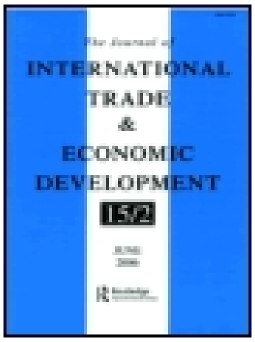

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Does GVC participation help industrial upgrading in developing countries? New evidence from panel data analysis

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ABSTRACT

This paper assesses the impact of manufacturing global value chain (GVC) participation on industrial upgrading in developing countries. After constructing a novel manufacturing GVC dataset for 37 countries from 2001 to 2017, we apply panel fixed-effect estimation to evaluate whether value chain integration could lead to industrial upgrading. Our findings show that increasing participation in manufacturing GVC has led to structural change in the industrial sector. In the baseline model, we find a percentage rise in manufacturing GVC corresponds to 0.35–0.43% increase in the share of high-tech sector. Further analysis reveals that the upgrading channel is primarily derived from forward linkages, while backward linkages contribute in diminishing low-tech manufacturing activities. Our findings are robust under alternative estimation techniques. This linear transformation confirms earlier studies and thus highlights the critical role of GVC in promoting industrial upgrading in developing countries.

KEYWORDS Global value chain; industrial upgrading; developing countries; panel fixed-effects

JEL CLASSIFICATIONS F14, O14, O33, C33

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1. Introduction

According to economic literature, participation in global value chains (GVC) is expected to create more jobs and raise incomes, owing primarily to productivity gains. Most studies claim that by participating in GVC, businesses can gain access to new international markets, specialize in core tasks, gain access to higher quality and sophisticated inputs, and learn from new ideas, technology transfer, and spillover to boost productivity growth and expand the export scale (Collier and Venables 2007; Criscuolo and Timmis 2017; Pahl and Timmer 2020). At the macro level, the World Bank's report (2020) highlights strong economic development and poverty reduction in developed and

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developing countries, which is fueled by technical innovation and diffusion via global production-sharing activities.[1]

Despite plentiful evidence on the importance of GVC participation to increase productivity, little is known, however, whether integration into GVC has any significant effect on industrial upgrading. In this paper, industrial upgrading refers to the classification of Lall (2000), where industrial products are clustered based on their technological level. Higher technology products require a higher technological qualification; therefore, a shift from a low-technology industry to the high-technology one signifies industrial upgrading. This linear sophistication approach to define industrial upgrading has also been applied by Lall, Weiss, and Zhang (2006) and Sturgeon and Gereffi (2012).

Furthermore, the exceptional speed with which the GVC phenomena has spread raises concerns about the diverse repercussions of GVC participation. Kummritz (2015) demonstrates that GVC participation has different effects for low and high-income countries, with the latter gaining more. This argument is depicted in Figure 1 that shows the diverging path of manufacturing GVC participation between developing and developed countries. GVC appears to be particularly disadvantageous to countries with limited capabilities (Fagerberg, Lundvall, and Srholec 2018). Many developing countries have historically established manufacturing activity in GVC through foreign direct investment (FDI), with foreign corporations relocating or opening plants in their countries for basic assembly or component production. Foreign corporations can help to develop competitive domestic industries, but they can also stifle innovation by failing to establish backward and forward links within the national economy and neglecting to transfer technology to local firms (Paus 2014; Paus and Gallagher 2008). In this regard, the main question would be whether developing countries experience industrial upgrading with active participation in GVC.

The purpose of this paper is mainly to answer the question mentioned above. Specifically, this paper empirically investigates the extent of participation in GVC helps developing countries upgrade their manufacturing industries. Furthermore, the present

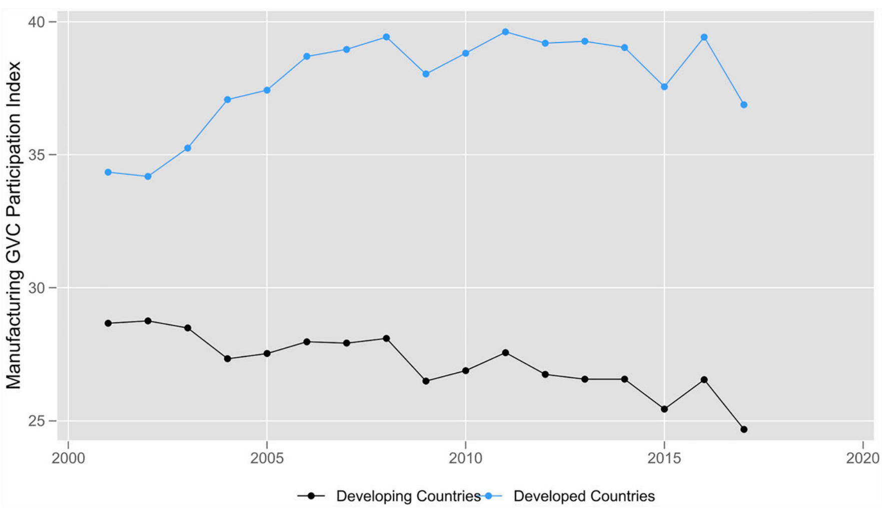

Figure 1. Manufacturing GVC Participation Index 2001–2017 Source: UNCTAD-Eora GVC Database.

study examines the channels of industrial upgrading, if any, by decomposing the GVC integration into forward and backward participation. To achieve the goals, we first build a novel dataset of GVC in the manufacturing industry for 37 developing countries from 2001 to 2017. In terms of method, we apply panel data analysis with fixed effect and further conduct robustness check by implementing a dynamic panel model.

