Modern Economy, 2025, 16(2), 271-283
https://www.scirp.org/journal/me
ISSN Online: 2152-7261
ISSN Print: 2152-7245

Energy, Competitiveness and Participation in Global Value Chains

Facinet Conte

Economics Department, Université Général Lansana Conté de Sonfonia, Conakry, Guinea
Email: facinetmballou@gmail.com

How to cite this paper: Conte, F. (2025). Energy, Competitiveness and Participation in Global Value Chains. *Modern Economy, 16,* 271-283.
https://doi.org/10.4236/me.2025.162012

Received: October 12, 2024
Accepted: February 17, 2025
Published: February 20, 2025

Abstract

The objective of this study is to analyze the impact of energy consumption and competitiveness on countries' participation in global value chains (GVCs). The two-stage dynamic panel method is applied to data from 35 developing and 28 transition countries over the period 2000-2018. The empirical results of the study reveal that an improvement in competitiveness by one percentage point increases GVC participation, upstream and downstream participation by 0.003, 0.002, and 0.006 points respectively for developing countries. For transition countries, that improvement increases GVC participation, upstream and downstream participation by 0.238, 0.181 and 0.058 points respectively. It also emerges that competitiveness positively affects GVC participation. Finally, the results highlight that energy consumption and intensity positively affect GVC participation. The study highlights the importance of energy and competitiveness in improving developing and transition countries' participation in global value chains.

Keywords

Global Value Chains, Competitiveness, Energy, GMM in System

1. Introduction

Participation in global value chains (GVCs) is one of the most effective ways to support economic growth and competitiveness while combating climate change and limiting greenhouse gas emissions. Global value chains refer to the manufacturing of a single product on a global scale. Generally, three sources are responsible for the increase in the position of global value chains leading to energy and environmental efficiency, the first channel being the scale effect and the last two being the GVC-induced technical effect involving improved energy and environmental efficiency. First, participation in GVCs allows for economies of scale by increasing exports (Feder, 1983). Second, it encourages the import of immediate goods, which are generally the main vectors of technology diffusion (Sharma & Mishra, 2023; Sharma & Paramati, 2018). Finally, the third is the diffusion of technological progress and managerial experiences.

The progression of countries in global value chains leads to the relocation of production of polluting goods from their countries to host countries. The result is that energy consumption and pollutant emissions may increase in these countries, and the relocation of production implies a geographical transfer of energy consumption and high competitiveness between countries (Antweiler et al., 2001). It is noted that the scale effect and technological progress induced by global value chains imply a net reduction in energy consumption and pollutant emissions in all countries. Although production offshoring creates concentrations of energy consumption and pollutant emissions in countries that produce polluting goods, the net impacts for these countries are at best ambiguous, and global energy consumption and pollutant emissions could also benefit from production offshoring due to the scale effect and the technology effect induced by global value chains (Copeland & Taylor, 2004). Therefore, in the context of global sustainability, all countries participating in global value chains will be competitive because they would benefit more from international specialization and fragmentation of global production.

Competitiveness and productivity are a key factor in economic development and environmental sustainability. The theory builds on Porter's idea (Porter, 1990; Porter & Linde, 1995) that environmental policies can foster international competitiveness by inducing technological innovation, which would increase participation in GVCs by placing more emphasis on export dynamics.

Motivated by these arguments, we conduct an analysis in a large sample of countries, including developing and transition economies, to assess the sign and magnitude of the impact of energy consumption and competitiveness on countries' participation in global value chains. To our knowledge, this study is the first to conduct an analysis to assess the joint effect of energy consumption and competitiveness on participation in global value chains (GVCs). The existing literature establishes a bidirectional relationship between energy consumption and GVC participation on the one hand and between competitiveness and GVC participation on the other hand. However, there is a paucity of work on the joint effect of energy consumption and competitiveness on participation in global value chains (GVCs). The issue of assessing this effect has attracted increasing interest from our side.

The remainder of the paper is structured as follows. The next section presents a brief literature review. Section 2 presents the methodology, estimation strategy and describes the data. Section 3 reports and discusses the results and Section 5 concludes.

2. Literature Review

2.1. Energy Consumption and Participation in Global Value Chains

The literature establishes a bidirectional relationship between energy consumption and participation in GVCs. (Amri, 2019) examined the link between renewable and non-renewable energy consumption and trade in 72 developed and developing countries over the period 1990-2012. They find a bidirectional link between both types of energy consumption and trade in developed and developing countries. (Ben Jebli & Ben Youssef, 2015) with panel cointegration techniques find the same results. For some, energy is an indispensable resource for a country seeking to integrate GVCs. For others, it is rather participation in GVCs that influences energy consumption.

