007	0.010	0.001	0.001	0.001
AR(2)	0.525	0.673	0.885	0.930	0.123	0.146
Sargan OIR	0.000	0.000	0.000	0.001	0.001	0.001

Hansen OIR	1.000	1.000	1.000	0.156	0.303	0.213
DHT for instruments						
(a) instruments for levels						
H excluding group	0.000	0.000	0.503	0.303	0.240	0.165
Dif (null, H=exogenous)	1.000	1.000	1.000	0.168	0.352	0.281
(b) IV(year, ICT, eq(diff))						
H excluding group	0.386	0.55	1.000	0.167	0.191	0.242
Dif (null, H=exogenous)	1.000	1.000	1.000	0.305	0.576	0.310
Wald test	1.2e+05***	6.2e+05***	9.7e+05***	6.06e+07***	4.03e+07***	2.8e+07***
Instruments	19	19	19	92	92	92
Observations	215	215	214	1,787	1,802	1,798
Number of countries	22	22	21	122	122	121

Robust standard errors in parentheses; *** p<0.01, ** p<0.05, * p<0.1. DHT: Difference in Hansen Test for Exogeneity of Instruments Subsets. Dif: Difference. OIR: Overidentifying Restrictions Test. na: not applicable because at least one estimated coefficient needed for the computation of net effects is not significant. Source: Authors' calculation using WDI and EROA data.

Four important statistical tests are used to evaluate the validity of the GMM approach (Asongu and De Moor, 2017): (i) the null hypothesis of the second-order Arellano and Bond auto-correlation test (AR(2)) in difference for the absence of autocorrelation in the residuals is preferred over the first-order; (ii) The validity of the instruments is confirmed through the non-significant Hansen over-identification restrictions (OIR) test more robust that the Sargan OIR test but weakened by instruments, so we try to ensure that instruments are lower than the number of cross sections; (iii) The strict exogeneity hypothesis is confirmed with the non-significant result of the Difference in Hansen Test (DHT), this also confirms the validity of the Hansen OIR test; and (iv) the Wald test shows the global validity of the estimated coefficients.

Results are essentially discussed in terms of "net impacts" of the complementarity between the three ICT dimensions and both trade and foreign direct investment on GVC participation following Brambor (2005). This notion of net impact is also consistent with recent literature (Tchamyou et al, 2019; Asongu, 2017). The net impact is computed in order to assess the overall effect of the interaction between the ICT's dimensions and both trade and FDI in influencing GVC participation. In the case of the internet dimension in Africa and the World (Model 1 and 4), for instance, the first column of table 3 depicts that the unconditional effect of trade is 0.490 while the conditional impact from the interaction between trade and internet is 0.0102, and the net effect from the interaction between internet and trade is 0.494 [(0.0102 × 0.409) + 0.490], in Africa. In this computation, 0.409 represents the mean value of internet penetration in the sample. Then, the fourth column shows a net effect of 0.205 from the interaction between trade and internet on GVC participation at the Global level. These results offer robust confirmation of Hypothesis 2 *(H2): The positive effect of ICTs on GVC participation is amplified in economies with greater trade openness*.

While this study focuses on Africa, the inclusion of a global sample allows us to draw useful contrasts that inform regional policy. Notably, the net effects of ICT–trade complementarities are stronger in Africa (0.346 – 0.494) than the World (0.205 – 0.262), suggesting that when African economies pursue trade openness in parallel with digital infrastructure development, the GVC returns are disproportionately higher. This confirms our Hypothesis 4 *(H4): The effect*

of ICTs on GVC participation is more pronounced in African countries compared to the World. This result is consistent with the notion of ICT-led leapfrogging in Africa, where digital tools substitute for gaps in physical and institutional infrastructure and enable integration despite structural constraints.

But this net effect is not computed in the case of the complementarity with FDI because at least one estimated coefficient needed for the computation is not significant. Then, we cannot confirm Hypothesis 3 *(H3): The complementarity between ICT adoption and foreign direct investment (FDI) does not consistently enhance GVC participation in Africa*—likely due to weak domestic linkages and limited spillovers in many recipient economies.

The remaining columns show the results of the complementarity with mobile phones and fixed telephones. First, with mobile phones, the net effect on GVC participation are positives of 0.346 and 0.262 in Africa and the World respectively, from the interaction with trade. Second, with fixed telephone, in both cases, the net effect is not computed for the same reasons already mentioned above.

Finally, the internet variable consistently emerges as the most robust and significant ICT component across all specifications—both in direct effect and in interaction with trade. This confirms Hypothesis 5 *(H5): Among ICT components, internet penetration is the most significant predictor of increased GVC participation*. The ability of the internet to support real-time coordination, digital trade platforms, e-commerce, and cross-border collaboration gives it a distinctive advantage over voice-based or legacy communication technologies.

