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Does GVC Participation Improve the Productivity of Korean Manufacturing Firms? : Evidence from Subgroup Analysis Using Enterprise-level Data*

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Abstract

Purpose – Considering the recent instability of world economy and its heavy dependence on foreign, Korea must formulate breakthrough approaches to proactively cope with these adverse global developments. As such, this study aims to ascertain how participation in global value chains (GVCs) relates to corporate productivity and derive policy implications.

Design/methodology – This study utilizes the microdata of Korean manufacturers to develop indicators of GVC participation at the enterprise level and analyzes the effects of GVC participation on the firm's total factor productivity by using fixed effect model.

Findings – Enterprises with highest rates of export-side GVC participation see their productivity grow as their export-side GVC participation rates increase. In addition, when companies are classified by their export-side GVC participation rates, increasing export values improves all firm's productivity. In particular, those with low participation rates are analyzed to achieve higher productivity by increasing their imports, not only exports, which implies that companies with lower export-side GVC participation can boost productivity by reinforcing their export and import activities.

Originality/value – This research paper distinguishes itself from others in that it makes a novel attempt to design the indicators of GVC participation at the enterprise level, not at the national or industry level. In addition, this study contributes to the existing literature by dividing companies into subgroups depending on their GVC participation rates for each of export and import and identifying variances in the effect of GVC participation on productivity growth among subgroups.

Keywords: Enterprise-level Data, Fixed Effect Model, Global Value Chain, GVC Participation Rate, Total Factor Productivity

JEL Classifications: D24, F14, F61

1. Introduction

Rapidly spreading nationalism and escalating geopolitical tensions have led to conflicts between countries, accelerating economic instability worldwide. Korea is vulnerable to these worsening developments with its high dependence on trade and the high proportion of intermediate goods in its exports. Considering this trading structure in Korea, the prolonged US–China trade feud can significantly shrink US demand for Chinese products, which in turn will decrease Korea's exports of intermediate goods to China. To make matters worse, the

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nation has recently suffered global supply chain disruptions during the COVID-19 pandemic and the Russia–Ukraine war. Keenly recognizing the extremely high external dependence for its core industries of materials, components, and equipment when Japan restricted its exports of materials to Korea in July 2019, Korea has also made extensive investments to promote these industries (materials, components, and equipment) under the banner of "internalization of global value chains."

Major advanced economies are seeking ways of developing resilient and flexible supply chains to effectively navigate a series of tough global challenges.[1] Korea is no exception in these rapidly changing global trade environments. It is imperative that the nation proactively cope with these changes by leveraging supply chain internalization through the domestic production of key necessities and construction of flexible supply chains.

This study sets its sights on delivering global value chain (GVC) participation rates at the enterprise-level, exploring the relationship between GVC participation and productivity, and ultimately presenting relevant policy implications centered on GVC participation.

GVCs refer to production networks in which multiple countries participate in each stage of production along the paths taken by produced goods to reach the end consumers. The types and degrees of participation in the production process, as well as the added value created throughout the process, vary between countries. How to measure the degrees of GVC participation is a critical aspect of GVC-related research (Gereffi et al., 2001), and many attempts have been made to address this measurement issue (Gereffi et al., 2001; Hummel et al., 2001; Koopman et al., 2014; Wang et al., 2017). Additionally, the World Input–Output Database (WIOD) and OECD's Trade in Value-added Database (TiVA) are available to capture the flow of added value in cross-border trade.

The GVC participation rate is generally derived from the sum of forward and backward GVC participation where forward GVC participation corresponds to the ratio of the domestic value-added, created from intermediate goods sent to third economies for further processing and export through supply chains, to the economy's total gross exports, whereas backward GVC participation corresponds to the ratio of the foreign value-added portion, created from intermediate goods imported from third economies, to the economy's total gross exports[2]. Although these GVC participation rates can be derived from global input–output tables such as WIOD, this study attempted to narrow such GVC participation rates down from the national level to the enterprise level, which entails detailed firm-level datasets such as the export/import amounts of intermediate goods and a list of trade counterparts like those in global input–output tables. Nevertheless, in the absence of exhaustive data, this study took full advantage of available data to attain higher accuracy. Statistics Korea provides the Survey of Business Activities (SBA), which contains data on domestic companies' general corporate matters, financial status, and inter-company transactions. We converted yearly data into panel data and used sales, cost of sales, and export/import amounts in the category of inter-company transactions to measure the degree of GVC participation for each company. Based on a fixed effects model, we further analyzed how the degrees of GVC participation affect corporate productivity.

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[1] The US launched the "Building Resilient Supply Chains" initiative with a focus on identifying supply chain vulnerabilities and enhancing the flexibility of core industrial supply chains, while the EU is pursuing a range of policies whose objective centers on improving value chain resilience (Gereffi, 2022).

[2] Borin and Mancini (2015) showed how GVC-related trade can be computed using world input output tables.

This study is organized as follows. Section 2 provides an overview of previous research on GVC participation and corporate performance, and Section 3 discusses the empirical framework and method employed in this study. Section 4 starts by comparing corporate-specific variables of GVC-participating companies and non-GVC-participating companies and delivers analytical results for GVC-participating companies. In addition to analyses targeting all GVC-participating companies, we divided companies into several groups depending on the degree of export- and import-side GVC participation and compared the differences between companies with various degrees of GVC participation. This is another area that sets this study apart from others.