To summarize our findings, the result from the main analysis shows that GVC participation boosts high-tech manufacturing value-added while lessening the share of low-tech manufacturing businesses. In the extended analysis, we further decompose GVC into forward and backward participation to disentangle the channels in which GVC participation facilitates industrial upgrading. Our results show that forward participation significantly improves the performance of high-tech industries. On the other hand, backward participation is linked to the decline of the low-tech manufacturing industries. To our knowledge, this paper provides the first empirical evidence on the relationship between participation in GVC and the process of industrial upgrading with the main focus in developing countries. Thus, the paper contributes to the rapidly growing literature investigating the benefits of GVC participation.

The rest of this paper is organized as follows. Section 2 presents the theoretical background linking GVC participation and industrial upgrading. Section 3 describes the model specification and data sources used in the empirical analysis. Section 4 presents and discusses the results, and finally, Section 5 concludes the paper with remarks.

2. Literature review

Various scholars have acknowledged that GVC participation positively impacts industrial upgrading. Gereffi (1999) can be regarded as one of the pioneering scholars that review the impact of GVC on industrial upgrading. The author calls this a commodity chain (see also Gereffi and Korzeniewicz 1994), which is now widely known as GVC. In a nutshell, GVC-induced industrial upgrading represents an upscaling in the production process over time; for example, from a simple assembling to a very complex fabricating with extensive international production networks. Industrial upgrading also means strengthening the institutions of a company to be more involved in international trade networks. In a more specific context, industrial upgrading is also related to production activities in both forward and backward relationships. Forward relationships are usually associated with the marketing process, which includes an analysis of buyers of their products in a commodity network. The backward relationship is more related to technology and knowledge to produce goods that can be exported.

Generally, empirical studies on GVC are primarily concerned with its effects on productivity vis-à-vis industrial upgrading. There are at least two reasons why the analyses of the impact of GVC on productivity are plentiful. First, the availability of adequate data can trigger much literature that directly analyzes the relationship between GVC and productivity. Second, the outcomes of such an analysis are more likely to result in actual policy implications to enhance productivity in a country immediately. However, existing literature – at least the recent ones – do not provide sufficient evidence and policy implications specific for developing countries. To mention a few, Yanikkaya, Altun, and Tat (2021) examine the GVC participation's impact on productivity in 40 developed and developing countries during the period 1996–2009. They find that GVC forward participation helps raise total factor productivity in the manufacturing industry but does not affect total factor productivity in the service sector. Although they can analyze the impact of GVC by sector, they do not consider the economic structure differences between developed and developing countries. With that being said, the results could potentially be misleading if one would draw policy advice for developing countries. Analyzing the impact of GVC on productivity growth, Pahl and Timmer (2020) also find similar results; participating in GVC has positive effects on productivity growth in the manufacturing industry sector. Again, the weakness of their paper is that they use datasets in a mixture of developed and developing countries and long-term periods (1970–2008). Although they perform heterogeneity analysis with an estimation model for all countries and separate the analysis only for developing countries, in their model, they do not apply control variables that are necessary for developing countries. As a result, their findings may not be exact in understanding how GVC affects productivity in developing countries.

Unlike clear evidence from studies of GVC effects on productivity, empirical investigation demonstrates that the impact of GVC on industrial upgrading is still not as evident as outlined in theory. The conclusion of Mehta (2021) is probably one of the most recent empirical data on the association between GVC and industry upgrading. His study is unique in that it covers the stages of productivity gain through many participation channels; backward and forward linkages. Backward GVC participation constitutes the majority of developing countries' early stages of industrial advancement. Later on, this will be supplemented by a growing share of forward GVC linkage, which will boost production capacity. His work focuses on upgrading in the context of productivity, as well as confining the scope to the electronic industry. While we agree with the strategy, we believe that clustering industrial activities according to their technological level is just as important for a better understanding of industrial upgrading.

Based on the shortcomings in the previous empirical, this study attempts to close the gap in the literature with studies that are more targeted at analyzing the impact of GVC on industrial upgrading more accurately. There are at least two reasons for this. First, our study focuses on cases in developing countries over a more recent period and presents a control variable corresponding to cases in developing countries. This will increase the accuracy of the estimation results and not be biased in concluding the discussion for policymaking. Second, no less important, this study examines the impact of GVC with more emphasis on shifting the structure of the manufacturing industry. This would be more appropriate to describe the relationship between GVC and industrial upgrading.

3. Materials and method

This section elaborates on our primary data and how we put them into empirical testing. First, we describe GVC and industrial data used in this paper. A balanced panel dataset of 37 developing countries for 2001–2017 period is collected.[2] A novel data imputation method is applied to balance our industrial data.[3] This is then followed by an elaboration of our estimation strategy using two-way fixed-effects estimation, complemented with a dynamic panel data estimation, i.e. Difference and System GMM as robustness checks.

3.1. Manufacturing GVC data

Multi-region input-output (MRIO) trade data is used to calculate GVC trade participation. The data is available from the UNCTAD-Eora Global Value Chain project.

