OPEN FORUM

Impacts of digital business on global value chain participation in European countries

Le Thanh Ha[1]

Abstract

As the first empirical study of the nonlinear effects of digital business on global value chains (GVC), we provide insight into the nonlinear effects of digital business on the global value chain (GVC) values. We employ four indicators, including the value of online selling, sales through E-commerce, and customer relationship management (CRM) usage, to capture the prevalence of digital business in the economy. By testing a sample of 25 European countries that have been analyzed using various econometric techniques over the period 2012–2019, our estimation results confirm that GVC values are a U-shaped function of digitalization. That is, an increase in digitalization pervasiveness initially induces more significant risks and uncertainties, hindering European countries from getting involved in or scale-up within the GVC. However, a rise in digitalization pervasiveness goes beyond a specific threshold, which facilitates GVC activities as more opportunities are created. Furthermore, our findings suggest that digital business contributes significantly to reducing the adverse influences of global uncertainty on the GVC values, while the marginal effects of digital business on GVC values become more pronounced in countries with the most advanced institutional structure.

1 Introduction

Since the early 1980s, global value chains (GVCs) have produced a major transformation in the world economy as well as in the structure of international trade flows (Amador and Cabral 2016). This transformation is driven not only by the information and communication technology (ICT) revolution but also by the reduction of trade restrictions and the development of the political system (Antràs 2020). Firstly, a network of multilateral cooperation resulting from participation in GVC can promote worldwide companies to optimize the utilization of foreign parts and components in manufacturing. Secondly, it pushes the shift in the vision of intermediate input producers from merely concentrating on satisfying the demands of the domestic market to expanding the global market outreach.

The GVC consists of multiple stages involved in the production of a product or service, satisfying the condition with which different countries will take part in creating values in at least two of such stages (Antràs 2020). A firm is considered a part of GVC if its manufacturing process takes place in at least one stage in GVC. In simple terms, the GVC is defined as a production process that includes value-added from at least two countries. Therefore, the GVCs are closely linked with the cooperation of countries around the globe, especially for international trade activities, including export and import. Despite being clearly presented in different forms such as trade, intermediate inputs, and cross-border services, it is still challenging to capture and measure GVCs in production. Following that, with GVC involvement, resource efficiency is improved across sectors and countries and manufacturing phases. That enhances growth, employment, and trade both domestically and internationally as a result (Antràs 2020).

✉ Le Thanh Ha
  halethanh.kt@gmail.com

1   National Economics University, Hanoi, Vietnam

In the literature, many scholars argue that an enhancement of GVC participation and scaleup values can be obtained by the digital transformation process. Along with the rapid development of Industry 4.0, a revolution in digital technology and production system, which booms dramatically in many countries around the world, especially in Germany or China, promisingly leads to fundamental changes in the way that firms perform in the manufacturing industries in the future (Lüthje 2019). By considering ICT, Jamil (2021) highlights the social impacts of digitalization on some sectors, such as transport, health, business, and education, in both developed and developing economies. The ICT also appears to have favorable effects on the economic growth (Myovella et al. 2020) or innovative activities and productivity of firms (Bouwman et al. 2019), the financial sector (Ha 2022a; Mignamissi and Djijo 2021), or employment sector (Avom et al. 2021; Mossberger et al. 2022).

Undoubtedly, digitalization has become increasingly common in public disclosure in recent years. However, many variants of the term have been used and, in some cases, have been misused or used in an inaccurate manner (Tilen and Andrej 2018). A distinction must be made between digital transformation and digitization. Digitization is concerned with automated routines and tasks such as the conversion of analog into digital information. In contrast, digitalization is the addition of digital components to product or service offerings, and digital transformation is a more comprehensive introduction of new business models and digital platforms (Abdul et al. 2021). Brennen and Kreiss (2016) report that both digitization and digitalization involve the use of a digital tool to scan an analog record into a digital record, which is then saved in PDF format. To digitize, this PDF format is typically stored on a hard drive on a computer, whereas to digitalize, the PDF is uploaded via the Internet to a cloud service, which can be accessed from anywhere at any time. In the European Union (EU), digitalization has been identified as a major driver of economic and social change, though the process has been described as uneven (Jurica et al. 2016). Also, a European survey found that around 70% of directors from Austria, Germany, and Switzerland believed the pandemic would accelerate the pace of digital transformation (Crina et al. 2021).

Prior scholars contend that the advent of digital technologies has altered the way in which businesses operate globally (Dethine et al. 2020) and allowed businesses to gain a competitive edge in the global economy (Lee and Falahat 2019). The digital revolution can also be seen as an avenue for promoting internationalization (Dethine et al. 2020). In periods of uncertainty, digitalization is likely to benefit exports by facilitating access to goods and services (OECD 2020). There are more efficient movements of goods across borders due to the leverage of digital technologies. Digitalization makes the border processes more transparent

and accessible to traders. Applying digital technologies to production and business processes has enhanced the productivity and efficiency of communication between customers and suppliers (Rehnberg and Ponte 2018). Furthermore, digitization has also largely converted the nature of work in GVC factories, causing a shift from traditional machines to modern machines, artificial intelligence, robots, as well as enhancing the communication effectiveness among factory workers or between GVC services and online collaboration platforms (Helmerich et al. 2021).

Contrary to the digital transformation trend, participating in GVC of the EU region has appeared with great challenges. Bontadini et al. (2019) and demonstrated that the EU region has a significant degree of GVC participation. However, this trend is shrinking the fastest. Furthermore, the intra-regional trade integration in the European region is also declining. Still, the level of trade integration between European countries to countries outside the European region is stable but at a lower level. This current trend raises a warning for the European region since the importance of GVC participation is undeniable. Dorrucci et al. (2019) argue that trade in GVCs is a critical channel for transferring know-how, technology, and process innovation within European regions and between European countries with the rest of the world. The role of GVC participation in improving productivity, expanding economic activities, and global trade is also highlighted in Dorrucci et al. (2019). Therefore, it is critical to take measures to improve the trend and level of GVC participation in the European region. In this paper, we propose that digitalization is an appropriate development strategy to help the European countries gain competitiveness in GVC. We analyze digitalization's linear and nonlinear effects on GVC participation to serve this purpose.

A number of limitations have been identified in previous studies. First of all, no paper provides an in-depth analysis of digitalization's effects on the GVC participation or the scaleup within GVC. A second issue is that scholars agree that cross-sectional dependence biases the results obtained using the conventional method (Canh et al. 2021; Le et al. 2022). Previous studies in this field have still not paid enough attention to this issue. Third, the nonlinear association between digitalization and GVC, suggesting that the favorable effects of digitalization only appear if its development reaches a certain threshold, have not been exploited extensively thus far. Importantly, the previous studies have abstracted channels through which digitalization influences the GVC values. To provide more insights into the digitalization-GVC nexus, further analyses are offered to highlight the role of digital business in mitigating the adverse influences of world uncertainty on the GVC values. Moreover, the current paper emphasizes the importance of institutional quality in guaranteeing the success of digital businesses in promoting GVC

activities. Our study aims at filling these gaps by seeking the answers to the research question: what are the effects of digitalization on GVCs of European countries?.

This study contributes to the existing literature in several ways. First, our study is the first effort to empirically analyze the effects of digital transformation, especially in the business sector, on the GVC values. Second, the theoretical contribution of this paper is premised on the combination between a resource-based view and a dynamic capability view in investigating the relationship between digitalization and GVC. From an empirical approach, we apply the panel corrected standard errors (PCSE) model to a sample of 25 European countries during the period 2012–2019. For a robustness check, our study also applies the feasible generalized least squares (FGLS) model to examine our findings when we consider heteroscedasticity and fixed effects. Since we expect that there is a nonlinear relationship between digital business and GVC participation, the squared terms of variables capturing the process of digital business transformation are added to the theoretical model. For simulation purposes, we utilize the predictive margins analysis.

Following this empirical approach, our paper provides some critical findings. According to our estimation results, GVC values are a U-shaped function of digitalization. As a result, an increase in digitalization pervasiveness initially introduces greater risks and uncertainties, which prevent European countries from becoming involved in or scaling up within the GVC. However, beyond a particular threshold, a rise in digitalization pervasiveness can facilitate GVC activities by providing additional opportunities. Furthermore, our findings suggest that digital business contributes significantly to reducing the adverse influences of global uncertainty on the GVC values, while the marginal effects of digital business on GVC values become more pronounced in countries with the most advanced institutional structure.

The remaining portions of this document are organized as follows. In Sect. 2, the relevant literature is reviewed, while in Sect. 3, the model, data, and estimation procedure are described. Section 4 reports empirical results, and discussion is provided in Sect. 5. Section 6 concludes the paper.

2 Literature review

2.1 Theoretical framework

In this paper, we use the resource-based view (RBV) by Grant (1991) to link digitalization to GVC activities. According to Autio et al. (2018), digitalization is the process of integrating digital technologies and infrastructures into various aspects of business, economics, society, etc. Today, many individuals are accustomed to the use of information technology in manufacturing and commerce. Every part of

the economy has been progressively digitized as the industrial revolution progressed. A slew of new business models arose as a result. Electronic machines have become an essential component of both the manufacturing process and the operation of the product distribution chain. E-commerce, digital data analysis, and other technologies are collectively allowing organizations to grow more effectively. Small and medium-sized businesses can gain competitive advantages either directly or indirectly with digital information technology systems, especially in the digital economy. As proposed in RBV by Grant (1991), digitization is a practical resource that supplements internationalizing firms' competitive advantages. By combining these two different views, we believe that digitalization helps countries improve their competitiveness in the global market as a result of effects on competitive advantages, including price, product, and service. Many other scholars also attempt to conceptualize digitalization from different views in the literature. In particular, Shin (2014, 2016a) and Shin et al. (2019) employ a socio-technical framework to assess and predict the development and effect of digitalization, such as blockchains, algorithm, artificial intelligence (AI), and Internet of Things (IoTs), while Shin (2016b) conducts socio-technical evaluation on the big data phenomenon by using a normalization process theory.

2.2 Drivers of global value chain participation

Our paper considers the effects of seven main drivers of GVC participation, including output growth, natural resource uses, foreign direct investment (FDI), industrialization level, human capital, institutional issue, and freedom to trade internationally. The reasons for our selection are as follows. Using the Heckscher–Ohlin model, resource endowments, such as natural resources, labor, and capital, are critical in defining international specialization and, as a result, GVC involvement (Fernandes et al. 2020). Especially in low-income countries, low-skilled labor generates a competitive advantage for assembly-type stages of production, which accelerates the backward GVC participation due to high imports of inputs (Le et al. 2022). Meanwhile, the presence of high-skilled labor that can be assigned to the stages of the value chain that require more skill facilitates GVC advancement. Hence, the level of output growth favors the production process, thus supporting the participation of GVCs. Also, Le et al. (2022) use the Heckscher-Ohlin model to contend that the natural resources are utilized in a number of downstream production processes; therefore, having a lot of them enhances a country's forward GVC involvement.

In this paper, we also follow prior scholars to highlight the importance of domestic industrial capacity. There is no evident link between domestic industrial capacity and GVC involvement. To reduce cross-hauling of semi-processed

commodities between stages, a nation may specialize in contiguous stages of production in GVCs (Fernandes et al. 2020). Exports from nations with a sizable domestic manufacturing capacity may have more successive stages resulting in a lower percentage of imported inputs compared to domestic inputs. Consequently, backward participation in the GVC may decrease. In contrast, developing nations may be forced to import more final commodities for local consumption, causing them to focus on downstream phases of manufacturing with higher foreign value-added, thus increasing backward participation in GVC (Fernandes et al. 2020; Yi 2010). The growth of a more significant domestic industry implies a more extensive domestic supplier base, which decreases search frictions, makes it easier to replace local suppliers if production is disrupted, and may lead to higher domestic value-added and forward GVC involvement (Fernandes et al. 2020).

In this paper, we also emphasize the importance of the institutional issue. The extensive firm-to-firm contacts defined by contracts and specialized products and investments (Antràs 2020) are the fundamental contrasts between GVC and traditional trade. As a result, both conventional and GVC trading are hampered by a lack of contract enforcement (Acemoglu et al. 2007; Chor 2010; Levchenko 2007; Nunn 2007). There is evidence of a link between high GVC assimilation and a good rule of law (Kowalski et al. 2015). Because a GVC's performance is influenced by the strength of its weakest point, manufacturing delays caused by poor contract enforcement could be particularly costly. Hence, institution quality could be considered an important factor influencing relational GVC participation. Democracy, or the democratization of information, has an impact on the transparency of information which results in major changes in the GVC (Friedman (2006). Consumers are better, which leads to the alleviation of disadvantages of SMEs while helping to assert connections. In addition, investors are focusing on a system of democratic capitalism, dependent on the strength of markets and compound interest, and more people will be self-sufficient in a globalizing society. Instead of focusing on conserving present wealth, as conservatives typically do, the GVC can be altered by the increment of the circle of capital owners (Friedman (2006). In Table 4 in Appendix, we demonstrate detailed information about related papers to each used variable in this paper.