2. Literature Review

If all export and import activities are also viewed as GVC participation in a broad sense, there has been numerous studies to investigate the relationship between GVC and productivity. Aw and Hwang (1995) showed that the larger size of exporters relative to non-exporters explains the bulk of the difference in output between the two groups of producers. Bernard and Wagner (2001) found that exporting today by a plant increases the probability by 50 percent that the plant will export tomorrow, and large and productive companies also had a higher probability of exporting. Bernard et al. (2003) examined the impact of globalization and dollar appreciation on productivity, plant entry and exit, and labor turnover in U.S. Hallward-Driemeier, M. et al. (2002) found that Firms with foreign ownership and firms that export are significantly more productive, and the productivity gap is larger the less developed is the local market using firm level data from five East Asian countries.

Most previous studies in Korea also confined themselves to corporate export activities—rather than GVCs—for relational analysis with business performance. Lee Si-Wook and Choi Yong-Seok (2009) employed data on establishments in the manufacturing sector in Korea to demonstrate the presence of export-induced learning effects in relation to total factor productivity (TFP). Jung Ji-Eun et al. (2018) analyzed the effects of individual manufacturing companies' export activities on employment and productivity growth over two different periods, namely before and after the global financial crisis, and concluded that firms with a parent company achieved higher growth in TFP through export activities than those without a parent company. Kim Tae-Gi and Choi Ji-Hye (2017) analyzed the characteristics of exporting companies and the effect of exports on corporate performance, drawing the conclusion that companies with a large portion of exports experience higher productivity growth.

Some of the studies that employ GVC participation rates include Kim Sei-Wan and Choi Moon-Jung (2021), whose analysis revolved around the effect of changes in cross-border forward and backward GVC participation on economic growth, while Choi Nam-Suk (2016), analyzed how Korean conglomerates expanding their GVCs affected job creation in Korea. However, these studies utilized industry-level (not enterprise-level) GVC participation rates of the OECD and WTO. The lack of research that defines enterprise-level or establishment-level GVC participation rates and analyzes their causal effects on corporate performance may be attributable to the elusive nature of these definitions.[3] Measuring "'GVC participation rate"

[3] Based on establishment-level data, Huh Jung et al. (2018) defined GVC-participating companies as those that engage in both export and import activities and concluded that GVC participation can boost employment, sales, added value, and productivity. However, their analysis was confined to delving into

as the sum of forward and backward GVC participation rates, must be preceded by in-depth analyses of granular export/import data, including value-added created from exporting intermediate goods and the breakdown of trade counterparts. However, such detailed data is currently inaccessible at the enterprise-level.

To tackle this issue, this study designed the indicators of GVC participation at the enterprise-level using whatever datasets were available and applied them to ascertain the effect of GVC participation for a given company.

Additionally, unlike many previous studies that utilized establishment-level microdata to measure GVC participation or uncover the relationship between export/import activities and corporate performance, the present study employed enterprise-level data. An establishment is an individual unit within a firm that has some production-related roles but has no control over decisions that affect production, such as the ones related to the import of raw materials and intermediate goods, or the export of finished products. These decisions are primarily made at the enterprise level and hence using enterprise-level data is more appropriate and valid.

Lastly, from the perspective of exports and imports, this study categorized companies into groups depending on their degree of GVC participation for comparative analysis. Dividing two groups of companies, one with high export-side GVC participation and the other with low export-side GVC participation, this study identified potentially varying effects of GVC participation for each of export or import on productivity, together with the magnitude of the effects. This is another unique feature of this study.

3. Empirical Framework and Method

3.1. Data

The data of manufacturing firms are obtained from the Survey of Business Activities (SBA) provided by Statistics Korea. Covering all industries, the survey, which is released annually, contains comprehensive data on overall business activities such as basic corporate information, type of legal organization, number of employees, assets, affiliated companies, and inter-company transactions. The SBA aptly meets the purpose of this study, which is to delve into the effect of GVC participation on productivity growth. Considering that all major decisions are made at an enterprise, not at individual establishments within an enterprise, the survey data is greatly helpful as it furnishes the enterprise-level data, which in turn facilitates the analytical process of ascertaining the potential effects of the corporate decision to participate in GVC on business performance. For the analysis of 10,118 enterprises, we combined cross-sectional and time-series data over 2006–2019 to form panel data.

3.2. Total Factor Productivity

Total Factor Productivity (TFP) was used to represent productivity. As TFP is measured by estimating production function residuals, the process of estimating the production function should be preceded. There are several methods to estimate production functions, such as

the relationship between establishments' GVC participation and corporate performance and did not go as far as defining "GVC participation rate" at the establishment level.

ordinary least squares (OLS), fixed effects (FE), Olley and Pakes (1996) and Levinsohn and Petrin (2003). TFP estimated through OLS has a limitation in that endogeneity between inputs and unobservable productivity shock prevents consistent estimators from being delivered. The-Fixed effects (FE) method consider firm's productivity as a time invariant variable, which is also not appropriate. Olley and Pakes (1996) developed a new approach which uses corporate investment as a proxy variable of the unobservable firm-specific productivity shock to control for correlation between input and the productivity. After that, Levinsohn and Petrin (2003) showed that intermediate inputs can also be a proxy variable of productivity shock using Olley and Pakes (1996) method. One of the reasons why Levinsohn and Petrin (2003) used intermediate input as a proxy rather than the investment is that, unlike the sample Olley and Pakes (1996) used, over-half of their sample reports zero investment.