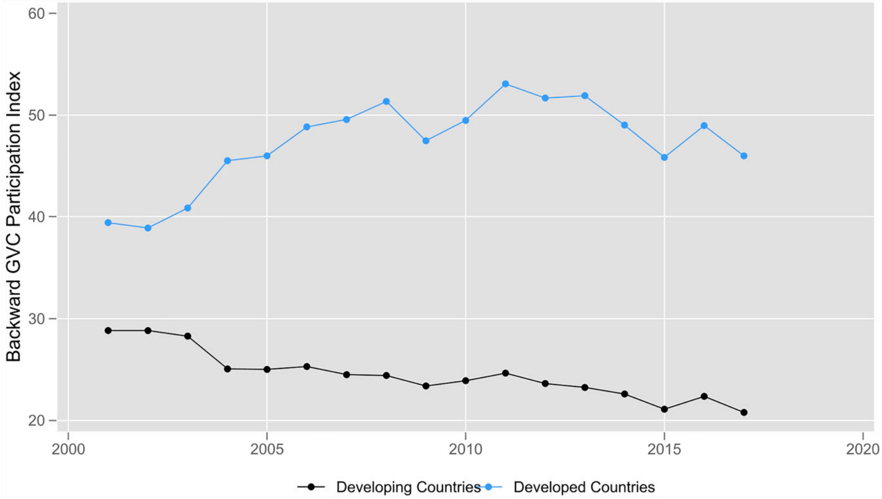

Figure 2. Backward GVC Index 2001–2017.

Equation (1) shows the basic formula to calculate the general GVC index where it decomposes into domestic value-added used in other countries export (DVX) and foreign value added (FVA), which is the export component of imported intermediate inputs.

$$\mathrm{GVCindex}_{it} = \frac{\mathrm{DVX}_{it} + \mathrm{FVA}_{it}}{\mathrm{GrossExport}_{it}} \tag{1}$$

In order to construct our manufacturing GVC data, first, we cluster the MRIO data into 26 sub-sectors covering the years 2001–2017, the latest available data. The manufacturing sub-sectors are mainly; food and beverages, textile and garment, woods, paper, basic metal, chemical and pharmaceutical, furniture, and recycling activities. These correspond to the ISIC divisions 10–45. We thus take the percentage value of these manufacturing sub-sectors against the gross exports of each country (see equation [2]). The mean value of manufacturing GVC per country is available in Table A of the Appendix.

$$\mathrm{ManufacturingGVCindex}_{it} = \frac{\mathrm{ManifacturingDVX}_{it} + \mathrm{ManufacturingFVA}_{it}}{\mathrm{GrossExport}_{it}} \tag{2}$$

Following Aslam, Novta, and Rodrigues-Bastos (2017); Koopman, Wang, and Wei (2014); Ndubuisi and Owusu (2021), we further calculate the forward and backward participation index by separating the manufacturing DVX_{it} and manufacturing FVA_{it} into standalone calculations against Gross Export_{it}.[4] Figure 2 illustrates the backward GVC index of 37 developing and 35 developed countries from 2001 to 2017, while Figure 3 shows forward GVC participation of the same countries for the same period. We can see from the figures that developing countries are less integrated into backward GVC while they are more integrated in forward GVC, all within the manufacturing sector. This is in contrast with the trend in developed countries, where they show more extensive backward participation and minor forward participation. Summary statistics of manufacturing GVC variables are presented in Table 1.

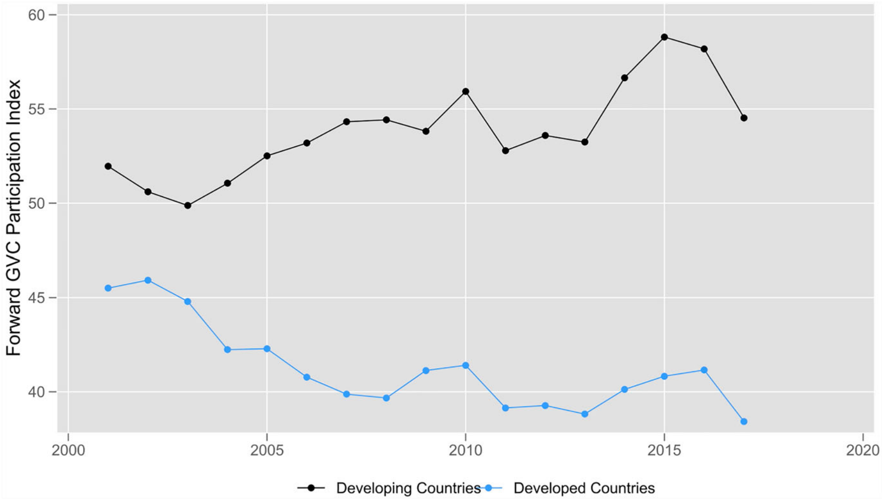

Figure 3. Forward GVC Index 2001–2017.

Table 1. Summary statistics.

Variable	Definition	Mean	Std.dev.	Min.	Max.
Dependent variables					
Low-tech. Manufacturing	Share of total value-added manufacturing	45.14	17.08	13.09	96.34
Med-tech. Manufacturing	Share of total value-added manufacturing	49.16	16.39	3.39	85.03
Hi-tech. Manufacturing	Share of total value-added manufacturing	5.70	7.82	−0.19	55.03
Main independent variables					
Manufacturing GVC	Share of gross export	27.26	11.40	5.59	62.97
Backward man. GVC	Share of gross export	24.64	16.99	1.06	105.38
Forward man. GVC	Share of gross export	9.39	4.51	2.18	20.65
Control variables					
Trade Openness	Share of GDP	81.66	37.03	22.11	210.37
FDI Share	Share of GDP	4.15	4.67	−37.15	43.91
Inflation	Annual growth	6.39	6.33	−9.73	52.98
Log per Capita GDP	Constant 2010 USD	8.38	0.73	6.52	9.39
Urban Population	Share of total population	58.39	16.20	20.24	90.75
Population Growth	Annual growth	0.90	1.11	−3.85	5.43

Source: UNIDO, UNCTAD-EORA, WDI.