The former highlights the effects of energy on GVC participation. Kan et al. (2019) argue that the prosperity of the global economy is largely achieved at the expense of the overwhelming global consumption of primary energy. Furthermore, (Makarov et al., 2022) studied the relationship between countries' energy indicators and GVC participation indices. It is found that countries with higher energy consumption and fuel-exporting countries have higher participation in downstream GVCs. Energy-importing countries and more energy-intensive countries have higher participation in upstream GVCs. Similarly, Wu et al. (2020) find that renewable energy consumption is positively related to GVC participation.

The latter highlights the effects of participation in GVCs on energy consumption. At this level, two literatures emerge. The first stipulates that participation in GVCs can reduce energy consumption (Achabou et al., 2017; Khattak et al., 2015; Örgün, 2014) through new energy technologies, knowledge and improved learning and innovation capacities. This literature considers that integration in GVCs allows countries to have access to knowledge and improved learning and innovation capacities (Pietrobelli & Rabellotti, 2010). The second literature states that participation in GVCs can increase energy consumption (Kaltenegger et al., 2017). (Wu & Chen, 2017) believe that participation in GVCs can lead to energy leakage or waste. Given the production process spread across multiple economies, energy extracted in country X can be exported to country Y for the production of goods and services that will ultimately be consumed by country Z. Using the panel vector autoregressive (PVAR) model and the system generalized method of moment (System-GMM), (Wu et al., 2020) studied the dynamic causality between GVC participation, renewable energy consumption, and carbon dioxide (CO_2) between 1990 and 2015 for 172 countries. The results show that GVC participation leads to negative renewable energy consumption.

2.2. Competitiveness and Participation in Global Value Chains

The economic literature establishes a bidirectional relationship between competitiveness and participation in GVCs. The first literature is based on the effects of competitiveness on participation in GVCs. Furthermore, competitiveness is considered as an indicator of participation in GVCs. The most competitive firms in the market are those that export the most. The second literature is based on the effects of participation in GVCs on the competitiveness of economies. This literature considers that participation in GVCs promotes competitiveness through the reduction of production factor costs, access to new varieties of quality inputs and access to technology.

Through participation in GVCs, firms can acquire high-quality foreign inputs. It can also facilitate technology transfer. The acquisition of quality inputs and technology can reduce production costs and increase productivity. Global value chains offer the opportunity to share production processes with global leading firms, which in turn share their knowledge, capital, management practices and technical assistance with local firms (Boffa et al., 2021). This will contribute to improving product quality and firm competitiveness. (Bas, 2012), analyzing the effect of input trade liberalization on export decisions in Argentina, finds that trade in intermediate inputs allows firms to increase their efficiency, increase their exports and improve their profitability and competitiveness.

The participation of firms in GVCs affects the quality of exports through imported inputs (Fang et al., 2023). In this sense, (Manova & Zhang, 2012) show that Chinese firms are relatively efficient in export markets thanks to better quality inputs. (Giovannetti et al., 2014) explores the impact of belonging to a supply chain on the internationalization of firms. They find a positive and significant impact of integration into supply chains on the probability of exporting. On the other hand, another literature considers participation in GVCs as a brake on countries' competitive policies. Thus, integration in GVCs creates a dependence of countries on the outside. When a country integrates the international production network, its production will depend not only on local resources but also on imported intermediate goods. Also, policies to protect local industries will be ineffective in GVCs. Therefore, the competitiveness of the national economy will increasingly depend on foreign partners.

3. Research methodology

3.1. Estimation Strategy

To assess the joint effect of energy consumption and competitiveness on participation in global value chains (GVCs), we use the following econometric model:

$$GVC_{it} = \alpha_0 + \alpha_1 GVC_{it-1} + \alpha_2 IGC_{it} + \alpha_3 Energy_{it} + \alpha_4 X_{it} + \gamma^i + \theta_t + \varepsilon_{it} \tag{1}$$

where GVC_{it} is the GVC participation index, upstream and downstream participation, IGC_{it} the overall competitiveness index, $Energy_{it}$ represents the two types of energy measurement variables (i.e., energy consumption per capita and electricity production per capita) , X_{it} represents the vector of control variables, namely, GDP per capita, trade openness, inward foreign direct investment, weighted average tariff applied to imported goods. To account for initial participation in GVCs, and unobserved country-specific effects, we include the dependent variable (GVC) lagged by one period and a country θ_t and time-specific effect γ^i, in addition to the idiosyncratic error term ε_{it}.

