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ORIGINAL ARTICLE OPEN ACCESS

Does Global Value Chain Participation Matter for Economic Upgrading? A Nonlinear Insight

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ABSTRACT

In recent decades, global value chains (GVCs) have come to dominate much of world trade. Participation in GVCs is widely regarded as a key driver of development by enabling countries to climb the value-added ladder. However, tighter governance structures within GVCs can make these benefits uncertain. This paper investigates the dynamic impact of GVC participation on economic upgrading using a semiparametric smooth coefficient model with panel data from 62 countries over 1995–2018. We uncover a novel N-shaped nonlinear relationship between GVC participation and economic upgrading, extending beyond the linear or U-shaped patterns found in earlier research. This relationship reveals three stages: initial learning with rising upgrading effects, an intermediate 'upgrading trap' with declining effects, and an advanced breakthrough stage with renewed rise. Decomposing transmission mechanisms shows that while GVC participation imposes output efficiency costs, it enhances upgrading by improving input factor productivities. Critically, forward linkage participation proves more effective than backward linkage for escaping the upgrading trap. Middle-income countries exhibit the strongest internal input factor efficiency gains from GVC participation alongside the highest dispersion in overall outcomes. These findings offer policy insights for designing openness and industry policies tailored to a country's development stage and GVC position.

JEL Classification: F6, O4, O5

1 | Introduction

Global value chains (GVCs) have become the dominant form of international trade and production (WTO 2019), with countries increasingly specialising in specific value-added tasks or stages instead of producing final goods (Gereffi and Frederick 2010). The production processes of most commodities from design through assembly to sales are fragmented across borders. Countries can participate in GVCs through backward and forward linkages (Koopman et al. 2014). Backward linkages capture the foreign value-added embedded in a country's exports (buyer-driven perspective), while forward linkages measure the domestic value-added that is exported and used by foreign countries in their exports (seller-driven perspective). This

interconnectedness has added complexity to the study of international trade and industrial development (UNCTAD 2013). Along these lines, Taglioni and Winkler (2016) argued that the fragmented production in GVCs has reshaped not only the structure of trade but also the cross-border movement of labour, technology, investment, and human capital, which are significant determinants of economic upgrading (the process by which countries move to higher value-added activities in global production and trade (Gereffi and Fernandez-Stark 2011)). This means GVCs offer a powerful framework for understanding the processes behind economic upgrading.

The upgrading dilemmas faced by a growing number of countries have prompted doubts about the benefits of GVC

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participation. Empirical studies (e.g., Kummritz, Taglioni, & Winkler, Kummritz et al. 2017; Mao 2021; Thakur and Sharma 2025) point out that the impact of GVC participation may vary depending on the degree of participation and other factors. Some case studies (e.g., Navas-Alemán 2011; Lee et al. 2018) found that some firms participating in GVCs may be locked into low value-added tasks. Blažek (2016) and Epede and Wang (2022) theorise that GVCs present both opportunities and challenges for participating actors. Those suggest that there is a nonlinear relationship between GVC participation and economic upgrading. Nevertheless, few studies consider how GVC participation affects the efficiency of both internal and external input factors to influence economic upgrading, failing to depict a comprehensive dynamic relationship.

Recent geopolitical tensions have further highlighted the strategic importance of GVC participation for development (WTO 2023). The Trump administration's trade policies and the subsequent US-China trade tensions have raised fundamental questions about the resilience and restructuring of global production networks (e.g., Vandenbussche et al. 2022; Fajgelbaum et al. 2024; Handley et al. 2025). These disruptions highlight the importance of understanding how GVC participation affects economic upgrading, particularly for developing and middle-income countries seeking to navigate an increasingly fragmented global trade environment.

This study re-examines the link between GVC participation and economic upgrading, addressing several key questions: (i) what is the effect of GVC participation on economic upgrading? (ii) is this relationship linear, or does it exhibit more complex nonlinearity? (iii) is there evidence of upgrading trap and how to escape it? (iv) what are the transmission mechanisms through which GVC participation affects economic upgrading? Answering these questions is crucial for advancing both theoretical and empirical insights into their relationship and making a specific upgrading policy.

To explore the above research questions, this study adopts a three-step semi-parametric smooth coefficient (SPSC) model. This method specifies a production function to avoid any restriction and inflexibility. Following Li, Huang, Li, and Fu (Li et al. 2002), we treat the GVC variable as an environmental variable rather than a factor input. This specification allows us to explore the upgrading effects of GVC participation via its impact on the marginal returns to other factors. Their coefficients are specified as an unknown smooth function, allowing the exploration of complex nonlinearities between GVC participation and economic upgrading. The three-step procedure also alleviates the endogeneity.

Our empirical results, based on data from 62 countries from 1995 to 2018 collected from the Trade in Value Added (TiVA) database OECD-TiVA 2021 edition, reveal several key findings. First and most importantly, we uncover an N-shape relationship between GVC participation and economic upgrading. This result points to the risk of an upgrading trap. Second, we find a negative neutral impact but positive overall effect of GVC participation on economic upgrading. Decomposition of mechanisms indicates that countries sacrifice output efficiency to integrate into global production but can gain

upgrading benefits through enhancing input factor efficiencies. Furthermore, GVC participation enhances economic upgrading via the trade channel, while its effect via the foreign direct investment (FDI) channel remains largely non-existent. Third, forward GVC participation emerges as critical for overcoming the upgrading trap at intermediate levels of participation. The upgrading efficiency of input factors induced by GVC participation appears to be stronger for middle-income countries, highlighting the significance of domestic capacity building.

This paper makes two key contributions. First, for the first time, this study investigates whether an N-shaped relationship exists, providing a new perspective on the dynamics of GVC participation. By adopting a more flexible functional form, we challenge the prevailing assumption of linear relationships (Kummritz 2016) and reveal a more complete nonlinear pattern than the U-shaped relationships found in prior studies (Lee et al. 2018; Mao 2021; Thakur and Sharma 2025). The N-shaped relationship captures the full “in-out-in again” upgrading trajectory that U-shaped specifications fail to depict. Second, the findings may help policymakers to map GVC stages, identify upgrading traps, and select participation patterns for formulating a new policy agenda to achieve sustained upgrading. By decomposing transmission mechanisms and isolating heterogeneity across countries and participation patterns, this study offers a new analytical approach for understanding the upgrading trap phenomenon. The derivation of neutral and non-neutral effects provides a methodological framework that can inform the design of stage-specific and channel-targeted policy interventions. This approach is particularly valuable considering the changes in trade structures and cross-border movements of labor, investment, and capital caused by fragmented production in GVCs (Taglioni and Winkler 2016).

The rest of the paper is organised as follows. Section 2 reviews the relevant literature. In Section 3, we outline the model, discuss the empirical strategy, and describe the data sources. The main empirical results and their discussion are presented in Section 4. Section 5 concludes the paper.

2 | Related Literature

The central idea behind GVC participation is that it can stimulate firms and countries' productivity growth. Indeed, it is argued that trade can improve value-added (comprehensive upgrading) via various channels including the specialisation of production, resource reallocation, high quality inputs access, knowledge spillovers and global competition (Crisuolo and Timmis 2017). Along these lines, various theoretical models have highlighted this range of channels through which GVC enhances productivity (see Li and Liu 2014; Grossman and Rossi-Hansberg 2008; Baldwin and Robert-Nicoud 2014; Javorcik 2004). In a nutshell, through these channels, GVC participation allows firms to upgrade and operate at the higher end of the quality spectrum of the value chain.

Numerous empirical studies have sought to quantify the effects of GVC participation. Many have documented a positive and statistically significant relationship between GVC

participation and outcomes such as growth and productivity (e.g., Kummritz 2016; Formai and Vergara Caffarelli 2016; Kummritz et al. 2017; Edwards et al. 2018; Montalbano et al. 2018; Pahl and Timmer 2020; Constantinescu et al. 2019; Banga 2022). Other studies highlight its positive effects on employment (e.g., Lopez-Gonzalez 2016; Pahl et al. 2019; Ma et al. 2019) and export upgrading (e.g., Ndubuisi and Owusu 2021).