3.2. Industrial and control variables data source

Our main industrial data source is derived from UNIDO industrial statistics. We use manufacturing value-added as our primary focus of study. The data is structured based on its technological level content following ISIC Rev. 3 definition of technology intensity level (see Figure 4), similar to the classification of Lall (2000). We utilize the value-added approach in building our industrial data and cluster them into three levels; (1) low technology manufacturing, (2) medium technology manufacturing, and (3) high technology manufacturing. We then calculate the share of each cluster with the total value of 100% for each country.

Table 1 provides the summary statistics of our data. In general, the medium technological content of manufacturing value-added dominates the industrial structure of developing countries at a little over 49%. This is followed by the low-tech. content at

High-technology industries

- Aircraft and spacecraft
- Pharmaceuticals
- Office, accounting and computing machinery
- Radio, TV and communciations equipment
- Medical, precision and optical instruments

Medium-high-technology industries

- Electrical machinery and apparatus, n.e.c.
- Motor vehicles, trailers and semi-trailers
- Chemicals excluding pharmaceuticals
- Railroad equipment and transport equipment, n.e.c.
- Machinery and equipment, n.e.c.

Medium-low-technology industries

- Building and repairing of ships and boats
- Rubber and plastics products
- Coke, refined petroleum products and nuclear fuel
- Other non-metallic mineral products
- Basic metals and fabricated metal products

Low-technology industries

- Manufacturing, n.e.c.; Recycling
- Wood, pulp, paper, paper products, printing and publishing
- Food products, beverages and tobacco
- Textiles, textile products, leather and footwear

Figure 4. ISIC Rev. 3 Technology intensity definition. Source: OECD.

around 45%. Lastly, the high tech. content takes the lowest share of the manufacturing value-added. Its mean share stands at 5.70%.

The rest indicators in Table 1 serve as the control variables in our estimation. The data are classified as economic and demographic data. These are the necessary data to explain industrial growth and structural change. Our economic-related data are (1) trade openness, (2) FDI share to GDP, (3) annual inflation rate, (4) log per capita GDP. Meanwhile, our demographic control data consisted of (5) urban population share and (6) annual population growth.

3.3. Estimation strategy

Our preferred estimation equation is as follows:

$$y_{it} = a_{it} + \beta_1 mGVC_{it} + \beta_2 X_{it} + \gamma_i + \mu_t + \varepsilon_{it} \tag{3}$$

where y represents sub-sectoral output share of country i in the year t in the industry sector classified based on its technological level (low-tech. manufacturing, medium-tech. manufacturing, and hi-tech. manufacturing). The total value of all three sectors is 100. $mGVC$ is the main interest variable, manufacturing GVC participation of country i in the year t, which is an index from 0 to 100 with higher value indicates higher participation. β_1 is the interest coefficient of the estimate that signify the effects of manufacturing GVC participation on each level of the industrial sector. X represents time-varying control variables necessary to explain the industrial and structural change. To control for unobserved heterogeneity that may affect our main results, we apply country fixed-effects γ_i and year fixed-effects μ_t to purge the error term from being correlated with the interest variables. We further tested the consistency of our year fixed-effects by employing time-trend and regional time trend in the subsequent specifications. Lastly, ε is the error term assumed to be uncorrelated with the β estimates.

As we believe that countries' participation in GVC is not randomly assigned but subject to each country's trade policy, we carry out equation (1) using fixed-effects ordinary least square. To check for the robustness of our estimation results, we apply difference (Arellano and Bond 1991) and system GMM (Arellano and Bover 1995; Blundell and Bond 1998), which offers more efficient estimation (Roodman 2009). We thus alternate our equation (1) into the dynamic model under difference GMM (equation [4]) and system GMM (equation [5]), respectively:

$$\Delta y_{it} = \beta_0 \Delta y_{it-1} + \beta_1 \Delta mGVC_{it} + \beta_2 \Delta X_{it} + \Delta \varepsilon_{it} \quad (4)$$

$$y_{it} = a_{it} + \beta_0 y_{it-1} + \beta_1 mGVC_{it} + \beta_2 X_{it} + \gamma_i + \mu_t + \varepsilon_{it} \quad (5)$$

To verify the validity of our GMM specifications, we enclose the AR-1 and AR-2 autocorrelation test as well as Hansen J-test for instrument proliferation. All results from equations (3)–(5) are reported under robust standard errors following Abadie et al. (2017).

4. Empirical results and discussion

4.1. The impacts of GVC across technology intensity levels

Table 2 presents our baseline finding on the impact of manufacturing GVC on industrial value-added. Across all specifications, we applied robust standard error to control for autocorrelation. Columns (1)–(3) show the coefficient results for low-tech. manufacturing. There we can observe negative tendencies despite no significance for result in column (1), where country and year fixed effects are applied. This could suggest that GVC participation has a long-term effect of reducing low-tech. activities in developing countries.