2.3 Digitalization and global value chain participation

The digital economy has developed during the rising trend of the fourth industrial revolution, offering up new business models with more valuable resources (Bettiol et al. 2020). Manufacturing is beginning to adopt new technologies such as robots, component manufacturing, the Internet, big data,

and machine learning. The application model of technology in production and business has changed the structure and process of cross-border business (Alcácer et al. 2016). As stated by Laplume et al. (2016), recent studies are paying more attention to the effect of technology on GVCs configuration, whereas the question of the influences of digitalization has still been kept unanswered in the literature. In this paper, we contend that digitalization is one of the important factors affecting various dimensions of GVCs. Both information technology and digital platforms in support of innovation generate values for GVCs and transfer these values across the border with greater efficiency and flexibility. Digitization allows SMEs to be more able to convert their business models by cooperating with new organizations, adapting multi-sided platforms, and improving existing partnerships (Nambisan et al. 2019). The forms of digital technologies, including big data, cloud computing, and artificial intelligence, are believed to yield positive impacts on the scale-up of GVCs through the better results of production efficiency, product research and development, as well as on logistics.

Furthermore, barriers to international trade are gradually being reduced along with the application of digital communication and tracking technologies like radio frequency identification (RFID). Thereby, more opportunities are created for both smaller companies to participate in GVCs and large corporations to facilitate production supervision, leading to longer and more complex GVCs. In technologically advanced emerging countries, digitalization accelerates the upgrading and diversification of manufacturing, reduces barriers and restrictions, and provides customers with better accessibility (Li et al. 2019). Scholars also revealed the influences of different types of digitalization. For example, the literature has indicated the social-technical impacts of big data that help to understand the developmental processes through which new practices of thinking and enacting are implemented (Shin 2016b) or the effects of building and disrupting a variety of networks on the development of China's financial technology industry (Shim and Shin 2016) or in the industry of Korea (Shin 2016a). By working together, a shared digital platform among SMEs can also be seen as a global virtual value chain characterized by technology and intangible production inputs.

In this paper, we indicate that there are two channels through which digitalization affects the GVC values, namely cost reduction and communication efficiency improvement. Participation in GVCs requires a variety of conditions, of which technology has proven to be an indispensable element in coordinating production phases and logistics operations (Amador and Cabral 2016). In particular, paperless trade such as E-invoices, E-signatures, pre-clearance of shipments while goods are in transit, single windowing, and use of blockchain ledger technology in the supply chain related

to tax or border compliance process has been an emerging phenomenon (Verny et al., 2020). As a result, adopting digital and information communication innovations will significantly decrease restrictions, barriers, delays, uncertainty, and opportunities for rent-seeking at borders, thus ultimately impacting participation in GVC production and associated investments (Miroudot and Cadestin 2017). Accordingly, Baldwin and Venables (2013) reveal that the barriers and distance constraints within production stages in GVC have been significantly reduced due to the ICT revolution. The differences in culture, lifestyle, and language of worldwide localities always exist and largely affect online transactions (Wellman et al. 2003). In general, digital technology highly minimizes the cost of information or even makes it close to zero (Goldfarb and Tucker 2019).

Regarding an improvement in communication efficiency, Bogers et al. (2016) and Strange and Zucchella (2017) indicate a different effect of digitalization, which improves the GVC values. Specifically, digitalization pushes the accelerating transformation of GVCs from centralization into decentralization. There exists a 'hybrid' approach with a concentration on localization and a development of a model where customers effectively monitor the productive activities of manufacturers. Customers are more likely to get involved in the GVC, either as a primary product information and feedback provider or as a local manufacturer. Relying on an extensive network, the information technology platform supports the selling process of new products and services because it helps collect information from customers who experience products trial anywhere in the world and thus permits adjusting their activities to adapt and develop in accordance with those perspectives.

Among all types of digitalization, digital business plays a critical role in promoting GVC involvement. Based on the business-to-consumer (B2C) and business-to-business (B2B) electronic platforms, digitalization creates strong incentives for the supply and distribution of products manufactured in GVCs. Cloud data, data analysis software tools, and related information "dashboards" enhance the "visibility" of the supply chain to enable real-time tracking and rapid allocation of resources to respond to customer demands. Simultaneously, these aspects also promote the quality of delivery service and customer care. Radio frequency identification sensor technology enhances the traceability of components as well as the final products. The information collected from analytical tools also facilitates the strategic decisions of international businesses when they have to decide whether they select a production place and adjust supply to reflect the demands of customers during the period of economic shocks (Verbeke 2020). Digitalization is important for small companies and large multinationals due to its significant facilitation in sales, payment, finance, and logistics (Geaneotes and Mignano 2020). Furthermore, digital business models based

on the provision and adoption of open-source software tools facilitate the participation of GVCs and the expansion of GVCs. Digitization supports multinational corporations in distributing products faster across the border and supports small companies in overcoming difficulties in the export process. McCormick and Somaya (2020) find that the exports of firms are boosted by the adoption of international mobile and Internet technologies, thereby contributing to overcoming infrastructure and domestic institutional gaps.

In light of our discussion, we propose the following hypothesis:

H1: Digital business leads to a rise in global value chain values.

Based on our discussion, we hypothesize:

H2: There exists a nonlinear effect of digital business on GVC values.

3 Empirical methodology

The model used to investigate the nexus of digital business and global value chain (GVC) participation can be presented as follows:

$$\ln\text{GVC}_{it} = \beta_0 + \beta_1 \text{DB}_{i,t} + \beta_3 \text{CONTROL}_{i,t} + \zeta_t + \eta_i + \varepsilon_{ijt,}$$
(1)

where i and t stand for the nation i and year t, respectively, and t and i are added to the model to acquire the country and year fixed effect model, respectively, and $\varepsilon_{ijt,}$ is the error term. The dependent variable, GVC_{it}, is the measure of the intensity of GVC participation (GVC), calculated as the proportion ò gross exports. Before regressing the model, we take the natural logarithm of GVC values. For further analysis, we also employ backward participation measured by foreign value-added and forward participation measured by domestic value-added. These variables are calculated as the proportion of gross exports. The former is the foreign value-added embedded in own exports or the value-added embedded in the foreign inputs used to produce export goods (backward or "downstream" GVC participation). The latter is the domestic value-added embedded in third-country exports (forward, or "upstream" GVC participation). The value-added in intermediate goods are exported to a trade partner and then reprocessed and exported further by the trade partner. GVC can be calculated by summing all of GVC-related components divided by gross export. In addition to a more accurate representation of the GVC phenomenon, these GVC variables allow us to eliminate the problem of the standard approach, which underestimates the involvement of less export-oriented economies (Ignatenko et al. 2019; Le et al. 2021). We take the data for backward and forward GVC from the EORA database. We take a natural

logarithm of backward (lnBackward) and forward (lnForward) integration and replicate the estimation by using new dependent variables. This variable is taken from the EORA database described in Lenzen et al. (2013), which covers 190 countries from 2010 to 2018.

Following Ha (2022a, b), Ha and Thanh (2022), and Myovella et al. (2020), our key explanatory variable, digital business ($DB_{i,t}$), includes selling online (eCOMM_SO), e-Commerce sales (eCOMM_ES), e-Commerce web sales (eCOMM_WS), and e-Business, and customer relation management (eBUSS_CRM) usage. We take the digital business data from the European Statistics (Eurostat) (Eurostat—Community survey on ICT usage in Households and by Individuals, Eurostat—ICT in Enterprises survey). The dataset is available from 2012 to 2019.

3.1 Control variables

Based on the discussions of previous papers listed in the literature survey, the following variables are selected as control variables. In particular, our set of control variables includes the income level (INC) measured by the real gross domestic product (GDP) per capita at the constant 2010 US dollars, the level of industrialization (IND) measured as a share of value-added in the industry sector to GDP, the degree of openness proxied by the freedom to trade internationally index (EF_FTI) and a net inflow of foreign direct investment (FDI) as in Latif et al. (2018), an environmental factor proxied by nature rents (NR) measured as a share of the sum of coal rents, mineral rents, natural gas rents, and forest rents, a demographic factor proxied by human development (HDI) captured by the human capital index, and the political factors captured by the level of democratization (PM). Most of the data of the variables are collected from World Development Indicator (WDI), except that the level of democratization is obtained from the Finnish Social Science Data Archive (FSSDA), and GE is taken from the World Bank Group Indicator (WBGI), we source the remaining control variables from the World Development Indicator (WDI).

After collecting the data, we merge and clean the country database, and we finally achieve a sample covering 25 European countries for the period 2012–2019.[1] In Table 4 in Appendix, we clearly explain descriptions of variables, including definitions, measures, sources, and summary statistics. The correlation matrix between the key variables in this study is shown in Table 5 in Appendix, which reveals that there may exist a positive association between digital business and GVC participation.

In this study, the cross-sectional dependency (CD) test (Pesaran 2021) is implemented to check the existence of CD problems in our sample. Next, to check the stationarity of the data with the existence of CD, we use the Levin–Lin–Chu unit root test developed by Levin et al. (2002) and the Im–Pesaran–Shin unit root test developed by Im et al. (2003). Since both the tests and applied methods require strongly balanced data, we strictly follow the empirical procedure to clean data by removing countries that have a gap, missing observations, or outliers. After cleaning the data, the number of European countries used to perform the empirical estimations in the next step is 25. This paper cannot be applied to other regions since a similar database is not available. The results are shown in Table 6 in Appendix. The results reveal the existence of CD in most variables, except for FDI. Columns 3 and 4 of this table present the results of the Levin–Lin–Chu and Im–Pesaran–Shin unit root tests, which point out that only some variables are stationary. Therefore, the same tests are employed for the first difference of variables, and stationarity is confirmed as indicated in columns (6) and (7).

Because our sample is characterized by a small number of countries (N) and a small-time interval (T), further the existence of CD and stationarity of the first difference variables are also proven. Based on Beck and Katz (1995) and Nguyen et al. (2020), we use the panel corrected standard error (PCSE) model. In addition, to deal with endogeneity resulting from the simultaneity between GVC values and digital business, a 1-year lag of all independent variables is utilized. For a robustness check, a feasible generalized least squares model (FGLS) (Canh and Thanh 2020; Liao and Cao 2013) is also applied. The two-step generalized method of moment (the two-step GMM) is also applied to further deal with the endogeneity presented in Eq. (1) to ensure the accuracy of our findings as Gala et al. (2018), Sweet and Eterovic (2019).

In brief, our empirical approach is presented as follows. First, data is cleaned before performing the empirical tests and applied methods. Second, we check the presence of CD (by using the CD test) and the stationarity (the Levin–Lin–Chu unit-root test and the Im–Pesaran–Shin unit-root test) of included variables. Third, the PCSE, FGLS, and two-step GMM models are employed to investigate the relationship between digitalization and GVC participation. The nonlinear impacts of digitalization are examined by adding the squared term of digitalization variables into Eq. (1).

---

[1] The detailed information of included countries is provided in Table 3.

Table 1 Digital business and global value chain participation: A linear effect

Variables	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	PCSE estimate				FGLS estimate			
	lnGVC	lnGVC	lnGVC	lnGVC	lnGVC	lnGVC	lnGVC	lnGVC
L.eCOMM_OS	− 0.002**				− 0.002			
	(0.001)				(0.001)			
L.eCOMM_ES		− 0.006***				− 0.006***		
		(0.001)				(0.002)		
L.eCOMM_ES_WS			− 0.010***				− 0.010***	
			(0.002)				(0.002)	
L.eBUSS_CRP				− 0.006***				− 0.006***
				(0.001)				(0.002)
L.INC	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	(0.000)	(0.000)	(0.000)	(0.000)	(0.001)	(0.001)	(0.001)	(0.001)
L.FDI	0.003	− 0.002	− 0.007	− 0.002	0.003	− 0.002	− 0.007	− 0.002
	(0.023)	(0.022)	(0.021)	(0.022)	(0.022)	(0.022)	(0.021)	(0.022)
L.IND	0.006***	0.008***	0.008***	0.008***	0.006***	0.008***	0.008***	0.008***
	(0.001)	(0.001)	(0.001)	(0.001)	(0.002)	(0.002)	(0.002)	(0.002)
L.NR	− 0.023***	− 0.024***	− 0.018***	− 0.024***	− 0.023***	− 0.024***	− 0.018**	− 0.024***
	(0.002)	(0.002)	(0.002)	(0.002)	(0.008)	(0.008)	(0.008)	(0.008)
L.HDI	2.964***	3.286***	3.701***	3.286***	2.964***	3.286***	3.701***	3.286***
	(0.278)	(0.221)	(0.323)	(0.221)	(0.560)	(0.526)	(0.523)	(0.526)
L.PM	− 0.161**	− 0.128***	− 0.183***	− 0.128***	− 0.161	− 0.128	− 0.183	− 0.128
	(0.064)	(0.039)	(0.056)	(0.039)	(0.129)	(0.116)	(0.114)	(0.116)
L.EF_FTI	0.010	0.025***	0.026***	0.025***	0.010	0.025	0.026	0.025
	(0.006)	(0.007)	(0.010)	(0.007)	(0.033)	(0.033)	(0.032)	(0.033)
Observations	150	150	150	150	150	150	150	150
Number of countries	25	25	25	25	25	25	25	25

Standard errors in parentheses

***$p < 0.01$, **$p < 0.05$, *$p < 0.1$

4 Empirical results

4.1 Baseline results

The results of estimating the relationship between digital business and GVC involvement are illustrated in Table 1. Columns (1)–(4) in this table show the regression results according to the PCSE model. Regression results according to the FGLS model are presented in columns (5)–(8). Both models give similar results. Regression coefficients of variables that reflect influences of digital business through selling online (eCOMM_OS), e-Commerce sales (eCOMM_ES), e-Commerce web sales (eCOMM_WS), and e-Business, including customer relationship management (CRM) usage (eBUSS_CRP) are negative and statistically significant except for the coefficient of eCOMM_OS, which is not statistically significant in the FGLS model. Those results imply that digital business has a negative effect on global

value chain participation. That means that developing digital businesses can reduce the intensity of GVC participation.