Here, we borrowed Olley and Pakes (1996) to estimate a production function. The reasons are as follows. First, 98% of the total datasets used in this study provides the item representing the acquisition value of tangible assets during the term that can be employed as an investment variable. Second, although our sample also provides the item representing raw material costs that can be employed as an intermediate input variable, we decided it is not appropriate to use this as a proxy. Because, as mentioned in Levinsohn and Petrin (2003), raw materials are easy to store, these are put into production over several periods of time, and hence these are not accurate as a variable to estimate the productivity in a particular year. Third, the investment variable is sensitive to economic cycles, so using this variable as a proxy can control for some of the cyclical component of TFP (Bae Chan-Kwon et al., 2015). Hence, we use Olley and Pakes (1996) rather than Levinsohn and Petrin (2003).

To estimate TFP, we start by assuming that the production function of each enterprise takes the form of a Cobb-Douglas function. Specifically, the production function looks as follows:

$$Y_{it} = A_{it} K_{it}^{\beta_k} L_{it}^{\beta_l} \tag{1}$$

where Y_{it} represents output of firm i in period t, K_{it} and L_{it} are inputs of capital and labor, respectively, and A_{it} represents firm's productivity.

Taking natural logs of (1) results in a linear production function,

$$y_{it} = \beta_0 + \beta_k k_{it} + \beta_l l_{it} + \omega_{it} + \varepsilon_{it} \tag{2}$$

where y_{it}, k_{it} and l_{it} refer to natural logarithms of Y_{it}, K_{it} and L_{it}, respectively, and $\ln(A_{it}) = \beta_0 + \omega_{it}$ represents firm's productivity. β_0 represents the time invariant mean efficiency across firms, and ω_{it} represents time and firm specific deviation from that mean. ε_{it} is an i.i.d. component representing unexpected deviation from the mean. Therefore, estimating (2) and solving for $\beta_0 + \omega_{it}$ gives the log of TFP.

We calculated the value-added to obtain production amount that is used as the output in estimating the production function. When calculating value-added, operating profit, labor income, depreciation, rent, and taxes and fees were combined in compliance with the criteria for the analysis of value-added of listed companies.[4] Payroll costs from operating expenses

[4] It is measured by summing up operating profit, labor income, depreciation expenses, rent, and tax and public dues.

were used for labor income.[5] Labor input was the sum of regular employees and daily employed workers, while individual companies' total tangible assets by year were used to represent capital input. Just as Olley and Pakes (1996) employed an investment variable as a proxy variable for productivity shock, this study used the acquisition value of tangible assets during the term in the SBA as an investment variable. In Section 4.1, Table 1, showing descriptive statistics of all the variables used in this study, contains the descriptive statistics of the variables used in estimating productivity, and Table 2 and Table 3 in Section 4.2 show the estimation results of production function and TFP, respectively.

3.3. GVC Participation rate

This study aims to ascertain the degree of GVC participation at the enterprise level rather than at the national or industry level, and explore the relationship between GVC participation rates and corporate productivity. As discussed in Section 1, the precise estimation of GVC participation rates at the enterprise level requires detailed data on the value of intermediate items both exported and imported and trade counterparts (countries and companies). However, the SBA only provides direct export and import values, the amount of customs clearance in the name of a given company, without any data on the export and import of intermediate goods. Allowing for this limitation, this study equated "GVC-participating companies" to companies that reported both export and import values and used "exports to sales" and "imports to cost of sales" of a given company as indicators of the degree of GVC participation.

The ratio of exports to sales represents export values as a fraction of the total sales revenues during the term. Although the export values provided by the SBA do not necessarily represent the amounts of goods exported during the term, it was assumed that most of the export values in the manufacturing sector would come from goods, so we used the ratio of exports to sales (ratio_export) as an indicator to denote export-side GVC participation. The ratio of imports to cost of sales represents the import value as a fraction of cost of sales incurred during the term. Like export values, import values provided by the survey do not necessarily refer to the amounts of raw materials and intermediate goods imported, yet it was assumed that a significant portion of the items imported under the name of a manufacturing company would be raw materials and intermediate goods. Therefore, we employed the ratio of imports to cost of sales (ratio_import) as an indicator to represent import-side GVC participation.

Furthermore, this study consulted several previous studies to control for the effects of other factors and employed company-specific variables such as the number of employees (employ), capital intensity(K/L), average wages (average wage), presence of a parent company (parent), and year and industry fixed-effects as control variables.

In addition, this study converted all nominal variables in the survey into real variables by applying the appropriate price indices provided by the Bank of Korea for each item: 1) domestic supply price index for capital goods was used to represent tangible assets and the acquisition value of tangible assets during the term, 2) producer price indices, which corresponded to each industry at the division level of industry classification, were used for sales and cost of sales, 3) export price indices substituted export values, and 4) import values were replaced by domestic supply price indices.

[5] For 2006–2009, the sum of total payroll, retirement benefits, and fringe benefits was used instead of total payroll costs.

3.4. Model

Using estimated TFP as a dependable variable, this study analyzes the following panel fixed-effects models.

$$TFP_{it} = GVC_{it} + X_{it} + \delta_i + e_{it} \quad (3)$$

$$TFP_{it} = EX_{it} + IM_{it} + X_{it} + \delta_i + e_{it} \quad (4)$$

The dependent variable, TFP_{it}, is log of company i's total factor productivity at time t. GVC_{it} is log of GVC participation rate of company i at time t (ln(ratio_export), ln(ratio_import)) and X_{it} is log of company-specific variables such as number of employees (ln(employ)), capital intensity (ln(K/L)) and average wages (ln(average wage)). δ_i denotes presence of a parent company, industry fixed effect and year fixed effect, and e_{it} is the error term. EX_{it} and IM_{it} in model (4) denote the amount of export and import, respectively.