We test the robustness of our initial result in Table 2 by applying the control variables. Results are presented in Table 3. Upon including these variables, the coefficients are now becoming significant for the group of low-tech. manufacturing (columns 1 through 3). GVC participation has a negative impact at around −0.27 and −0.36. On the second part of the regression of medium-tech. manufacturing, results still show no significance.

We can see results for the medium-tech on the second estimation set for the column (4) through (6). Out of the three models, none of them show any significance. Meanwhile, on the last set of estimation for the hi-tech. manufacturing, in columns (7) through (9), results show a significantly positive impact of GVC. Our initial model (column 7) suggests that a marginal increase of GVC participation would result in 0.43% increase on hi-tech. manufacturing share. Lastly, for the high-tech. activities on columns (7) through (9), we find a robust result with our initial finding that GVC participation is positively correlated with the increasing value-added share of that sector. To support our finding, in Figure A of the Appendix, we demonstrate the relationship between GVC participation with the share of low, medium, and high-tech manufacturing. According to the plots, GVC participation appears to have a negative link with low-tech manufacturing, a positive relationship with high-tech manufacturing, and no obvious relationship with medium-tech manufacturing.

4.2. Backward and forward participation

Despite the consistent results that show linear transformation effect of GVC participation, it is of this research's interest to explore the findings further. First, we test the impact of backward GVC participation in the manufacturing sector. Secondly, we also look at the other side of it which is forward participation. As shown earlier, the backward and forward linkages have different dynamics for developing countries. Thus, one should

Table 2. Baseline results.

	Low-tech. manufacturing			Med-tech. manufacturing			Hi-tech. manufacturing		
Variables	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Manufacturing GVC	−0.310	−0.512***	−0.457***	−0.117	0.159	0.081	0.427*	0.353*	0.375*
	(0.202)	(0.144)	(0.134)	(0.237)	(0.225)	(0.240)	(0.222)	(0.194)	(0.200)
Constant	57.695***	477.065*	493.647*	47.290***	−366.306	−402.244	−4.986	−10.760	8.597
	(4.994)	(258.168)	(247.349)	(5.913)	(266.170)	(241.291)	(6.055)	(133.680)	(120.909)
Country Fixed-Effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year Fixed-Effects	Yes	No	No	Yes	No	No	Yes	No	No
Time Trend	No	Yes	No	No	Yes	No	No	Yes	No
Reg. FE x Time Trend	No	No	Yes	No	No	Yes	No	No	Yes
Observations	537	537	537	537	537	537	537	537	537
Number of countries	37	37	37	37	37	37	37	37	37
R-sq.	0.117	0.073	0.107	0.086	0.027	0.082	0.058	0.027	0.041
F-statistics	6.312***	13.601***	.	10.079***	2.066	.	3.125***	2.506*	.

Notes: Manufacturing GVC comprises of foreign value added (FVA) components of import and domestic value added used in other countries' export within ISIC division 10-33. Low-tech. manufacturing corresponds to ISIC division 10-18, med-tech. manufacturing to ISIC division 19, 20, 22-25, 28-33, while hi-tech. manufacturing refers to ISIC division 21, 26, 27, 30 (aircraft and spacecraft). Robust standard errors are in parentheses, *0.1 **0.05 ***0.01.

Table 3. Main estimation results.

	Low-tech. manufacturing			Med-tech. manufacturing			Hi-tech. manufacturing		
Variables	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Manufacturing GVC	−0.269*	−0.364***	−0.314**	−0.102	0.038	−0.030	0.372**	0.326*	0.344*
	(0.147)	(0.132)	(0.141)	(0.256)	(0.245)	(0.264)	(0.179)	(0.168)	(0.170)
Trade (% of GDP)	0.012	−0.009	−0.021	−0.036	−0.011	0.002	0.023	0.020	0.018
	(0.045)	(0.042)	(0.049)	(0.052)	(0.047)	(0.051)	(0.024)	(0.021)	(0.026)
FDI (% of GDP)	0.035	−0.011	−0.016	−0.023	0.043	0.064	−0.013	−0.032	−0.048
	(0.080)	(0.065)	(0.070)	(0.085)	(0.064)	(0.064)	(0.022)	(0.030)	(0.034)
Inflation (Annual %)	0.071	0.037	0.041	−0.005	0.042	0.060	−0.066*	−0.080*	−0.101**
	(0.058)	(0.051)	(0.054)	(0.065)	(0.068)	(0.064)	(0.036)	(0.040)	(0.045)
Per capita GDP	−35.715	−24.850	2.912	4.492	−10.099	−50.985	31.223	34.950	48.072**
	(40.838)	(38.333)	(46.517)	(45.977)	(43.322)	(45.234)	(20.425)	(20.871)	(19.970)
Per capita GDP^2	1.330	0.563	−1.149	0.634	1.681	4.026	−1.964	−2.244*	−2.876**
	(2.436)	(2.276)	(2.800)	(2.717)	(2.555)	(2.657)	(1.209)	(1.252)	(1.236)
Urban population (% of Total)	0.249	0.233	0.340	−0.368	−0.360	−0.547*	0.120	0.127	0.207
	(0.223)	(0.226)	(0.238)	(0.315)	(0.315)	(0.286)	(0.174)	(0.175)	(0.185)
Pop. growth (Annual %)	−2.743**	−2.766**	−2.675**	1.456	1.439	1.026	1.287	1.327	1.649
	(1.305)	(1.226)	(1.318)	(1.489)	(1.384)	(1.418)	(1.226)	(1.224)	(1.233)
Constant	244.605	−263.688	−330.601	−9.271	467.631	318.301	−135.334	−103.943	112.300
	(171.525)	(524.346)	(533.730)	(191.301)	(616.270)	(624.816)	(86.814)	(220.010)	(207.546)
Country Fixed-Effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year Fixed-Effects	Yes	No	No	Yes	No	No	Yes	No	No
Time Trend	No	Yes	No	No	Yes	No	No	Yes	No
Reg. FE x Time Trend	No	No	Yes	No	No	Yes	No	No	Yes
Observations	537	537	537	537	537	537	537	537	537
Number of countries	37	37	37	37	37	37	37	37	37
Adj. R-squared	0.197	0.167	0.191	0.131	0.091	0.141	0.088	0.062	0.092
F-statistics	11.305***	5.905***	.	12.464***	1.629	.	8.522***	1.155	.