The estimation method used in this study is the system GMM method. Three reasons prompted us to adopt the GMM method. The first contains the conditions for using the system GMM method, while the latter two show why this method is suitable for our model. First, the number of countries (N = 35) is larger than the number of years (T = 19), which helps control bias in the dynamic panel (Baltagi, 2005; Bond, 2002; Roodman, 2009). Therefore, the N>T condition of the GMM method is satisfied. Second, our estimation models reveal a dynamic relationship between the explanatory variables and GVC participation, with past GVC deepening influencing present GVC deepening. However, the inclusion of the lagged dependent variable and the short observation period indicate a potential endogeneity bias. Third, the estimation method addresses the problem of reverse causality and endogeneity for all variables (dependent and explanatory). Therefore, the use of instrumental variables is necessary to correct the endogeneity bias.

Indeed, there are two types of GMM estimators applicable to dynamic panels (system GMM estimator and first-difference GMM estimator). The former is both efficient and robust to heteroscedasticity, while the latter is inefficient and lacks robustness to heteroscedasticity (Roodman, 2009). However, the system GMM estimator is more suitable. On the other hand, the application of system GMMs sometimes leads to the risk of too many instruments, which can invalidate the set of instruments and distort the test results. However, the application of two-stage system GMMs can improve the efficiency of the latter. Moreover, a large number of instruments can lead to a downward bias in the two-stage system GMM standard errors due to poorly estimated weighting matrices. Windmeijer (2005) highlights this problem, suggesting a correction that accounts for variability in the weighting matrix. To minimize bias, Windmeijer's (2005) correction is implemented in this analysis. Finally, to test the validity of the instruments, we use and present two model diagnostics: Hansen's test for overidentification and a test for serial autocorrelation.

3.2. Data

The data used in this study come from four sources: the UNCTAD-Eora database for GVCs, the World Economic Forum indicators for the Global Competitiveness Index (GCI), the Global Carbon Project (GCP) for CO2 emissions, and the World Development Indicators (WDI) for control variables (**Table 1**). The dependent variable represents the index of participation in global value chains (GVCs), backward and forward participation. It is measured by the percentage of gross exports and indicates the share of foreign inputs (backward participation) and domestically produced inputs used in third-country exports (forward participation) (De Backer & Miroudot, 2014; Miroudot, & Ye, 2021; Casella et al., 2019).

Our variables of interest include the Global Competitiveness Index (GCI), primary energy consumption per capita and energy intensity level. The Global Competitiveness Index (GCI), which takes scores from 1 to 7 (a higher average score means a higher degree of competitiveness), is calculated as a weighted average of several components of competitiveness grouped into 12 pillars. Energy is represented by both types of measurement variables (i.e. energy consumption per capita and energy intensity level). The list of countries considered in this work is provided in the Appendix (**Table A1**, **Figures A1-A3**).

Table 1. Description and source of variables.

Variables	Description	Sources
FVA	Upstream participation	UNCTAD-Eora
DVA	Downstream participation	UNCTAD-Eora
GVC	GVC participation index	UNCTAD-Eora
IGC	Global competitiveness index	WEF
CE/hbt	Energy consumption per capita	WDI
Energy_int	Energy intensity level	WDI
CO_2_per_capita	CO_2 emission	GCP
EDUCATION	Education	UNDP
OPEN	(Exports + Imports)/GDP	WDI
GDP/capita	Gross domestic product per capita	WDI
FDI_incoming	Inward foreign direct investment (% of GDP)	WDI
PRICE	Weighted average rate	WDI

Notes: GCP means Global Carbon Project; WDI means World Development Indicators; WEF means World Economic Forum. ***Source*: *Author*.**

4. Results and Discussion

We present our results based on the GMM estimation approach in order to properly address endogeneity issues. The model is well specified, as confirmed by specification tests. Two tests are important in the estimation by the GMM method in a system. We have the Hansen over-identification test which allows to test the validity of the lagged variables as instruments and the Arellano & Bond (1991) autocorrelation test. In the different estimations carried out, the value of the Hansen test probabilities is higher than the 5% threshold (**Table 2**), which attests that our instruments have been well chosen. This validation of the quality of the instruments is reinforced by the results of the second-order autocorrelation test which is deduced by reading the value of the AR (2) test probabilities which are also higher than the 5% threshold in the different estimations (**Table 2** and **Table 3**).

Table 2. Effect of energy and competitiveness on participation in GVCs in developing countries.

