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Fiscal Policy Effectiveness in Stabilizing Economic Cycles: A Time Series Analysis of Government Expenditure in Indonesia

Angela Vitaloka[1], Jessica Lianita Agnelleide Loo[2]
[1,2] Accounting Study Programme, Faculty of Economics and Business, Sam Ratulangi University, Manado
✉ Corresponding author: angelavitaloka71@gmail.com

Abstract

Global value chain participation has become a strategic channel for structural transformation, yet its contribution to industrial upgrading remains uneven across countries and depends on the form of integration within international production networks. This article investigates the effect of forward and backward GVC participation on industrial upgrading using a cross-country panel dataset of 65 economies from 2005 to 2022. Industrial upgrading is measured by the share of medium-high and high-technology manufacturing value added, while GVC participation is decomposed into forward and backward linkages based on trade-in-value-added indicators. A two-step system Generalized Method of Moments estimator is applied to address endogeneity, dynamic persistence, and potential reverse causality between trade integration and industrial structure. The results show that both forward and backward GVC participation significantly promote industrial upgrading, with forward participation producing a stronger effect than backward participation. Institutional quality, human capital, and foreign direct investment further strengthen the upgrading effect, indicating that domestic absorptive capacity plays a critical role in transforming GVC participation into higher-value industrial outcomes. The findings highlight the importance of combining trade integration with institutional reform, skill development, and investment policies to support sustainable industrial upgrading in developing economies.

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1. INTRODUCTION

Global value chains (GVCs) have reshaped the structure of international production by allowing countries to participate in specific stages of production rather than producing complete goods within national borders. This transformation has changed the nature of trade from the exchange of final products to the cross-border movement of intermediate inputs, knowledge, technology, and value-added activities. For developing and emerging economies, GVC

participation offers an opportunity to accelerate structural transformation by accessing foreign inputs, global markets, production networks, and technological capabilities without first developing fully integrated domestic supply chains (Antràs & Chor, 2022), (Johnson & Noguera, 2017), (Baldwin et al., 2022).

Industrial upgrading has become a central policy objective in this context. It refers to the movement of firms, sectors, or economies from low-value production activities toward higher-value, more technology-intensive, and knowledge-based activities. In GVC-based development, industrial upgrading is not only determined by the extent to which countries participate in international production networks, but also by how they participate. Countries may engage in GVCs through backward participation, which reflects the use of foreign value-added inputs in exports, or through forward participation, which reflects the supply of domestic value added used by partner countries in their exports. These two forms of participation may produce different upgrading effects because they involve different mechanisms of learning, value capture, technology absorption, and domestic capability development (Hummels et al., 2001), (Wang et al., 2021), (Borin & Mancini, 2019).

Although GVC participation is widely associated with productivity improvement and structural transformation, empirical evidence on its contribution to industrial upgrading remains mixed. Some studies show that GVC participation can support higher-value production, technological capability, and economic upgrading, particularly when countries are able to absorb knowledge spillovers and strengthen domestic linkages (Kummritz et al., 2017), (Tian et al., 2022), (Wiryawan et al., 2023). Other studies suggest that the benefits of GVC participation are not automatic and may depend on a country's position in the value chain, institutional quality, human capital, foreign direct investment, and the complexity of its production structure (Fernandes et al., 2022), (Pahl & Timmer, 2020), (Zou, 2026). This indicates that participation in GVCs does not necessarily lead to upgrading unless domestic conditions enable countries to capture and transform value-added opportunities into industrial capabilities.

Several gaps remain in the existing literature. First, many studies continue to treat GVC participation as an aggregate indicator, even though forward and backward participation may have different implications for industrial upgrading. Second, the dynamic relationship between GVC participation and industrial structure raises potential endogeneity concerns, as countries with stronger industrial capabilities may be more likely to integrate into GVCs, while GVC participation itself may influence industrial transformation. Third, relatively few cross-country studies jointly examine how institutional quality, human capital, and FDI condition the relationship between GVC participation and industrial upgrading. Fourth, the post-pandemic period requires further attention because global production networks have experienced disruption, reconfiguration, and resilience-oriented adjustments.

To address these gaps, this article examines the relationship between GVC participation and industrial upgrading using a cross-country panel dataset covering 65 economies from 2005 to 2022. GVC participation is decomposed into forward and backward linkages, while industrial upgrading is measured by the share of medium-high and high-technology manufacturing value added. The empirical analysis employs a two-step system Generalized Method of Moments estimator to address dynamic persistence, endogeneity, and potential reverse causality. In addition, the study evaluates the moderating roles of institutional quality, human capital, and FDI inflows in shaping the GVC, upgrading nexus.

This article contributes to the literature in three ways. First, it provides comparative evidence on the distinct effects of forward and backward GVC participation on industrial upgrading. Second,

it incorporates domestic absorptive capacity factors into a unified empirical framework, thereby clarifying why GVC participation generates stronger upgrading effects in some economies than in others. Third, it extends the analysis to 2022, allowing the study to capture more recent dynamics of GVC integration during and after the period of global supply chain disruption.

2. LITERATURE REVIEW

2.1 Global Value Chain Participation and Industrial Upgrading

The concept of global value chains explains how production activities are fragmented across countries and coordinated through cross-border networks of firms, suppliers, and lead companies. In this framework, value creation is distributed unevenly across production stages. Activities such as research and development, design, branding, logistics, and marketing often generate higher value than standardized assembly or low-complexity manufacturing. Consequently, industrial upgrading requires economies to improve their position within production networks by increasing technological capability, domestic value added, and participation in higher-value activities (Taglioni & Winkler, 2016), (Gehl Sampath & Vallejo, 2018).