Subsequently, we consider the impacts of control variables on GVC. The results show that the impacts of income level (INC) and the net inflow of foreign direct investment (FDI) on GVC participants are minimal, almost trivial, and not statistically significant. Besides, the level of industrialization (IND), natural rents (NR), and freedom to trade international (EF_FTI) all have statistically significant impacts on GVC. Specifically, IND and EF_FTI appear to have a positive effect on GVC, whereas the effect of NR on GVC is negative. These findings are in line with those in studies by Allard et al. (2016) and Fernandez-Stark et al. (2011). The effect of the democratization level (PM) is negative, and the degree of influence is quite high compared to that of the previously stated variables (absolute value between 0.13 and 0.18). These findings are consistent with those of Allard et al. (2016), Ge et al. (2020) and Miranda and Wagner

Table 2 Digital business and global value chain participation: a nonlinear effect

Variables	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	PCSE estimate				FGLS estimate			
	lnGVC	lnGVC	lnGVC	lnGVC	lnGVC	lnGVC	lnGVC	lnGVC
L.eCOMM_OS	− 0.008***				− 0.008**			
	(0.003)				(0.004)			
L.eCOMM_OS^2	0.000**				0.000*			
	(0.000)				(0.000)			
L.eCOMM_ES		− 0.013**				− 0.013*		
		(0.005)				(0.008)		
L.eCOMM_ES^2		0.000*				0.000		
		(0.000)				(0.000)		
L.eCOMM_ES_WS			− 0.025***				− 0.025***	
			(0.006)				(0.009)	
L.eCOMM_ES_WS^2			0.000***				0.000*	
			(0.000)				(0.000)	
L.eBUSS_CRP				− 0.013**				− 0.013*
				(0.005)				(0.008)
L.eBUSS_CRP^2				0.000*				0.000
				(0.000)				(0.000)
L.INC	0.000	0.000	− 0.000	0.000	0.000	0.000	− 0.000	0.000
	(0.000)	(0.000)	(0.000)	(0.000)	(0.001)	(0.001)	(0.001)	(0.001)
L.FDI	− 0.002	− 0.003	− 0.007	− 0.003	− 0.002	− 0.003	− 0.007	− 0.003
	(0.023)	(0.022)	(0.022)	(0.022)	(0.022)	(0.022)	(0.021)	(0.022)
L.IND	0.006***	0.008***	0.007***	0.008***	0.006***	0.008***	0.007***	0.008***
	(0.001)	(0.001)	(0.001)	(0.001)	(0.002)	(0.002)	(0.002)	(0.002)
L.NR	− 0.024***	− 0.026***	− 0.025***	− 0.026***	− 0.024***	− 0.026***	− 0.025***	− 0.026***
	(0.003)	(0.002)	(0.003)	(0.002)	(0.008)	(0.008)	(0.009)	(0.008)
L.HDI	3.191***	3.400***	3.927***	3.400***	3.191***	3.400***	3.927***	3.400***
	(0.269)	(0.245)	(0.348)	(0.245)	(0.571)	(0.536)	(0.533)	(0.536)
L.PM	− 0.225***	− 0.148***	− 0.211***	− 0.148***	− 0.225*	− 0.148	− 0.211*	− 0.148
	(0.067)	(0.042)	(0.064)	(0.042)	(0.134)	(0.117)	(0.114)	(0.117)
L.EF_FTI	0.008	0.018***	0.015**	0.018***	0.008	0.018	0.015	0.018
	(0.007)	(0.007)	(0.008)	(0.007)	(0.033)	(0.034)	(0.032)	(0.034)
Observations	150	150	150	150	150	150	150	150
Number of countries	25	25	25	25	25	25	25	25

Standard errors in parentheses

***$p < 0.01$, **$p < 0.05$, *$p < 0.1$

(2017). Notably, the influence of human capital (HDI) on GVC participants is positive, statistically significant (in both models), and much larger (regressed coefficients range from 2.96 to 3.7). These results suggest that human capital plays an important role in enhancing GVC participation.

Early results suggest that the process of digital business transformation prevents countries from joining the GVC. However, as we argued in this paper, these effects will be reversed if the degree of digital business transformation reaches a certain threshold. In other words, a U-shaped relationship between digital business and GVC values appears to be emerging from our findings. Therefore, the following analysis investigates whether digital business and GVC have nonlinear relationships. In so doing, we add the squared terms of the variables representing the digital business to the estimation model. Table 2 shows that statistically significant and positive coefficients are found for all squared terms. The findings provide evidence for the existence of the nonlinear relationship between digital business and GVC values. The coefficients of all squared terms are
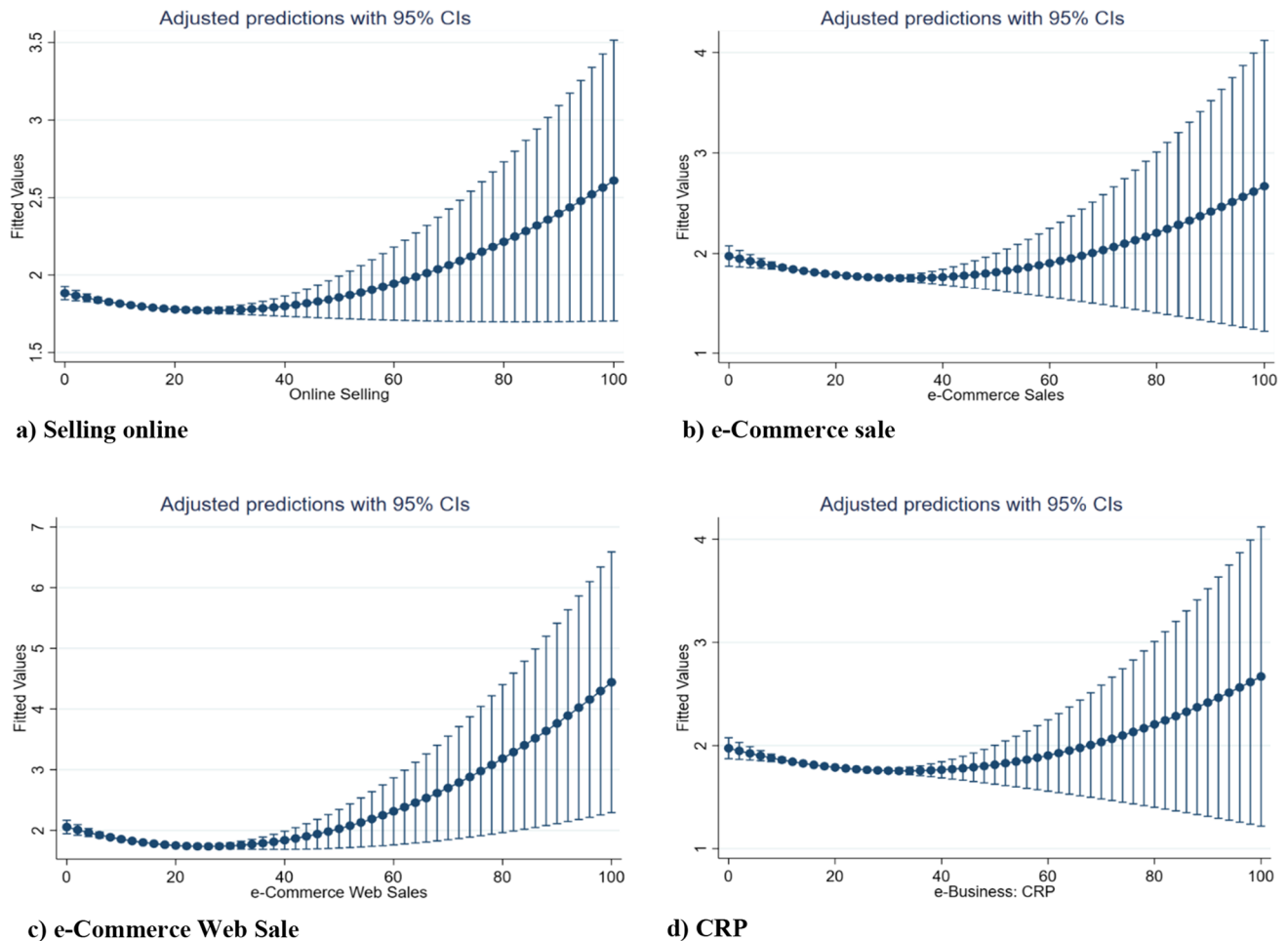
a) Selling online

b) e-Commerce sale

c) e-Commerce Web Sale

d) CRP

Fig. 1 Predictive margin of digital business on global value chain participation

positive, indicating that this is a U-shaped relationship. In other words, the initial implementation of digital business reduces the probability of participation or the scale within GVC. However, when the digital business degree reaches a certain level, it is more likely that they will positively affect GVC values. The results imply that digital business will boost the probability of participation and the ability to scale up a country's position within the supply chain network. To further demonstrate this point, we illustrate the predictive margin of a digital business on the GVC participant in Fig. 1.

Advantages can explain the positive influences of digitalization on the trade value from a high competition in the foreign markets due to technological changes (Azar and Ciabuschi 2017), the cost reduction (Porter and Heppelmann 2014), or a higher industrial efficiency (Dalenogare et al. 2018). The positive nexus between digitalization and trade value is supported by previous research, such as Özsoy et al. (2021) in developing countries or Solomon and van Klyton

(2020) in African countries. A similar study by Abeliansky and Hilbert (2017) examines how the costs of transactions in global trade structures can change over time structures. With a high number of subscriptions to telecom services and a fast bandwidth speed, transaction costs are reduced. However, these papers face limitations when using ICT only as a digitalization proxy. By using various measures, we emphasize the role of the integration of technologies into the business sector. Another novelty of this paper comes from the U-shaped nonlinear effects of digitalization on GVC values. Our results suggest that an improvement in GVC participation requires digitalization to develop to a certain extent. Otherwise, digitalization may deteriorate GVC values. Put it differently, digitalization is a double-edged sword since it may adversely influence the economy and GVC activities. In the early stages of the development of GVC strategy, it is appropriate to aim to promote GVC participation and competitions within the GVC. However, an improvement

of GVC values only occurs if digitalization develops to a certain extent. As argued by Tarafdar et al. (2013), there exist the adverse effects of IT, regarded as a "collection of negative phenomena". Kim et al. (2011) indicate a variety of adverse influences of digitalization, such as spam, malware, hacking, and violation of digital property rights. Ivanova et al. (2019) and Radanliev et al. (2020) also argue the high external costs arising from digitalization, and only a large-sized firm has the financial capacity to cover them. Moreover, digitalization leads to a prevalence of corruption (Ha 2022b). Implementing the digital transformation to a certain level allows countries to access global markets more easily and efficiently (Strange and Zucchella 2017).

In persistent dynamic panels, the use of lags of each variable can be weak instruments for the first differenced variables, hence producing biased results, as argued by Bond et al. (2001). To resolve this issue, we follow Arellano and Bover (1995) and Blundell and Bond (1998) to develop the two-step system GMM. A short dynamic panel can be created using this method (Roodman 2009), as examples are provided in this article. It is also critical to employ the two-step GMM to resolve unobserved heterogeneity and endogeneity arising in our model (Blundell and Bond 1998; Roodman 2009). This study uses the approach of the two-step system GMM with the Windmeijer (2005) correction and a collapsed instrument set as in Roodman (2009). Two-step system GMMs use extra instrument sets to correct bias estimates. Various tests, including the Hansen test of over-identifying restrictions (Parente and Silva 2012), To verify the validity of the additional instruments, the difference-in-Hansen test is conducted (Roodman2009). Results reported in Tables A.****9, and A.*****10 confirm our findings that GVC values are a U-shaped function of digital business.

4.2 Further analysis: different measures of GVC

For further analysis, we apply the same approach as the abovementioned to evaluate the relationship between digital business and backward and forward global value chains (both linear and nonlinear). The estimation results are shown in Tables 7 and 8 in Appendix. In Table 7, for both backward and forward GVC, the respective impacts of digital business are equal in magnitude and direction. The effects of digital trading indicators are both negative and statistically significant. That is completely consistent with the conclusions drawn in Table 5. Same as above, we also examine whether there exists a nonlinear relationship between digitalization and GVC by adding squared terms, as shown in Table 8. Not surprisingly, the results give the same implications as those in Table 2. The relationship between digital business and both forward and backward value supply chains is nonlinear and follows a U-shape. Besides, the control variables' level

and direction of the impact are not significantly different for the forward—and backward value supply chains.