	(1)	(2)	(3)	(4)	(5)	(6)
	CVM	CVM	FVA	FVA	DVA	DVA
IGC	0.0034*	0.0012	0.0023***	0.0053***	0.0056***	−0.0003
	(0.0004)	(0.0001)	(0.0001)	(0.058)	(0.0048)	(0.0003)
CE/hbt (log)	−0.00444		0.155***		0.0911***	
	(0.0229)		(0.0509)		(0.0217)	
Energy_int (log)		0.0100*		0.0186***		−0.00408
		(0.0051)		(0.0040)		(0.0131)

Continued

CO_2_per_capita	0.0065	0.0077	0.0085	0.0095*	0.0062	−0.0011
	(0.0055)	(0.0054)	(0.0053)	(0.0050)	(0.0048)	(0.0053)
GDP/capita	0.0019**	0.0020**	0.0027**	0.0020***	0.0013**	0.0023***
	(0.0009)	(0.0008)	(0.0011)	(0.0005)	(0.0006)	(0.0007)
IDE_incoming	0.0013	0.0013	−0.0001	0.0009	−0.0030**	−0.0014
	(0.0019)	(0.0016)	(0.0012)	(0.0011)	(0.0011)	(0.0011)
OPEN	0.0013***	0.0011***	0.0030***	0.0010***	0.0010***	0.0005
	(0.0003)	(0.0002)	(0.0005)	(0.0002)	(0.0003)	(0.0004)
EDUCATION	0.472**	−0.191	0.747	−0.0349	0.622***	−0.184
	(0.213)	(0.131)	(0.441)	(0.113)	(0.156)	(0.141)
PRICE	−0.00240*	−0.0034**	−0.0008	−0.0008	−0.0028*	0.0000
	(0.0014)	(0.0015)	(0.0028)	(0.0008)	(0.0014)	(0.0012)
Constant	−0.366**	−0.319***	0.0863	−0.267***	0.0299	0.0131
	(0.152)	(0.110)	(0.159)	(0.0809)	(0.0447)	(0.183)
Observations	209	209	209	209	209	209
Fisher-Prob	0.000	0.000	0.000	0.000	0.000	0.000
Hansen (p-value)	0.390	0.360	0.729	0.533	0.734	0.242
Number of instr	22	22	22	22	22	22
AR (1)	0.000	0.000	0.000	0.000	0.000	0.000
AR (2)	0.144	0.151	0.254	0.902	0.178	0.337

Note: ***, ** and * indicate significance at 1, 5 and 10% respectively.

Table 2 above presents the effects of energy consumption, competitiveness and control variables on participation in global value chains (GVCs). First, column (1) presents the effects of the overall competitiveness index (IGC), energy consumption per capita (EC/capita) and control variables on participation in global value chains and column (2) presents the effects of IGC, energy intensity level (Energy_int) and control variables on participation in GVCs. Then, column (3) presents the effects of IGC, EC/capita and control variables on upstream participation in GVCs and column (4) presents the effects of IGC, ELEC/capita and control variables on upstream participation in GVCs. Finally, column (5) presents the effects of IGC, CE/hbt and control variables on downstream participation in GVCs and column (6) presents the effects of IGC, energy intensity level and control variables on downstream participation in GVCs. The results are analyzed separately for developing and transition countries to capture the nuanced differences in GVC participation across these groups.

The results show that all coefficients of the IGC estimates are positive and significant at the 1%, 5% or 10% level in all columns. Indeed, a one percent improvement in competitiveness increases GVC participation, upstream and downstream participation by 0.003, 0.002, and 0.006 points respectively (see columns (1), (3) and (5)). This result means that competitiveness positively influences GVC participation, upstream and downstream participation. Also, the most competitive firms in the market are those that participate the most in GVCs. In contrast, for transition countries, the estimated effects of competitiveness are smaller, with a one percent improvement in competitiveness increasing GVC participation, upstream participation, and downstream participation by 0.238, 0.181 and 0.058 points, respectively (**Table 3**). These results suggest that while competitiveness plays a positive role in GVC participation in developing countries, its impact is significantly more modest compared to transition countries.

Also, the results show that all the coefficients assigned to energy consumption and intensity are positive and significant at 1% in most cases in developing countries and transition countries. These results imply that energy consumption and intensity positively affect GVC participation. This result corroborates with those of (Wu et al., 2020) who find that renewable energy consumption is positively related to GVC participation. Similarly, for (Makarov et al., 2022), countries with higher energy consumption and fuel exporting countries have higher participation in downstream global value chains and that energy importing countries and countries with higher energy intensity have higher participation in upstream global value chains. Similarly, the coefficients associated with GDPPC, FDI, OUV, EDUCATION are positive and significant. This means that these variables have a positive and significant influence on GVC participation. On the other hand, the estimates show that the coefficients assigned to TARIF are negative. This result is explained by the fact that an increase in taxes reduces exports and/or imports and therefore GVCs.