The equation (3) is our main model, and we add model (4) as an auxiliary model to confirm the relationship between GVC participation rates and TFP.

Only GVC-participating companies were subject to the analysis in the above models. The analytical procedures are as follows. First, all GVC-participating companies were analyzed to ascertain the effect of GVC participation (both GVC participation rates and the amount of export and import) on their productivity. The companies under analysis were then divided into subgroups depending on the export- and import-side GVC participation rates. Lastly, these subgroups were further assessed to uncover any differences among subgroups regarding the significance and level of effect that GVC participation for each of export and import had on TFP.

4. Empirical Analysis and Results

4.1. Sample description

Table 1 presents the descriptive statistics of the variables used in the study. The number of 10,118 firms and the number of total observations of 62,889 are contained in total sample. Because we used unbalanced panel, the number of enterprises that are contained in a year is different by year. Table A showing the number of enterprises in each year is included in Appendix. We divided total sample into GVC participating companies and non-participating companies. As described in Section 3.3, companies participating in both exports and imports are defined as GVC participating companies, so those participating only in exports or imports are not applicable to GVC participating companies. So, even for a same company, it may be included in GVC participation companies in some years and not in some years.

Table 1. Descriptive Statistics

Variable	# Obs / # Firms	Mean	Standard deviation	Min	Max
value-added	62,881 / 10,117	49,900.86	401,520.20	-66,120.27	34,300,000
capital	62,887 / 10,118	93,972.90	638,456.40	1.00	45,000,000
employ	62,889 / 10,118	341.13	1,429.657	9.00	94,395.43
investment	62,889 / 10,118	19,689.95	183,819.30	0.97	14,100,000
ratio_export	62,888 / 10,117	0.20	0.22	0	1.33
ratio_import	62,854 / 10,111	0.12	0.16	0	2.13
export	62,889 / 10,118	94,740.66	795,719.40	0	59,700,000
import	62,889 / 10,118	49,639.10	440,427.70	0	23,000,000
K/L	62,887 / 10,118	159.02	6,169.91	2	21,395
average wage	62,889 / 10,118	43.23	20.65	0.05	1,018.94
parent	62,889 / 10,118	0.18	0.35	0	1

Note: The unit of value-added, capital, investment, export, import, K/L, average wage is 1,000,000 KRW (equivalent to 700 USD).

4.2. Production function and TFP

To examine the effect of GVC participation on productivity, estimating the TFP should be preceded. The estimation results of the production function and TFP according to the process described in Section 3.1 are shown in Table 2 and Table3, respectively.

Table 2. Estimation Results of Production Function

		Coefficient	Standard error	T-value	P-value
ln(employ)		0.7631 ***	0.0149	51.32	0.000
ln(capital)		0.1526 ***	0.0095	16.10	0.000
Number of obs / firms			61,602 / 9971		
Obs per group	min		1.00		
	avg		6.20		
	max		14.00		

Note: *p<0.1, **p<0.05, ***p<0.001.

Table 3. Descriptive statistics of TFP

	Mean	Standard deviation	Min	Max	Observations		
overall	3.98	0.67	-4.03	7.99	N	=	61,602
between		0.64	-3.62	7.13	n	=	9,971
within		0.40	-2.35	6.89	T-bar	=	6.1781

4.3. Simple comparison between GVC-participating companies and non-participating companies

Table 4 exhibits the summary statistics of major variables and makes a simple comparison between companies that engage in import/export activities and those that do not. It shows the means of major company-specific variables such as corporate productivity and size for GVC-participating companies and non-participation companies.

It can be simply observed that differences in means of productivity, value-added, investment, and employment between GVC-participating companies and non-participating companies.

Table 4. Summary Statistics - GVC-participating VS Non-participating Companies

Variable	GVC-participating companies			Non-participating companies		
	Mean (s.d.)	Min	Max	Mean (s.d.)	Min	Max
# Obs / # Firm	43,045 / 7,187	-	-	10,251 / 4,288	-	-
ln(TFP)	4.07 (0.62)	-1.26	6.85	3.72 (0.65)	-4.03	6.06
K/L	173.64 (275.63)	0.01	11,019.99	113.37 (240.96)	0.01	8,071.55
value-added	66,417.94 (479,313.90)	-49,521.82	34,300,000	8,920.22 (38,416.36)	-40,711.16	1,947,192.00
employ	421.88 (1,688.98)	9.00	94,395.43	133.23 (333.54)	25.00	14,666.00
capital	125,089.60 (757,912.00)	0.99	45,000,000	17,200.36 (136,448.40)	0.97	5,942,439.00
investment	26,469.15 (219,008.40)	0.97	14,100,000	3,350.64 (18,391.32)	0.97	803,123.60
average wage	45.45 (18.50)	0.08	428.04	36.02 (16.20)	0.05	436.15
parent	0.21 (0.37)	0	1	0.11 (0.31)	0	1

Note: The unit of value-added, capital, investment, export, import, K/L, average wage is 1,000,000 KRW (equivalent to 700 USD).

The t-test results for the major variables between the two groups are presented in Table 5. According to the results, the means of GVC-participating companies are much higher in all aspects such as productivity, capital intensity, value-added, size (asset and employment).