4.3 Further analysis: effects of digital business in the economy featuring high global uncertainty and a well-developed institutional system

We discuss how digital business affects the adverse effects of global uncertainty (UNC) on GVC participants in this section. To examine our prediction, we use the World Uncertainty Index, which counts the frequency of appearance of the word "uncertainty" (UNC_Word) or the number of pages having the word "uncertainty" (UNC_Page). The "uncertainty" data are sourced from the Economist Intelligence Unit (EIU). The interactions between digitalization variables and uncertainty variables are incorporated in Eq. (1). Then, we show the results in Table 9 in Appendix. Based on the results, we can see that both the coefficients of *UNC* and *eCOMM* are mostly negative and statistically significant. However, the coefficient of interaction between digital business and global uncertainty is positive and statistically significant (except for e-Commerce: online selling). The results imply the direction of influence has been reversed from being negative to being positive due to the simultaneous combination of global uncertainty and digital business. In other words, conducting digital business activities in countries with high global uncertainty can mitigate the adverse impacts of global uncertainty on the GVC values of such countries. A contribution to existing knowledge has been made by this finding regarding uncertainty and GVC values (Constantinescu et al. 2019; Ferreira et al. 2021; Tam 2018; Verbeke 2020). Constantinescu et al. (2019) also demonstrate that uncertainty adversely affects the overall trade growth. These effects become more significant on the GVC value due to two opposing forces, of which the GVC values are more dependent on relation-specific investments that are sensitive to uncertainty, but trade patterns are stickier due to these investments. OECD (2021a; b) shows that the Covid-19 crisis as a kind of global uncertainty results in disruptions in the supply chains of some manufacturing and medical products. Moreover, facing high uncertainty, firms tend to reduce investment and slow down their production activities (Dixit 1989; Oriani and Sobrero 2008). This, in turn, adversely affects the participation in the GVC and the expansion within the GVC. However, a knowledge-based economy with diversified production activities is more resilient in the context of a volatile global market (Barnes et al. 2015; Joya 2015). Therefore, a country already implementing the digital transformation process may be less affected by world uncertainty and hence, can either maintain or quickly recover perceived benefits of operating officially

among firms and individuals. Moreover, given the robust relationship between digitalization and economic growth (Niebel 2018), trade (Adeleye et al. 2021), and productivity (Cardona et al. 2013), economic prosperity allows a country with a highly sophisticated economy to strengthen communication efficiency and reduce trade costs. That, in turn, leads to the expansion of GVCs and the promotion of GVC participation. Consequently, a high level of digitalization will encourage firms and individuals to get involved in the GVC even when they face economic uncertainty.

The aim of this study is to examine how institutional quality contributes to digital business success through an empirical analysis. To examine our belief, we add interactions between the level of government effectiveness and digital business variables and variables capturing the level of institutional quality. The results are outlined in Table 10 in Appendix. The coefficients of interaction between digital business and institutional quality are all positive and statistically significant. Therefore, institutional quality plays a decisive role that ensuring the success of digital businesses in encouraging countries to join the GVC or improving their position within the GVC. For a robustness check, we also employ the quality of the institutional system, which is reflected by voice and accountability (VA), political stability and absence of violence/terrorism (PV), government effectiveness (GE), regulatory quality (RQ), rule of law (RL), and control of corruption (CC). These variables are taken from the International Country Risk Guide. To save space, these estimation results are provided upon request. In this regard, our study illuminated the importance of good institutions in administering the GVC. The current literature suggests that participation in the GVC is significantly determined by institutional quality (Ge et al. 2020; Mitra et al. 2020). The improvement of institutional quality helps reduce not only the perceived costs of operating officially but also the perceived benefits of joining the GVCs among firms and individuals (Ignatenko et al. 2019). Moreover, in a nation with good institutions, the risk and uncertainty associated with communication efficiency and trade costs can be minimized. Furthermore, institutional quality is a critical determinant in promoting digital transformation in a country (Vu 2021). As a result, the contribution of digitalization in enhancing the GVC values becomes more apparent when countries are characterized by better institutional quality.

5 Discussions

5.1 The double-edged sword of digitalization in global value chain participation

Our study also supports the view that digitalization is a double-edged sword since it may adversely influence the economy and GVC activities. The literature has indicated the dark part of digitalization. Tarafdar et al. (2013) refer to the adverse effects of IT as a "collection of negative phenomena" that the use of IT potentially infringes the well-being of individuals, organizations, and societies. By reviewing the dark side of digitalization over two decades, Pirkkalainen and Salo (2016) suggest that technostress, information overload, IT addiction, and IT anxiety are all referred to as four dark side phenomena. By indicating a taxonomy of the dark side of the Internet (as a sub-dimension of digital technology), Kim et al. (2011) indicate a variety of adverse influences of digitalization, such as spam, malware, hacking, and violation of digital property rights.

Following Ivanova et al. (2019) and Radanliev et al. (2020), there may exist difficulties in managing firms' servers and thus put them at risk of system failure or data loss. Prior scholars, such as Damgaard et al. (2018) argue that digital transformation generates difficulties not only in geographically connecting investments but also in separating real financial integration and diversification from financial engineering. High dependency on intangible assets that leads to little or no physical contact causes investment valuation to be imprecise, thus increasing difficulties in raising funds through initial public offerings (Damgaard et al. 2018). Additionally, the environment is adversely affected by newly developed technologies (Hilty and Bieser 2017; Yadav and Iqbal 2021). These difficulties make small firms hesitant to digitize their operations, especially in nations where labor is cheap. They will choose the old-fashioned way of doing business with people as their primary resource, eschewing technological investment due to its high cost.

Another dark side of digitalization is that digitalization leads to a prevalence of corruption (Ha 2022b). Smith (1978) contends that the corruptive behavior makes the introduction and application of law inequitable, thus impeding the country's economic and commercial development, and the efficiency of firms' operation. Furthermore, the legitimacy-based view asserts that the favorable treatments from the government officials and easier access to rare and valuable resources rewarded from better political legitimacy discourage firms from neither changing nor being aware of alternative strategic choices to gain competitive advantages (DiMaggio and Powell 1983). Instead, firms become further embedded in the favorable conditions in the long run and enjoy the "economic rent" obtained from this legitimacy (Meyer and Rowan 1977). In this regard, bribery-paying firms may have fewer incentives to engage with GVC participation which requires them to take more risks and bear more costs (Dong 2017). The reason is that they could ensure long-term business growth in the domestic market, at low costs and risks, given the legitimacy obtained from the bribery practices. In fact, managerial experience and entrepreneurial attitudes demonstrate crucial determinants

of GVC participation (Harvie et al. 2010). Given the strong position in the domestic market, the more the firms rely on "economic rent" obtained from bribery, the more likely that the managers would gear the resources and capabilities away from the international market. In the long run, those managers will have less experience in global trade and become even more hesitant to engage in GVC.

Hence, the effect of digitalization on GVC is ambiguous, and the negative effects outweigh the positive ones, digitalization may adversely impact the GVC.

5.2 A nonlinear effect of digitalization on global value chain participation

The nonlinear digitalization-GVC association may take a U-shape. Since digitalization is a new enabler of economic growth, a U-shaped impact on GVC participation would be reasonable. This paper proposes a new evolution pattern of GVCs in a digitalization process. In light of the focus on digitalization, it is important to remember that digitalization is not an isolated phenomenon (Salento 2018). Digitalization affects organizations and the environment in which they operate**.** The successful implementation of new practices requires the integration of technological processes, which may be complex or simple (Landmark et al. 2019; Mazali 2018). In order to develop and implement new practices, it is essential to provide appropriate and functional solutions to all employees within the organization. It is, therefore, important that GVC actors facilitate digitalization so that operators understand its importance and are able to assume greater responsibility within their organizations. If this issue is not addressed, the chances of successful organizational transformation of GVC actors are greatly diminished (Orlikowski 1996). Accordingly, we believe that digitalization can have an adverse effect on GVC participation in an initial phase of digitalization development.

In addition to benefits from a digital transformation, GVC participants must enhance their product offerings to meet new industry standards and market demands (Thun et al. 2019, 2021). As a result of advancements in digital technologies, the pace of change in market needs has increased (Abrell et al. 2016). Several technology-related factors have been noticed as potential challenges when working with modern production technologies, such as technical difficulties, poor usability, and reduced situation awareness (Körner et al. 2019). Many stressors have been identified as technical difficulties, especially software-related problems (crashes, software errors, delayed system responses to user input, and software freezes). In addition to interruptions and added time pressure, Körner et al. (2019)

also indicate that technical problems negatively affect multi-tasking. The main consequences of these barriers are interruption of workflow and slowdown of the work process, increasing the time pressure, and hindering a participant in GVCs. It is also observed that digitalization does not always reach the operational level. In this top-down process, operators are less likely to be satisfied with new digital tools (Thun et al. 2019, 2021).

Additionally, four process-related factors have been identified as enabling digitalization: (1) process context; (2) process performance; (3) process knowledge; and (4) process communication (Gröger et al. 2013). The main goal of these processes is to present the importance of digitalization implementation for the company and the individual's own role and tasks. However, as Caruso (2018) argued, there are difficulties in helping individuals realize the potential of digitalization, which has positive effects on productivity and economic opportunities. Increasing productivity and securing competitive advantages within the GVC network can only be attained if firms adopt new forms of work organization simultaneously with the introduction of new technologies (Thun et al. 2021). The development and implementation processes of digitalization need further exploration as well as the consequences of the interfaces between humans, digital technology, and organizations. Developing an understanding of this knowledge can be accomplished by examining what happens in actual digitization projects. Therefore, in an early phase of the digital transformation process, firms may fail to be involved in GVCs or scale-up within GVC.

Another reason to explain the possibility of adverse consequences of digitalization on GVCs in the early phase of digitalization is its serious negative externalities, including ratcheting-up climate change (Ha 2022b; Ha and Thanh 2022; Kim et al. 2011; Tarafdar et al. 2013; World Economic Forum 2020). While some technology firms have made efforts to improve their practices, they are still regarded as among the most environmentally destructive and unsustainable organizations (World Economic Forum 2020). They are increasing the extraction of rare earth minerals and precious metals such as cobalt in order to meet the voracious demand for hardware. The redundancy of technologies and planned obsolescence are responsible for mountains of waste. The expansion of internet services accounts for one-tenth of global electricity consumption. These environmental issues cannot be easily addressed in the early phase of digitalization. While there has been an increase in the trend of making GVC greener to meet the global demands, the environmental degradation due to digitalization makes GVC actors less attractive (Hu et al. 2021; OECD 2013).

Unquestionably, there are benefits and advantages obtained from new technologies and digitalization, such as processes and production optimization, transaction cost reductions, and therefore an improvement of their position within supply chains. However, progress will be hindered if these structural and environmental challenges cannot be addressed.

5.3 New contributions to the literature

Our study provides both theoretical and empirical evidence on the existence of nonlinear effects of digitalization on GVC participation. It is also the first to study the influences of digitalization on GVC by using a comprehensive concept instead of simple measures, such as ICT, innovation, or novel technology adoptions as in previous papers. By using various digitalization measures, we contend that digitalization has adverse impacts on GVC participation in the early phase of the digital transformation process. The favorable effect then appears after the digitalization development reaches a certain level. Our findings are expected to provide critical insights to both economists and authorities in designing policies to promote digitalization and GVC participation.

6 Conclusions

In this paper, we focus on investigating the relationship between digital business and global value chain participation by employing data from 25 European countries for the period 2012–2019. To assess the prevalence of digital business in the economy, we use four representative indicators, including the value of online selling, E-commerce sale, E-commerce web sales, and E-business. Through the empirical results, we find that there exists a nonlinear relationship between digital business and the probability of joining or scaling up in GVC. More specifically, such a relationship follows a U-shape. In addition, we also provide evidence supporting the findings that the adverse impact of global uncertainty on GVC participation can be mitigated through digital business, while the positive impact of digital business on the success of countries within the GVC is significantly influenced by institutional quality.

6.1 Theoretical contributions

We develop a theoretical framework to extend the insight of the digitalization-GVC nexus. The integration level of digital technology into the business plays a vital role in promoting GVC participation or scale-up within GVC. While prior scholars investigate the influences of ICTs or simple

forms of digitalization on some aspects of the economy and society without delving into other dimensions, we expect to provide a comprehensive understanding of the association between digitalization and GVC with theoretical reasoning and empirical support. We also distinguish between backward and forward GVC, in which the former is the foreign value-added embedded in own exports (backward, or "downstream" GVC participation), and the latter is the domestic value-added embedded in third-country exports (forward, or "upstream" GVC participation). This article extends and enriches the literature on the digitalization-GVC linkage.

6.2 Practical implications

Firstly, we provide empirical evidence for digital business roles as an effective tool to promote GVC values. Encouraging GVC participation is vital for the European region since GVC involvement is regarded as a critical channel for transferring know-how, technology, and process innovation within European regions and between European countries with the rest of the world (Dorrucci et al. 2019). Bontadini et al. (2019) contend that the European countries are losing their competition within GVC. While there is a decreasing trend of intra-regional trade integration, extra-regional trade also experiences a decrease in trade volume. On the policy front, implementing digital business could be a viable path to either penetrate to GVCs or move to higher ladders of value contribution in the chain. It is important to emphasize that digital transformation has a positive effect on GVC values, but it is only effective if the government consistently pursues digital transformation. Enterprises and individuals should be supported through technical, legal, and financial measures that make it easier for them to adapt to digital transformations. It is also recommended that given low human capital and starting point of low capabilities, some European countries are constrained in their abilities and motivation to improve national capabilities. Hence, they have a 'low digitalization level and low production capabilities' vicious circle. This is regarded as a trap of economic stasis where countries with few capabilities will have negligible or no return to the accumulation of more capabilities. Consequently, they are trapped in low value-added activities with little diversification and/or opportunity to move up in their chain (Hausmann and Hidalgo (2011). Our findings suggest that those countries should invest more in tangible and intangible assets (Gruber 2019) to enhance human capital, that from preconditions for better accumulation and integration of knowledge for economic structural change and take some courage to jump out of the "safe zone" with low value-added activities

to the production of more value-added goods and science-based manufacturing.