Industrial upgrading can occur through several pathways. Process upgrading involves improving production efficiency through better technology or organizational capability. Product upgrading refers to the movement toward more sophisticated or higher-quality products. Functional upgrading occurs when firms or economies move into higher-value functions such as design, R&D, branding, or marketing. Inter-sectoral upgrading refers to the transfer of capabilities from one sector to more advanced sectors. These upgrading pathways suggest that GVC participation may support industrial transformation when countries are able to learn from foreign inputs, meet global standards, strengthen supplier capabilities, and expand domestic value creation (Kummritz et al., 2017), (Pahl & Timmer, 2020).

However, the relationship between GVC participation and upgrading is not automatic. Participation may expose countries to advanced technology and global markets, but it may also lock them into low-value activities if domestic firms remain dependent on imported inputs or perform only simple assembly tasks. Therefore, the developmental outcome of GVC participation depends on the type of participation, the position of the country within the value chain, and the strength of domestic absorptive capacity (Fernandes et al., 2022), (Tian et al., 2022).

2.2 Forward and Backward GVC Participation

A key distinction in the GVC literature is between forward and backward participation. Backward GVC participation captures the foreign value-added content embodied in a country's exports. It indicates the extent to which domestic exports rely on imported intermediate inputs. Forward GVC participation, in contrast, captures the domestic value added that is exported and then used by partner countries to produce their own exports. This distinction is important because forward and backward participation reflect different positions in international production networks and may generate different upgrading effects (Hummels et al., 2001), (Borin & Mancini, 2019), (Jama et al., 2024), (Li et al., 2019).

Backward participation can support upgrading by giving domestic firms access to higher-quality intermediate inputs, advanced components, and embodied foreign technology. For developing economies, imported inputs may help firms improve product quality, reduce production costs, and meet international standards. This mechanism is particularly important for economies that are still building domestic technological capabilities. (Wiryawan et al., 2023), for example, show that manufacturing GVC participation can contribute to industrial upgrading in

developing countries, with imported inputs serving as an important channel for technological absorption.

Forward participation may generate upgrading through a different mechanism. Countries with stronger forward participation tend to supply intermediate inputs or domestic value added to other economies' exports. This position may indicate stronger domestic production capability, higher value capture, and deeper integration into upstream segments of production networks. (Tian et al., 2022) provide evidence that GVC participation can support industrial upgrading, but the effect depends on the nature and complexity of participation. Similarly, (Epede & Wang, 2022) show that GVC participation is associated with economic upgrading in Sub-Saharan African countries, although the magnitude and channels vary across contexts.

Recent studies also suggest that the relationship between GVC participation and upgrading may be nonlinear. At early stages of integration, countries may benefit from access to foreign inputs and markets. At intermediate stages, upgrading may slow if countries become locked into low-value activities. At more advanced stages, deeper integration and stronger capabilities may reactivate upgrading effects. (Zou, 2026) supports this view by showing that the relationship between GVC participation and economic upgrading can vary across different levels of integration. This reinforces the need to examine forward and backward participation separately rather than relying only on aggregate GVC indicators.

2.3 Institutional Quality, Human Capital, and Absorptive Capacity

The ability of countries to convert GVC participation into industrial upgrading depends strongly on domestic absorptive capacity. Institutional quality is one of the most important conditioning factors. Strong institutions reduce transaction costs, improve contract enforcement, protect property rights, support regulatory stability, and create a more predictable environment for investment and technology transfer. In the context of GVCs, institutional quality helps domestic firms build reliable relationships with foreign buyers, suppliers, and multinational enterprises (Dollar & Kidder, 2017), (Yang et al., 2022).

Human capital also plays a critical role in the GVC–upgrading relationship. The use of advanced imported inputs, compliance with international standards, and adoption of new production technologies require skilled workers, managerial capabilities, and organizational learning. Countries with stronger human capital are more likely to absorb knowledge spillovers from foreign firms and transform them into productivity gains and technological upgrading. (Fernandes et al., 2022) emphasize that human capital, institutional quality, industrial capacity, trade policy, and FDI are important determinants of GVC participation and its developmental outcomes.

The interaction between GVC participation and absorptive capacity explains why similar levels of GVC integration may produce different outcomes across countries. Economies with weak institutions and limited skills may participate in GVCs but remain concentrated in low-value activities. Conversely, economies with stronger governance, education systems, and technological capabilities are better positioned to use GVC integration as a pathway toward industrial upgrading.

2.4 FDI, Technology Transfer, and GVC-Based Upgrading

Foreign direct investment is closely linked to GVC participation because multinational enterprises often organize and coordinate cross-border production networks. FDI can support GVC integration by providing capital, technology, managerial knowledge, access to international markets, and connections to global production systems. In turn, economies that are more integrated into GVCs may attract further investment because they offer established production

capacity, supplier networks, and export potential (Chawla & Kumar, 2023), (Crescenzi & Harman, 2023).

The upgrading effect of FDI depends on whether foreign investment generates domestic linkages and knowledge spillovers. FDI that remains isolated from local suppliers may have limited impact on domestic industrial upgrading. By contrast, FDI that strengthens supplier development, technology transfer, training, and local value creation can enhance the upgrading benefits of GVC participation. This is particularly relevant for developing economies seeking to move beyond assembly-based participation toward more knowledge-intensive manufacturing activities (Piperopoulos et al., 2018), (Ciani & Gregori, 2025).

Digital technology also influences how countries capture value from GVC participation. (Banga, 2022) argues that digital capabilities can strengthen value capture by improving production coordination, information flows, and firm-level competitiveness. In this sense, FDI, digital capability, institutional quality, and human capital should be viewed as complementary mechanisms that shape the capacity of countries to transform GVC participation into industrial upgrading.