A key limitation of the existing literature is the implicit assumption that the effects of GVC participation are linear and thereby overlooks potential negative effects. Lee et al. (2018), building on the “catch-up cycle” theory (Lee and Malerba 2017), challenge this assumption by suggesting a nonlinear relationship between GVC participation and economic upgrading. They argue that while GVC participation is beneficial during the early stages due to domestic spillovers from foreign sources, sustained upgrading at later stages requires additional effort to re-enter and deepen participation in GVCs after initial progress has been achieved. “This dynamic sequence of “in-out-in again” would generate a nonlinear curve in terms of the degree of participation in the GVC...” (Lee et al. 2018, 428). Their analysis supports the existence of a U-shaped relationship between GVC participation and economic upgrading, a finding corroborated by Taguchi (2014), Mao (2021), and Thakur and Sharma (2025). Despite these contributions, they have failed to illustrate a comprehensive nonlinearity to support the “in-out-in again” dynamics.

These empirical studies, although to some extent considering the GVC to upgrading transmission mechanisms, have not considered the model specification. GVC participation is usually included in the production function as an additional factor input. Such a specification violates the theory of marginal productivity. GVC participation changes the allocation and cross-country flows of various factors (Taglioni and Winkler 2016). We need to consider the efficiency impact of GVC participation on other input factors. SPSC model can be used to respond to the two empirical gaps.

3 | Empirical Strategy and Data Description

3.1 | Econometric Method

The empirical models in previous studies (e.g., Kummritz et al. 2017; Mao 2021; Jona-Lasinio and Meliciani 2019) are based on a GVC participation-augmented production function. The linear specification, with variables in log terms, is generally written as:

$$y_{it} = \alpha_0 + \beta_1 z_{it} + \beta_2 k_{it} + \beta_3 l_{it} + \beta_4 h_{it} + \mu_i + \mu_t + \varepsilon_{it} \quad (1)$$

where y is economic upgrading; z stands for GVC participation; k is physical capital; l represents labour force; h is human capital (all variables are expressed in their natural logarithms); μ_i and μ_t represents, respectively, countries fixed-effects and time specific effects; ε is the error term, and i and t present country and year subscripts, respectively.

There are two main concerns with the above functional specification. First, it overlooks the non-Hicks-neutral impact of GVCs on factor inputs, which may generate biased estimates.

To be more specific, existing studies treat GVC participation as a productivity factor, that is, the specification is assumed to be $Y = A(z)f(K, L, H)$. K , L and H are, respectively aggregate Capital, Labour and Human capital. A , generally represents the technology index and is derived as a Solow residual, in which Hicks-neutrality is assumed. One implication of this assumption is that GVC participation impacts on productivity by changing the production frontier without affecting the rate of marginal substitution. However, GVC participation may impact on the application of the type of production technology; because the upstream countries can control or change the production activity in downstream countries (Gereffi, Humphrey, & Sturgeon, Gereffi et al. 2005), and technological change may be distorted by other inputs (Ahmad 1966; Stevenson 1980). As a result, non-neutrality of the production function is a more reasonable assumption.

Second, the specification depicted by Equation (1), as aforementioned, does not allow for a nonlinear effect of GVC participation. To address this issue, some studies (see Mao 2021; Thakur and Sharma 2025) propose a U-shaped nonlinearity by adopting a specification with a quadratic term:

$$y_{it} = \alpha_0 + \beta_1 z_{it} + \beta_2 z_{it}^2 + \beta_3 k_{it} + \beta_4 l_{it} + \beta_5 h_{it} + \mu_i + \mu_t + \varepsilon_{it} \quad (2)$$

The main issue with Equation (2) is that it does not allow other forms of nonlinearity, for example, N-shape, which cannot be ruled out theoretically. Other studies (see Kummritz et al. 2017) attempted to capture the nonlinear effect of GVC by including interaction terms in their specification. The equation can be written as Equation (3).¹

$$y_{it} = \beta_0(z_{it}; \alpha) + \beta_1(z_{it}; \delta)k_{it} + \beta_2(z_{it}; \gamma)l_{it} + \beta_3(z_{it}; \rho)h_{it} + \mu_i + \mu_t + \varepsilon_{it} \quad (3)$$

However, this approach does not address nonlinearity related to heterogeneity in the effect of GVC participation on productivity (Henderson and Kumbhakar 2006). To circumvent these issues, this study adopts a SPSC modelling approach, which allows various GVC-economic upgrading linkages. Equation (1) under this setting can now be written as:

$$y_{it} = \beta_0(z_{it}) + \sum_j \beta_j(z_{it}) \times X_{jit} + \mu_i + \mu_t + \varepsilon_{it} \quad (4)$$

where y and z are defined as above; X_j stands for the other variables included in the model, in addition to GVC participation. All remaining terms in Equation (4) are defined as above. Under this setting, GVC participation, z , is allowed to affect economic upgrading directly but also via other determining factors of it. This is interesting in itself, as we are able to highlight the transmission mechanisms from GVC participation to economic upgrading.

3.2 | Identification Strategy and Estimation Procedure

Whilst various SPSC techniques have been proposed to estimate models such as Equation (4) (see for example Li et al. 2002), it is

worth bearing in mind that GVC participation is potentially endogenous. Because productivity or upgrading could also impact the degree of GVC participation through changing the manufacturing pattern and GVC position (e.g., Formai and Vergara Caffarelli 2016; Kummritz 2016). Moreover, the other variables included in Equation (4) could also be potential endogenous. All in all, failing to take the endogeneity issue into consideration may generate bias estimates. Recently, some studies have developed new SPSC alternatives to address this deficiency (see Das 2005; Cai et al. 2006; Delgado et al. 2019; Zhang and Sun 2019; among others). The method developed by Zhang and Sun has an edge on the other proposed methods, because it allows all regressors on the right-hand side to be endogenous.² In fact, Zhang and Sun (2019) proposed a three-step procedure to deal with the issue of endogeneity.

To illustrate the procedure, in the present context, Equation (4) is rewritten as follows:

$$y_{it} = m(z_{it}, X_{it}, \mu_i, \mu_t) + \varepsilon_{it} \quad (5)$$

where X is a K -vector of possible endogenous regressors, which include, in our context, the standard input factors, k and l ; human capital h ; as well as FDI and trade openness. Recall that z is GVC participation. Clearly, if z and X are not exogenous, then $E(\varepsilon_{it} | z_{it}, X_{it}, \mu_i, \mu_t) \neq 0$ which means that instruments are required to avoid bias estimates. Zhang and Sun (2019) use the Newey, Powell, and Vella (Newey et al. 1999)'s triangular equation system to derive the following reduced-form equations:

$$\begin{cases} X_{it} = f(R_{it}) + \psi_{it} \\ z_{it} = g(S_{it}) + \sigma_{it} \end{cases} \quad (6)$$

where R are the instruments for X , and S are the instruments for z . This ensures that $E(\psi_{it} | R_{it}) = 0$ and $E(\sigma_{it} | S_{it}) = 0, \forall i, t$.

Assuming that the instruments and fixed-effects are mean independent of the error term in Equation (4), the whole exercise in the SPSC approach consists of estimating the ensuing conditional expectation:

$$E(y_{it} | z_{it}, X_{it}, \mu_i, \mu_t, \psi_{it}, \sigma_{it}) = \beta_0(z_{it}) + \sum_j \beta_j(z_{it}) X_{jit} + \mu_i + \mu_t + \eta(\psi_{it}, \sigma_{it}) \quad (7)$$

where $\eta(\psi_{it}, \sigma_{it}) = E(\varepsilon_{it} | \psi_{it}, \sigma_{it})$ represents a control function.