Table 5. T-test results - GVC-participating VS Non-participating Companies

Variable	GVC-participating companies (A)	Non-participating companies (B)	Difference (A)-(B)		t	Degrees of freedom
	Mean (s.e.)	Mean (s.e.)	Mean	s.e.		
ln(TFP)	4.07 (0.003)	3.72 (0.006)	0.35	0.01	47.98 ***	52,235
K/L	173.64 (1.214)	113.37 (1.956)	60.27	2.67	22.61 ***	53,292
value-added	66147.94 (3905.008)	8920.22 (285.288)	57497.72	8003.22	7.18 ***	53,288
employ	421.88 (12.040)	133.23 (2.576)	288.65	24.70	11.68 ***	53,294
capital	125089.60 (5591.109)	17200.36 (934.910)	104337.30	11468.08	9.41 ***	53,292
invest-ment	26469.15 (1749.511)	3350.64 (149.847)	23118.51	3585.82	6.45 ***	53,294
average wage	45.45 (0.130)	36.06 (0.176)	9.39	0.28	33.57 ***	53,294
parent	0.21 (0.002)	0.12 (0.003)	0.10	0.004	23.75 ***	53,294

Notes: 1. H_0: $mean(A) - mean(B) = 0$
2. *$p<0.1$, **$p<0.05$, ***$p<0.001$.

4.4. All GVC-participating companies

Table 6 shows the analytical results of all GVC-participating companies. Column (3) represents estimation result of model (3), and Column (4) represents the estimation result of model (4). the log values of exports and imports are used as explanatory variables. In model (3), for both export- and import- side, GVC participation rate did not deliver a statistically significant impact on productivity, but in model (4), a positive correlation can be witnessed between export/import amounts and productivity. In other words, it was analyzed that a one percent increase in exports and imports raises TFP by 0.05% and 0.03%, respectively. This aligns with Kim & Choi (2017), who found that firms' export activities increase TFP.

With the analysis of all GVC-participating companies showing no significant effect of GVC participation, we moved on to conduct more in-depth analyses. In Section 4.5 and 4.6,

analysis was performed by dividing companies into five groups according to the quantiles derived from each of export- and import-side GVC participation rates. Table 7 and Table 8 present summary statistics by group.[6]

Table 6. Analysis Results - All GVC-participating Companies

	(3)			(4)		
	Coeff. (s.e.)		**T-value**	**Coeff. (s.e.)**		**T-value**
ln(ratio_export)	- 0.0006 (0.0023)		- 0.27	-		-
ln(ratio_import)	- 0.0021 (0.0022)		- 0.95	-		-
ln(export)	-		-	0.0518 (0.0022)	***	23.89
ln(import)	-		-	0.0310 (0.0021)	***	14.70
ln(employ)	- 0.0748 (0.0095)	***	- 7.89	- 0.1500 (0.0097)	***	- 15.52
ln(K/L)	- 0.0506 (0.0058)	***	- 8.79	- 0.0615 (0.0057)	***	- 10.78
ln(average wage)	0.1237 (0.0050)	***	24.72	0.1168 (0.0049)	***	23.62
Number of obs / firms	42,201 / 7,105			42,201 / 7,105		
Obs per group min	1			1		
Obs per group avg	5.9			5.9		
Obs per group max	14			14		
R-sq within	0.0509			0.0756		
R-sq between	0.0099			0.0769		
R-sq overall	0.0014			0.0597		

Notes: 1. Model Summary (model (3)) $F(7104, 35055)$ =5.52, $Prob>F$=0.0000
(model (4)) $F(7104, 35055)$ =5.24, $Prob>F$=0.0000

2. *$p<0.1$, **$p<0.05$, ***$p<0.001$.

[6] As described in Section 4.1, The reason why the number of firms for each sub-group is different and the total number of firms is not equal to sum of the number of firms for each sub-group is that even the same company may be classified as a GVC-participation company in some year and may not be included in some year.

Table 7. Summary Statistics – Group by Export-side GVC participation rates

Mean (s.d.)	EX1	EX2	EX3	EX4	EX5
# Obs / # Firms	8,609 / 2,414	8,609 / 2,747	8,609 / 2,974	8,609 / 3,047	8,609 / 2,939
ln(TFP)	4.10 (0.69)	4.07 (0.69)	4.05 (0.67)	4.06 (0.63)	4.09 (0.59)
ratio_export	0.70 (0.15)	0.35 (0.06)	0.17 (0.03)	0.06 (0.02)	0.01 (0.01)
ratio_import	0.23 (0.28)	0.18 (0.20)	0.16 (0.18)	0.15 (0.18)	0.14 (0.18)
export	418,417.50 (16,964.78)	193,960 (1,389,301)	35,107.48 (1,369.35)	9,285.98 (32,110.35)	905.48 (3,062.34)
import	142,924.80 (752,500.60)	128,869 (906,892.30)	42,878.17 (271,497.20)	29356.97 (346,786.40)	15,480.85 (116,468.40)
employ	782.93 (2,787.86)	494.76 (2,657.48)	300.13 (640.10)	287.01 (492.79)	244.58 (443.40)
K/L	178.87 (365.64)	188.736 (239.93)	171.00 (312.16)	163.15 (182.24)	166.44 (220.56)
average wage	45.51 (18.95)	46.28 (22.00)	45.44 (24.27)	44.98 (22.02)	45.06 (21.13)

Note: The unit of value-added, capital, investment, export, import, K/L, average wage is 1,000,000 KRW (equivalent to 700 USD).