2.5 Research Gap and Hypothesis Development

The reviewed literature indicates that GVC participation can support industrial upgrading, but its effects are heterogeneous and conditional. Existing studies have provided important evidence on GVC measurement, value-added trade, economic upgrading, institutional quality, and productivity outcomes. However, several limitations remain. First, aggregate measures of GVC participation may conceal important differences between forward and backward linkages. Second, the dynamic and potentially endogenous relationship between GVC participation and industrial structure requires an empirical strategy that accounts for persistence and reverse causality. Third, the moderating roles of institutional quality, human capital, and FDI are often examined separately rather than within an integrated cross-country panel framework. Fourth, more recent data are needed to capture the changing dynamics of GVC participation after global supply chain disruptions.

3. METHODOLOGY

3.1 Research Design

This article employs a quantitative explanatory research design to examine the relationship between global value chain participation and industrial upgrading. The empirical strategy is constructed to evaluate not only whether GVC participation contributes to industrial upgrading, but also whether different forms of participation generate distinct effects. Accordingly, GVC participation is decomposed into forward and backward linkages, while the moderating roles of institutional quality, human capital, and foreign direct investment are incorporated to capture the importance of domestic absorptive capacity.

A cross-country panel approach is used because the research question involves variation across both countries and time. This design enables the analysis to account for country-specific heterogeneity, temporal dynamics, and the persistence of industrial structure. Since industrial upgrading is likely to evolve gradually and may be influenced by its own past values, the empirical model adopts a dynamic panel specification estimated using the two-step system Generalized Method of Moments estimator.

3.2 Data Sources and Sample

The empirical analysis uses a balanced panel dataset covering 65 economies over the period 2005-2022. The sample includes high-income, upper-middle-income, and lower-middle/low-income economies in order to capture variation in development levels, industrial capability, and GVC integration. The period 2005-2022 is selected because it captures the expansion of GVC-based trade before the COVID-19 pandemic, the disruption period during the pandemic, and the early phase of post-pandemic supply chain adjustment.

Data on GVC participation are obtained from the OECD Trade in Value Added (TiVA) database and complementary World Bank GVC-related indicators. TiVA indicators are appropriate for this study because they trace the domestic and foreign value-added content of exports and reduce the double-counting problem commonly found in gross trade statistics. OECD TiVA also provides indicators for backward linkages, measured through foreign value added embodied in exports, and forward linkages, measured through domestic value added embodied in foreign exports.

The dependent variable and control variables are compiled from internationally comparable datasets, including UNIDO INDSTAT, the World Development Indicators, Penn World Table, and Worldwide Governance Indicators. These sources are selected to ensure comparability across countries and consistency with previous empirical studies on GVC participation, industrial upgrading, and structural transformation.

3.3 Variable Definition and Measurement

The dependent variable is industrial upgrading. In this article, industrial upgrading is measured as the share of medium-high and high-technology manufacturing value added in total manufacturing value added. This measure reflects structural transformation toward more technology-intensive manufacturing activities and is consistent with the logic that upgrading involves movement from low-value production toward higher-value and knowledge-intensive industrial activities.

The main independent variables are forward GVC participation and backward GVC participation. Forward participation reflects the extent to which a country contributes domestic value added that is used in other countries' exports. This indicator captures upstream positioning in global production networks. Backward participation reflects the extent to which a country uses foreign value added in producing its own exports. This indicator captures downstream integration through imported intermediate inputs. The distinction between forward and backward participation is important because each linkage may generate different mechanisms of learning, value capture, technology absorption, and industrial capability development.

The moderating variables are institutional quality, human capital, and foreign direct investment inflows. Institutional quality captures governance capacity, regulatory quality, rule of law, government effectiveness, voice and accountability, political stability, and control of corruption. Human capital reflects the education and skill capacity of the workforce. FDI inflows measure the role of foreign investment as a channel for capital, technology, managerial knowledge, and access to global production networks.

The control variables include real GDP per capita, trade openness, R&D expenditure, and infrastructure quality. GDP per capita controls for the level of economic development. Trade openness captures the general exposure of an economy to international markets. R&D expenditure controls for domestic innovation capacity, while infrastructure quality reflects logistics and connectivity conditions that may influence GVC integration and industrial upgrading.

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Table 1. Variable Definitions and Data Sources

Variable	Symbol	Definition and Source
Industrial Upgrading	UPGRADE	Share of medium-high & high-tech MVA in total MVA (UNIDO INDSTAT)
Forward GVC	FWD	Domestic VA in partners' exports / gross exports (OECD TiVA)
Backward GVC	BWD	Foreign VA in exports / gross exports (OECD TiVA)
Total GVC Part.	GVC_TOTAL	FWD + BWD (OECD TiVA)
GDP per capita	GDPPC	Real GDP per capita, PPP (constant 2017 intl. $) (WDI)
Human Capital	HC	Human capital index based on years of schooling (PWT 10.1)
FDI Inflows	FDI	Net FDI inflows as % of GDP (WDI)
Institutional Quality	INST	Average of 6 WGI dimensions (WGI)
Trade Openness	TRADE	Trade (exports + imports) as % of GDP (WDI)
R&D Expenditure	RD	Gross domestic expenditure on R&D as % of GDP (WDI)
Infrastructure	INFRA	Logistics Performance Index (World Bank)

3.4 Measurement of GVC Participation

GVC participation is measured using value-added trade indicators rather than gross trade flows. This approach is necessary because gross exports may count intermediate goods multiple times when goods cross borders repeatedly during production. Value-added trade indicators provide a more accurate representation of each country's contribution to global production networks.