The estimation procedure involves three steps. In the first step, following Nadaraya (1965) and Watson (1964), one uses the Nadaraya-Watson kernel estimator to estimate the reduced form Equation (6) to derive the residuals for $\hat{\psi}_{it}$ and $\hat{\sigma}_{it}$. In the second step, $\hat{\beta}_0(z_{it}), \hat{\beta}_j(z_{it}), \hat{\mu}_i, \hat{\mu}_t$, and $\hat{\eta}(\hat{\psi}_{it}, \hat{\sigma}_{it})$ are obtained by estimating

$$\begin{aligned} y_{it} &= E(y_{it} | z_{it}, X_{it}, \mu_i, \mu_t, \hat{\psi}_{it}, \hat{\sigma}_{it}) \\ &= \beta_0(z_{it}) + \sum_j \beta_j(z_{it}) X_{jit} + \mu_i + \mu_t + \eta(\hat{\psi}_{it}, \hat{\sigma}_{it}) \end{aligned} \quad (8)$$

Therefore, one can test the significance of $\hat{\eta}(\hat{\psi}_{it}, \hat{\sigma}_{it})$ to confirm the joint significance of the endogeneity between X_{it} and z_{it} . Once the endogeneity is supported, the estimation proceeds to

the next step. Otherwise, the first step should be skipped and $\eta(\cdot)$ can be dropped in the second step. The third step consists of deriving $\hat{\beta}_0(z_{it})$ and $\hat{\beta}_j(z_{it})$ for all j . This is achieved through estimating, via local-linear estimation for bandwidth selection (see Li and Racine 2007), the following equation:

$$y_{it} - \hat{\eta}(\hat{\psi}_{it}, \hat{\sigma}_{it}) - \hat{\mu}_i - \hat{\mu}_t = \beta_0(z_{it}) + \sum_j X'_{jit} \beta_j(z_{it}) + \omega_{it} \quad (9)$$

It is worth noting that in addition to obtaining the estimated coefficient functions $\beta_0(z_{it})$ and $\beta_j(z_{it})$, this step also allows one to derive their first order derivatives as,

$$\frac{\partial y_{it}(z)}{\partial z} = \frac{\partial \beta_0(z)}{\partial z} + \sum_j X'_{jit} \left(\frac{\partial \beta_j(z)}{\partial z} \right) \quad (10)$$

One also can use the bandwidth to decide whether a parametric or the SPSC model should be adopted. If the bandwidth is less than twice the standard errors of z_{it} , there is nonlinearity and SPSC model should be used. Bootstrapping with 99 replications is implemented to get standard errors and the first order derivatives after correcting autocorrelation and heteroscedasticity based on Mammen (1993) and Horowitz (1997).

3.3 | Data Discussion

3.3.1 | Sample and Data

Our analysis covers 1995–2018, a period that coincides with the rapid expansion of GVCs following the establishment of the WTO in 1995 and China's accession, as a major global manufacturing hub and trade centre, to the WTO in 2001. While GVC participation is indeed a gradual process whose effects may materialise over extended periods, this 24-year window provides three advantages. First, 1995 marks a natural starting point as it coincides with the theoretical development of GVC frameworks, building on earlier global commodity chain concepts (Gereffi and Korzeniewicz 1994) and culminating in the formalisation of GVC concept (Gereffi et al. 2005), and the availability of consistent OECD-TiVA data. Second, earlier periods lack comprehensive value-added data. Studies using pre-1995 data (e.g., Pahl and Timmer 2020) rely on backward linkages only and require merging datasets with different survey thresholds, introducing additional measurement error. Third, ending at 2018 allows us to avoid contamination from two major external shocks: the US-China trade war 1.0 (2018–2020) and the COVID-19 pandemic, both of which fundamentally disrupted GVC structures and could confound our upgrading analysis. To further address concerns about time dynamics, we conduct robustness checks using both the full sample (1995–2018) and a shorter period (1995–2011), presented in Appendix S1.

3.3.2 | GVC Indicator

To measure GVC participation, this study follows Koopman et al. (2014) and Wang, Wei, Yu, and Zhu (Wang et al. 2017). The authors integrate the literature on vertical specialisation

(Hummels, Ishii, & Yi, Hummels et al. 2001) and the literature on trade in value-added (Johnson and Noguera 2012) to provide a more generalised measure. In this approach, the value-added process is decomposed into two components, namely the backward and forward linkages-based GVC positions. The backward linkage assesses the extent that intermediate goods produced overseas are imported by domestic firms to produce their exports. It represents the buyer-driven GVCs. The forward linkage measures the extent that goods produced by domestic firms are used by foreign companies to manufacture products. It captures the producer side or seller perspective in GVCs. Put differently, the backward component is the share of foreign value-added in gross export and the forward component is the share of domestic value-added in foreign exports. GVC participation (z) is measured as the sum of backward linkages (foreign value-added in exports) and forward linkages (domestic value-added in foreign exports), as shown in Equation (11).

$$z = \frac{DVAX}{\text{Foreign Exports}} + \frac{FVAX}{\text{Domestic Gross Exports}} = z_1 + z_2 \quad (11)$$

where the DVAX is domestic value-added; FVAX is foreign value-added; z_1 is backward GVC participation; z_2 is forward GVC participation. We express this ratio in natural logarithms, with values ranging from 2.833 to 4.383 (Table A2). The raw participation ratios range from 0.17 to 0.80, which we multiply by 100 for percentage, yielding values from 17 to 80. The logarithmic scale facilitates our SPSC estimation and helps normalise the distribution.

Existing studies used the OECD-TiVA (2016) and OECD-TiVA (2018) datasets. The former covers the 1995–2011 period and the latter covers the 2005–2015 period. However, they adopt a different measurement approach, thus making the two periods incomparable. The GVC indicators are obtained from the up-to-date OECD-TiVA (2021) database before Covid-19, which covers 62 countries over the period 1995–2018 and avoids external shocks after 2018.

3.3.3 | Dependent Variable

We measure economic upgrading (y) using value-added per labour in constant 2017 US dollars (Kummriz et al. 2017), which captures comprehensive upgrading through improving skills, capital, and production process. Value-added per labour is collected from the OECD-TiVA (2021) database. Value-added is the combination of firm and worker gains (total profit and compensation), illustrating the improvement of productivity and change in employment. In natural logarithms, our dependent variable ranges from -7.519 to -1.429 . This log-transformation maintains consistency with our production function specification and allows coefficient interpretation as elasticities.

3.3.4 | Other Variables

The remaining variables are taken from the World Development Indicators and Penn World Table 10.0. k (capital) is proxied

by capital stock at constant 2017 national prices (in mil. 2017 US\$); l (labour) comprises over 15-year-old people who are employed or unemployed but seeking work; h (human capital) is proxied by human capital index, based on years of schooling and returns to education (e.g., Barro and Lee 2013; Cohen and Leker 2014). FDI Inflows (share Gross Domestic Product (GDP)) and Trade (share of GDP) are included, in an extended model, to capture possible transmission channels from GVC participation to value added (see for instance, Crescenzi, Harman, & Arnold, Crescenzi et al. 2018; Li et al. 2021; Crescenzi and Harman 2023; Gehl Sampath and Vallejo 2018). Summary statistics of the variables are offered in Table A2. All variables are expressed in logarithms to fit the specification for production function in log terms.

4 | Results and Discussion

4.1 | Preliminary and Baseline Results

Figure 1 presents preliminary evidence of nonlinear relationships between GVC participation and economic upgrading across income groups based on the World Bank's 1995 classification. Several patterns merit attention. First, high-income countries (green dots) show a slight positive relationship, with the United States appearing as an outlier, achieving high upgrading despite moderate GVC participation, likely due to its large domestic market and upstream position in technology-intensive sectors (Frankel and Romer 1999). We exclude the US from subsequent analysis to ensure robust estimates. Second, middle-income countries (red dots) exhibit a pronounced dip in the relationship around GVC participation 3.6–3.7, suggesting potential “upgrading trap” at intermediate participation levels. Third, low-income countries (blue dots) initially show a negative correlation at lower participation levels, turning positive as participation increases, consistent with learning-by-doing and delayed technology spillovers. We also reclassify Türkiye, Estonia, Poland, and the Slovak Republic as middle-income countries, as they transitioned to this category within 1–2 years of our sample start (1995–1997). These preliminary observations motivate our formal nonlinear analysis below.

Before presenting the main results, we first address the diagnostic checks required for the SPSC technique. The validity of kernel methods in semi-parametric estimations depends on non-stationary variables being co-integrated (Wang and Phillips 2009). Panel unit root tests (Im et al. 2003; Choi 2001) and co-integration tests (Pedroni 2004) confirm that all non-stationary variables in our model are co-integrated (detailed results in Tables A3 and A4). We also test for endogeneity by examining the significance of the term $\hat{\eta}(\hat{\psi}_{it}\hat{\sigma}_{it})$. The results indicate that physical capital, labour, and GVC participation are endogenous at the 5% significance level.