Furthermore, our findings reveal that digital business development will be a key factor in helping the country mitigate the adverse impacts in the context of high global uncertainty. Digitalization should be considered a vital tool that helps countries overcome challenges stemming from global uncertainty during uncertain times. Furthermore, the governments of these European countries should also build up a well-developed institutional system to enhance the success probability of using the digital business to promote the GVC values of countries.

6.3 Limitations and further research directions

There are two limitations to this article. Firstly, archival data covering only European countries are gathered. It is critical to consider the role of digitalization in encouraging GVC participation in the developing regions as well. Even though GVCs provide developing countries with more opportunities, their involvement in the global trade network is still limited (Dollar 2019; OECD 2019). The governments of these developing economies need an accurate and comprehensive assessment of their digital transformation implementation and the level of involvement in value chains. The problem is that there has been a shortage of surveys conducted, which follow strict guidelines to collect information about various forms or simply about a developing economy's level of digitalization adaptation. Secondly, GVC participation is affected to a greater or lesser extent by digitalization as the result of many factors, such as level of economic development, economic complexity

performance, and government policies, among others. It is critical to consider these channels when examining the digitalization-GVC nexus. Third, it is also important to distinguish digitalization's short-run and long-run influences on GVC. The use of a relatively short time duration may produce biased estimation, leading to unreliable findings. The study in the future should consider these issues in order to provide policymakers and economists with more insightful lessons on how they can promote digital transformation and participation in global value chains in this region.

Appendix

See Tables 3, 4, 5, 6, 7, 8, 9, 10, 11 and 12.

Table 3 Countries in the sample

EU countries		
Austria	Hungary	Portugal
Belgium	Iceland	Slovak Republic
Bulgaria	Ireland	Slovenia
Czech Republic	Italy	Sweden
Denmark	Lithuania	
Spain	Luxembourg	
Estonia	Latvia	
United Kingdom	Malta	
Greece	Netherlands	
Croatia	Poland	

Table 4 Statistical description

Variable	Related papers	Measure	Source	Obs	Mean	SD	Min	Max
lnGVC	Ignatenko et al. (2019) and Le et al. (2021), Koopman et al. (2010) and others	GVC values: a natural logarithm of GVC values	UNCTAD-EORA	175	1.80	0.15	1.46	2.03
lnBackward	Ignatenko et al. (2019) and Le et al. (2021), Koopman et al. (2010) and others	Backward GVC: a natural logarithm of foreign value-added to GVC values	UNCTAD-EORA	175	1.78	0.15	1.45	2.03
lnForward	Ignatenko et al. (2019) and Le et al. (2021), Koopman et al. (2010) and others	Forward GVC: a natural logarithm of domestic value-added to GVC values	UNCTAD-EORA	175	1.74	0.15	1.41	1.99
eCOMM_OS	Ha (2022a, 2022b), Ha and Thanh (2022) and Myovella et al. (2020)	Online selling: a share of individuals selling goods and services online	Eurostat	175	16.19	9.01	2.00	48.00
eCOM_ES	Ha (2022a, b), Ha and Thanh (2022) and Myovella et al. (2020)	E-commerce sales: a share of enterprises with sales	Eurostat	175	19.24	6.79	6.00	38.00
eCOM_WS	Ha (2022a, b), Ha and Thanh (2022) and Myovella et al. (2020)	E-commerce web sales: a share of enterprises with web sales (via websites, apps, or online marketplaces)	Eurostat	175	15.67	5.73	5.00	35.00
eBUSS_CRP	Ha (2022a, b), Ha and Thanh (2022) and Myovella et al. (2020)	CRP: a share of enterprises with E-commerce, customer relation management (CRM), and secure transaction	Eurostat	175	19.24	6.79	6.00	38.00
INC	Doan and Le (2021), Fernandes et al. (2020), Latif et al. (2018), Le et al. (2021), Efogo (2020)	Real GDP per capital (constant 2010 US dollars)	WDI	175	35.56	25.53	1.05	110.81
FDI	Arkolakis et al. (2012), Buelens and Tirpák (2017), Kowalski et al. (2015), Efogo (2020)	Net FDI inflow: a share of GDP	WDI	175	-0.02	0.38	-2.92	1.63
IND	Antràs (2020), Latif et al. (2018), Yi (2003, 2010)	Industrialization level: a value-added of industry sector to GDP	WDI	175	22.87	5.94	10.52	38.38
NR	Fernandes et al. (2020) and Efogo (2020)	Natural rents: a share of the sum of coal rents, mineral rents, natural gas rents, and forest rents to GDP (%)	WDI	175	0.71	1.45	0.00	10.33
HDI	Allard et al. (2016), Fernandez-Stark et al. (2011), Gereffi and Fernandez-Stark (2018), Kowalski et al. (2015), Efogo (2020)	Human capital: a log of human capital index	WDI	175	0.89	0.04	0.80	0.96
PM	Acemoglu et al. (2007), Chor (2010), Costinot (2009), Levchenko (2007), Nunn (2007) 23 See Kowalski et al. (2015)	Democratization level: index of democratization	FSSDA	175	0.74	0.12	0.27	0.89
EF_FTI	Fernandes et al. (2020), Johnson and Noguera (2016), Kowalski et al. (2015), Laget et al. (2018), Orefice and Rocha (2014)	Freedom to trade internationally: an index of freedom to exchange, buying, selling, making contracts…	Fraser Institute	175	8.34	0.32	7.24	8.95

UNCTAD-EORA the UNCTAD_Eora global value chains database, *WDI* World Development Indicator, *FSSDA* Finnish Social Science Data Archive, *WBGI* World Bank Group Indicator

Table 5 Correlation coefficients

	lnGVC	lnBackward	lnForward	eCOMM_OS	eCOMM_ES	eCOMM_WS	CRP	INC	FDI	IND	NR	HDI	PM	EF_FTI	VIF
lnGVC	1														
lnBackward	0.980***	1													
lnForward	0.989***	0.949***	1												
eCOMM_OS	0.231**	0.196**	0.210**	1											
eCOM_ES	0.350***	0.317***	0.340***	0.563***	1										
eCOM_WS	0.279***	0.248***	0.267***	0.571***	0.973***	1									
eBUSS_CRP	0.350***	0.317***	0.340***	0.563***	0.973***	0.973***	1								3.01
INC	0.395***	0.354***	0.370***	0.422***	0.461***	0.483***	0.461***	1							2.03
FDI	0.000926	−0.0265	0.0137	0.0622	0.00860	−0.00359	0.00860	0.112	1						1.07
IND	0.184*	0.166*	0.155*	−0.00439	0.300***	0.251***	0.300***	−0.144	−0.00831	1					1.53
NR	−0.00506	0.0247	−0.104	0.291***	0.276***	0.335***	0.276***	0.304***	0.0669	0.371***	1				1.55
HDI	0.589***	0.559***	0.577***	0.480***	0.413***	0.418***	0.413***	0.451***	0.0582	0.0254	0.206**	1			2.03
PM	0.323***	0.330***	0.308***	0.181*	0.330***	0.357***	0.357***	0.436***	0.0947	−0.166*	0.169*	0.441***	1		2.24
EF_FTI	0.108	0.108	0.160*	0.135	0.163*	0.133	0.163*	−0.0188	−0.0433	−0.237***	−0.360***	0.180*	0.100	1	1.52

*,**,***Significant levels at 10%, 5%, and 1%, respectively

Table 6 Cross-sectional dependence tests and stationary tests

Variable (in level)	CD-test, Pesaran (2004)	Levin–Lin–Chu unit-root test	Im-Pesaran–Shin test (Z-bar)	Variable (in difference)	Levin–Lin–Chu unit-root test	Im-Pesaran–Shin test (Z-bar)
lnGVC	37.96***	−31.66***	−0.71	DlnGVC	−28.59***	−2.99***
lnBackward	32.09***	−1.77**	1.76	DlnBackward	−19.94***	−3.10***
lnForward	35.27***	−38.71***	0.11	DlnForward	−17.93***	−2.34***
eCOMM_OS	6.21***	−4.83***	−0.43	DeCOMM_OS	−13.43***	−3.24***
eCOM_ES	13.56***	−0.90	−1.25*	DeCOM_ES	−15.01***	−3.96***
eCOM_WS	16.77***	−7.48***	−2.00**	DeCOM_WS	−22.73***	−4.07***
eBUSS_CRP	13.55***	−0.90	−1.25*	DeBUSS_CRP	−15.01***	−3.96***
INC	41.69***	−5.54***	2.84	DINC	−47.61***	−2.63***
FDI	0.56	−0.03	−3.52***	DFDI	−7.07***	−4.73***
IND	3.81***	−26.32***	−0.46	DIND	−27.98***	−2.77***
NR	23.17***	−22.37***	−2.61***	DNR	−7.74***	−1.84*
HDI	42.06***	−4.90***	−1.59**	DHDI	−10.22***	−3.54***
PM	9.38***	−6.42	0.37	DPM	−10.66***	−2.62***
EF_FTI	24.53***	−11.17***	−1.06	DEF_FTI	−10.24***	−3.25***

Regarding the CD test, the null hypothesis is that the cross-section is independent. p value is closed to zero, implying that data are correlated across panel groups. Regarding the Levin–Lin–Chu unit-root and Im-Pesaran–Shin test, the null hypothesis is "All panels contain unit root" and the alternative hypothesis is "Al least one panel is stationary"

*,**,***Significant levels at 10%, 5%, and 1%, respectively

Table 7 Digital business and backward and forward global value chains: a linear effect

Variables	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	PCSE estimate							
	lnBackward				lnForward			
LeCOMM_OS	− 0.003***				− 0.002**			
	(0.001)				(0.001)			
LeCOMM_ES		− 0.006***				− 0.006***		
		(0.001)				(0.001)		
LeCOMM_ES_WS			− 0.011***				− 0.009***	
			(0.002)				(0.002)	
LeBUSS_CRP				− 0.006***				− 0.006***
				(0.001)				(0.001)
LINC	− 0.000**	− 0.000	− 0.000**	− 0.000	0.000	0.000	0.000	0.000
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
LFDI	− 0.009	− 0.015	− 0.020	− 0.015	0.011	0.006	0.002	0.006
	(0.026)	(0.024)	(0.024)	(0.024)	(0.021)	(0.020)	(0.019)	(0.020)
LIND	0.005***	0.007***	0.007***	0.007***	0.006***	0.009***	0.008***	0.009***
	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
LNR	− 0.015***	− 0.016***	− 0.009***	− 0.016***	− 0.033***	− 0.034***	− 0.028***	− 0.034***
	(0.002)	(0.001)	(0.002)	(0.001)	(0.003)	(0.003)	(0.002)	(0.003)
LHDI	2.988***	3.237***	3.695***	3.237***	3.035***	3.312***	3.683***	3.312***
	(0.265)	(0.183)	(0.287)	(0.183)	(0.283)	(0.255)	(0.348)	(0.255)
LPM	− 0.103	− 0.048	− 0.109**	− 0.048	− 0.181***	− 0.143***	− 0.193***	− 0.143***
	(0.063)	(0.035)	(0.052)	(0.035)	(0.062)	(0.039)	(0.055)	(0.039)
L.EF_FTI	0.010	0.025***	0.027***	0.025***	0.023***	0.037***	0.038***	0.037***
	(0.006)	(0.007)	(0.010)	(0.007)	(0.007)	(0.009)	(0.010)	(0.009)
Observations	150	150	150	150	150	150	150	150
Number of countries	25	25	25	25	25	25	25	25

Standard errors in parentheses

***$p < 0.01$, **$p < 0.05$, *$p < 0.1$

Table 8 Digital business and backward and forward global value chains: a nonlinear effect