Table 8. Summary Statistics – Group by Import-side GVC participation rates

Mean (s.d.)	IM1	IM2	IM3	IM4	IM5
# Obs / # Firms	8,609 / 2,468	8,609 / 2,954	8,609 / 3,284	8,609 / 3,394	8,609 / 3,240
ln(TFP)	4.20 (0.72)	4.13 (0.66)	4.05 (0.65)	4.00 (0.63)	3.98 (0.59)
ratio_export	0.32 (0.29)	0.29 (0.26)	0.25 (0.25)	0.24 (0.24)	0.19 (0.23)
ratio_import	0.51 (0.23)	0.21 (0.04)	0.10 (0.02)	0.04 (0.01)	0.01 (0.00)
export	209,677.90 (1,285,385)	216,494.80 (1,452,891)	82,764.96 (547,394.90)	97,724.51 (746,573.90)	51,014.29 (595,084.50)
import	252,188.90 (1,041,624)	79,363.57 (476,826.20)	19,188.96 (94,665.93)	7,943.53 (48,347.43)	824.82 (8,305.68)
employ	475.46 (2,247.68)	593.52 (2,311.93)	386.74 (1,115.20)	384.23 (1,655.44)	269.47 (1,353.55)
K/L	211.21 (359.72)	175.68 (205.48)	167.04 (224.17)	153.48 (180.65)	160.79 (232.48)
average wage	48.50 (22.25)	46.49 (19.62)	45.04 (20.79)	44.09 (20.79)	43.14 (20.17)

Note: The unit of value-added, capital, investment, export, import, K/L, average wage is 1,000,000 KRW (equivalent to 700 USD).

4.5. Grouping by export-side GVC participation rates

Based on export value as a proportion of total sales, all GVC-participating companies were divided into five groups (EX1, EX2, EX3, EX4, and EX5). Specifically, creating percentile based on exports to sales, and divided it into five groups. The changes in the productivity of two group, EX1 and EX4, depending on export-side GVC participation rates were analyzed Table 9. The analysis results for the other groups (EX2, EX3 and EX5) are included in Table C in Appendix. According to the tables, EX1 with the highest export-side GVC participation rate saw its TFP increase by about 0.22% as the degree of their export-side GVC participation rate rose. No significant effect of GVC participation rate on productivity was witnessed in EX2 and EX3, while increasing export-side GVC participation adversely affected productivity in EX4 and EX5. In these two groups, a one percent increase in export-side GVC participation reduced productivity by 0.03% and 0.01%, respectively. Import-side GVC participation rates did not have any statistically significant effect on productivity in any of the five groups.

Meanwhile, from the results of model (4), all groups witnessed a positive effect of rising amount of export on their productivity. If the increase in exports and imports are also viewed as an increase in GVC participation, it was also confirmed that the higher the export-side GVC participation, the greater the increase in productivity with expanding exports. This is consistent with the results of previous studies that increasing exports boosts productivity. In the EX3, EX4, and EX5 groups, a positive effect of rising imports on productivity was observed, which implies that companies with low export-side GVC participation can enhance TFP by reinforcing their export/import activities.

Although no statistically significant results were obtained from the Table 6, some significant relationships between export-side GVC participation and TFP were observed in some groups. With Table 6 revealing the differences between the groups with high GVC participation rates and those with low GVC participation rates, the upper and lower groups were further subdivided and analyzed. Those results are shown in Table 10.

According to the results in Table 10, in all groups outside the top and bottom 10%, export-side GVC participation had a statistically significant effect on productivity. The comparative analyses of top 20% vs. bottom 20%, the top 30% vs. the bottom 30%, the top 40% vs. the bottom 40%, and the top 50% vs. the bottom 50% indicated that an increase in export-side GVC participation exerted contrasting effects on productivity; it raised productivity in all upper groups but significantly reduced productivity in all bottom groups. Additionally, the gains in productivity achieved by the upper groups with their increasing GVC participation were greater than the losses in productivity suffered by the bottom groups. From these results, it can be derived that the higher export-side GVC participation, the higher productivity improvement obtained through the activation of export-side GVC participation. However, no correlation was observed between import-side GVC participation rates and productivity growth in all group.

4.6. Grouping by import-side GVC participation rates

We also divided the companies into five groups (IM1, IM2, IM3, IM4, and IM5) based on import value as a proportion of cost of sales. however, we only found that for IM1, productivity growth of 0.05% as import share increased by 1% and for IM4, 0.009% decrease in productivity as export share increase by 1%.

Like Table 10, Table 11 shows the analytical results of upper and bottom groups depending on their degree of import-side GVC participation.

Unlike the analytical results of export-side GVC participation in Section 4.5., no significant effect of GVC participation rates was observed in most groups.

All upper groups saw no correlation between their import-side participation and productivity growth. In the top 10%, a one percent increase in export-side GVC participation even led to a slight reduction -0.016%- in productivity. Increasing import-side GVC participation raised productivity by 0.013% in the bottom 10%, while slightly reducing productivity in the bottom 50%. These results imply that even companies with high participation in GVC on the import-side cannot expect productivity improvement through activation of participation in GVC on not only export-side but also import-side.