5. Concluding remarks

This study investigates the nexus between ICT use and participation in GVC based on a sample of 32 African countries over the period 1996 to 2018. The baseline regression is done using a fixed-effects approach to control for potential unobserved confounders. Then to control the possibility that ICT use is endogenous, this relationship is estimated in a linear dynamic panel model with the system GMM estimator.

After correcting for potential endogeneity biases, the empirical results show that two dimensions of ICT, which are the internet and mobile telephone, have a significant and positive impact on participation in GVC both in Africa and the World. The positive impact of internet penetration on GVC participation is particularly noteworthy, as it suggests that Africa is capitalizing on the opportunities presented by the digital era to enhance its economic engagement with the world. The positive and significant effect of mobile phone adoption on GVC participation in Africa underscores the pivotal role of mobile technology in driving economic inclusion and global integration. Mobile phones provide a versatile and accessible means of communication, bridging the gap between remote regions and global markets. This finding highlights the transformative impact of mobile technology in facilitating trade and value chain activities in Africa, as businesses leverage the convenience and flexibility of mobile communication to intensify their participation in GVCs.

Further, potential channels through the effects of ICT on participation in GVC are tested by adding cross variables between the dimensions of ICT and both trade and foreign direct investment in the dynamic model. The key insight from the results is the complementarity between internet penetration, mobile phone adoption, and trade in intensifying GVC participation in Africa. The positive impact of internet and mobile phone usage, when combined with trade, creates synergies that result in higher GVC participation proportions in Africa compared to the World average. This suggests that the convergence of digital connectivity and trade opportunities enhances the region's ability to integrate into global value chains more effectively. As African firms leverage digital platforms to expand their reach, trade relationships become more accessible and efficient, leading to a reinforcing cycle of economic integration.

This study confirms that ICT adoption plays a vital role in facilitating participation in GVC, but it also reveals that not all ICT investments are equally effective, and their impacts vary significantly across contexts. First, internet penetration stands out as the most influential ICT component, suggesting that governments should prioritize investments in broadband and internet accessibility, rather than legacy fixed-line systems, which show limited or negative effects. Second, the interaction models demonstrate that ICT and trade openness are mutually reinforcing, particularly in African countries. This highlights the importance of coupling digital infrastructure strategies with trade facilitation policies to unlock their full potential. Third, the results indicate that FDI does not automatically enhance the ICT–GVC nexus in Africa, pointing to a need for policies that improve domestic absorptive capacity, strengthen linkages between foreign and local firms, and align investment flows with digital development objectives. Together, these findings call for a more tailored and integrated digital-industrial policy approach—one that goes beyond generic ICT expansion and strategically links technology, trade, and investment to promote deeper GVC integration.

While this study provides novel insights into the role of ICTs in shaping GVC participation, it is not without limitations. First, the use of country-level indicators may hide important heterogeneity at the firm or sector level, where GVC participation actually takes place. Second, our aggregation at the continental level, particularly for Africa, may mask sub-regional differences in ICT infrastructure, policy environments, and trade performance. Third, our ICT indicators are limited to communications infrastructure (internet, mobile, fixed telephony) and do not capture other dimensions of digitalization such as computing infrastructure, digital skills, or platform integration. Future research could build on this work by using micro-level (firm or industry) data to explore how ICT adoption interacts with firm characteristics, sectoral dynamics, and institutional environments to drive GVC integration.

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Reference

Ahmad, N. A., Ismail, N. W., & Hook, L. S. (2011). The role of ICT infrastructure on Malaysian trade. *Journal of Economics and Management*, 5 (1), 140, 148.

Atasoy, B. S. (2021). The determinants of export sophistication: Does digitalization matter? *International Journal of Finance & Economics*, 26(4), 5135-5159.

Amador, J., Cabral, S. (2017). Networks of value-added trade. *World Economy*. 40 (7), 1291–1313.

Amendolagine, V., Presbitero, A.F., Rabellotti, R. and Sanfilippo, M. (2019), "Local sourcing in developing countries: The role of foreign direct investments and global value chains", *World Development*, Vol. 113, pp. 73–88.

Añón Higón, D., Máñez, J. A., Sanchis, A., & Sanchis, J. A. (2025). Digitalisation and global value chain participation: evidence from Spanish manufacturing firms. *Industry and Innovation*, 1-36.

Arellano, M. (2002), "Sargan's intrumental variables estimation and the generalized method of moments", *Journal of Business & Economic Statistics*, Taylor & Francis, Vol. 20 No. 4, pp. 450–459.

Arellano, M. and Bond, S. (1991), "Some tests of specification for panel data: Monte Carlo evidence and an application to employment equations", *The Review of Economic Studies*, Wiley-Blackwell, Vol. 58 No. 2, pp. 277–297.