To address this, we implement two approaches to instrument for these variables. The first approach involves constructing external instruments, while the second approach uses lags as instruments for robustness. For physical capital and labour, we construct instruments following Swamy and Fikkert (2002). Specifically, we use the lagged age-dependency ratio, defined as the ratio of individuals younger than 15 or older than 64 to

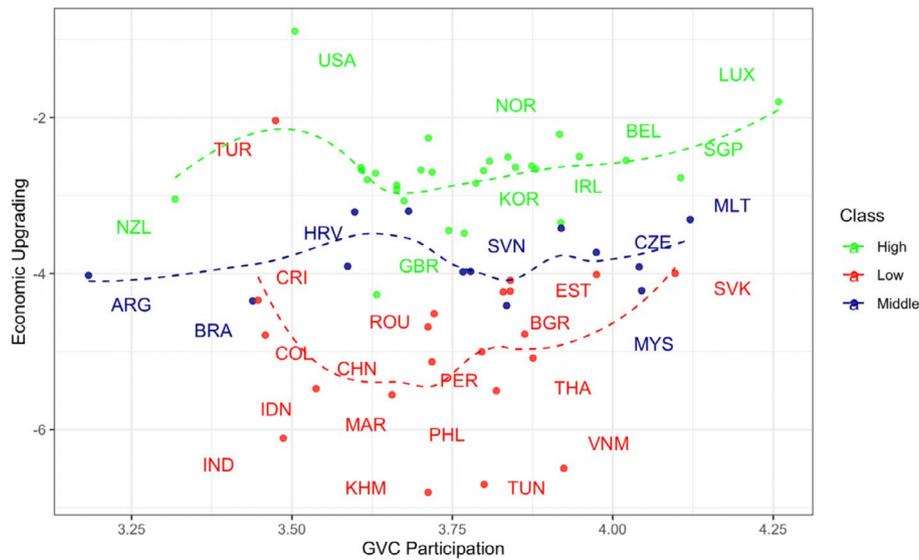


FIGURE 1 | The relationship between upgrading and GVC participation by income group. [Colour figure can be viewed at [wileyonlinelibrary.com](https://onlinelibrary.wiley.com)].

the working population, and the first-order lags of input factors. The rationale for using the age-dependency ratio satisfies exclusive restriction and instrumental correlation. First, dependents typically do not contribute to value-added tasks. Moreover, economic upgrading does not affect past fertility or mortality rates, making the lagged age-dependency ratio a valid instrument. Second, extra dependents (children and elderly people) increase family consumption and reduce saving, which directly affects k (physical capital). Furthermore, a higher age-dependency ratio may mean more young population who will enter to the labour market, therefore influencing l (labour).

For the key variable of interest, GVC participation, the instrument is calculated as the average FVAX originating from the United States, Japan, and Germany, embedded in the exports of three countries with the closest income levels (GDP per capita in 2017 USD) to country i in the sample. It is constructed based on the theory of Baldwin and Lopez-Gonzalez (2015) and on a similar instrument for US imports growth in Chinese goods (Autor, Dorn, & Hanson, Autor et al. 2013). They argued that headquarter economies—USA, Germany, and Japan—are the main exporters of intermediates in GVCs due to technological asymmetry between them and “factory” economies, driving GVC expansion and thereby satisfying the instrumental correlation condition. To avoid potential violations of the exclusion restriction, we define proximity based on development level rather than geography, as upgrading spillover effects are unlikely between economies at similar stages of development (Constantinescu et al. 2019; Raei, Ignatenko, & Mircheva, Raei et al. 2019).

Table 1 presents our baseline parametric and SPSC estimates. All instruments pass the test of IV validity and over-identification. First-stage F-statistics exceed 10 for all endogenous variables. The Chi-squared statistic is 849.777, with a P-value near to 0. Panel A reports two-stage least squares (2SLS) estimates of the

linear model (Equation 1). The coefficient of α_1 shows a positive effect of GVC participation on economic upgrading. The means that, *ceteris paribus*, a 1% increase in GVC participation leads to the value added per labour to increase by 0.449%. Panel B presents the parametric model with interaction terms (Equation 3), which shows that a slightly smaller effect (0.401) of GVC participation on economic upgrading. The interaction with labour ($\frac{\partial \beta_2}{\partial z}$) is statistically significant, suggesting non-neutral effects. However, the bandwidth test (Racine and Li 2004) indicates that this specification is insufficient: the nonlinearity of variable z may need to consider by SPSC model, given that the bandwidth (0.064) of z is less than two times its standard deviation (0.056).

Panel C reports the SPSC baseline model results (Equation 4). The first four coefficients in Panel C show the estimates of the elasticities of the variables included in Equation (4) with respect to value added. The key insight lies in decomposing the GVC effect on economic upgrading into neutral and non-neutral components. The neutral impact, captured by $\frac{\partial \beta_0}{\partial z}$, represents the direct output efficiency effect, while non-neutral effect, $\frac{\partial \beta_j(z)}{\partial z}$, $j = 1(k), 2(l), 3(h)$, capture how GVC participation affects the marginal productivity of input factors. The overall effect of GVC participation is given by $\frac{\partial y}{\partial z}$.

The results reveal substantial heterogeneity across GVC participation levels. The neutral effect $\frac{\partial \beta_0}{\partial z}$ is significantly negative on average (-3.241), suggesting that countries incur output efficiency costs when integrating into global networks initially. Nevertheless, this sacrifice may be indeed worthwhile, because joining the GVCs can have a positive upgrading effect through various channels. The non-neutral effect through labour is significantly positive on average ($\frac{\partial \beta_2}{\partial z} = 0.221$), indicating that GVC participation enhances labour productivity. Effects through physical ($\frac{\partial \beta_1}{\partial z}$) and human capital ($\frac{\partial \beta_3}{\partial z}$) show mixed significance across quartiles, suggesting that the upgrading efficiency of these factors is highly sensitive to the level of GVC participation.

TABLE 1 | Baseline results from SPSC models.

Panel A: 2SLS Estimation of Equation (1)									
	β_1	β_2	β_3	α_1					
	0.676*	-0.277*	0.357	0.449*					
	(0.051)	(0.090)	(0.243)	(0.119)					
Panel B: 2SLS Estimation of Equation (3)									
	$\beta_1(\mathbf{z}, \delta)$	$\beta_2(\mathbf{z}, \gamma)$	$\beta_3(\mathbf{z}, \rho)$	$\partial\beta_1 / \partial\mathbf{z}$	$\partial\beta_2 / \partial\mathbf{z}$	$\partial\beta_3 / \partial\mathbf{z}$	$\partial\mathbf{y} / \partial\mathbf{z}$		
Mean	0.691*	-0.297*	0.439*	0.085	0.096*	0.280	0.401*		
	(0.054)	(0.090)	(0.249)	(0.051)	(0.048)	(0.370)	(0.123)		
Panel C: Three-step Estimation of Equation (4)									
	$\beta_0(\mathbf{z})$	$\beta_1(\mathbf{z})$	$\beta_2(\mathbf{z})$	$\beta_3(\mathbf{z})$	$\partial\beta_0 / \partial\mathbf{z}$	$\partial\beta_1 / \partial\mathbf{z}$	$\partial\beta_2 / \partial\mathbf{z}$	$\partial\beta_3 / \partial\mathbf{z}$	$\partial\mathbf{y} / \partial\mathbf{z}$
Mean	0.074	0.667*	-0.220*	0.081	-3.241*	0.009	0.221*	0.173	0.554*
	(0.264)	(0.015)	(0.017)	(0.105)	(1.557)	(0.075)	(0.085)	(0.657)	(0.133)
25th	-0.082	0.671*	-0.201*	-0.112*	-5.524*	-0.156*	0.128*	-0.700	0.253*
	(0.116)	(0.007)	(0.007)	(0.043)	(1.107)	(0.053)	(0.060)	(0.403)	(0.087)
50th	0.025	0.689*	-0.175*	-0.043	-0.654	-0.026	0.207*	-0.278	0.478*
	(0.153)	(0.008)	(0.009)	(0.057)	(1.166)	(0.055)	(0.064)	(0.514)	(0.090)
75th	0.220	0.695*	-0.145*	0.087	-0.296	0.086	0.365*	0.972	0.862*
	(0.193)	(0.009)	(0.010)	(0.096)	(1.309)	(0.061)	(0.068)	(0.733)	(0.117)

Note: (a) Standard errors are reported in the parentheses. (b) 25th, 50th, and 75th are the different percentile. (c) Alternative coefficients of Equation (3) are reported in Table A5 of Appendix A and intercept is meaningless due to the fixed-effect in 2SLS model. (d) All variables are expressed in logarithms. *Represent 5% significance level.