Variables	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	FGLS estimate							
	lnBackward				lnForward			
L.eCOMM_OS	− 0.010***				− 0.009***			
	(0.002)				(0.003)			
L.eCOMM_OS^2	0.000***				0.000**			
	(0.000)				(0.000)			
L.eCOMM_ES		− 0.021***				− 0.012**		
		(0.006)				(0.005)		
L.eCOMM_ES^2		0.000**				0.000		
		(0.000)				(0.000)		
L.eCOMM_ES_WS			− 0.034***				− 0.023***	
			(0.008)				(0.006)	
L.eCOMM_ES_WS^2			0.001***				0.000***	
			(0.000)				(0.000)	
L.eBUSS_CRP				− 0.021***				− 0.012**
				(0.006)				(0.005)
L.eBUSS_CRP^2				0.000**				0.000
				(0.000)				(0.000)
L.INC	− 0.000	− 0.000***	− 0.001***	− 0.000***	0.000	0.000	− 0.000	0.000
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
L.FDI	− 0.014	− 0.016	− 0.020	− 0.016	0.007	0.006	0.002	0.006
	(0.026)	(0.024)	(0.024)	(0.024)	(0.021)	(0.020)	(0.020)	(0.020)
L.IND	0.005***	0.006***	0.006***	0.006***	0.007***	0.008***	0.008***	0.008***
	(0.001)	(0.000)	(0.000)	(0.000)	(0.001)	(0.001)	(0.001)	(0.001)
L.NR	− 0.016***	− 0.021***	− 0.021***	− 0.021***	− 0.034***	− 0.036***	− 0.035***	− 0.036***
	(0.002)	(0.003)	(0.004)	(0.003)	(0.003)	(0.003)	(0.003)	(0.003)
L.HDI	3.255***	3.454***	4.034***	3.454***	3.267***	3.402***	3.888***	3.402***
	(0.268)	(0.216)	(0.327)	(0.216)	(0.270)	(0.274)	(0.368)	(0.274)
L.PM	− 0.178***	− 0.086**	− 0.150**	− 0.086**	− 0.246***	− 0.159***	− 0.218***	− 0.159***
	(0.066)	(0.037)	(0.062)	(0.037)	(0.066)	(0.043)	(0.063)	(0.043)
L.EF_FTI	0.008	0.013	0.011	0.013	0.022***	0.032***	0.028***	0.032***
	(0.007)	(0.008)	(0.009)	(0.008)	(0.008)	(0.008)	(0.008)	(0.008)
Observations	150	150	150	150	150	150	150	150
Number of countries	25	25	25	25	25	25	25	25

Standard errors in parentheses

***$p<0.01$, **$p<0.05$, *$p<0.1$

Table 9 Interaction between digital business and global uncertainty

Variables	(1) E-commerce: online selling	(2) E-commerce: online selling	(3) E-commerce: sales	(4) E-commerce: sales	(5) E-commerce: web sales	(6) E-commerce: web sales	(7) E-business: CRP	(8) E-business: CRP
	UNC_Word	UNC_Page	UNC_Word	UNC_Page	UNC_Word	UNC_Page	UNC_Word	UNC_Page
LeCOMM	− 0.01	− 0.01	− 0.02***	− 0.02***	− 0.02***	− 0.03***	− 0.02***	− 0.02***
	(0.006)	(0.006)	(0.005)	(0.005)	(0.006)	(0.007)	(0.005)	(0.005)
L.UNC	− 0.12	− 0.21	− 0.39***	− 0.48***	− 0.38***	− 0.49***	− 0.39***	− 0.48***
	(0.150)	(0.185)	(0.129)	(0.181)	(0.127)	(0.179)	(0.129)	(0.181)
L.UNC*eCOMM	0.01	0.01	0.02***	0.02***	0.02***	0.02***	0.02***	0.02***
	(0.006)	(0.007)	(0.005)	(0.006)	(0.006)	(0.008)	(0.005)	(0.006)
L.INC	0.00	0.00*	0.00	0.00	0.00	0.00	0.00	0.00
	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
L.FDI	− 0.00	− 0.00	− 0.01	− 0.01	− 0.01	− 0.01	− 0.01	− 0.01
	(0.023)	(0.022)	(0.022)	(0.023)	(0.023)	(0.023)	(0.022)	(0.023)
L.IND	− 0.00	− 0.00	0.00**	0.00**	0.00*	0.00*	0.00**	0.00**
	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
L.NR	− 0.02**	− 0.02***	− 0.01***	− 0.01***	− 0.01	− 0.01	− 0.01***	− 0.01***
	(0.008)	(0.007)	(0.005)	(0.004)	(0.005)	(0.005)	(0.005)	(0.004)
L.HDI	2.59***	2.58***	3.30***	3.41***	3.68***	3.77***	3.30***	3.41***
	(0.359)	(0.326)	(0.369)	(0.410)	(0.446)	(0.500)	(0.369)	(0.410)
L.PM	− 0.28***	− 0.27***	− 0.19***	− 0.19***	− 0.22***	− 0.21***	− 0.19***	− 0.19***
	(0.078)	(0.077)	(0.053)	(0.056)	(0.059)	(0.061)	(0.053)	(0.056)
L.EF_FTI	0.02	0.02	0.04*	0.05*	0.05*	0.05*	0.04*	0.05*
	(0.024)	(0.022)	(0.025)	(0.023)	(0.026)	(0.025)	(0.025)	(0.023)
Observations	132	132	132	132	132	132	132	132
Number of countries	22	22	22	22	22	22	22	22

Standard errors in parentheses

***$p < 0.01$, **$p < 0.05$, *$p < 0.1$

Table 10 Interaction between digital business and institutional quality

Variables	(1) Online selling	(2) E-commerce sale	(3) E-commerce web sale	(4) CRP
LeCOMM	− 0.01***	− 0.01***	− 0.02***	− 0.01***
	(0.002)	(0.002)	(0.003)	(0.002)
L.GE	− 0.17***	− 0.17***	− 0.19***	− 0.17***
	(0.025)	(0.016)	(0.021)	(0.016)
L.GE*eCOMM	0.01***	0.01***	0.01***	0.01***
	(0.001)	(0.001)	(0.002)	(0.001)
L.INC	0.00***	0.00**	0.00	0.00**
	(0.000)	(0.000)	(0.000)	(0.000)
L.FDI	− 0.00	− 0.00	− 0.00	− 0.00
	(0.023)	(0.023)	(0.022)	(0.023)
L.IND	0.01***	0.01***	0.01***	0.01***
	(0.001)	(0.001)	(0.001)	(0.001)
L.NR	− 0.03***	− 0.03***	− 0.03***	− 0.03***
	(0.004)	(0.003)	(0.003)	(0.003)
L.HDI	3.39***	3.36***	3.71***	3.36***
	(0.284)	(0.246)	(0.307)	(0.246)
L.PM	− 0.20***	− 0.12***	− 0.17***	− 0.12***
	(0.065)	(0.046)	(0.062)	(0.046)
L.EF_FTI	0.02***	0.02**	0.01	0.02**
	(0.008)	(0.007)	(0.009)	(0.007)
Observations	150	150	150	150
Number of countries	25	25	25	25

Standard errors in parentheses

*** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$

Table 11 A linear effect of digital business and global value chain participation: two-step GMM model

Variables	(1)	(2)	(3)	(4)
	PCSE estimate			
	lnGVC	lnGVC	lnGVC	lnGVC
LeCOMM_OS	− 0.0004*			
	(0.000)			
LeCOMM_ES		− 0.0006		
		(0.000)		
LeCOMM_ES_WS			− 0.0025**	
			(0.001)	
LeBUSS_CRP				− 0.5824*
				(0.303)
L.INC	0.0031**	0.0002	− 0.0002	0.0011**
	(0.001)	(0.001)	(0.002)	(0.000)
L.FDI	− 0.0000	− 0.0000	− 0.0003	− 0.0004
	(0.000)	(0.000)	(0.000)	(0.000)
L.IND	0.0042	− 0.0019	− 0.0106	0.0105*
	(0.004)	(0.002)	(0.008)	(0.006)
L.NR	− 0.0003	− 0.0005	0.0003	− 0.0008
	(0.000)	(0.000)	(0.001)	(0.001)
L.HDI	0.1254	0.0002	− 0.0002	0.0017
	(0.133)	(0.001)	(0.002)	(0.003)
L.PM	0.1254	− 0.0539	0.7923**	0.3330
	(0.133)	(0.123)	(0.343)	(0.247)
L.EF_FTI	− 0.0486**	− 0.0168	− 0.0246	− 0.0850**
	(0.023)	(0.012)	(0.034)	(0.036)
Observations	150	150	150	150
Number of countries	25	25	25	25
AR (1): p value	0.056*	0.051*	0.059*	0.051*
AR (2): p value	0.455	0.635	0.386	0.763
Hansen test: p value	0.550	0.181	0.460	0.291
Diff-Hansen test: p value	0.728	0.462	0.728	0.661
AR (1): p value	0.056*	0.051*	0.059*	0.051*

***$p < 0.01$, **$p < 0.05$, *$p < 0.1$

Table 12 A nonlinear effect of digital business and global value chain participation: two-step GMM model

Variables	(1)	(2)	(3)	(4)
	PCSE estimate			
	lnGVC	lnGVC	lnGVC	lnGVC
L.eCOMM_OS	− 0.00066*			
	(0.001)			
L.eCOMM_OS^2	0.00001*			
	(0.000)			
L.eCOMM_ES		− 0.00218**		
		(0.002)		
L.eCOMM_ES^2		0.00004*		
		(0.000)		
L.eCOMM_ES_WS			− 0.00079*	
			(0.001)	
L.eCOMM_ES_WS^2			0.00003**	
			(0.000)	
L.eBUSS_CRP				− 0.00034*
				(0.001)
L.eBUSS_CRP^2				0.00003**
				(0.000)
L.INC	0.00003	− 0.00014	− 0.00000	− 0.00009
	(0.000)	(0.000)	(0.000)	(0.000)
L.FDI	− 0.00191	0.00114	− 0.00805	− 0.00765
	(0.002)	(0.006)	(0.005)	(0.005)
L.IND	− 0.00023	0.00005	− 0.00061	− 0.00046
	(0.000)	(0.001)	(0.000)	(0.001)
L.NR	0.00009	0.00142	− 0.00050	0.00063
	(0.001)	(0.001)	(0.001)	(0.001)
L.HDI	0.06185	0.25940**	− 0.05028	− 0.10868
	(0.122)	(0.127)	(0.158)	(0.162)
L.PM	− 0.02403	− 0.03131	0.00244	0.00317
	(0.021)	(0.029)	(0.013)	(0.031)
L.EF_FTI	− 0.00132	0.01323*	− 0.00279	− 0.00025
	(0.004)	(0.007)	(0.002)	(0.004)
Observations	150	150	150	150
Number of countries	25	25	25	25
AR (1): *p* value	0.049*	0.063*	0.041*	0.069*
AR (2): *p* value	0.458	0.638	0.737	0.399
Hansen test: *p* value	0.850	0.181	0.182	0.469
Diff-Hansen test: *p* value	0.129	0.360	0.469	0.618

Standard errors in parentheses

***$p < 0.01$, **$p < 0.05$, *$p < 0.1$

Data availability statement Data available on request due to privacy/ethical restrictions.

References

Abeliansky AL, Hilbert M (2017) Digital technology and international trade: is it the quantity of subscriptions or the quality of data speed that matters? Telecommun Policy 41(1):35–48. https://doi.org/10.1016/j.telpol.2016.11.001

Abrell T, Pihlajamaa M, Kanto L, vom Brocke J, Uebernickel F (2016) The role of users and customers in digital innovation: insights from B2B manufacturing firms. Inf Manag 53(3):324–335. https://doi.org/10.1016/j.im.2015.12.005

Acemoglu D, Antràs P, Helpman E (2007) Contracts and technology adoption. Am Econ Rev 97(3):916–943. https://doi.org/10.1257/aer.97.3.916

Adeleye BN, Adedoyin F, Nathaniel S (2021) The criticality of ICT-trade nexus on economic and inclusive growth. Inf Technol Dev 27(2):293–313. https://doi.org/10.1080/02681102.2020.1840323

Alcácer J, Cantwell J, Piscitello L (2016) Internationalization in the information age: a new era for places, firms, and international business networks? J Int Bus Stud 47(5):499–512. https://doi.org/10.1057/jibs.2016.22

Allard C, Kriljenko JIC, Chen W, Gonzalez-Garcia JR, Kitsios E, Treviño J (2016) Trade integration and global value chains in Sub-Saharan Africa: in pursuit of the missing link. Dep Pap. https://doi.org/10.5089/9781498349901.087.A001

Amador J, Cabral S (2016) Global value chains: a survey of drivers and measures. J Econ Surv 30(2):278–301. https://doi.org/10.1111/joes.12097

Antràs P (2020) Conceptual aspects of global value chains. World Bank Econ Rev 34(3):551–574. https://doi.org/10.1093/wber/lhaa006

Arellano M, Bover O (1995) Another look at the instrumental variable estimation of error-components models. J Econometr 68(1):29–51. https://doi.org/10.1016/0304-4076(94)01642-D

Arkolakis C, Costinot A, Rodríguez-Clare A (2012) New trade models, same old gains? Am Econ Rev 102(1):94–130. https://doi.org/10.1257/aer.102.1.94

Autio E, Nambisan S, Thomas LDW, Wright M (2018) Digital affordances, spatial affordances, and the genesis of entrepreneurial ecosystems. Strateg Entrep J 12(1):72–95. https://doi.org/10.1002/sej.1266

Avom D, Dadegnon AK, Igue CB (2021) Does digitalization promote net job creation? Empirical evidence from WAEMU countries. Telecommun Policy 45(8):102215. https://doi.org/10.1016/j.telpol.2021.102215

Azar G, Ciabuschi F (2017) Organizational innovation, technological innovation, and export performance: the effects of innovation radicalness and extensiveness. Int Bus Rev 26(2):324–336. https://doi.org/10.1016/j.ibusrev.2016.09.002

Baldwin R, Venables AJ (2013) Spiders and snakes: offshoring and agglomeration in the global economy. J Int Econ 90(2):245–254. https://doi.org/10.1016/j.jinteco.2013.02.005