Asongu, S.A. and De Moor, L. (2017), "Financial globalisation dynamic thresholds for financial development: evidence from Africa", *The European Journal of Development Research*, Springer, Vol. 29 No. 1, pp. 192–212.

Asongu, S.A., Le Roux, S. and Biekpe, N. (2017), "Environmental degradation, ICT and inclusive development in Sub-Saharan Africa", *Energy Policy*, Vol. 111, pp. 353–361.

Avom, D., Nkengfack, H., Fotio, H.K. and Totouom, A. (2020), "ICT and environmental quality in Sub-Saharan Africa: Effects and transmission channels", *Technological Forecasting and Social Change*, Elsevier, Vol. 155, p. 120028.

Baldwin, R.E. (2011), "21st Century Regionalism: Filling the gap between 21st century trade and 20th century trade rules", *Available at SSRN 1869845*.

Belotti, F., Borin, A. and Mancini, M. (2020), "icio: Economic analysis with inter-country input-output tables in Stata", *World Bank Policy Research Working Paper*, No. 9156.

Blundell, R. and Bond, S. (1998), "Initial conditions and moment restrictions in dynamic panel data models", *Journal of Econometrics*, Elsevier, Vol. 87 No. 1, pp. 115–143.

Brambor, T., Clark, W.R. and Golder, M. (2006), "Understanding Interaction Models: Improving Empirical Analyses", *Political Analysis*, Vol. 14 No. 1, pp. 63–82.

Cardona, M., Kretschmer, T., Strobel, T. (2013). ICT and productivity: conclusions from the empirical literature. *Information Economics and Policy*. 25 (3), 109–125.

Cassetta, E., Monarca, U., Dileo, I., Di Berardino, C., & Pini, M. (2020). The relationship between digital technologies and internationalisation. Evidence from Italian SMEs. *Industry and Innovation*, 27(4), 311-339.

Casella, B., Bolwijn, R., Moran, D. and Kanemoto, K. (2019), "Improving the analysis of global value chains: the UNCTAD-Eora Database", *TRANSNATIONAL CORPORATIONS*, Vol. 26 No. 3, p. 28.

Cette, G., Clerc, C. and Bresson, L. (2015), "Contribution of ICT diffusion to labour productivity growth: the United States, Canada, the Eurozone, and the United Kingdom, 1970-2013", *International Productivity Monitor*, Centre for the Study of Living Standards, No. 28, p. 81.

Clarke, G.R.G. (2008), "Has the internet increased exports for firms from low and middle-income countries?", *Information Economics and Policy*, Vol. 20 No. 1, pp. 16–37.

Clarke, G.R.G. and Wallsten, S.J. (2006), "Has the Internet Increased Trade? Developed and Developing Country Evidence", *Economic Inquiry*, Vol. 44 No. 3, pp. 465–484.

Cummins, J. (2000), "7. The Threshold and Interdependence Hypotheses Revisited", *Language, Power and Pedagogy*, Multilingual Matters, pp. 173–200.

Dachs, B., Kinkel, S., J¨ ager, A., (2019). Bringing it all back home? Backshoring of manufacturing activities and the adoption of Industry 4.0 technologies. *Journal of World Business*. 54 (6), 101017.

Dalenogare, L. S., Benitez, G. B., Ayala, N. F., & Frank, A. G. (2018). The expected contribution of Industry 4.0 technologies for industrial performance. *International Journal of production economics*, 204, 383-394.

Del Prete, D., Giovannetti, G. and Marvasi, E. (2017), "Global value chains participation and productivity gains for North African firms", *Review of World Economics*, Vol. 153 No. 4, pp. 675–701.

De Marchi, V.D., Maria, E.D., Gereffi, G. (2018). Local Clusters in Global Value Chains: Linking Actors and Territories through Manufacturing and Innovation. Routledge.

Dewan, S. and Ramaprasad, J. (2014), "Social media, traditional media, and music sales", *Mis Quarterly*, JSTOR, Vol. 38 No. 1, pp. 101–122.

Djoumessi, Y.F. (2021), "What innovations impact agricultural productivity in Sub-Saharan Africa?", *Journal of Agriculture and Food Research*, Elsevier, Vol. 6, p. 100228.

Djoumessi, Y.F. and Mbongo, L. de B.E. (2022), "An analysis of information Communication Technologies for natural disaster management in Africa", *International Journal of Disaster Risk Reduction*, Elsevier, Vol. 68, p. 102722.

Fedyunina, A. A., Gorodnyi, N. A., & Simachev, Y. V. (2024). How the adoption of Industry 4.0 technologies is related to participation in global and domestic value chains: Evidence from Russia. *International Journal of Innovation Studies*, 8(2), 93-108.