Most importantly, the overall effect ($\frac{\partial y}{\partial z}$) is significantly positive across all quartiles, ranging from 0.253 at the first quartile to 0.862 at the third quartile, with a mean of 0.554. This substantial variation, a more than three-fold difference between the first and third quartiles, confirms that the GVC-upgrading relationship exhibits fundamental nonlinearity. The upgrading effect of GVC participation is not constant but varies dramatically depending on a country's degree of integration into GVCs. These findings highlight the inadequacy of parametric specifications and motivate a deeper investigation into the mechanisms generating this heterogeneity.

4.2 | Main Results

4.2.1 | An N-Shaped Relationship: From Learning to Trap to Breakthrough

In the next step, we extend the basic model by including FDI and trade as control variables. This is a sensible approach as economies generally participate in GVC through trade (Gehl Sampath and Vallejo 2018) and cross-border investment (Crescenzi et al. 2018; Crescenzi and Harman 2023). There are also two other benefits in proceeding this way. On the one hand, it tests whether our findings are robust to specification changes, and on the other hand, and perhaps more importantly, it allows us to explore upgrading and trade-FDI linkages.

The results, which are summarised by Table 2, show that controlling for trade and FDI does not have an implausible effect on the three input factors estimates. It is also worth noting that, once the trade and FDI channels are controlled for, the overall effect of GVC participation on economic upgrading, $\frac{\partial y}{\partial z}$, is much stronger. In fact, the results indicate that, *ceteris paribus*, every 1% increase in GVC participation is matched by a slightly higher increase in upgrading by 1.256%. This may imply that trade or investment through embedded GVC optimises the economy's allocation and use of factors, which enhances economic upgrading.

To shed light on the nonlinear effects induced by GVC participation, a fruitful exercise would be to examine the variation in the partial derivatives of the GVC participation distribution. Figure 2, constructed based on estimates of specific observations, shows how the partial derivatives vary with GVC participation. The green line represents the 95% confidence region and the black line in the middle depicts the associated partial derivative estimates.

We first characterise the overall effect of GVC participation on upgrading. Figure 2 plots the total derivative ($\frac{\partial y}{\partial z}$) against GVC participation levels, revealing our central finding: the relationship between GVC participation and economic upgrading follows a quasi-N-shaped pattern. The N-shaped relationship exhibits three distinct stages. In the initial stage (GVC Participation

TABLE 2 | Results for extended SPSC models.

Panel A							
	$\beta_0(z)$	$\beta_1(z)$	$\beta_2(z)$	$\beta_3(z)$	$\beta_4(z)$	$\beta_5(z)$	
Mean	0.008	0.624*	-0.553*	0.053	-0.464*	0.021*	
	(0.327)	(0.008)	(0.010)	(0.085)	(0.038)	(0.011)	
Panel B							
	$\partial\beta_0/\partial z$	$\partial\beta_1/\partial z$	$\partial\beta_2/\partial z$	$\partial\beta_3/\partial z$	$\partial\beta_4/\partial z$	$\partial\beta_5/\partial z$	$\partial y/\partial z$
Mean	-5.876*	-0.036	0.275*	1.064*	0.479*	0.041	1.256*
	(2.008)	(0.057)	(0.069)	(0.539)	(0.235)	(0.079)	(0.154)
25th	-5.945*	-0.136*	0.209*	0.119	0.107	-0.014	0.935*
	(1.549)	(0.043)	(0.053)	(0.376)	(0.183)	(0.060)	(0.082)
50th	-4.688*	-0.059	0.218*	0.214	0.349*	0.034	1.071*
	(1.686)	(0.046)	(0.057)	(0.417)	(0.183)	(0.066)	(0.099)
75th	-2.277	0.002	0.228*	1.745*	0.807*	0.083	1.502*
	(1.859)	(0.061)	(0.070)	(0.567)	(0.214)	(0.084)	(0.144)

Note: (a) Standard errors are reported in the parentheses. (b) 25th, 50th, and 75th are the different percentile.
*Represent 5% significance level.

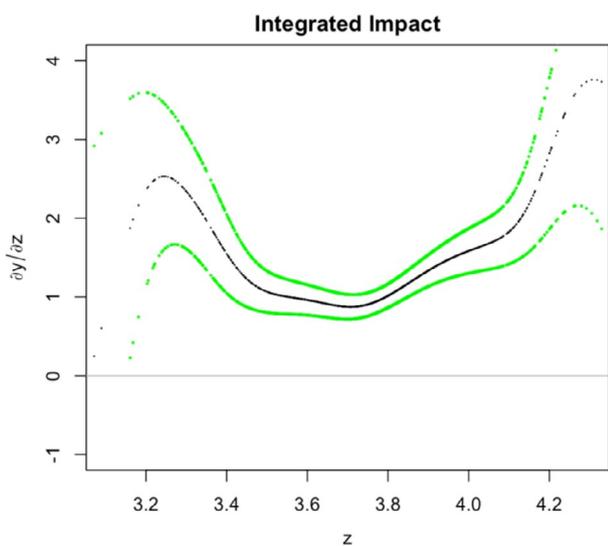


FIGURE 2 | Overall effect of GVC participation on economic upgrading. [Colour figure can be viewed at [wileyonlinelibrary.com](https://onlinelibrary.wiley.com)]

<3.3), the upgrading effect is positive and increasing, reaching a local maximum around 3.3. Countries at this stage benefit from learning-by-doing and technology spillovers as they enter global production networks (Baldwin and Yan 2014). In the intermediate stage ($3.3 < \text{GVC Participation} < 3.7$), the upgrading effect declines significantly, hitting its lowest point around 3.7. This represents an “upgrading trap” where countries struggle to move beyond low value-added tasks despite deeper GVC integration. The improvement may be stagnant because upstream economies are likely to lock the technology to avoid potential competition from the latecomers. This type of GVC governance could be classified as quasi-hierarchy and may hinder functional upgrading temporarily (Humphrey and Schmitz 2002). In the

advanced stage ($\text{GVC Participation} > 3.7$), the upgrading effect rises again and eventually surpasses the initial peak. Countries at this stage successfully break through the trap by strengthening the local industrial policy and domestic capabilities to strengthen competitiveness (Pyke 1992).

This N-shaped pattern represents a novel contribution to the literature. Previous studies have documented either linear relationships (Kummritz 2016; Formai and Vergara Caffarelli 2016; Lopez-Gonzalez 2016) or U-shaped patterns (Taguchi 2014; Lee et al. 2018; Mao 2021; Thakur and Sharma 2025). Our more flexible semiparametric approach reveals a fuller dynamic that better captures the “in-out-in again” cycle theorised by Lee et al. (2018). The complete N-shaped pattern has important policy implications: countries at different stages of GVC participation face qualitatively different upgrading challenges and require stage-appropriate policy interventions.