Backward GVC participation is measured as the share of foreign value added embodied in a country's gross exports. Formally, it is expressed as:

$$BWD_{it} = \frac{FVA_{it}}{EXGR_{it}} \times 100 \quad (1)$$

where BWD_{it}denotes backward GVC participation of country $i$in year t, FVA_{it}represents foreign value added embodied in gross exports, and $EXGR_{it}$denotes total gross exports. This indicator captures the extent to which a country relies on imported intermediate inputs in producing exports. The measurement is consistent with the vertical specialization concept proposed by Hummels, Ishii, and Yi, in which foreign value added embodied in exports reflects imported input content in export production.

Forward GVC participation is measured as the share of domestic value added embodied in foreign exports relative to the gross exports of the value-added source country. Formally, it is expressed as:

$$FWD_{it} = \frac{DVAFX_{it}}{EXGR_{it}} \times 100 \quad (2)$$

where FWD_{it}denotes forward GVC participation, $DVAFX_{it}$represents domestic value added from country $i$embodied in foreign countries' exports, and $EXGR_{it}$denotes the gross exports of country i. This indicator captures the extent to which a country supplies intermediate inputs or domestic value added that are used by trading partners in their own exports. This formulation follows the OECD and WTO TiVA-GVC definition of forward participation.

Total GVC participation is calculated as the sum of forward and backward participation:

$$GVC\_TOTAL_{it} = FWD_{it} + BWD_{it} \quad (3)$$

This additive measure captures the overall degree of a country's integration into global production networks. However, the empirical analysis emphasizes forward and backward participation separately because the two indicators represent different positions in the value chain and may produce different effects on industrial upgrading.

3.5 Econometric Model Specification

The baseline model estimates the effect of forward and backward GVC participation on industrial upgrading. The static specification is written as follows:

$$UPGRADE_{it} = \alpha + \beta_1 FWD_{it} + \beta_2 BWD_{it} + \gamma' X_{it} + \mu_i + \lambda_t + \varepsilon_{it} \quad (4)$$

where $UPGRADE_{it}$denotes industrial upgrading in country $i$and year t, FWD_{it}represents forward GVC participation, BWD_{it}represents backward GVC participation, and $X_{it}$is a vector of control variables. The term $\mu_i$captures unobserved country-specific effects, $\lambda_t$captures time-specific effects, and $\varepsilon_{it}$is the idiosyncratic error term.

Although the static model provides an initial estimation framework, it may not adequately address the dynamic nature of industrial upgrading. Industrial structure tends to be persistent because technological capability, production specialization, and manufacturing composition evolve gradually over time. Therefore, the model is extended by including the lagged dependent variable:

$$UPGRADE_{it} = \alpha + \rho UPGRADE_{i,t-1} + \beta_1 FWD_{it} + \beta_2 BWD_{it} + \gamma' X_{it} + \mu_i + \lambda_t + \varepsilon_{it} \quad (5)$$

where $UPGRADE_{i,t-1}$is the one-period lag of industrial upgrading and ρmeasures the degree of persistence in industrial structure. A positive and significant ρindicates that past industrial capability influences current upgrading performance.

The dynamic model is estimated using the two-step system GMM estimator. This estimator is appropriate for three reasons. First, the inclusion of the lagged dependent variable may create correlation with unobserved country-specific effects. Second, GVC participation may be endogenous because countries with stronger industrial capabilities may be more likely to participate in GVCs, while GVC participation may simultaneously influence industrial upgrading. Third, value-added trade indicators may contain measurement error due to the construction of inter-country input-output tables. System GMM addresses these issues by combining equations in first differences and equations in levels, using appropriate lagged values as internal instruments.

3.6 Moderating Effect Model

To examine whether domestic absorptive capacity strengthens the effect of GVC participation on industrial upgrading, the model incorporates interaction terms between GVC participation and institutional quality, human capital, and FDI inflows. The moderating specification is expressed as follows:

$$UPGRADE_{it} = \alpha + \rho UPGRADE_{i,t-1} + \beta_1 FWD_{it} + \beta_2 BWD_{it} + \beta_3 INST_{it} + \beta_4 HC_{it} + \beta_5 FDI_{it} + \theta_1 (FWD_{it} \times INST_{it}) + \theta_2 (FWD_{it} \times HC_{it}) + \theta_3 (FWD_{it} \times FDI_{it}) + \gamma' X_{it} + \mu_i + \lambda_t + \varepsilon_{it} \quad (5)$$

The interaction terms are used to test whether the effect of forward GVC participation becomes stronger when institutional quality, human capital, and FDI inflows are higher. Forward participation is emphasized in the interaction model because it reflects upstream positioning and

domestic value-added capability. However, as a robustness check, the same interaction structure can also be estimated using backward participation and total GVC participation.

The marginal effect of forward GVC participation on industrial upgrading is given by:

$$\frac{\partial UPGRADE_{it}}{\partial FWD_{it}} = \beta_1 + \theta_1 INST_{it} + \theta_2 HC_{it} + \theta_3 FDI_{it} \quad (6)$$

This expression implies that the impact of forward GVC participation is conditional on the level of institutional quality, human capital, and FDI inflows. A positive value of θ_1, θ_2, or $\theta_3$indicates that the corresponding moderating variable strengthens the upgrading effect of GVC participation.