Table 9. Analysis Results – Group by Export-side GVC Participation Rates

	EX1		**EX4**	
	(3) Coeff. (s.e.)	**(4) Coeff. (s.e.)**	**(3) Coeff. (s.e.)**	**(4) Coeff. (s.e.)**
ln(ratio_ export)	0.2192 ***	-	- 0.0278 *	
	(0.0410)		(0.0143)	
ln(ratio_ import)	- 0.0000	-	0.0080	
	(0.0062)		(0.0050)	
ln(export)	-	0.7322 ***		0.2484 ***
		(0.0164)		(0.0119)
ln(import)	-	- 0.0093 *		0.0256 ***
		(0.0053)		(0.0048)
ln(employ)	- 0.0523 **	- 0.6127 ***	- 0.1608 ***	- 0.3619 ***
	(0.0240)	(0.0241)	(0.0247)	(0.0252)
ln(K/L)	- 0.0757 ***	- 0.1424 ***	- 0.0552 ***	- 0.8420 ***
	(0.0153)	(0.0133)	(0.0146)	(.00140)
ln(average wage)	0.1391 ***	0.0823 ***	0.0603 ***	0.0377 ***
	(0.0123)	(0.0107)	(0.0110)	(0.0106)
Number of obs / firms	8,338 / 2,358		8,482 / 2,999	
Obs per group				
min	1		1	
avg	3.5		2.8	
max	14		14	
R-squared				
within	0.0630	0.3041	0.0605	0.1407
between	0.0001	0.4055	0.0079	0.1944
overall	0.0000	0.3844	0.0093	0.1625
Model Statistics				
F-value	F(2,357, 5,941) = 4.06	F(2,357, 5,941) = 3.69	F(2,998, 5,445) = 4.27	F(2,998, 5,445) = 3.37
Prob>F	0.0000	0.0000	0.0000	0.0000

Note: **p<0.1, **p<0.05, ***p<0.001.*

Table 10. Analysis Results –Top vs Bottom Group by export-side GVC participation rates

Coefficient (s.e.)	Top 10%	Top 20%	Top 30%	Top 40%	Top 50%
# Obs / # Firms	4,156 / 1,488	8,338 / 2,358	12,537 / 3,057	16,754 / 3,703	20,973 / 4,304
ln(ratio_export)	0.0932 (0.0971)	0.2192*** (0.0409)	0.1367*** (0.0237)	0.1027*** (0.0153)	0.0706*** (0.0108)
ln(ratio_import)	- 0.0030 (0.0097)	- 0.0000 (0.0062)	- 0.0028 (0.0048)	- 0.0059 (0.0040)	- 0.0055 (0.0035)
ln(employ)	0.0118 (0.0373)	- 0.0523** (0.0240)	- 0.0574** (0.0190)	- 0.0291* (0.0160)	- 0.0460*** (0.0142)
ln(K/L)	- 0.0727 ** (0.0237)	- 0.0757*** (0.0153)	- 0.0468*** (0.0119)	- 0.0487*** (0.0102)	- 0.0517*** (0.0091)
ln(average wage)	0.1963 *** (0.0199)	0.1391*** (0.0123)	0.1219*** (0.0095)	0.1300*** (0.0082)	0.1292*** (0.0073)
Model statistics					
F-value	3.22	4.06	4.35	4.58	4.77
Prob>F	0.0000	0.0000	0.0000	0.0000	0.0000
Coefficient (s.e.)	**Bottom 10%**	**Bottom 20%**	**Bottom 30%**	**Bottom 40%**	**Bottom 50%**
# Obs / # Firms	4,255 / 1,838	8,498 / 2,900	12,725 / 3,771	16,965 / 4,484	21,206 / 5,096
ln(ratio_export)	- 0.0096 (0.0072)	- 0.0127** (0.0045)	- 0.0146*** (0.0037)	- 0.0116*** (0.0031)	- 0.0129*** (0.0028)
ln(ratio_import)	0.0037 (0.0074)	- 0.0075 (0.0048)	- 0.0037 (0.0037)	0.0012 (0.0032)	- 0.0003 (0.0028)
ln(employ)	- 0.3652*** (0.0404)	- 0.3024*** (0.0245)	-0.2456*** (0.0195)	- 0.1988*** (0.0162)	- 0.1649*** (0.0140)
ln(K/L)	- 0.0738*** (0.0217)	- 0.5910*** (0.0129)	-0.0367*** (0.0107)	- 0.0412** (0.0090)	- 0.0459*** (0.0079)
ln(average wage)	0.0771*** (0.0163)	0.0763*** (0.0112)	0.0800*** (0.0091)	0.0828*** (0.0077)	0.0923*** (0.0069)
Model statistics					
F-value	3.42	3.90	4.20	4.62	4.92
Prob>F	0.0000	0.0000	0.0000	0.0000	0.0000

Note: *p<0.1, **p<0.05, ***p<0.001.

Table 11. Analysis Results – Top vs Bottom Group by import-side GVC participation rates