Table 3. Effect of energy and competitiveness on participation in GVCs in transition countries.

	(1)	(2)	(3)	(4)	(5)	(6)
	CVM	CVM	FVA	FVA	DVA	DVA
IGC	0.238***	0.171***	0.181***	0.0595**	0.0579***	0.0394*
	(0.0369)	(0.0291)	(0.0550)	(0.0288)	(0.0160)	(0.0212)
CE/hbt (log)	0.269***		0.230***		0.403***	
	(0.0510)		(0.0272)		(0.0725)	
Energy_int (log)		0.0269***		0.00733**		0.0361***
		(0.0042)		(0.0027)		(0.0079)
CO_2_per_capita	−0.0080***	0.0064***	−0.0061***	−0.00229**	−0.0124***	0.0069**
	(0.0020)	(0.0016)	(0.0014)	(0.0009)	(0.0031)	(0.0027)
GDP/capita	0.0014***	0.0019***	0.0002	0.0003***	0.001**	0.0069**
	(0.0003)	(0.0003)	(0.0003)	(0.0000)	(0.001)	(0.0027)
FDI_incoming	0.0000	0.0006***	0.0003	0.0034	0.002**	0.00211***
	(0.0002)	(0.0002)	(0.0002)	(0.0020)	(0.0010)	(0.0003)
OPEN	−0.0003	−0.0001	0.0003**	0.0005***	0.001***	0.0007***
	(0.0002)	(0.0000)	(0.0001)	(0.0000)	(0.000)	(0.0001)

Continued

EDUCATION	−0.0459	0.0631**	0.0604*	−0.0023	0.6030***	0.0004*
	(0.0408)	(0.0306)	(0.0346)	(0.0202)	(0.154)	(0.0002)
PRICE	−0.0030*	−0.0072**	−0.0004	−0.0044***	−0.0030***	−0.0026
	(0.0015)	(0.0028)	(0.0028)	(0.0012)	(0.0010)	(0.0525)
Constant	−1.042***	0.0561***	−0.891***	0.0236	−1.746***	0.0939***
	(0.2480)	(0.0201)	(0.1170)	(0.0205)	(0.3210)	(0.0310)
Observations	262	295	262	295	262	295
Fisher-Prob	0.000	0.000	0.000	0.000	0.000	0.000
Hansen (p-value)	0.544	0.716	0.174	0.102	0.108	0.339
Number of instr	25	25	25	25	25	25
AR (1)	0.000	0.000	0.000	0.000	0.000	0.000
AR (2)	0.178	0.325	0.108	0.601	0.384	0.324

Note: ***, ** and * indicate significance at 1, 5 and 10% respectively.

5. Conclusion

Energy remains a key factor in economic competitiveness and participation in global value chains. Energy costs have a significant impact on the competitiveness of industries since countries with affordable energy can produce goods and services at lower costs to enhance their competitiveness in the global market. This paper aims to analyze the impact of energy consumption and competitiveness on countries' participation in global value chains (GVCs). A dynamic empirical model based on the generalized method of moments (GMM) is used to control for unobserved heterogeneity and potential endogeneity of explanatory variables is applied to data from 35 developing and 28 transition countries. This study covers the period from 2000 to 2018. The empirical results of the study reveal that an improvement in competitiveness by one percentage point increases GVC participation, upstream and downstream participation by 0.003, 0.002, and 0.006 percentage points respectively in developing countries. For transition countries, competitiveness increases GVC participation, upstream participation, and downstream participation by 0.238, 0.181 and 0.058 points, respectively. Finally, empirical estimates highlight that energy consumption and intensity positively affect GVC participation.

In developing countries, where the effect of competitiveness on participation in GVCs is modest, economic policies should focus on strengthening structural factors that limit the influence of competitiveness. This includes significant investments in basic infrastructure such as transportation, energy, and telecommunications to reduce logistical costs and enhance firms' access to international markets. Moreover, for both developing and transition countries, policymakers should focus on ensuring reliable access to energy, particularly by investing in renewable energy infrastructure to enhance sustainability and reduce dependence on fossil fuels, aligning with global trends in green production.

Conflicts of Interest

The author declares no conflicts of interest regarding the publication of this paper.