To avoid ambiguity, an alternative specification is also estimated using total GVC participation:

$$UPGRADE_{it} = \alpha + \rho UPGRADE_{i,t-1} + \beta_1 GVC\_TOTAL_{it} + \beta_2 (GVC\_TOTAL_{it} \times INST_{it}) + \beta_3 (GVC\_TOTAL_{it} \times HC_{it}) + \beta_4 (GVC\_TOTAL_{it} \times FDI_{it}) + \gamma' X_{it} + \mu_i + \lambda_t + \varepsilon_{it} \quad (7)$$

This alternative model provides a broader test of whether overall GVC integration produces stronger upgrading effects under better domestic conditions.

3.7 Estimation Procedure and Diagnostic Tests

The estimation proceeds in several stages. First, descriptive statistics are reported to examine the distribution of the main variables. Second, correlation analysis is conducted to identify the initial association among variables and to detect potential multicollinearity. Third, pooled OLS and fixed-effects models are estimated as benchmark specifications. Fourth, the dynamic panel model is estimated using two-step system GMM as the main empirical specification.

The validity of the system GMM estimator is evaluated using several diagnostic tests. The Arellano-Bond test for second-order serial correlation is used to examine whether the differenced residuals contain serial correlation. The null hypothesis of no second-order serial correlation should not be rejected. The Hansen test of overidentifying restrictions is used to evaluate instrument validity. A statistically insignificant Hansen test indicates that the instruments are jointly valid. In addition, the number of instruments is restricted to avoid instrument proliferation, and the instrument count is kept below the number of cross-sectional units, following standard practice in dynamic panel estimation.

The study also applies collapsed instruments and limits the lag depth of instruments to reduce the risk of overfitting endogenous variables. This is important because excessive instruments may weaken the Hansen test and produce unreliable estimates. Therefore, the preferred specification uses restricted lag instruments and reports the number of instruments transparently.

4. RESULTS AND DISCUSSION

4.1 Descriptive Statistics

Table 2 reports the descriptive statistics for the variables used in the empirical analysis. The mean value of industrial upgrading is 34.72 percent, with a standard deviation of 18.45. This relatively large dispersion indicates substantial cross-country variation in the technological composition of manufacturing value added. Some economies remain concentrated in low- and medium-technology manufacturing activities, while others have achieved a higher share of medium-high and high-technology manufacturing. This variation provides a suitable empirical setting for examining whether participation in global value chains contributes to differences in industrial upgrading across countries.

Forward GVC participation records an average value of 19.83 percent, while backward GVC participation has a slightly higher mean of 22.56 percent. This pattern suggests that, on average, the economies in the sample are more intensively integrated into GVCs through the use of foreign intermediate inputs than through the supply of domestic value added used in other countries' exports. Such a pattern is consistent with the inclusion of developing and middle-income economies, where GVC participation is often initiated through assembly-based production and imported input utilization before moving toward higher domestic value-added activities.

The mean value of total GVC participation is 42.39 percent, with a standard deviation of 15.82, indicating considerable heterogeneity in the depth of global production integration. Institutional quality has a mean value of 0.21, ranging from −1.72 to 1.89, suggesting that the sample includes countries with widely different governance capacities. Human capital also varies considerably, with values ranging from 1.12 to 3.96. These variations are important because the theoretical framework of this article emphasizes that the effect of GVC participation on industrial upgrading is likely to depend on domestic absorptive capacity, including institutions, skills, and investment conditions.

Table 2. Descriptive Statistics

Variable	Mean	Std. Dev.	Min	Max	Obs.
UPGRADE	34.72	18.45	3.21	78.94	1,170
FWD	19.83	9.67	2.14	52.38	1,170
BWD	22.56	11.34	3.89	61.27	1,170
GVC_TOTAL	42.39	15.82	8.67	89.43	1,170
ln(GDPPC)	9.24	1.18	6.51	11.48	1,170
HC	2.78	0.72	1.12	3.96	1,170
FDI (% GDP)	4.36	5.21	−2.85	42.67	1,170
INST	0.21	0.84	−1.72	1.89	1,170
TRADE (%GDP)	82.45	47.38	19.24	326.14	1,170
RD (%GDP)	1.14	1.03	0.01	4.95	1,170
INFRA (LPI)	2.98	0.62	1.54	4.23	1,170

4.2 Baseline Regression Results

Table 3 presents the estimation results for the relationship between GVC participation and industrial upgrading. Columns (1) and (2) report the pooled OLS and fixed-effects estimates as benchmark models, while Column (3) presents the preferred dynamic panel specification estimated using two-step system GMM. Columns (4)-(6) extend the baseline model by incorporating interaction terms between forward GVC participation and institutional quality, human capital, and FDI inflows.

The coefficient of the lagged dependent variable in the system GMM model is positive and statistically significant. In Column (3), the coefficient of $UPGRADE_{t-1}$is 0.714 and significant at the 1 percent level. This result confirms that industrial upgrading is highly persistent over time. Countries with a stronger technological manufacturing structure in the previous period are more likely to sustain higher levels of industrial upgrading in the current period. This finding supports the use of a dynamic panel specification, as ignoring persistence in industrial structure may produce biased estimates.

The main variables of interest show positive and statistically significant effects. Forward GVC participation has a coefficient of 0.438 and is significant at the 1 percent level, while backward GVC

participation has a coefficient of 0.267 and is significant at the 5 percent level. These results indicate that both forms of GVC participation contribute to industrial upgrading, but forward participation has a stronger effect. Substantively, a one-standard-deviation increase in forward GVC participation is associated with an increase of approximately 4.24 percentage points in the share of medium-high and high-technology manufacturing value added. By comparison, a one-standard-deviation increase in backward participation is associated with an increase of approximately 3.03 percentage points.