Fernandes, A.M., Mattoo, A., Nguyen, H. and Schiffbauer, M. (2019), "The internet and Chinese exports in the pre-ali baba era", *Journal of Development Economics*, Vol. 138, pp. 57–76.

Fernandes, A.M., Mattoo, A., Nguyen, H., Schiffbauer, M., 2019. The internet and Chinese exports in the pre− Alibaba era. *Journal of Development Economics*. 138, 57–76.

Freund, C.L., Weinhold, D., (2004). The effect of the internet on international trade. *Journal of International Economics*. 62 (1), 171–189.

Fort, T. C. (2017). Technology and production fragmentation: Domestic versus foreign sourcing. *The Review of Economic Studies*, 84(2), 650-687.

Forman, C. and van Zeebroeck, N. (2019), "Digital technology adoption and knowledge flows within firms: Can the Internet overcome geographic and technological distance?", *Research Policy*, Vol. 48 No. 8, p. 103697.

Fort, T.C. (2016), "Technology and Production Fragmentation: Domestic versus Foreign Sourcing", *The Review of Economic Studies*, p. rdw057.

Foster, C. and Graham, M. (2017), "Reconsidering the role of the digital in global production networks", *Global Networks*, Vol. 17 No. 1, pp. 68–88.

Foster, C., Graham, M., Mann, L., Waema, T. and Friederici, N. (2018), "Digital Control in Value Chains: Challenges of Connectivity for East African Firms", *Economic Geography*, Vol. 94 No. 1, pp. 68–86.

Frank, A.G., Dalenogare, L.S., Ayala, N.F. (2019). Industry 4.0 technologies: implementation patterns in manufacturing companies. *International Journal of production economics*. 210, 15–26.

Freund, C. and Weinhold, D. (2002), "The Internet and International Trade in Services", *American Economic Review*, Vol. 92 No. 2, pp. 236–240.

Gopalan, S., Reddy, K. and Sasidharan, S. (2022), "Does digitalization spur global value chain participation? Firm-level evidence from emerging markets", *Information Economics and Policy*, p. 100972.

Grossman, G.M. and Rossi-Hansberg, E. (2008), "Trading tasks: A simple theory of offshoring", *American Economic Review*, Vol. 98 No. 5, pp. 1978–97.

Grundke, R., Jamet, S., Kalamova, M., Keslair, F., & Squicciarini, M. (2017). Skills and global value chains: A characterisation. OECD Science, Technology and Industry Working Papers.

GSMA. (2017), *2017 State of the Industry Report on Mobile Money*, GSM Association.

Hagsten, E. and Kotnik, P. (2017), "ICT as facilitator of internationalisation in small- and medium-sized firms", *Small Business Economics*, Vol. 48 No. 2, pp. 431–446.

Heavin, C., & Fitzgerald, B. (2004). Institutional impacts on the development of an industry: The Irish experience. *Journal of Global Information Technology Management*, 7(4), 66–85.

Hagsten, E., Kotnik, P. (2017). ICT as facilitator of internationalisation in small and medium− sized firms. *Small Business Economics*. 48 (2), 431–446.

Hallward-Driemeier, M., Nayyar, G. (2017). Trouble in the Making? the Future of Manufacturing-Led Development. World Bank Publications.

Inklaar, R., Jong-A-Pin, R. and De Haan, J. (2008), "Trade and business cycle synchronization in OECD countries—A re-examination", *European Economic Review*, Elsevier, Vol. 52 No. 4, pp. 646–666.

Jean, R.J., Sinkovics, R.R., Cavusgil, S.T. (2010). Enhancing international customer–supplier relationships through IT resources: a study of Taiwanese electronics suppliers. *Journal of International Business Studies*. 41 (7), 1218–1239.

Jin, Y., Vonderembse, M., Ragu-Nathan, T.S., Smith, J.T., 2014. Exploring relationships among IT-enabled sharing capability, supply chain flexibility, and competitive performance. *International Journal of Production Economics*. 153, 24–34.

Kano, L., Tsang, E.W., Yeung, H.W.C. (2020). Global value chains: a review of the multidisciplinary literature. *Journal of International Business Stud*ies. 51 (4), 577–622.

Karamujic, L. (2025). Impact of national institutions on cloud computing adoption. Comparison to mobile broadband adoption. *Journal of Global Information Technology Management*, 1-24.

Keller, J. and Heiko, A. (2014), "The influence of information and communication technology (ICT) on future foresight processes—Results from a Delphi survey", *Technological Forecasting and Social Change*, Elsevier, Vol. 85, pp. 81–92.

Kersan-Škabić, I. (2019). The drivers of global value chain (GVC) participation in EU member states. *Economic research-Ekonomska istraživanja*, 32(1), 1204-1218.