References

Achabou, M. A., Dekhili, S., & Hamdoun, M. (2017). Environmental Upgrading of Developing Country Firms in Global Value Chains. *Business Strategy and the Environment, 26,* 224-238. https://doi.org/10.1002/bse.1911

Amri, F. (2019). Renewable and Non-Renewable Energy and Trade into Developed and Developing Countries. *Quality & Quantity, 53,* 377-387. https://doi.org/10.1007/s11135-018-0758-x

Antweiler, W., Copeland, B. R., & Taylor, M. S. (2001). Is Free Trade Good for the Environment? *American Economic Review, 91,* 877-908. https://doi.org/10.1257/aer.91.4.877

Arellano, M., & Bond, S. (1991). Some Tests of Specification for Panel Data: Monte Carlo Evidence and an Application to Employment Equations. *The Review of Economic Studies, 58,* 277-297. https://doi.org/10.2307/2297968

Baltagi, B. H. (2005). *Econometric Analysis of Panel Data*. Wiley.

Bas, M. (2012). Input-Trade Liberalization and Firm Export Decisions: Evidence from Argentina. *Journal of Development Economics, 97,* 481-493. https://doi.org/10.1016/j.jdeveco.2011.05.010

Ben Jebli, M., & Ben Youssef, S. (2015). Output, Renewable and Non-Renewable Energy Consumption and International Trade: Evidence from a Panel of 69 Countries. *Renewable Energy, 83,* 799-808. https://doi.org/10.1016/j.renene.2015.04.061

Boffa, M., Jansen, M., & Solleder, O. (2021). Participating to Compete: Do Small Firms in Developing Countries Benefit from Global Value Chains? *Economies, 9,* Article 12. https://doi.org/10.3390/economies9010012

Bond, S. R. (2002). Dynamic Panel Data Models: A Guide to Micro Data Methods and Practice. *Portuguese Economic Journal, 1,* 141-162. https://doi.org/10.1007/s10258-002-0009-9

Casella, B., Bolwijn, R., Moran, D., & Kanemoto, K. (2019). UNCTAD Insights: Improving the Analysis of Global Value Chains: The Unctad-Eora Database. *Transnational Corporations, 26,* 115-142. https://doi.org/10.18356/3aad0f6a-en

Copeland, B. R., & Taylor, M. S. (2004). Trade, Growth, and the Environment. *Journal of Economic Literature, 42,* 7-71. https://doi.org/10.1257/.42.1.7

De Backer, K., & Miroudot, S. (2014). Mapping Global Value Chains. ECB Working Paper No. 1677. *SSRN Electronic Journal*. https://ssrn.com/abstract=2436411

Drobot, E., Makarov, I., Petrenko, Y., & Koshebayeva, G. (2022). Relationship between Countries' Energy Indicators and the Indices of GVC Participation: The Case of APEC Member Economies. *Energies, 15,* Article 1675. https://doi.org/10.3390/en15051675

Fang, X., Wei, Z., Zhang, Y., & Zhi, Y. (2023). Does Global Value Chain Engagement Improve Export Quality? Evidence from Chinese Manufacturing Firms. *Economic Research-Ekonomska Istraživanja, 36,* Article 2180054. https://doi.org/10.1080/1331677x.2023.2180054

Feder, G. (1983). On Exports and Economic Growth. *Journal of Development Economics, 12,* 59-73. https://doi.org/10.1016/0304-3878(83)90031-7

Giovannetti, G., Marvasi, E., & Sanfilippo, M. (2014). Supply Chains and the Internalization of SMEs: Evidence from Italy. *SSRN Electronic Journal*. https://doi.org/10.2139/ssrn.2441121

Kaltenegger, O., Löschel, A., & Pothen, F. (2017). The Effect of Globalisation on Energy Footprints: Disentangling the Links of Global Value Chains. *Energy Economics, 68,* 148-168. https://doi.org/10.1016/j.eneco.2018.01.008

Kan, S., Chen, B., & Chen, G. (2019). Worldwide Energy Use across Global Supply Chains: Decoupled from Economic Growth? *Applied Energy, 250,* 1235-1245. https://doi.org/10.1016/j.apenergy.2019.05.104

Khattak, A., Stringer, C., Benson-Rea, M., & Haworth, N. (2015). Environmental Upgrading of Apparel Firms in Global Value Chains: Evidence from Sri Lanka. *Competition & Change, 19,* 317-335. https://doi.org/10.1177/1024529415581972

Manova, K., & Zhang, Z. (2012). Export Prices across Firms and Destinations. *The Quarterly Journal of Economics, 127,* 379-436. https://doi.org/10.1093/qje/qjr051

Miroudot, S., & Ye, M. (2021). Decomposing Value Added in Gross Exports. *Economic Systems Research, 33,* 67-87. https://doi.org/10.1080/09535314.2020.1730308

Örgün, B. O. (2014). GVCs Participation as Development Strategy. *Procedia—Social and Behavioral Sciences, 150,* 1287-1296. https://doi.org/10.1016/j.sbspro.2014.09.145

Pietrobelli, C., & Rabellotti, R. (2010). *Global Value Chains Meet Innovation Systems. IDB Working Paper Series, IDB-WP-232 (November).* http://www.iadb.org

Porter, M. E. (1990). *Porter the Competitive Advantage of Nations*. Free Press.