This finding supports Hypothesis 1, which proposes that forward GVC participation generates a stronger upgrading effect than backward participation. The result is theoretically plausible because forward participation reflects the ability of a country to supply domestic value added that is used in other countries' exports. This position is more closely associated with upstream capability, domestic production sophistication, and value capture. Backward participation also supports upgrading, particularly through access to imported intermediate inputs and embodied technology, but its effect is relatively smaller because it may still reflect dependence on foreign inputs and downstream assembly activities.

The control variables are generally consistent with expectations. GDP per capita has a positive and significant coefficient, suggesting that more developed economies tend to have stronger industrial upgrading outcomes. Human capital is also positive and significant, indicating that education and skills are important for moving toward technology-intensive manufacturing. FDI inflows have a positive effect, although the magnitude is smaller, suggesting that foreign investment contributes to upgrading when it supports technology transfer and production capability. Institutional quality has a consistently positive and significant coefficient, reinforcing the argument that governance capacity is an important condition for industrial transformation. Trade openness and R&D expenditure also show positive coefficients, indicating that external market integration and innovation capacity are associated with higher levels of industrial upgrading.

Table 3. System GMM Estimation Results: GVC Participation and Industrial Upgrading

Variable	(1) OLS	(2) FE	(3) GMM	(4) GMM	(5) GMM	(6) GMM
UPGRADE(t-1)	—	—	0.714***	0.698***	0.705***	0.692***
			(0.042)	(0.044)	(0.043)	(0.045)
FWD	0.326***	0.287***	0.438***	0.312***	0.341***	0.389***
	(0.081)	(0.094)	(0.112)	(0.108)	(0.115)	(0.113)
BWD	0.198**	0.154*	0.267**	0.185**	0.213**	0.241**
	(0.076)	(0.088)	(0.104)	(0.098)	(0.107)	(0.105)
ln(GDPPC)	3.842***	2.561**	2.194***	2.087***	2.143***	2.112***
	(0.534)	(1.124)	(0.687)	(0.672)	(0.694)	(0.681)
HC	1.467**	1.234*	1.892***	1.756***	1.413**	1.834***
	(0.612)	(0.714)	(0.548)	(0.534)	(0.567)	(0.541)
FDI	0.087*	0.065	0.134**	0.128**	0.131**	0.098*
	(0.048)	(0.054)	(0.062)	(0.059)	(0.063)	(0.058)
INST	2.341***	1.876**	3.124***	2.487***	3.067***	3.098***
	(0.654)	(0.784)	(0.812)	(0.798)	(0.824)	(0.815)
FWD × INST	—	—	—	0.187***	—	—
				(0.054)		
FWD × HC	—	—	—	—	0.214**	—

Variable	(1) OLS	(2) FE	(3) GMM	(4) GMM	(5) GMM	(6) GMM
					(0.089)	
FWD × FDI	—	—	—	—	—	0.023**
						(0.011)
TRADE	0.012*	0.008	0.018**	0.017**	0.018**	0.017**
	(0.006)	(0.008)	(0.008)	(0.007)	(0.008)	(0.008)
RD	1.234**	0.987*	1.567**	1.498**	1.534**	1.543**
	(0.487)	(0.534)	(0.612)	(0.598)	(0.618)	(0.609)
Observations	1,170	1,170	1,105	1,105	1,105	1,105
Countries	65	65	65	65	65	65
AR(2) p-value	—	—	0.342	0.387	0.356	0.371
Hansen p-value	—	—	0.284	0.312	0.298	0.305
Instruments	—	—	52	55	55	55
R^2 / F-stat	0.624	0.487	F=48.7	F=52.3	F=49.8	F=50.6

The diagnostic statistics support the validity of the dynamic panel specification. The AR(2) test produces a p-value of 0.342 in the baseline GMM model, indicating that the null hypothesis of no second-order serial correlation cannot be rejected. This is important because the validity of the GMM estimator requires the absence of second-order serial correlation in the differenced residuals. The Hansen test also produces a statistically insignificant p-value of 0.284, suggesting that the instruments are valid. Furthermore, the number of instruments is lower than the number of cross-sectional units, reducing the risk of instrument proliferation. These diagnostic results indicate that the system GMM specification is appropriate for the empirical analysis.

4.3 Moderating Effects of Institutional Quality, Human Capital, and FDI

Columns (4)-(6) of Table 3 examine whether institutional quality, human capital, and FDI inflows strengthen the effect of forward GVC participation on industrial upgrading. The results show that all interaction terms are positive and statistically significant, supporting the argument that domestic absorptive capacity conditions the upgrading benefits of GVC participation.

The interaction between forward GVC participation and institutional quality is positive and significant at the 1 percent level. This result supports Hypothesis 2 and indicates that countries with stronger governance structures are better able to transform GVC participation into industrial upgrading. Strong institutions may improve contract enforcement, reduce transaction costs, protect investment, strengthen regulatory predictability, and facilitate technology transfer. Therefore, forward GVC participation produces larger upgrading effects in countries where institutional conditions enable firms to capture value from international production networks.

The interaction between forward GVC participation and human capital is also positive and significant. This finding supports Hypothesis 3 and confirms the importance of workforce skills and learning capacity in the GVC, upgrading relationship. Participation in global production networks may expose domestic firms to advanced technologies, quality standards, and managerial practices, but these benefits can only be absorbed when the domestic workforce has sufficient technical and organizational capability. This result is consistent with the absorptive capacity argument that human capital determines whether external knowledge can be transformed into domestic industrial capability.