Notes: Manufacturing GVC comprises of foreign value added (FVA) components of import and domestic value added used in other countries' export within ISIC division 10-33. Low-tech. manufacturing corresponds to ISIC division 10-18, med-tech. manufacturing to ISIC division 19, 20, 22–25, 28–33, while hi-tech. manufacturing refers to ISIC division 21, 26, 27, and 30 (aircraft and spacecraft). Robust standard errors are in parentheses, * 0.1 ** 0.05 *** 0.01

look more profound in this area to fully understand the impact of GVC. For all estimation reports in the following tables, we apply the complete control variables and robust standard errors.

The result of backward participation is shown in Table 4. Across the three sectors, we can see that there are significantly negative results for the low-tech. manufacturing (columns 1 through 3). Positive results are also shown for the medium-tech sector. However, they are only significant in columns (5) and (6). Furthermore, we fail to find any significant results for the high-tech. manufacturing sector. This table suggests that backward GVC participation drives industrial change by decreasing low-tech. activities.

Table 5 presents our estimation results for the forward participation. Here we do not find statistically significant results for the low and medium-tech. sectors, unlike the previous result. Meanwhile, we find positive results for the hi-tech. sector (columns 7 through 8). Our initial specification suggests that a percentage increase in GVC participation would yield to 0.56% higher share of hi-tech. value-added activities.

4.3. Robustness test

Table 6 presents our robustness check for the results shown in Table 3 using difference and system GMM. In the low-tech. industry sector, we confirm our previous results in the first and second columns, while the third one with Two-Step System GMM fails to show significance. The models passed the autocorrelation test at the second-order (AR-2) while also sufficing the Hansen J-test, suggesting no overidentifying restriction in the specifications. For the second group, we also do not find a significant result to confirm whether medium-tech. sector takes benefit or is disadvantaged due to the increasing manufacturing GVC participation.

Lastly, the third group shows that the positive linkage from the previous result is confirmed under alternative estimation methods. This also suffices the post-estimation routines, the AR test and Hansen J-test.

5. Discussion

We present our findings based on empirical investigation for the context of developing countries. It supports the linear perspective offered by Gereffi (1999) and others (Collier and Venables 2007; Criscuolo and Timmis 2017) that increasing GVC participation would lead to a higher level of industrial sophistication. As the latter concept is closely related to productivity, thus our findings also align with the scholarly works of Yanikkaya, Altun, and Tat (2021) and Pahl and Timmer (2020). However, it is necessary to point out that this study is more unique than the previous, wherein we dive deeper not only by observing the more dynamic group of countries (the developing ones) but also looking at their industrial structure.

We stretch our work further by decomposing our GVC data based on its production linkage, backward and forward. To the best of our knowledge, this is not something that has been carried out in previous research with the exception of Mehta (2021) whose work estimates the above-mentioned linkages with labor productivity. Upon doing this exercise, we reveal the different mechanisms of industrial upgrading. Backward participation is shown to be correlated with decreasing share of low-tech output with a seemingly positive impact on the medium-tech sector despite concern in one of the specifications. This suggests lower productivity gain, similar to the finding of Mehta (2021). He argues that

Table 4. Backward manufacturing GVC and industrial upgrading in developing countries.

	Low-tech. manufacturing			Med-tech. manufacturing			Hi-tech. manufacturing		
Variables	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Backward man. GVC	−0.177**	−0.188**	−0.210***	0.129	0.139*	0.198**	0.048	0.048	0.012
	(0.073)	(0.085)	(0.065)	(0.087)	(0.082)	(0.077)	(0.087)	(0.086)	(0.081)
Constant	259.447	−254.085	−284.808	−18.532	436.125	215.761	−140.915	−82.040	169.047
	(173.470)	(526.835)	(517.883)	(193.449)	(619.774)	(609.076)	(97.674)	(229.549)	(203.954)
Control variables	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Country Fixed-Effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year Fixed-Effects	Yes	No	No	Yes	No	No	Yes	No	No
Time Trend	No	Yes	No	No	Yes	No	No	Yes	No
Reg. FE x Time Trend	No	No	Yes	No	No	Yes	No	No	Yes
Observations	537	537	537	537	537	537	537	537	537
Number of countries	37	37	37	37	37	37	37	37	37
R-sq.	0.200	0.166	0.195	0.135	0.096	0.151	0.069	0.046	0.074

Notes: Manufacturing GVC comprises of foreign value added (FVA) components of import and domestic value added used in other countries' export within ISIC division 10-33. Low-tech. manufacturing corresponds to ISIC division 10-18, med-tech. manufacturing to ISIC division 19, 20, 22–25, 28–33, while hi-tech. manufacturing refers to ISIC division 21, 26, 27, 30 (aircraft and spacecraft). Robust standard errors are in parentheses, * 0.1 ** 0.05 *** 0.01.