Koopman, R., Wang, Z. and Wei, S.-J. (2014), "Tracing value-added and double counting in gross exports", *American Economic Review*, Vol. 104 No. 2, pp. 459–94.

Lim, B., Yoo, J., Hong, K. and Cheong, I. (2021), "Impacts of Reverse Global Value Chain (GVC) Factors on Global Trade and Energy Market", *Energies*, Multidisciplinary Digital Publishing Institute, Vol. 14 No. 12, p. 3417.

Love, I. and Zicchino, L. (2006), "Financial development and dynamic investment behavior: Evidence from panel VAR", *The Quarterly Review of Economics and Finance*, Elsevier, Vol. 46 No. 2, pp. 190–210.

Luong, T.A. and Nguyen, T.H. (2021), "The impact of ICT on service trade", *The Singapore Economic Review*, World Scientific, Vol. 66 No. 04, pp. 1073–1086.

Morrison, A., Pietrobelli, C. and Rabellotti, R. (n.d.). “Global Value Chains and Technological Capabilities”:, p. 26.

Niebel, T. (2018), “ICT and economic growth – Comparing developing, emerging and developed countries”, *World Development*, Vol. 104, pp. 197–211.

Nordas, H.K., Piermartini, R. (2004). Infrastructure and Trade. WTO Staff Working Papers, No. ERSD-2004-04. WTO.

Paunov, C. and Rollo, V. (2016), “Has the Internet Fostered Inclusive Innovation in the Developing World?”, *World Development*, Vol. 78, pp. 587–609.

Powell, R.M., Blowes, D.W., Gillham, R.W., Schultz, D., Sivavec, T., Puls, R.W., Vogan, J.L., *et al.* (1998), “Permeable reactive barrier technologies for contaminant remediation”, *US EPA*, Vol. 600.

Prentki, T. (2017), “Anthropology, Theatre and Development: The Transformative, Potential of Performance: Alex Flynn and Jonas Tinius Palgrave Macmillan, Basingstoke, United Kingdom, 2015, Hardback £14.60”, *The European Journal of Development Research*, Vol. 29 No. 1, pp. 265–267.

Reddy, K., Chundakkadan, R., Sasidharan, S., 2021. Firm innovation and global value chain participation. Small Business Economics. 57, 1995–2015.

Rigo, D. (2021), “Global value chains and technology transfer: new evidence from developing countries”, *Review of World Economics*, Vol. 157 No. 2, pp. 271–294.

Roodman, D. (2009a), “A note on the theme of too many instruments”, *Oxford Bulletin of Economics and Statistics*, Wiley Online Library, Vol. 71 No. 1, pp. 135–158.

Roodman, D. (2009b), “How to do xtabond2: An introduction to difference and system GMM in Stata”, *The Stata Journal*, SAGE Publications Sage CA: Los Angeles, CA, Vol. 9 No. 1, pp. 86–136.

Steinmüller, H. (2011), “The moving boundaries of social heat: Gambling in rural China”, *Journal of the Royal Anthropological Institute*, Wiley Online Library, Vol. 17 No. 2, pp. 263–280.

Strauss, H. and Samkharadze, B. (2011), “ICT capital and productivity growth”, *EIB Papers*, Vol. 16 No. 2, pp. 8–28.

Szalavetz, A. (2019), “Digitalisation, automation and upgrading in global value chains – factory economy actors versus lead companies”, *Post-Communist Economies*, Vol. 31 No. 5, pp. 646–670.

Szalavetz, A. (2020), “Digital transformation – enabling factory economy actors’ entrepreneurial integration in global value chains?”, *Post-Communist Economies*, Vol. 32 No. 6, pp. 771–792.

Tchamyou, V.S., Erreygers, G. and Cassimon, D. (2019), "Inequality, ICT and financial access in Africa", *Technological Forecasting and Social Change*, Vol. 139, pp. 169–184.

Timmer, M.P., Erumban, A.A., Los, B., Stehrer, R. and De Vries, G.J. (2014), "Slicing up global value chains", *Journal of Economic Perspectives*, Vol. 28 No. 2, pp. 99–118.

Torsekar, Mihir and John VerWey. (2019), "East Asia-Pacific's Participation in the Global Value Chain for Electronic Products", *Journal of International Commerce and Economics*.

Urata, S. and Baek, Y. (n.d.). "The Determinants of Participation in Global Value Chains: A Cross-Country, Firm-Level Analysis", p. 44.

Van Ark, B., O'Mahoney, M. and Timmer, M.P. (2008), "The productivity gap between Europe and the United States: trends and causes", *Journal of Economic Perspectives*, Vol. 22 No. 1, pp. 25–44.

Williamson, O. E. (1973), 'Markets and Hierarchies: Some Elementary Considerations', The *American Economic Review*, 63 (2): 316–325.

Williamson, O. E. (1975) Markets and Hierarchies: Analysis and Antitrust Implications. New York: Free Press.