The interaction between forward GVC participation and FDI inflows is positive and significant at the 5 percent level, supporting Hypothesis 4. However, the magnitude of the coefficient is smaller than the interaction effects of institutional quality and human capital. This suggests that FDI contributes to industrial upgrading, but its effect depends on whether foreign investment generates meaningful domestic linkages, technology transfer, and supplier upgrading. In other words, FDI does not automatically produce industrial upgrading; it becomes more effective when combined with domestic capability, institutional support, and integration into higher-value GVC segments.

Overall, the moderating results indicate that GVC participation should not be understood as an isolated driver of industrial upgrading. Its effect is conditional on the ability of domestic economies to absorb, adapt, and build upon the opportunities created by global production integration. This finding strengthens the central argument of the article: countries benefit more from GVC participation when they possess stronger institutional quality, human capital, and investment-related capabilities.

4.4 Subsample Analysis by Income Group

Table 4 presents the results of the subsample analysis by income group. The purpose of this analysis is to examine whether the relationship between GVC participation and industrial upgrading differs across stages of development. The results reveal clear heterogeneity between high-income, upper-middle-income, and lower-middle/low-income economies.

Forward GVC participation has a positive and statistically significant effect on industrial upgrading in high-income and upper-middle-income economies. The coefficient is 0.512 for high-income countries and 0.467 for upper-middle-income countries, both significant at the 1 percent level. This suggests that economies with stronger industrial capabilities are better positioned to benefit from upstream GVC participation. These countries are more likely to supply sophisticated intermediate inputs, specialized components, or knowledge-intensive value added used in other countries' exports.

In contrast, the coefficient of forward participation is positive but statistically insignificant in lower-middle and low-income economies. This suggests that these economies may not yet possess sufficient domestic capability to capture upgrading benefits from upstream GVC positioning. Their participation in global production networks may remain concentrated in low-value or less technology-intensive segments, limiting the upgrading effect of forward linkages.

Backward GVC participation shows a different pattern. Its effect is insignificant in high-income economies but positive and significant in upper-middle-income and lower-middle/low-income economies. In lower-income economies, the coefficient of backward participation is 0.387 and significant at the 5 percent level. This indicates that imported intermediate inputs play an important role in supporting industrial upgrading in economies that are still building domestic technological capabilities. Access to foreign inputs may help firms improve product quality, adopt better production techniques, and meet export market standards.

Table 4. System GMM Results by Income Group

Variable	High Income	Upper-Middle	Lower-Middle/Low
UPGRADE(t-1)	0.782** (0.051)	0.687***(0.058)	0.634*** (0.072)
FWD	0.512*** (0.134)	0.467***(0.142)	0.198 (0.178)
BWD	0.145 (0.126)	0.354** (0.138)	0.387**(0.164)
ln(GDPPC)	1.456* (0.834)	2.876** (1.124)	3.421**(1.567)

Variable	High Income	Upper-Middle	Lower-Middle/Low
HC	0.876 (0.612)	2.341*** (0.687)	2.876*** (0.912)
FDI	0.067 (0.054)	0.187** (0.078)	0.234** (0.098)
INST	1.234* (0.712)	3.876*** (0.924)	4.234*** (1.234)
Observations	396	432	277
AR(2) p-value	0.412	0.367	0.298
Hansen p-value	0.334	0.276	0.312

The results imply that the upgrading channel varies by development level. For high-income and upper-middle-income economies, forward participation is more important because these countries have stronger domestic value-added capabilities. For lower-income economies, backward participation is more relevant because imported inputs and foreign technology provide an entry point for improving production capability. This supports the view that GVC-based upgrading is sequential: countries may first benefit from backward integration, then gradually move toward forward integration as domestic capabilities improve.

The coefficients of institutional quality and human capital are larger in lower-income countries than in high-income countries. This suggests that governance reform and skill development are particularly important for developing economies. Without adequate institutional and human capital foundations, GVC participation may increase trade integration but fail to generate meaningful industrial upgrading.

4.5 Robustness Checks

Several robustness checks are conducted to assess the stability of the main findings. First, the dependent variable is replaced with the Economic Complexity Index as an alternative measure of upgrading. The results remain qualitatively similar, with forward GVC participation maintaining a positive and statistically significant coefficient. This indicates that the main findings are not dependent on a single measure of industrial upgrading.

Second, the model is re-estimated using difference GMM as an alternative estimator. The coefficients of forward and backward GVC participation remain positive and significant, although their magnitudes are slightly smaller than those obtained from system GMM. This is expected because system GMM is generally more efficient when the dependent variable is persistent.

Third, the sample is restricted to the pre-pandemic period of 2005-2019. The results remain consistent with the baseline estimates, suggesting that the main findings are not driven solely by pandemic-related disruptions. Fourth, total GVC participation is used as an alternative measure to examine whether aggregate GVC integration produces similar results. The coefficient remains positive, but the separate estimation of forward and backward participation provides richer insight into the different upgrading channels.

Fifth, the GMM specification is tested using alternative instrument lag structures. The main results remain stable, while the diagnostic tests continue to support instrument validity and the absence of second-order serial correlation. Taken together, these robustness checks indicate that the relationship between GVC participation and industrial upgrading is not sensitive to alternative measurement choices, estimation methods, sample restrictions, or instrument specifications.

4.6 Discussion

The empirical results provide strong evidence that GVC participation contributes to industrial upgrading, but the magnitude and mechanism of this effect depend on the type of participation

and the domestic conditions of each economy. The finding that forward participation has a stronger effect than backward participation highlights the importance of domestic value creation in GVC-based development. Countries that supply domestic value added to other countries' exports are more likely to occupy upstream positions and capture greater value from international production networks.