Table 5. Forward manufacturing GVC and industrial upgrading in developing countries.

	Low-tech. manufacturing			Med-tech. manufacturing			Hi-tech. manufacturing		
Variables	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Forward man. GVC	0.013	−0.221	−0.079	−0.571	−0.261	−0.569	0.558**	0.482**	0.648**
	(0.431)	(0.363)	(0.363)	(0.575)	(0.508)	(0.541)	(0.248)	(0.228)	(0.283)
Constant	246.061	−291.173	−386.848	−9.859	484.359	318.633	−136.201	−93.186	168.215
	(174.412)	(518.794)	(530.257)	(188.489)	(617.090)	(613.176)	(91.750)	(214.526)	(184.991)
Control variables	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Country Fixed-Effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year Fixed-Effects	Yes	No	No	Yes	No	No	Yes	No	No
Time Trend	No	Yes	No	No	Yes	No	No	Yes	No
Reg. FE x Time Trend	No	No	Yes	No	No	Yes	No	No	Yes
Observations	537	537	537	537	537	537	537	537	537
Number of countries	37	37	37	37	37	37	37	37	37
R-sq.	0.190	0.156	0.181	0.138	0.092	0.149	0.082	0.056	0.093

Notes: Manufacturing GVC comprises of foreign value added (FVA) components of import and domestic value added used in other countries' export within ISIC division 10-33. Low-tech. manufacturing corresponds to ISIC division 10-18, med-tech. manufacturing to ISIC division 19, 20, 22–25, 28–33, while hi-tech. manufacturing refers to ISIC division 21, 26, 27, 30 (aircraft and spacecraft). Robust standard errors are in parentheses, * 0.1 ** 0.05 *** 0.01

Table 6. Robustness test under alternative specifications.

	Low-tech. Manufacturing			Med-tech. Manufacturing			Hi-tech. Manufacturing		
Variables	Diff.-GMM (1)	Sys.-GMM (2)	Sys.-GMM2S (3)	Diff.-GMM (4)	Sys.-GMM (5)	Sys.-GMM2S (6)	Diff.-GMM (7)	Sys.-GMM (8)	Sys.-GMM2S (9)
Lag of dependent var.	0.439***	0.527***	0.736***	0.522***	0.553***	0.538***	0.411**	0.371**	0.410*
	(0.127)	(0.155)	(0.156)	(0.116)	(0.144)	(0.153)	(0.210)	(0.182)	(0.227)
Manufacturing GVC	−0.191*	−0.322*	−0.152	−0.0829	0.0435	0.137	0.229*	0.253*	0.218*
	(0.115)	(0.183)	(0.201)	(0.137)	(0.132)	(0.151)	(0.128)	(0.134)	(0.115)
Control variables	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Country Fixed-Effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year Fixed-Effects	Yes	No	No	Yes	No	No	Yes	No	No
Time Trend	No	Yes	No	No	Yes	No	No	Yes	No
Reg. FE x Time Trend	No	No	Yes	No	No	Yes	No	No	Yes
Observations	508	537	537	508	537	537	508	537	537
Number of Countries	37	37	37	37	37	37	37	37	37
Number of Instruments	39	41	41	39	41	41	39	41	41
AR-1	0.004	0.002	0.022	0.004	0.002	0.013	0.047	0.068	0.128
AR-2	0.422	0.348	0.421	0.060	0.098	0.100	0.173	0.163	0.298
Sargan (*P*-value)	0.701	0.866	0.866	0.063	0.079	0.079	0.00003	0.00001	0.00001
Hansen (*P*-value)	0.652	0.898	0.898	0.412	0.873	0.873	0.295	0.207	0.207

Notes: Manufacturing GVC comprises of foreign value added (FVA) components of import and domestic value added used in other countries' export within ISIC division 10-33. Low-tech. manufacturing corresponds to ISIC division 10-18, med-tech. manufacturing to ISIC division 19, 20, 22–25, 28–33, while hi-tech. manufacturing refers to ISIC division 21, 26, 27, 30 (aircraft and spacecraft). Robust standard errors are in parentheses, * 0.1 ** 0.05 *** 0.01

strong backward linkage is the second stage in industrial upgrading, equipping countries with learning opportunities to increase their production capability.

Meanwhile, industrial transformation towards higher value-added industries is gained with forward participation, where it enables high-tech. sector to grow. One could refer this as the third stage in Mehta's (2021) model. However, while he explains in detail the process in the context of the electronic industry, this paper can confirm the trend more broadly in the manufacturing sector. In the end, we argue that GVC participation remains necessary to promote industrial upgrading. Our study becomes more relevant for industrial development fields as we use developing countries as the focus of discussion. Amidst the growing concern on the impact of GVC, we provide evidence of its crucial role for developing countries. This enriches our understanding of the issue that is useful for policymakers.