Williamson, O. E. (1979),'Transaction-cost Economics: The Governance of Contractual Relations'

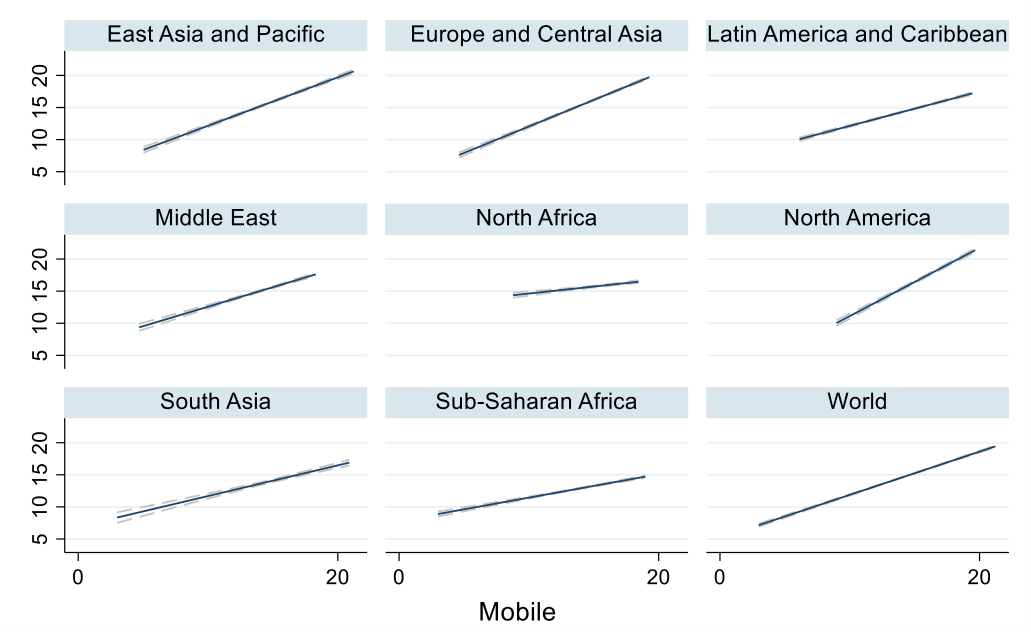
, The Journal of Law and Economics, 22(2): 233–261.

Williamson, O. E. (1985) The Economic Institutions of Capitalism. New York: Free Press.

Yushkova, E. (2014), "Impact of ICT on trade in different technology groups: analysis and implications", *International Economics and Economic Policy*, Springer, Vol. 11 No. 1, pp. 165–177.

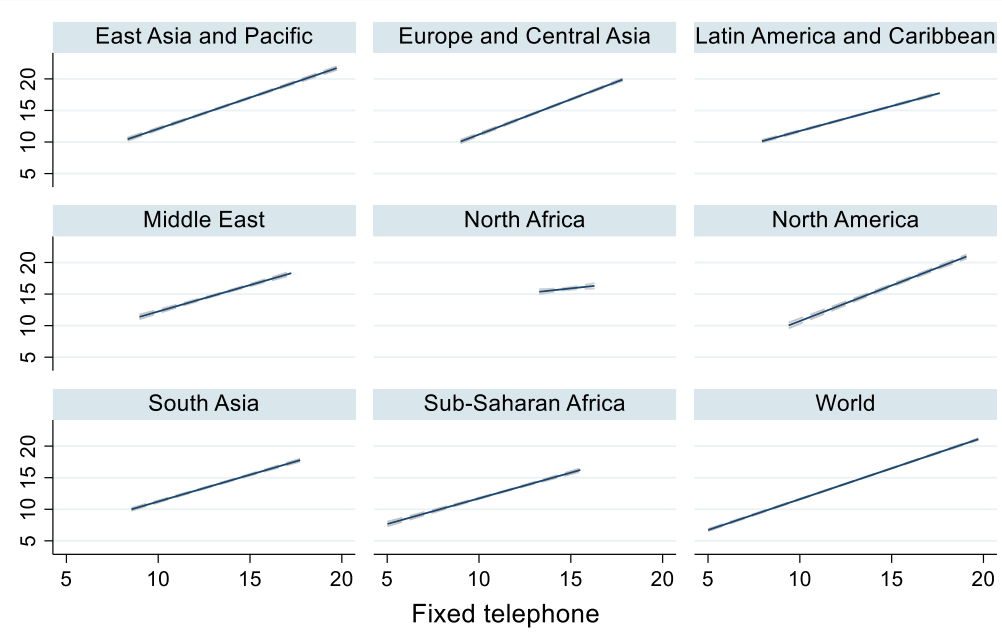
Appendix

Figure A1: Fitted plot of Mobile phone effect on GVC by region



Source: Authors using WDI and EROA data.