Porter, M. E., & Linde, C. V. D. (1995). Toward a New Conception of the Environment-Competitiveness Relationship. *Journal of Economic Perspectives, 9,* 97-118. https://doi.org/10.1257/jep.9.4.97

Roodman, D. (2009). How to Do Xtabond2: An Introduction to Difference and System GMM in Stata. *The Stata Journal: Promoting Communications on Statistics and Stata, 9,* 86-136. https://doi.org/10.1177/1536867x0900900106

Sharma, C., & Mishra, R. K. (2023). Imports, Technology, and Employment: Job Creation or Creative Destruction. *Managerial and Decision Economics, 44,* 152-170. https://doi.org/10.1002/mde.3671

Sharma, C., & Paramati, S. R. (2018). Measuring Inequality of Opportunity for the Backward Communities: Regional Evidence from the Indian Labour Market. *Social Indicators Research, 138,* 479-503. https://doi.org/10.1007/s11205-017-1676-3

Windmeijer, F. (2005). A Finite Sample Correction for the Variance of Linear Efficient Two-Step GMM Estimators. *Journal of Econometrics, 126,* 25-51. https://doi.org/10.1016/j.jeconom.2004.02.005

Wu, J., Lian, Z., Zheng, Z., & Zhang, H. (2020). A Method to Evaluate Building Energy Consumption Based on Energy Use Index of Different Functional Sectors. *Sustainable Cities and Society, 53,* Article 101893. https://doi.org/10.1016/j.scs.2019.101893

Wu, X. F., & Chen, G. Q. (2017). Global Primary Energy Use Associated with Production, Consumption and International Trade. *Energy Policy, 111,* 85-94. https://doi.org/10.1016/j.enpol.2017.09.024

Appendix

Table A1. List of countries.

Developing Countries		Transition Countries	
Algeria	Mali	Argentine	Portugal
Angola	Mauritania	Belgique	Russia
Burundi	Mauritius	Brazil	Singapore
Cameroon	Morocco	Canada	Slovenia
Cape Verde	Mozambique	Chine	Sweden
Chad	Namibia	Coréé du Sud	Switzerland
Democratic Congo	Nigeria	Denmark	United Arabe Unis
Ivory Coast	Rwanda	Spain	United Kingdom
Egypt	Senegal	Estonia	United State
Gabon	Seychelles	Finland	
Gambia	Sierra Leone	France	
Ghana	South Africa	Germany	
Guinea	Tanzania	Greece	
Kenya	Togo	Irland	
Lessoto	Tunisia	Italy	
Liberia	Uganda	Japan	
Madagascar	Zambia	Luxembourg	
Malawi		Norway	

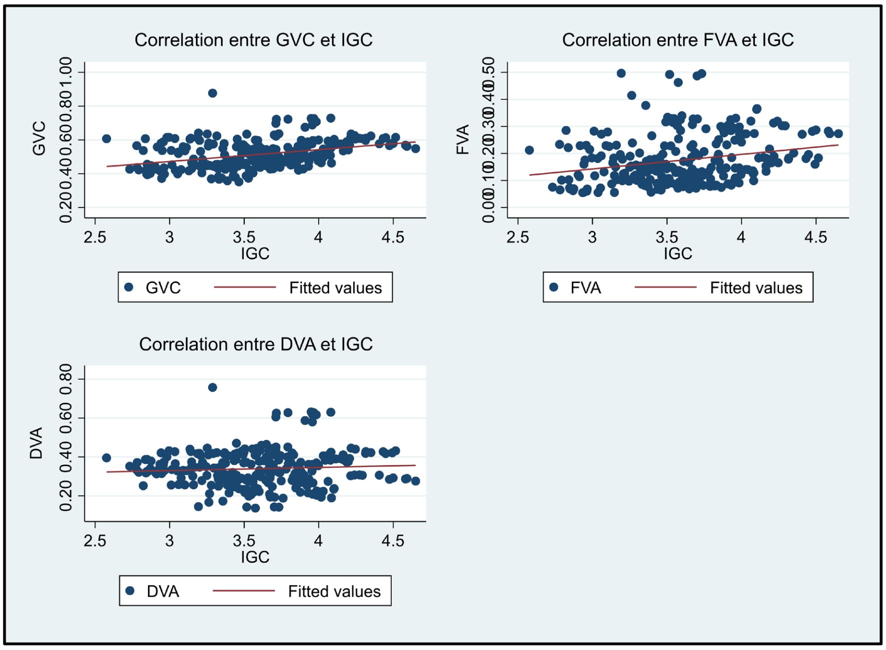

Figure A1. Correlation between GVC participation and IGC.