6. Conclusions

There has been an ongoing debate on the importance of GVC for development, with many countries that seem to loosen their ties. This research tries to contribute to the discussion by providing a fresh perspective on the impact of GVC participation in the manufacturing sector and how it relates to the change in countries' industrial structures. We build a novel dataset of manufacturing GVC participation index involving 37 countries from 2001 and 2017, and then we carry it under multiple estimation methods. This research consistently reveals that GVC participation has positively impacted industrial upgrading in the long run. Increasing participation correlates with the increasing share of high-tech. manufacturing value-added, at the expense of decreasing low-tech. sector. However, the upgrading channel differs. Backward GVC participation slashes low-tech manufacturing activities, while forward participation pushes for the increasing share of the high-tech sector. Our findings are robust to dynamic panel estimation methods, i.e. Difference and System GMM. Furthermore, the finding goes along with classical literature that proposes positive interaction between GVC and industrial upgrading. We conclude that forging GVC participation remains necessary for developing countries to upgrade their industrial structure and thus achieve sustainable income growth.

Notes

1. They acknowledge, however, that there is an unequal distribution of the gains from GVC participation. This heterogeneity across and within countries could expand the development gap among the participating countries and industries.
2. We follow the World Bank's definition on developing countries; low-income, lower-middle-income, and upper-middle-income with per capita GDP in 2010 constant price less than USD 12,000.
3. The imputation for missing observations is implemented in R software using the Multivariate Imputation by Chained Equations (MICE) package developed by Van Buuren and Groothuis-Oudshoorn (2011). Specifically, we applied a random forest method from the MICE package for imputing missing observation of high tech. manufacturing value added. In contrast to linear regression (the default setting in MICE implementation), the random forest method compensates for potential nonlinearity and handles collinearity among model variables. The random forest method is particularly advantageous in our case since the high tech. manufacturing value added is regressed on the observed low and medium tech. manufacturing value added.
4. This method is based on the study of (Hummels, Ishii, and Yi 2001) that differentiate production into those two roles, since both are interlinked in the value-chain and equally important. FVA is referred to as a measure of 'backward participation', given that it measures imported intermediate inputs that used to generate output for export. DVX is a measure of 'forward participation', i.e. it

measures exports of intermediate goods that are used as inputs for the production of exports of other countries.

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Disclosure statement

No potential conflict of interest was reported by the author(s).

Data availability statement

The data that support the findings of this study are available in the UNCTAD-Eora GVC Database https://worldmrio.com/unctadgvc/

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Appendix

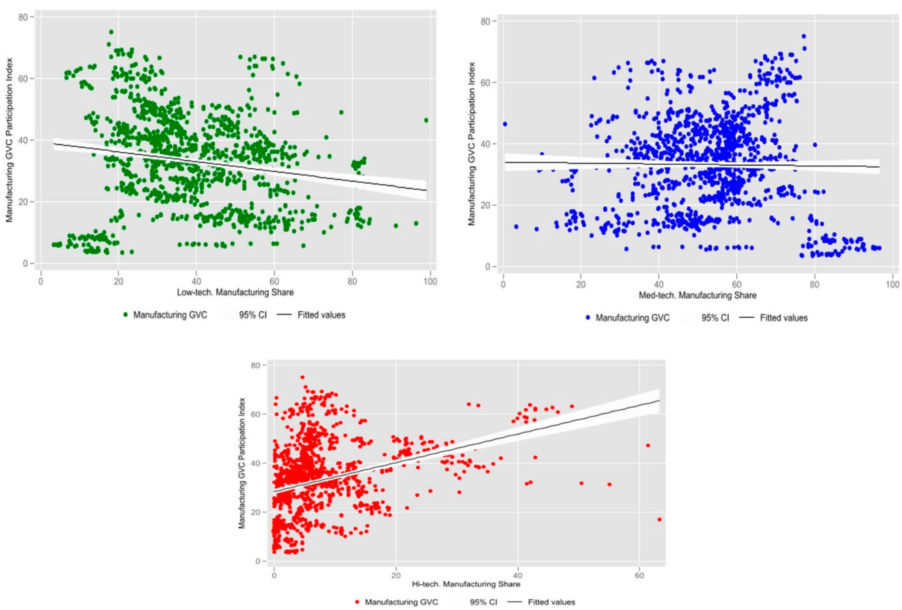

Figure A1. Manufacturing GVC and Manufacturing Share.

Table A1. List of countries and mean Manufacturing GVC 2001–2017 (% of gross export).

No.	Country name	Mean GVC	No.	Country name	Mean GVC
1.	Albania	56.98	20.	Lithuania	69.05
2.	Brazil	42.91	21.	Malaysia	65.83
3.	Bulgaria	60.94	22.	Mauritius	53.05
4.	China	43.99	23.	Mexico	42.44
5.	Colombia	35.47	24.	Mongolia	48.90
6.	Costa Rica	39.86	25.	Morocco	54.20
7.	Croatia	57.75	26.	Peru	48.53
8.	Ecuador	35.55	27.	Philippines	62.85
9.	Egypt	48.65	28.	Poland	70.48
10.	Estonia	74.13	29.	Romania	68.03
11.	Fiji	35.58	30.	Russia	60.33
12.	Georgia	41.16	31.	Slovakia	77.44
13.	Hungary	74.54	32.	South Africa	57.22
14.	India	43.92	33.	North Macedonia	67.66
15.	Iran	48.13	34.	Thailand	53.47
16.	Jordan	43.22	35.	Tunisia	58.24
17.	Kenya	45.28	36.	Turkey	54.79
18.	Kyrgyzstan	48.83	37.	Viet Nam	54.99
19.	Latvia	64.14			

Notes: Our definition of developing countries follows World Bank's yearly country classification where it defines developing country as having per capita GDP less than around USD 12,000 in 2010 constant price.
Source: Authors' computation.