Figure A2: Fitted plot of Fixed-telephone effect on GVC by region



Source: Authors using WDI and EROA data.

Table A1: Correlation matrix

	GVC	Internet	Mobile	Ftelephone	FDI	Trade	GDP	Industry VA	Tech progress
GVC	1								
Internet	0.3667	1							
Mobile	0.4475	0.0394	1						
Ftelephone	0.5778	0.0437	0.6321	1					
FDI	-0.0406	0.1018	-0.0575	-0.0574	1				
Trade	-0.0182	0.2998	-0.1635	-0.1956	0.2931	1			
GDP	0.6683	0.1701	0.5278	0.7709	-0.0569	-0.1946	1		
Industry VA	0.6876	0.1378	0.6869	0.8677	-0.0635	-0.2011	0.9457	1	
Tech progress	0.512	0.0945	0.6801	0.6379	-0.0435	-0.1377	0.675	0.8325	1

Source: Authors' calculation using WDI and EROA data.

Table A2: Least squares estimates of ICT on GVC participation

	Africa			**World**		
VARIABLES	**(1)**	**(2)**	**(3)**	**(4)**	**(5)**	**(6)**
Internet	0.0715**			0.162***		
	(0.0284)			(0.0115)		
Mobile		0.0739***			0.114***	
		(0.0255)			(0.0121)	
Ftelephone			0.140**			-0.0871***
			(0.0602)			(0.0297)
FDI	-0.190***	-0.220***	-0.156***	-0.155***	-0.153***	-0.129***
	(0.0450)	(0.0471)	(0.0455)	(0.0184)	(0.0188)	(0.0191)
trade	1.478***	1.623***	1.516***	1.221***	1.432***	1.406***
	(0.171)	(0.153)	(0.168)	(0.0455)	(0.0442)	(0.0455)
GDP	1.227***	1.150***	1.411***	0.648***	0.778***	0.889***
	(0.225)	(0.230)	(0.218)	(0.0635)	(0.0637)	(0.0647)
Industry VA	-0.0872	-0.0487	-0.291	0.360***	0.193***	0.260***
	(0.170)	(0.172)	(0.176)	(0.0601)	(0.0608)	(0.0635)
Technological progress	0.0443	0.0473	-0.00573	0.0971***	0.110***	0.108***
	(0.0503)	(0.0501)	(0.0533)	(0.0137)	(0.0141)	(0.0156)
Constant	-19.57***	-20.18***	-21.08***	-15.13***	-16.74***	-18.03***
	(2.467)	(2.328)	(2.295)	(0.574)	(0.566)	(0.562)
Observations	222	222	221	1,856	1,872	1,870
F-test	211.35***	213.68***	209.4***	1976.62***	1888.15***	1805.48***
R-squared	0.855	0.856	0.854	0.865	0.859	0.853

Robust standard errors in parentheses; *** p<0.01, ** p<0.05, * p<0.1. Source: Authors' calculation using WDI and EROA data.

Table A3: Results of the FE of the interaction model

	Africa			World		
VARIABLES	**(1)**	**(2)**	**(3)**	**(4)**	**(5)**	**(6)**
Internet	0.274***			0.0923***		
	(0.0636)			(0.0171)		
Mobile		0.108**			0.117***	
		(0.0508)			(0.0160)	
Ftelephone			0.187			0.129***
			(0.114)			(0.0402)
FDI#Internet	0.0121**			0.00585***		
	(0.00592)			(0.00151)		
Trade#Internet	-0.0563***			0.0150***		
	(0.0160)			(0.00423)		
FDI#Mobile		0.0121***			0.00724***	
		(0.00427)			(0.00152)	
Trade#Mobile		-0.0158			-0.0227***	
		(0.0137)			(0.00385)	
FDI#Ftelephone			0.0246***			0.0134***
			(0.00703)			(0.00226)
Trade#Ftelephone			-0.0551*			-0.0340***
			(0.0297)			(0.00941)
FDI	-0.0730***	-0.236***	-0.372***	-0.0326***	-0.132***	-0.213***
	(0.0140)	(0.0650)	(0.0918)	(0.00550)	(0.0236)	(0.0334)
Trade	-0.0344	0.130	0.653*	0.164***	0.486***	0.631***
	(0.0569)	(0.221)	(0.386)	(0.0224)	(0.0607)	(0.137)
Industry VA	0.196***	0.125*	0.202***	0.421***	0.421***	0.492***
	(0.0683)	(0.0678)	(0.0614)	(0.0198)	(0.0200)	(0.0178)
Tech progress	0.0155	0.0133	0.0197	0.0112**	0.00848	0.00871
	(0.0136)	(0.0137)	(0.0142)	(0.00555)	(0.00554)	(0.00552)
Constant	9.753***	10.71***	7.243***	1.937***	-0.570	1.342*
	(1.696)	(1.966)	(1.830)	(0.426)	(0.479)	(0.702)
Observations	222	222	221	1,856	1,872	1,870
R-squared	0.997	0.997	0.997	0.997	0.997	0.997

Robust standard errors in parentheses; *** p<0.01, ** p<0.05, * p<0.1. Source: Authors' calculation using WDI and EROA data.