Barnes AP, Hansson H, Manevska-Tasevska G, Shrestha SS, Thomson SG (2015) The influence of diversification on long-term viability of the agricultural sector. Land Use Policy 49:404–412. https://doi.org/10.1016/j.landusepol.2015.08.023

Beck N, Katz JN (1995) What to do (and not to do) with time-series cross-section data. Am Polit Sci Rev 89(3):634–647. https://doi.org/10.2307/2082979

Bettiol M, Capestro M, Marchi VD, Maria ED (2020) Industry 4.0 investments in manufacturing firms and internationalization. In: "Marco Fanno" working papers (No. 0245; "Marco Fanno" working papers). Dipartimento di Scienze Economiche "Marco Fanno." accessed on 30 March 2022. https://ideas.repec.org/p/pad/wpaper/0245.html

Blundell R, Bond S (1998) Initial conditions and moment restrictions in dynamic panel data models. J Econometr 87(1):115–143. https://doi.org/10.1016/S0304-4076(98)00009-8

Bogers M, Hadar R, Bilberg A (2016) Additive manufacturing for consumer-centric business models: implications for supply chains in consumer goods manufacturing. Technol Forecast Soc Chang 102:225–239. https://doi.org/10.1016/j.techfore.2015.07.024

Bouwman H, Nikou S, de Reuver M (2019) Digitalization, business models, and SMEs: how do business model innovation practices improve performance of digitalizing SMEs? Telecommun Policy 43(9):101828. https://doi.org/10.1016/j.telpol.2019.101828

Buelens C, Tirpák M (2017) Reading the footprints: how foreign investors shape countries' participation in global value chains. Comp Econ Stud 59(4):561–584. https://doi.org/10.1057/s41294-017-0036-2

Canh NP, Thanh SD (2020) Financial development and the shadow economy: a multi-dimensional analysis. Econ Anal Policy 67:37–54. https://doi.org/10.1016/j.eap.2020.05.002

Cardona M, Kretschmer T, Strobel T (2013) ICT and productivity: conclusions from the empirical literature. Inf Econ Policy 25:109–125. https://doi.org/10.1016/j.infoecopol.2012.12.002

Caruso L (2018) Digital innovation and the fourth industrial revolution: epochal social changes? AI Soc 33(3):379–392. https://doi.org/10.1007/s00146-017-0736-1

Chor D (2010) Unpacking sources of comparative advantage: a quantitative approach. J Int Econ 82(2):152–167. https://doi.org/10.1016/j.jinteco.2010.07.004

Constantinescu C, Mattoo A, Ruta M (2019) Policy uncertainty, trade, and global value chains: some facts, many questions. The World Bank. https://doi.org/10.1596/1813-9450-9048

Costinot A (2009) On the origins of comparative advantage. J Int Econ 77(2):255–264. https://doi.org/10.1016/j.jinteco.2009.01.007

Dalenogare LS, Benitez GB, Ayala NF, Frank AG (2018) The expected contribution of Industry 4.0 technologies for industrial performance. Int J Prod Econ 204:383–394. https://doi.org/10.1016/j.ijpe.2018.08.019

Damgaard J, Elkjaer T, Johannesen N (2018) Piercing the veil. Finance Dev. https://doi.org/10.5089/9781484357415.022.A016

Dethine B, Enjolras M, Monticolo D (2020) Digitalization and SMEs' export management: impacts on resources and capabilities. Technol Innov Manag Rev 10(4):18–34. https://doi.org/10.2221/timreview/1344

DiMaggio PJ, Powell WW (1983) The iron cage revisited: institutional isomorphism and collective rationality in organizational fields. Am Sociol Rev 48(2):147–160. https://doi.org/10.2307/2095101

Dixit A (1989) Entry and exit decisions under uncertainty. J Polit Econ 97(3):620–638

Doan TN, Le HT (2021) Upgrading the global value chain with regime-wide rules of origin. Appl Econ Lett 28(2):143–147. https://doi.org/10.1080/13504851.2020.1739223

Dollar D (2019) How global value chains open opportunities for developing countries. Brookings accessed on 30 March 2022. https://www.brookings.edu/blog/order-from-chaos/2019/04/15/how-global-value-chains-open-opportunities-for-developing-countries/

Dong M (2017) Does corporate political activity make firms less risk taking. Undefined.accessed on 30 March 2022. https://www.semanticscholar.org/paper/Does-Corporate-Political-Activity-Make-Firms-Less-Dong/36ac26540a3ec1c1fdc1a6720eee7105c18bff36

Dorrucci E, Gunnella V, Al-Haschimi A, Benkovskis K, Chiacchio F, de Soyres F, Di Lupidio B, Fidora M, Franco-Bedoya S, Frohm E, Gradeva K, López-García P, Koester G, Nickel C, Osbat C, Pavlova E, Schmitz M, Schroth J, Skudelny F, Wörz J (2019) The impact of global value chains onthe euro area economy (research report no. 221). ECB occasional paper. https://doi.org/10.2866/870210

Fernandes AM, Kee HL, Winkler DE (2020) Determinants of global value chain participation: cross-country evidence (SSRN scholarly paper ID 3561987). Social Science Research Network. accessed on 30 March 2022 https://papers.ssrn.com/abstract=3561987

Fernandez-Stark K, Frederick S, Gereffi G (2011) Workforce development in the apparel global value chain. https://doi.org/10.13140/RG.2.1.4327.7284

Ferreira J-P, Ramos P, Barata E, Court C, Cruz L (2021) The impact of COVID-19 on global value chains: disruption in nonessential goods production. Reg Sci Policy Pract. https://doi.org/10.1111/rsp3.12416

Gala P, Camargo J, Magacho G, Rocha I (2018) Sophisticated jobs matter for economic complexity: an empirical analysis based on

input-output matrices and employment data. Struct Change Econ Dyn 45:1–8. https://doi.org/10.1016/j.strueco.2017.11.005

Ge Y, Dollar D, Yu X (2020) Institutions and participation in global value chains: evidence from belt and road initiative. China Econ Rev 61:101447. https://doi.org/10.1016/j.chieco.2020.101447

Geaneotes, Alexis; Mignano, Kathleen. 2020. Leveraging Inclusive Business Models to Support the Base of the Pyramid during COVID-19. EMCompass;No. 84. International Finance Corporation, Washington, DC. © International Finance Corporation. https://openknowledge.worldbank.org/handle/10986/34307

Gereffi G, Fernandez-Stark K (2018) Global value chain analysis: a primer (second edition). In: Gereffi G (ed) Global value chains and development: redefining the contours of 21st century capitalism. Cambridge University Press, Cambridge, pp 305–342. https://doi.org/10.1017/9781108559423.012

Global value chains: efficiency and risks in the context of COVID-19. (2021) OECD. Retrieved October 28, 2021, from https://www.oecd.org/coronavirus/policy-responses/global-value-chains-efficiency-and-risks-in-the-context-of-covid-19-67c75fdc/

Goldfarb A, Tucker C (2019) Digital economics. J Econ Lit 57(1):3–43. https://doi.org/10.1257/jel.20171452

Grant RM (1991) The resource-based theory of competitive advantage: implications for strategy formulation. Calif Manag Rev 33(3):114–135. https://doi.org/10.2307/41166664

Gröger C, Hillmann M, Hahn F, Mitschang B, Westkämper E (2013) The operational process dashboard for manufacturing. Procedia CIRP 7:205–210. https://doi.org/10.1016/j.procir.2013.05.035

Gruber H (2019) Proposals for a digital industrial policy for Europe. Telecommun Policy 43(2):116–127. https://doi.org/10.1016/j.telpol.2018.06.003

Ha LT (2022a) Effects of digitalization on financialization: empirical evidence from European countries. Technol Soc 68:101851. https://doi.org/10.1016/j.techsoc.2021.101851

Ha LT (2022b) Are digital business and digital public services a driver for better energy security? Evidence from a European sample. Environ Sci Pollut Res. https://doi.org/10.1007/s11356-021-17843-2

Ha LT, Thanh TT (2022) Effects of digital public services on trades in green goods: does institutional quality matter? J Innov Knowl 7(1):100168. https://doi.org/10.1016/j.jik.2022.100168

Harvie C, Narjoko D, Oum T (2010). "Firm Characteristic Determinants of SME Participation in Production Networks," Working Papers DP-2010-11, Economic Research Institute for ASEAN and East Asia (ERIA).

Helmerich N, Raj-Reichert G, Zajak S (2021) Exercising associational and networked power through the use of digital technology by workers in global value chains. Compet Chang 25(2):142–166. https://doi.org/10.1177/1024529420903289

Hilty L, Bieser J (2017) Opportunities and risks of digitalization for climate protection in Switzerland. University of Zurich, Zurich. https://doi.org/10.5167/uzh-14112

Hu D, Jiao J, Tang Y, Han X, Sun H (2021) The effect of global value chain position on green technology innovation efficiency: from the perspective of environmental regulation. Ecol Ind 121:107195. https://doi.org/10.1016/j.ecolind.2020.107195

Ignatenko A, Raei F, Mircheva B, Papi L (2019) Global Value chains: what are the benefits and why do countries participate? IMF working papers, 2019(018). https://doi.org/10.5089/9781484392928.001.A001

Im KS, Pesaran MH, Shin Y (2003) Testing for unit roots in heterogeneous panels. J Econometr 115(1):53–74. https://doi.org/10.1016/S0304-4076(03)00092-7

Ivanova IA, Pulyaeva VN, Vlasenko LV, Gibadullin AA, Sadriddinov MI (2019) Digitalization of organizations: current issues, managerial challenges and socio-economic risks. J Phys Conf Ser 1399:033038. https://doi.org/10.1088/1742-6596/1399/3/033038

Jamil S (2021) From digital divide to digital inclusion: challenges for wide-ranging digitalization in Pakistan. Telecommun Policy 45(8):102206. https://doi.org/10.1016/j.telpol.2021.102206

Johnson RC, Noguera G (2016) A portrait of trade in value added over four decades (working paper no. 22974; working paper series). National Bureau of Economic Research. https://doi.org/10.3386/w22974

Joya O (2015) Growth and volatility in resource-rich countries: does diversification help? Struct Change Econ Dyn 35:38–55. https://doi.org/10.1016/j.strueco.2015.10.001

Kim W, Jeong O-R, Kim C, So J (2011) The dark side of the Internet: attacks, costs and responses. Inf Syst 36(3):675–705. https://doi.org/10.1016/j.is.2010.11.003

Körner U, Müller-Thur K, Lunau T, Dragano N, Angerer P, Buchner A (2019) Perceived stress in human–machine interaction in modern manufacturing environments—results of a qualitative interview study. Stress Health 35(2):187–199. https://doi.org/10.1002/smi.2853

Kowalski P, Gonzalez JL, Ragoussis A, Ugarte C (2015) Participation of developing countries in global value chains: implications for trade and trade-related policies. OECD. https://doi.org/10.1787/5js33lfw0xxn-en

Laget E, Osnago A, Rocha N, Ruta M (2018) Deep trade agreements and global value chains. The World Bank. https://doi.org/10.1596/1813-9450-8491

Landmark AD, Kamsvaag PF, Andersen TK (2019) Using STSD for understanding the implementation of automation in organisations. Eur J Workplace Innov 4(2):Article 2. https://doi.org/10.46364/ejwi.v4i2.579

Laplume AO, Petersen B, Pearce JM (2016) Global value chains from a 3D printing perspective. J Int Bus Stud 47(5):595–609. https://doi.org/10.1057/jibs.2015.47

Latif Z, Mengke Y, Danish A, Latif S, Ximei L, Pathan ZH, Salam S, Jianqiu Z (2018) The dynamics of ICT, foreign direct investment, globalization and economic growth: Panel estimation robust to heterogeneity and cross-sectional dependence. Telemat Inform 35(2):318–328. https://doi.org/10.1016/j.tele.2017.12.006

Le HT, Hoang DP, Doan TN, Pham CH, To TT (2021) Global economic sanctions, global value chains and institutional quality: empirical evidence from cross-country data. J Int Trade Econ Dev 0(0):1–23. https://doi.org/10.1080/09638199.2021.1983634

Lee Y, Falahat M (2019) The impact of digitalization and resources on gaining competitive advantage in international markets: mediating role of marketing, innovation and learning capabilities. Technol Innov Manag Rev 9(11):26–39. https://doi.org/10.2221/timreview/1281

Lenzen M, Moran D, Kanemoto K, Geschke A (2013) Building eora: a global multi-region input-output database at high country and sector resolution. Econ Syst Res 25(1):20–49. https://doi.org/10.1080/09535314.2013.769938

Levchenko AA (2007) Institutional quality and international trade. Rev Econ Stud 74(3):791–819. https://doi.org/10.1111/j.1467-937X.2007.00435.x

Leveraging digital trade to fight the consequences of COVID-19. (n.d.). OECD. Retrieved August 6, 2021, from https://www.oecd.org/coronavirus/policy-responses/leveraging-digital-trade-to-fight-the-consequences-of-covid-19-f712f404/

Levin A, Lin C-F, James Chu C-S (2002) Unit root tests in panel data: asymptotic and finite-sample properties. J Econometr 108(1):1–24. https://doi.org/10.1016/S0304-4076(01)00098-7