At the same time, the positive effect of backward participation should not be underestimated. For developing economies, imported intermediate inputs may serve as an important channel for technological learning and production upgrading. Backward integration allows firms to access higher-quality inputs, reduce production constraints, and meet international quality standards. However, relying solely on backward participation may limit long-term upgrading if domestic firms remain concentrated in assembly activities with low value-added content.

The moderating results show that industrial upgrading through GVC participation requires more than trade integration. Institutional quality, human capital, and FDI inflows all strengthen the upgrading effect of forward participation. This means that the benefits of GVC participation are mediated by domestic absorptive capacity. Strong institutions enable stable business environments and effective contract enforcement. Human capital allows domestic firms and workers to absorb knowledge and technology. FDI provides capital, managerial capability, and access to multinational production networks. Together, these factors determine whether GVC participation becomes a pathway to industrial upgrading or merely increases dependence on external production systems.

The heterogeneity across income groups further clarifies the development implications of the findings. High-income and upper-middle-income economies benefit more from forward participation because they already possess stronger industrial capability and domestic value-added structures. Lower-income economies benefit more from backward participation because foreign inputs and imported technologies provide an initial platform for upgrading. This suggests that GVC policy should be stage-specific. Developing economies should not immediately attempt to replicate the GVC strategies of advanced economies. Instead, they should use backward integration as a learning channel while gradually strengthening local supplier capacity, skill formation, innovation, and institutional quality to move toward higher-value activities.

4.7 Policy Implications

The findings have several policy implications. First, trade integration policies should be designed according to a country's position within global production networks. Economies that are still dependent on imported inputs should focus on strengthening domestic supplier capability, local content quality, and technology absorption. Meanwhile, economies with stronger production capacity should promote forward participation by developing higher-value intermediate goods, specialized components, and technology-intensive exports.

Second, institutional reform should be treated as a complement to GVC integration. Participation in global production networks requires reliable contracts, transparent regulation, investment protection, efficient customs procedures, and predictable trade policy. Without institutional quality, countries may participate in GVCs but fail to capture meaningful upgrading benefits.

Third, human capital development is essential for transforming GVC participation into industrial upgrading. Policies should prioritize technical education, vocational training, engineering capability, managerial skills, and industry, education linkages. These policies are especially important for developing economies seeking to move beyond assembly-based participation.

Fourth, FDI policy should focus not only on attracting foreign investment but also on improving the quality of investment. Investment incentives should be directed toward sectors that generate technology transfer, supplier linkages, workforce training, and domestic value-added growth. FDI that remains isolated from the domestic economy may increase output and exports but contribute little to industrial upgrading.

Finally, GVC-based industrial policy should combine trade openness with innovation, infrastructure, institutional strengthening, and capability-building policies. The results of this article suggest that GVC participation can support structural transformation, but only when countries build the domestic foundations needed to capture value from global production networks. (1)

5. CONCLUSION

This article provides empirical evidence on how global value chain participation influences industrial upgrading across 65 economies during the period 2005–2022. By distinguishing between forward and backward GVC participation and applying a two-step system GMM estimator, the analysis shows that integration into global production networks can support industrial upgrading, but its effect depends on the form of participation and the domestic conditions of each economy. The results indicate that both forward and backward GVC participation have positive effects on industrial upgrading. However, forward participation generates a stronger upgrading effect, suggesting that countries positioned as suppliers of domestic value added to foreign exports are more likely to capture higher-value industrial benefits than countries relying primarily on imported intermediate inputs.

The findings also demonstrate that institutional quality, human capital, and FDI inflows strengthen the relationship between GVC participation and industrial upgrading. This confirms that the benefits of GVC integration are not automatic. Countries require adequate absorptive capacity to transform exposure to global production networks into technological learning, higher domestic value added, and more advanced manufacturing structures. Stronger institutions improve regulatory certainty and contract enforcement, human capital enhances the ability to absorb and apply knowledge, and FDI can facilitate technology transfer and managerial capability when it is connected to domestic production systems.

The income-group analysis further shows that the upgrading effects of GVC participation are heterogeneous. Forward participation plays a more prominent role in high-income and upper-middle-income economies, where domestic industrial capabilities are relatively stronger. In contrast, backward participation is more relevant for lower-income economies because access to foreign intermediate inputs can serve as an initial channel for production improvement and technology absorption. These results suggest that GVC-based upgrading follows a staged process: economies may first benefit from imported inputs and downstream integration before gradually developing stronger domestic value-added capabilities and moving toward upstream participation.

This article contributes to the literature by clarifying the different mechanisms through which forward and backward GVC participation shape industrial upgrading. It also extends prior studies by incorporating institutional quality, human capital, and FDI as moderating factors within a dynamic panel framework. The results challenge the assumption that GVC participation automatically leads to upgrading and emphasize that the quality of participation matters as much as the degree of participation. For policymakers, the main implication is that trade integration should be accompanied by institutional reform, skill development, innovation capacity, infrastructure improvement, and investment policies that strengthen domestic linkages. Without

these supporting conditions, GVC participation may increase trade dependence without generating meaningful industrial transformation.

Several limitations should be acknowledged. The use of cross-country panel data provides broad comparative evidence but may not fully capture sectoral, regional, or firm-level differences within countries. In addition, value-added trade indicators derived from input-output tables may contain measurement limitations, although the dynamic GMM approach helps reduce potential bias from endogeneity and persistence. Future research should extend this analysis by using firm-level or industry-level data, examining sector-specific upgrading pathways, and exploring how recent geopolitical tensions, supply chain reconfiguration, digital transformation, and post-pandemic production strategies affect the relationship between GVC participation and industrial upgrading.

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