4.2.2 | Mechanism Decomposition: Input Factors Drive Upgrading

To understand the mechanisms generating this N-shaped pattern, we decompose the overall effect into its constituent transmission channels set by the SPSC model. The mechanism decomposition reveals distinct patterns across different stages of GVC participation. We examine how neutral and non-neutral effects evolve from early to intermediate to advanced participation stages. Figures 3 and 4 show how each mechanism’s marginal effect evolves with GVC participation. One notable improvement of the extended model is the higher degree of precision in the estimates, as its confidence bands are much narrower compared to the baseline model (compare Figure 3 with Figure B1). More importantly, Figure 3 exhibits very similar nonlinear patterns to the baseline model, confirming that our core findings are robust

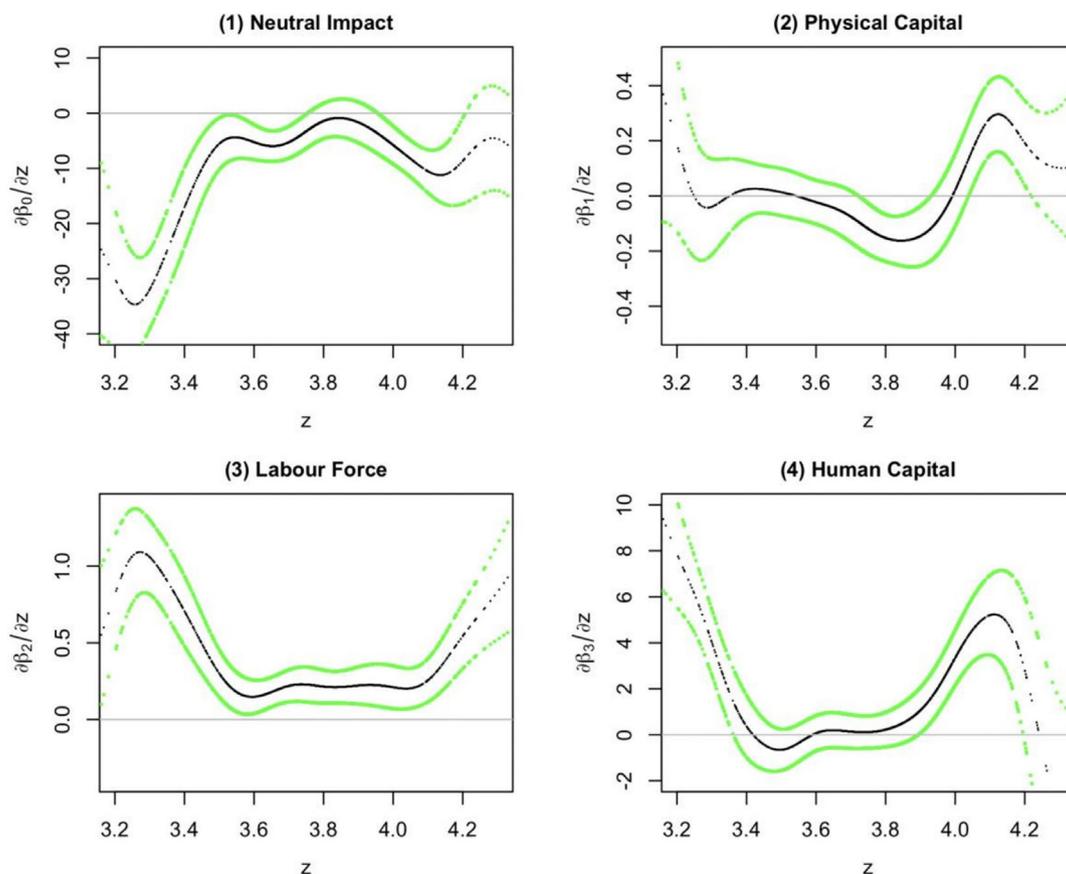


FIGURE 3 | Neutral and non-neutral effects of GVC participation on upgrading (extended mod.). [Colour figure can be viewed at [wileyonlinelibrary.com](https://onlinelibrary.wiley.com)]

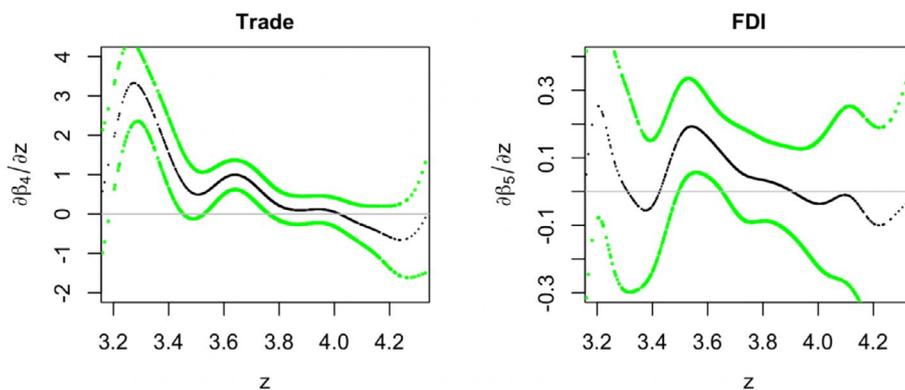


FIGURE 4 | Effects of GVC participation on trade and FDI-upgrading linkage. [Colour figure can be viewed at [wileyonlinelibrary.com](https://onlinelibrary.wiley.com)]

to the inclusion of trade and FDI controls. The extended model also reflects the upgrading blockades at the middle stage of GVC participation identified in the baseline specification.

Starting with the neutral effect (Sub-Figure 3 (1)), we observe that the output efficiency cost of GVC participation is most severe at early stages (GVC participation around 3.2–3.4), then gradually diminishes and approaches zero around intermediate levels (GVC participation around 3.6–3.8), before showing some fluctuation at advanced stages. This pattern suggests that the negative neutral effect is primarily an “entry cost” for countries adapting to global production networks, rather than a persistent burden.

However, the non-neutral effects through input factors reveal a different story. Sub-Figure 3 (2), (3), and (4) reveal distinct dynamic patterns across participation stages. For labour and human capital, the upgrading efficiency is initially positive at early participation levels but gradually declines as participation deepens, approaching zero at intermediate stages (GVC participation around 3.6–3.8). Physical capital shows an even more concerning pattern: it becomes significantly negative around GVC participation 3.8. This fluctuation of non-neutral effects can be explained by the fact that when technology and production processes become advanced and complex, upstream economies, to avoid competition, may restrict the emergence of spillovers and even force latecomers to perform simple tasks (Lee et al. 2018),

making production equipment and both unskilled and skilled labour less relevant for economic upgrading. However, after experiencing this prolonged period of insignificant or even negative effects at intermediate stages, all three input factors become positive and significant again at advanced participation levels (GVC participation > 4.0), indicating that countries successfully reactivate these channels only after achieving deep integration into GVCs. The importance of input factors for achieving sustainable upgrading through GVC participation aligns with Epede and Wang's (2022) theoretical model emphasising the role of resources and preconditions for latecomers.

Additional fruitful results that can be derived from our estimations are the effects of GVC participation trade and FDI-upgrading linkages (see Figure 4 and Table 2). GVC participation significantly increases the upgrading efficiency of trade openness ($\frac{\partial \beta_A}{\partial z} = 0.479$, on average), particularly at early and intermediate stages. One explanation of this positive role of GVC participation could be that trade leads to reallocation of resources (Amador and Cabral 2016). However, the positive effect becomes weaker with the increase in GVC participation. One potential explanation is that the building up of a well-established domestic value chain by latecomers brings high fixed costs of switching suppliers (e.g., Beverelli, Stolzenburg, Koopman, & Neumueller, Beverelli et al. 2019) and encourages intranational trade, thus weakening the significance of international trade (Frankel and Romer 1999).

By contrast, the FDI-upgrading linkage is largely insignificant across all participation stages. This finding resonates with Lectard and Rougier (2018), who demonstrate that while attracting FDI can be a powerful approach to export structure transformation, it is inherently risky and potentially unsustainable. Their analysis reveals that defying comparative advantage through FDI-led industrialisation often results in fragile economic structures that fail to generate lasting upgrading benefits. Our results provide empirical support for this cautionary view. Even as countries deepen their GVC participation, FDI does not emerge as a significant channel for economic upgrading.

4.2.3 | Heterogeneity by GVC Participation Patterns: Forward Versus Backward Linkages

The mechanism analysis above reveals a critical insight: economic upgrading through GVCs is driven primarily by enhancing domestic input efficiencies (labour, physical capital, and human capital) rather than by attracting FDI. Countries should prioritize building internal capabilities over relying on foreign-dominated production (Morgan and Cooke 1998). This insight raises an important question: do forward and backward linkages exhibit different upgrading dynamics?