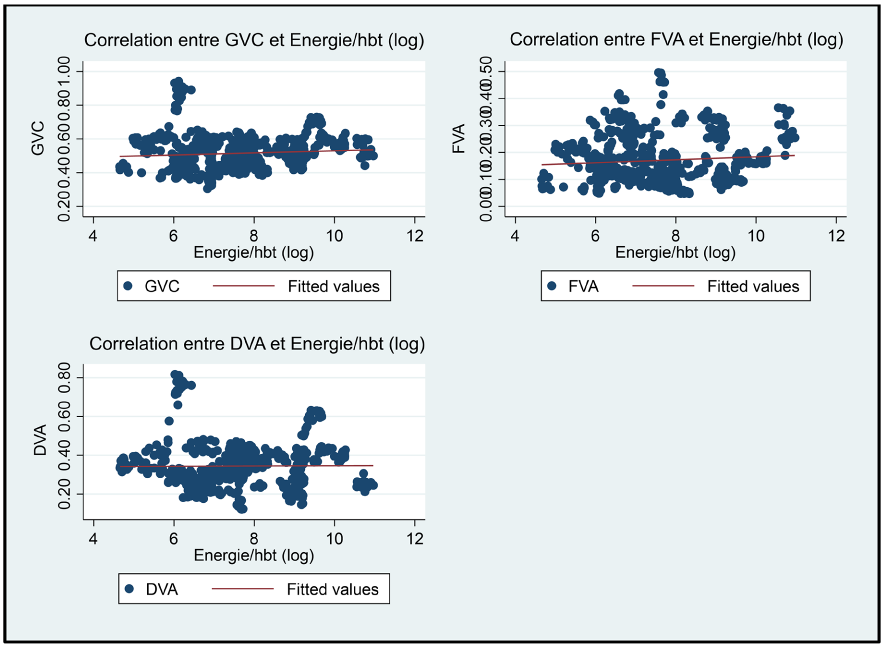

Figure A2. Correlation between participation in GVCs and Energy/hbt (log).

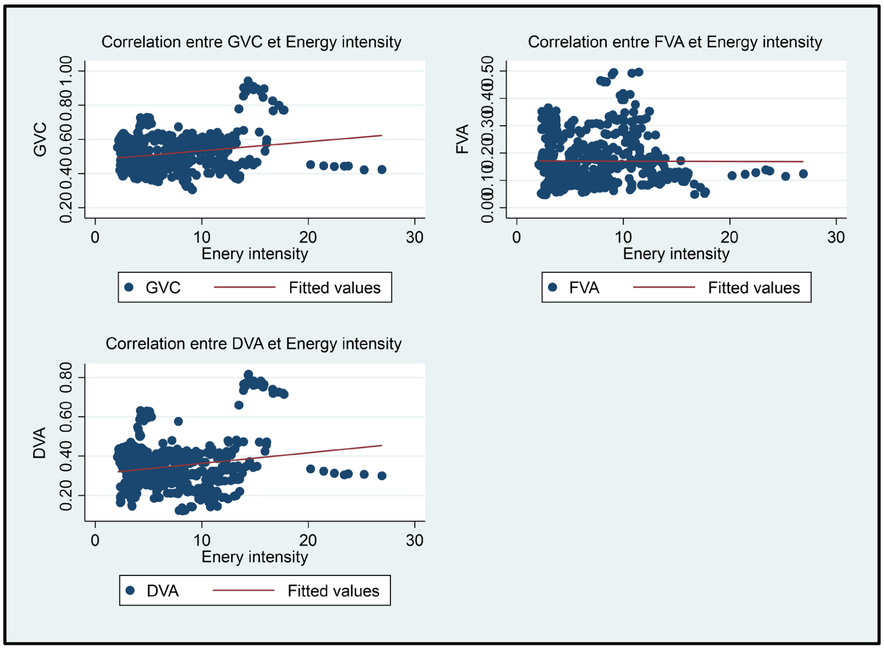

Figure A3. Correlation between participation in GVCs and Energy intensity.