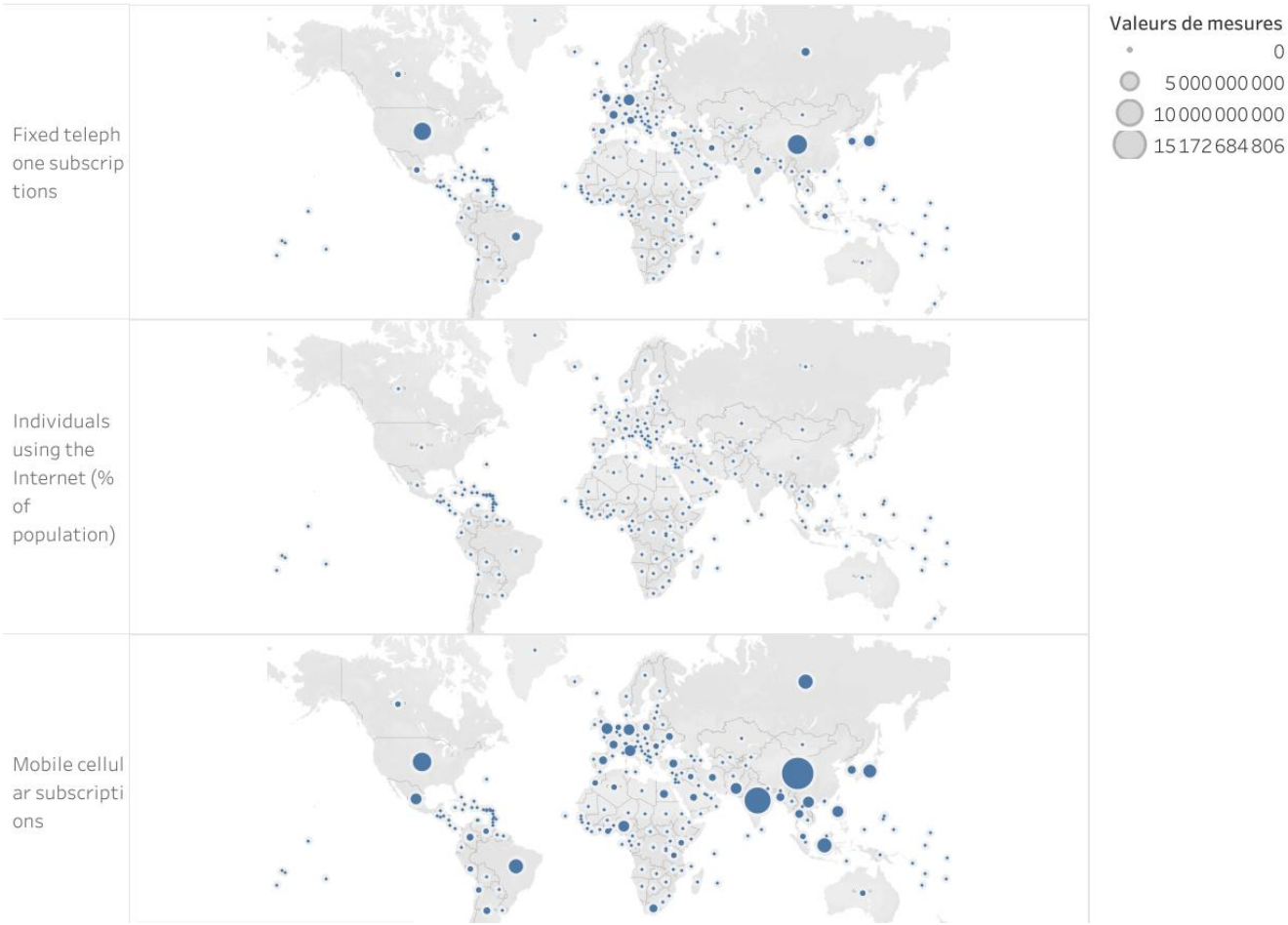
Table A4: Incremental R^2 from ICT variables

Model specification	**R^2**	**ΔR^2 vs previous**
Controls only	0.752	-
Controls + ICT	0.813	+0.061
Controls + ICT + FE	0.997	+0.018

Figure A3: GVC mapping

Source: Authors using EROA data.

Figure A4: ICT mapping



Source: Authors using WDI data.

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