We report the overall nonlinear relationship between GVC participation and economic upgrading, classified by forward and backward linkages. Overall, Figures 5 and 6 show that both GVC participation patterns exhibit a quasi-N-shaped nonlinear relationship with the overall upgrading effect. At the middle stage, the upgrading effect of both linkages shows negative or insignificant points. Interestingly, the two display subtle but important differences. Figure 5 shows that participation in

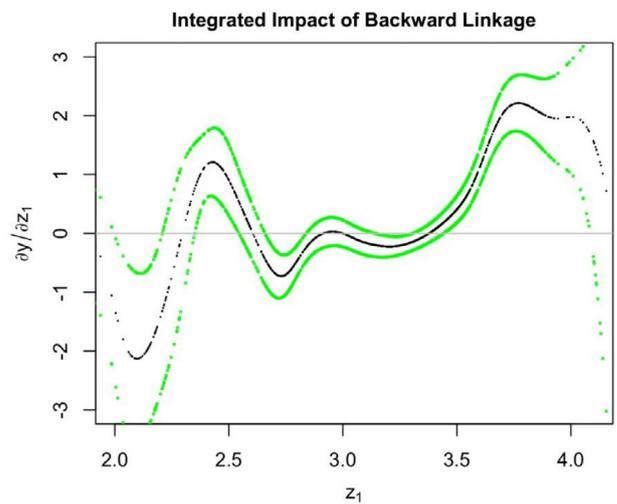


FIGURE 5 | Overall effect of backward participation on economic upgrading. Only report the estimates when $z_1 > 2.0$ because only 42 observations are below the threshold. [Colour figure can be viewed at wileyonlinelibrary.com]

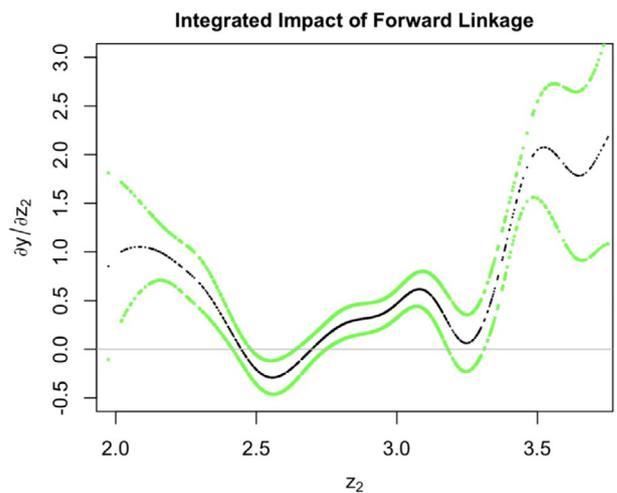


FIGURE 6 | Overall effect of forward participation on economic upgrading. [Colour figure can be viewed at wileyonlinelibrary.com]

GVCs through backward linkages initially has an overall negative impact on economic upgrading. As participation increases, the negative effect decreases and turns positive, reaching a turning point around 2.5 and entering a long-term 'upgrading trap' (z_1 from 2.6 to 3.5). After reaching the peak, it shows a decreasing return to upgrading via backward linkage at high-level participation. However, looking back at Figure 6, the initial overall upgrading effect of forward linkages is positive, and it decreases with increasing participation. After a short period of negative effect on economic upgrading (z_2 from 2.5 to 2.7), it turns into a positive impact with an increasing trend despite some fluctuations.

This means that at intermediate participation levels, economic upgrading can only be achieved through forward GVC participation. This finding aligns with Thakur and Sharma (2025), who show that only forward linkages drive innovation performance in an emerging country. This is relevant because forward linkages measure domestic capabilities (the extent to which

domestically produced goods are used by foreign firms in the production of final goods). Backward linkage, on the other hand, shows the extent to which domestic firms rely on foreign intermediate goods for assembly and production, mainly involving low value-added tasks. This may explain the initial negative effect. Over-reliance on backward linkage may decrease upgrading efficiency. According to the estimated results, on average, the total effect of backward GVC participation is insignificant, but that of forward GVC participation is significantly positive, indicating that strengthening internal capabilities is the key to maximize the upgrading effect of GVC participation.

4.2.4 | Heterogeneity by Income Groups: The Middle-Income Divergence

In this sub-section, we examine whether the upgrading effects of GVC participation vary across countries at different development stages. Given that these countries are at different levels of economic development, one would expect heterogeneous upgrading dynamics led by GVC participation (see Caselli 2005). Because our SPSC model provides observation-specific estimates, we employ the empirical cumulative distribution function (ECDFs) to characterise this heterogeneity. The horizontal axis shows the range, from small to large, of the overall impact of GVC participation on upgrading, while the vertical axis shows the percentile corresponding to each value of the overall impact. A lower ECDF line indicates a larger marginal effect for that group.

Figure 7 shows two key patterns. First, the ECDF of low-income countries is the lowest across most of the distribution, followed by middle-income countries, with high-income countries showing the highest ECDF line. This implies diminishing marginal effects of GVC participation on economic upgrading as countries develop. This is in line with the economic intuition that the closer one gets to the upgrading frontier, the less efficient it is to engage in global production for further improvement (Lee 2013; Rodrik 2013). Second, and more interestingly, when the overall effect exceeds 1, the ECDF for middle-income countries is lower than that for low-income countries. The upgrading effects of GVC participation in

middle-income countries are more likely to be concentrated at higher values. This means that some middle-income countries have demonstrated strong upgrading capabilities through GVC participation, while others remain constrained by lower effects. This high dispersion of upgrading effects in middle-income countries is consistent with the phenomenon of the “middle-income trap”. Some countries successfully escape while others remain stuck.

The ECDF on upgrading mechanisms across income groups shown in Figure 8 provides further insights. Middle-income countries most effectively improve the upgrading efficiency of domestic input factors through GVC participation (particularly labour, physical capital, and human capital). However, their neutral upgrading effects, and the efficiency gains through trade and FDI channels are the weakest among all groups. This pattern suggests that middle-income countries should prioritise domestic capability building, particularly physical and human capital accumulation (e.g., Piperopoulos, Wu, & Wang, Piperopoulos et al. 2018; Fu, Hou, & Liu, Fu et al. 2018; Beverelli et al. 2019; Epede and Wang 2022). This finding aligns with the successful history of the Asian tigers, who emphasised internal Research & Development and human capital development to climb the value-added ladder (Kharas and Kohli 2011).

4.2.5 | Robustness Checking

We subject our results and findings to some robustness checks. First, we re-estimate our main model but this time we only use internal lags as instruments. This way of instrumenting has widely been adopted in the empirical literature (see Li et al. 2021). In the second robustness check, we use an alternative dataset based on OECD-TIVA (2016), which covers the period 1995–2011. The quantitative estimates of our robustness checks are summarised, respectively, in Tables B1 and B2. Additionally, we also report the graphical representation on the effects of GVC participations in both cases (See Figures B2–B7). Starting with Table B1 based on internal lags as instruments, both the overall effects and partial derivatives are generally consistent with the estimates in Table 2. Furthermore, the nonlinear form of the neutral and non-neutral effects, as well as the integrated effect, as depicted by Figures B2–B4, are also consistent with Figures 2–4.

With respect to Table B2, the results of the sub-period 1995–2011 show that the estimates of $\frac{\partial y}{\partial z}$ are slightly smaller than those in Table 2; but the results are broadly in line. Figures B5 and B6 show that the trends in the neutral and non-neutral effects are generally consistent with those in Figures 2 and 3. Finally, Figure B7 exhibits an overall effect similar to the N-shaped curve between GVC participation and economic upgrading, revealing that the nonlinear pattern is robust across different time periods. It is worth noting that the relatively weaker upgrading effects at advanced participation stages in the shorter period (1995–2011) suggest that the later period (2012–2018) captured important breakthrough dynamics and maturation phase as some economies reached these higher participation levels and consolidated their positions, providing additional validation for our sample period choice.