Li F, Frederick S, Gereffi G (2019) E-commerce and industrial upgrading in the Chinese apparel value chain. J Contemp Asia 49(1):24–53. https://doi.org/10.1080/00472336.2018.1481220

Liao H, Cao H-S (2013) How does carbon dioxide emission change with the economic development? Statistical experiences from

132 countries. Glob Environ Change 23(5):1073–1082. https://doi.org/10.1016/j.gloenvcha.2013.06.006

Lüthje B (2019) Platform capitalism 'made in China'? Intelligent manufacturing, taobao villages and the restructuring of work. Sci Technol Soc 24(2):199–217. https://doi.org/10.1177/0971721819841985

Mazali T (2018) From industry 4.0 to society 4.0, there and back. AI Soc 33(3):405–411. https://doi.org/10.1007/s00146-017-0792-6

McCormick M, Somaya D (2020) Born globals from emerging economies: reconciling early exporting with theories of internationalization. Glob Strateg J 10(2):251–281. https://doi.org/10.1002/gsj.1368

Meyer JW, Rowan B (1977) Institutionalized organizations: formal structure as myth and ceremony. Am J Sociol 83(2):340–363

Mignamissi D, Djijo T, A. J. (2021) Digital divide and financial development in Africa. Telecommun Policy 45(9):102199. https://doi.org/10.1016/j.telpol.2021.102199

Miranda R, Wagner RA (2017) Bad neighbors: bordering institutions as comparative (dis)advantage (SSRN scholarly paper ID 2631248). Soc Sci Res Netw. https://doi.org/10.2139/ssrn.2631248

Miroudot S, Cadestin C (2017) Services in global value chains: from inputs to value-creating activities. OECD. https://doi.org/10.1787/465f0d8b-en

Mitra S, Gupta AS, Sanganeria A (2020) Drivers and benefits of enhancing participation in global value chains: lessons for India (India; Issue 79). Asian Development Bank.accessed on 30 March 2022. https://www.adb.org/publications/enhancing-participation-gvcs-lessons-india

Mossberger K, LaCombe S, Tolbert CJ (2022) A new measure of digital economic activity and its impact on local opportunity. Telecommun Policy 46(1):102231. https://doi.org/10.1016/j.telpol.2021.102231

Myovella G, Karacuka M, Haucap J (2020) Digitalization and economic growth: a comparative analysis of Sub-Saharan Africa and OECD economies. Telecommun Policy 44(2):101856. https://doi.org/10.1016/j.telpol.2019.101856

Nambisan S, Zahra SA, Luo Y (2019) Global platforms and ecosystems: implications for international business theories. J Int Bus Stud 50(9):1464–1486. https://doi.org/10.1057/s41267-019-00262-4

Nguyen CP, Schinckus C, Su TD (2020) The drivers of economic complexity: international evidence from financial development and patents. Int Econo 164:140–150. https://doi.org/10.1016/j.inteco.2020.09.004

Niebel T (2018) ICT and economic growth—comparing developing, emerging and developed countries. World Dev 104:197–211. https://doi.org/10.1016/j.worlddev.2017.11.024

Nunn N (2007) Relationship-specificity, incomplete contracts and the pattern of trade. Q J Econ 122(2):569–600

OECD (2013) Building green global value chains: committed public–private coalitions in agro-commodity markets. OECD. https://doi.org/10.1787/5k483jndzwtj-en

Orefice G, Rocha N (2014) Deep integration and production networks: an empirical analysis. World Econ 37(1):106–136. https://doi.org/10.1111/twec.12076

Oriani R, Sobrero M (2008) Uncertainty and the market valuation of R&D within a real options logic. Strateg Manag J 29(4):343–361. https://doi.org/10.1002/smj.664

Orlikowski WJ (1996) Improvising organizational transformation over time: a situated change perspective. Inf Syst Res 7(1):63–92. https://doi.org/10.1287/isre.7.1.63

Özsoy S, Ergüzel OŞ, Ersoy AY, Saygılı M (2021) The impact of digitalization on export of high technology products: a panel data approach*. J Int Trade Econ Dev. https://doi.org/10.1080/09638199.2021.1965645

Parente PMDC, Santos Silva JMC (2012) A cautionary note on tests of overidentifying restrictions. Econ Lett 115(2):314–317. https://doi.org/10.1016/j.econlet.2011.12.047

Pesaran MH (2021) General diagnostic tests for cross-sectional dependence in panels. Empir Econ 60(1):13–50. https://doi.org/10.1007/s00181-020-01875-7

Pirkkalainen H, Salo M (2016) Two decades of the dark side in the information systems basket: suggesting five areas for future research. Research papers.accessed on 30 March 2022. https://aisel.aisnet.org/ecis2016_rp/101

Porter ME, Heppelmann JE (2014) How smart, connected products are transforming competition. Harvard Business Review. accessed on 30 March 2022. https://hbr.org/2014/11/how-smart-connected-products-are-transforming-competition

Radanliev P, Roure DCD, Van Kleek M (2020) Digitalization of COVID-19 pandemic management and cyber risk from connected systems (SSRN scholarly paper ID 3604825). Soc Sci Res Netw. https://doi.org/10.2139/ssrn.3604825

Rehnberg M, Ponte S (2018) From smiling to smirking? 3D printing, upgrading and the restructuring of global value chains. Glob Netw 18(1):57–80. https://doi.org/10.1111/glob.12166

Roodman D (2009) How to do Xtabond2: an introduction to difference and system GMM in Stata. Stand Genom Sci 9(1):86–136. https://doi.org/10.1177/1536867X0900900106

Salento A (2018) Digitalisation and the regulation of work: theoretical issues and normative challenges. AI Soc 33(3):369–378. https://doi.org/10.1007/s00146-017-0738-z

Solomon EM, van Klyton A (2020) The impact of digital technology usage on economic growth in Africa. Utilities Policy 67:101104. https://doi.org/10.1016/j.jup.2020.101104

Strange R, Zucchella A (2017) Industry 4.0, global value chains and international business. Multinatl Bus Rev 25(3):174–184. https://doi.org/10.1108/MBR-05-2017-0028

Sweet C, Eterovic D (2019) Do patent rights matter? 40 years of innovation, complexity and productivity. World Dev 115:78–93. https://doi.org/10.1016/j.worlddev.2018.10.009

Tam PS (2018) Global trade flows and economic policy uncertainty. Appl Econ 50(34–35):3718–3734. https://doi.org/10.1080/00036846.2018.1436151

Tarafdar M, Gupta A, Turel O (2013) The dark side of information technology use. Inf Syst J 23(3):269–275. https://doi.org/10.1111/isj.12015

The dark side of the digital revolution—and how to fix it. (n.d.). World Economic Forum. Retrieved March 19, 2022, from https://www.weforum.org/agenda/2020/09/dark-side-digitalization/

Thun S, Bakås O, Storholmen TCB (2021) Development and implementation processes of digitalization in engineer-to-order manufacturing: enablers and barriers. AI Soc. https://doi.org/10.1007/s00146-021-01174-4

Thun S, Kamsvåg PF, Kløve B, Seim EA, Torvatn HY (2019) Industry 4.0: whose revolution? The digitalization of manufacturing work processes. Nordic J Work Life Stud. https://doi.org/10.18291/njwls.v9i4.117777

Verbeke A (2020) Will the COVID-19 pandemic really change the governance of global value chains? Br J Manag 31(3):444–446. https://doi.org/10.1111/1467-8551.12422

Vu TV (2021) Does institutional quality foster economic complexity? (SSRN scholarly paper ID 3509939). Soc Sci Res Netw. https://doi.org/10.2139/ssrn.3509939

Wellman B, Quan-Haase A, Boase J, Chen W, Hampton K, Díaz I, Miyata K (2003) The social affordances of the internet for networked individualism. J Comput Mediat Commun. https://doi.org/10.1111/j.1083-6101.2003.tb00216.x

Windmeijer F (2005) A finite sample correction for the variance of linear efficient two-step GMM estimators. J Econometr 126(1):25–51. https://doi.org/10.1016/j.jeconom.2004.02.005

Yadav A, Iqbal BA (2021) Socio-economic scenario of South Asia: an overview of impacts of COVID-19. South Asian Surv 28(1):20–37. https://doi.org/10.1177/0971523121994441

Yi K (2003) Can vertical specialization explain the growth of world trade? J Polit Econ 111(1):52–102. https://doi.org/10.1086/344805

Yi K-M (2010) Can multistage production explain the home bias in trade? Am Econ Rev 100(1):364–393. https://doi.org/10.1257/aer.100.1.364

Bond, S., Hoeffler, A.., & Temple, J. (2001). GMM Estimation of Empirical Growth Models. In Economics Papers (No. 2001-W21; Economics Papers). Economics Group, Nuffield College, University of Oxford. https://ideas.repec.org/p/nuf/econwp/0121.html

Shin, D. (2014). A socio-technical framework for Internet-of-Things design: A human centered design for the Internet of Things. Telematics and Informatics, 31(4), 519–531. https://doi.org/10.1016/j.tele.2014.02.003

Tilen, G., & Andrej, K. (2018). Conceptualization of Digitalization: Opportunities and Challenges for Organizations in the Euro-Mediterranean Area. University of Ljubljana, Slovenia, 11(2)

Jurica, N., Marcin, P., Tomasz, M., Karol, I., Kacper, R., & Kasper, Y. (2016). The rise of digital challengers: How digitlaization can become the next growth engine for Central and Eastern European. McKinsey & Company

Friedman, T. L. (2006). The World Is Flat [Updated and Expanded]: A Brief History of the Twenty-First Century. London: Macmillan

Crina, I., Mihaela, I & Emilia,T. (2021). The impact of digitization on economy in the context of the Coronavirus Pandemic. Globalization and Its Socio-Economic Consequences 2020, SHS Web of Conferences 92. http://doi.org/10.1051/shsconf/20219201018

Abdul, K., Hangjung, Zo., & Ananth, C. (2021). Digital transformation and environmental sustainability. MDPI Sustainability, 13, 1530. https://www.mdpi.com/20711050/13/3/1530

Verny, J., Oulmakki, O., Cabo, X., & Roussel, D. (2020). Blockchain & supply chain: Towards an innovative supply chain design. Projectics / Proyéctica / Projectique, 26(2), 115–130. https://doi.org/10.3917/proj.026.0115

Shin, D.-H. (2016b). Demystifying big data: Anatomy of big data developmental process. Telecommunications Policy, 40(9), 837–854. https://doi.org/10.1016/j.telpol.2015.03.007

Shin, D.-H. (2016a). Application of actor-network theory to network neutrality in Korea: Socio-ecological understanding of network dynamics. Telematics and Informatics, 33(2), 436–451. https://doi.org/10.1016/j.tele.2015.10.002

Shin, D. (Don), Fotiadis, A., & Yu, H. (2019). Prospectus and limitations of algorithmic governance: An ecological evaluation of algorithmic trends. Digital Policy, Regulation and 10.1007/s00146-022-01524-w Governance, 21(4), 369–383. https://doi.org/10.1108/DPRG-03-2019-0017

Shim, Y., & Shin, D.-H. (2016). Analyzing China's Fintech Industry from the Perspective of Actor–Network Theory. Telecommunications Policy, 40(2), 168–181. https://doi.org/10.1016/j.telpol.2015.11.005

Efogo, F. (2020). Financial Development and African Participation in Global Value Chains. In D. Seck (Ed.), Financing Africa's Development: Paths to Sustainable Economic Growth (pp. 33–52). Springer International Publishing. https://doi.org/10.1007/978-3-030 46482-0_3

Le, T. H., Hoang, P. D., & To, T. T. (2022). Is product proximity a driver for better energy security? Global evidence of nonlinear relationships between product proximity and energy security. International Journal of Sustainable Development & World Ecology, 0(0), 1–21. https://doi.org/10.1080/13504509.2022.2025500

Koopman, R., Powers, W., Wang, Z., & Wei, S.-J. (2010). Give Credit Where Credit Is Due: Tracing Value Added in Global Production Chains (Working Paper No. 16426; Working Paper Series). National Bureau of Economic Research. https://doi.org/10.3386/w16426

Hausmann, R., & Hidalgo, C. A. (2011). The network structure of economic output. Journal of Economic Growth, 16(4), 309–342. https://doi.org/10.1007/s10887-011 9071-4

Canh, P. N., Schinckus, C., & Thanh, S. D. (2021). What are the drivers of shadow economy? A further evidence of economic integration and institutional quality. The Journal of International Trade & Economic Development, 30(1), 47–67. https://doi.org/10.1080/09638199.2020.1799428

Brennen, J. S., & Kreiss, D. (2016). Digitalization. In The International Encyclopedia of Communication Theory and Philosophy (pp. 1–11). John Wiley & Sons, Ltd. https://doi.org/10.1002/9781118766804.wbiect111

Bontadini, F., Evangelista, R., Meliciani, V., & Savona, M. (2019). Integration in Global Value Chains and Employment in Europe (SSRN Scholarly Paper ID 3436703). Social Science Research Network. https://doi.org/10.2139/ssrn.3436703

OECD. (2020). How's Life in the Digital Age?: Opportunities and Risks of the Digital Transformation for People's Well-being. OECD. https://doi.org/10.1787/9789264311800-en

Publisher's Note Springer Nature remains neutral with regard to jurisdictional claims in published maps and institutional affiliations.