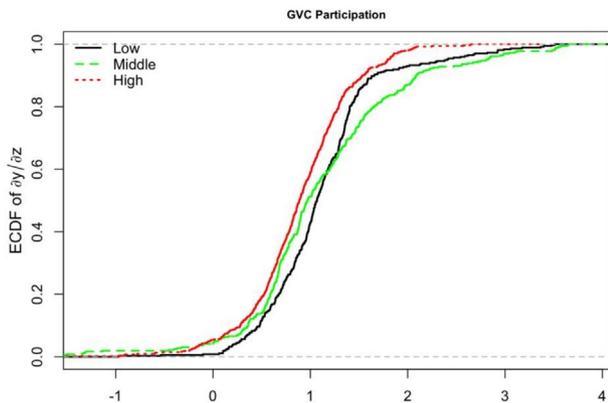


FIGURE 7 | Overall effect of GVC participation on upgrading (income groups). The horizontal coordinate is the range of coefficient value of overall effect from small to large. [Colour figure can be viewed at wileyonlinelibrary.com]

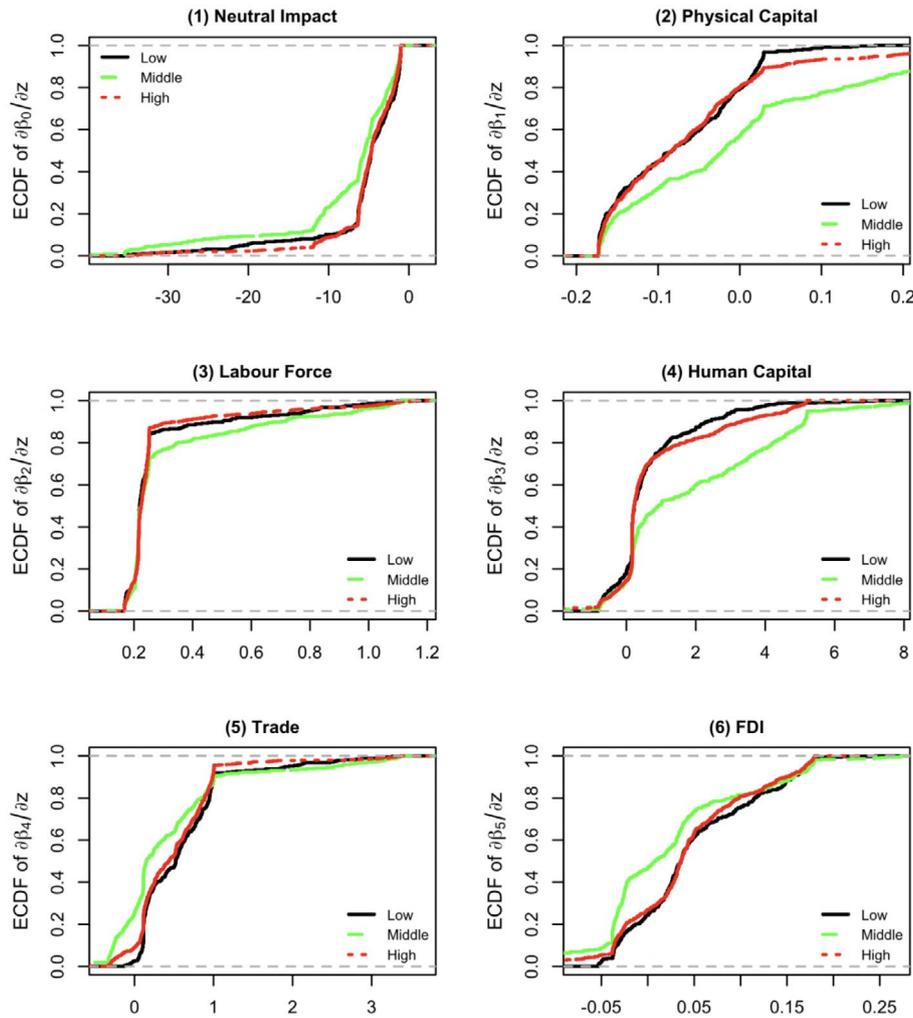


FIGURE 8 | Neutral and non-neutral effect of GVC participation on upgrading (income groups). [Colour figure can be viewed at [wileyonlinelibrary.com](https://onlinelibrary.com)]

5 | Conclusion

Existing studies have begun to doubt the positive effect of GVC participation on economic upgrading, but have failed to comprehensively capture the dynamics of the GVC-upgrading relationship in response to this skepticism. This paper provides new nonlinear evidence by treating GVC participation as an environmental variable that influences the intercept and factor slopes in the production function. Our analysis reveals an N-shaped nonlinear effect of GVC participation on economic upgrading, showing the process from learning-by-doing to upgrading trap to higher value-added stage. Backward and forward GVC participation show a similar pattern, but only forward linkage can enhance economic upgrading at the middle stage of participation. These findings represent a novel contribution that empirically complements the relationship that U-shaped specifications fail to show and supports the theoretical discussion on the low value-added trap. Decomposing this relationship into transmission mechanisms, we find that GVC participation has an overall positive effect on economic upgrading, while the neutral effect is significantly negative. This suggests that GVC participation primarily enhances upgrading through non-neutral effects, improving the efficiency of physical and human capital, labour, and trade, rather than through output efficiency.

Moreover, splitting our sample by low-, middle-, and high-income groups reveals that on average, the marginal effect of GVC participation exhibits a diminishing pattern as countries develop, with effects largest for low-income countries, followed by middle-income, then high-income groups. This pattern reflects that countries closer to the frontier gain less from GVC participation, consistent with catch-up growth theory. However, middle-income countries exhibit the highest dispersion in overall upgrading outcomes, consistent with the “middle-income trap” phenomenon, where some countries successfully leverage GVC participation for upgrading while others remain stuck. Examining the mechanisms underlying this heterogeneity reveals that middle-income countries’ upgrading efficiency of input factors is the most affected by GVC participation, but the efficiency of internationalisation activities is the least affected. These results underscore the importance of strengthening internal capacities for economic upgrading, particularly in transition economies.

These findings provide meaningful insights for both economists and policymakers. While augmented growth models often emphasise the benefits of globalisation, few studies have distinguished between neutral and non-neutral effects using flexible functional forms to capture nonlinear relationships. This study provides robust evidence for GVC participation as a new mode

of globalisation and responds to doubts about the positive upgrading effect via GVC participation. Our findings reinforce the value of integrating into GVCs. Countries, particularly middle-income countries, should prioritise forward linkage participation and improve physical and human capital and labour force to build well-established domestic value chains and break potential upgrading traps. Additionally, trade openness should be encouraged. However, countries need to be cautious about participating in GVC by attracting foreign capital as this could constrain their upgrading potential through GVC governance.

This study provides general insights into the nonlinear dynamics of GVC participation and economic upgrading using a flexible SPSC approach. Our identification of the N-shaped relationship and upgrading traps offers a framework for future research in several directions. First, future studies could examine how this relationship evolves under different external conditions. The latest TiVA (2025) edition extends coverage only through 2022, encompassing identification challenges from the US-China trade war and COVID-19 pandemic. Future datasets extending through 2026 or beyond would enable cleaner identification of how post-pandemic geopolitical fragmentation affects upgrading dynamics, providing timely policy insights. Second, incorporating domestic institutional factors such as intellectual property protection, labor regulations, or industrial policies could reveal how specific institutional contexts moderate GVC upgrading effects. Third, industry-specific analyses could identify which sectors are most vulnerable to upgrading traps and inform targeted interventions. Finally, exploring regional value chains may provide alternative pathways for countries seeking to escape upgrading traps in an increasingly uncertain trade environment.

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The author has nothing to report.

Conflicts of Interest

The author declares no conflicts of interest.

Data Availability Statement

The data that support the findings of this study are available from the corresponding author upon reasonable request.

Endnotes

¹ It can be depicted as $y_{it} = \alpha_0 + \alpha_1 z_{it} + \delta_0 k_{it} + \delta_1 k_{it} * z_{it} + \gamma_0 l_{it} + \gamma_1 l_{it} * z_{it} + \rho_0 h_{it} + \rho_1 h_{it} * z_{it} + \mu_i + \mu_t + \varepsilon_{it}$, where $\beta_0(z_{it}; \alpha) = \alpha_0 + \alpha_1 z_{it}$; $\beta_1(z_{it}; \delta) = \delta_0 + \delta_1 z_{it}$; $\beta_2(z_{it}; \gamma) = \gamma_0 + \gamma_1 z_{it}$; $\beta_3(z_{it}; \rho) = \rho_0 + \rho_1 z_{it}$.

² In the other methods, only GVC participation would have been endogenous. In other words, these methods consider factor inputs as exogenous.

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Supporting Information

Additional supporting information can be found online in the Supporting Information section. **Data S1:** twec70061-sup-0001-Appendix.pdf.