Coefficient (s.e.)	**Top 10%**	**Top 20%**	**Top 30%**	**Top 40%**	**Top 50%**
# Obs / # Firms	4,212 / 1,516	8,437 / 2,427	12,663 / 3,186	16,886 / 3852	21,112 / 4,463
ln(ratio_export)	- 0.0162 * (0.0088)	0.0030 (0.0060)	0.0057 (0.0048)	0.0035 (0.0041)	- 0.0020 (0.0037)
ln(ratio_import)	- 0.0551 (0.0436)	- 0.0332 (0.0234)	- 0.0118 (0.0152)	- 0.0015 (0.0112)	- 0.0061 (0.0086)
ln(employ)	- 0.0777 ** (0.0357)	- 0.0463** (0.0230)	- 0.0450** (0.0182)	- 0.0556*** (0.0157)	- 0.0733*** (0.0138)
ln(K/L)	- 0.0265 (0.0186)	- 0.0577*** (0.0133)	- 0.0580*** (0.0107)	- 0.0524*** (0.0092)	- 0.0542*** (0.0082)
ln(average wage)	0.1130 *** (0.0173)	0.0913*** (0.0111)	0.1012*** (0.0089)	0.1147*** (0.0077)	0.1152*** (0.0069)
Model statistics					
F-value	3.72	4.45	4.83	4.88	5.03
Prob>F	0.0000	0.0000	0.0000	0.0000	0.0000
Coefficient (s.e.)	**Bottom 10%**	**Bottom 20%**	**Bottom 30%**	**Bottom 40%**	**Bottom 50%**
# Obs / # Firms	4,238 / 2,020	8,464 / 3,195	12,664 / 4,045	16,867 / 4,743	21,069 / 5,343
ln(ratio_export)	- 0.0006 (0.0076)	0.0037 (0.0051)	0.0052 (0.0041)	- 0.0003 (0.0035)	- 0.0013 (0.0031)
ln(ratio_import)	0.0131* (0.0071)	- 0.0038 (0.0046)	- 0.0056 (0.0037)	- 0.0049 (0.0032)	- 0.0051* (0.0029)
ln(employ)	- 0.2697*** (0.0393)	- 0.2174*** (0.0257)	- 0.1839*** (0.0200)	- 0.1544*** (0.0167)	- 0.1196*** (0.0145)
ln(K/L)	0.0054 (0.0268)	- 0.0461*** (0.0163)	- 0.0556*** (0.0127)	- 0.0597*** (0.0104)	- 0.0470*** (0.0090)
ln(average wage)	0.1434*** (0.0182)	0.1489*** (0.0127)	0.1254*** (0.0100)	0.1319*** (0.0085)	0.1261*** (0.0075)
Model statistics					
F-value	3.13	3.43	3.75	3.95	4.19
Prob>F	0.0000	0.0000	0.0000	0.0000	0.0000

Collectively, our findings demonstrate that there are differences according to the current GVC participation rate, but the export-side GVC participation rather than import has a statistically significant relationship with the change in productivity.

5. Conclusions and Implications

Using enterprise-level data, this study proposed the indicators of GVC participation at the enterprise level and analyzed how changing degrees of GVC participation affect corporate productivity. Although the degrees of GVC participation at the national or industry level can be derived from global input–output tables such as WIOD, this study made a novel attempt to generate analogous GVC participation rates at the enterprise level. As such, we developed the indicators of GVC participation: "exports to sales" to represent export-side GVC participation and "imports to cost of sales" to represent import-side GVC participation, and analyzed the relationship between GVC participation rates and corporate productivity.

The analytical results are as follows. In the analysis of all GVC-participating companies, no effect of GVC participation rates on productivity growth was witnessed. However, the analysis of subgroups, divided by GVC participation rates for each of export and import, generated useful results. Companies with high export-side GVC participation saw a positive correlation between their increasing GVC participation and productivity growth. In addition to GVC participation rates, increases in exports and imports were also analyzed to boost productivity, which aligns with the results of previous studies that explored the relationship between exports and corporate performance. In particular, in groups with low export-side GVC participation rates, rising exports and imports significantly improved productivity. This implies that companies with lower export-side GVC participation can boost TFP by reinforcing their export and import activities.

This study has its limitations in that it failed to produce GVC participation rates as accurately as those at the national or industry level due to difficulties in securing comprehensive data. Nevertheless, we made the most of available data to generate reasonably accurate GVC participation rates for each of export and import at the enterprise level, while ascertaining the differences in productivity, alongside relevant underlying factors, that arise from varying degrees of each of export- and import-side GVC participation. We believe that this approach sets this study apart from previous studies.

Assuming that major production-related decisions, such as the export of goods and import of raw materials, are made at the enterprise level rather than at the establishment level, this study—unlike most previous studies that primarily referred to establishment-level data—employed enterprise-level data to identify the relationship between GVC participation and corporate performance, which is also significant. Furthermore, in addition to the analysis of all GVC-participating companies, this study divided companies into subgroups depending on their GVC participation rates for each of export and import and revealed the variances in the effect of GVC participation on productivity growth among subgroups, which merits special attention.

With the conclusion that GVC participation can boost productivity, further studies are needed to substantiate and expand the conclusion to present far more meaningful and significant analytical results. It would also be intriguing to focus on newcomers to GVCs and investigate their motives to join, which is left for future studies.

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Appendices

Table A. The Number of Companies by Year

Year	Total number of Firms	GVC participating	Non-GVC participating	Only export or Only import
2006	5,885	2,067	2,327	1,491
2007	5,791	2,258	1,947	1,586
2008	5,740	2,322	1,944	1,474
2009	5,398	2,543	1,537	1,318
2010	2,535	2,086	1,]71	278
2011	2,471	2,152	125	194
2012	3,152	2,267	406	479
2013	3,194	2,319	402	473
2014	2,931	2,365	252	314
2015	5,672	4,271	528	873
2016	4,588	4,515	1	72
2017	4,624	4,553	3	68
2018	4,801	4,709	5	87
2019	6,107	4,618	603	886

Table B. List of Sector Used in the Analysis and the Number of Companies by Sector

	classification	No. of firms		classification	No. of firms
10	Manufacture of food products	690	22	Manufacture of rubber and plastics products	835
11	Manufacture of beverages	69	23	Manufacture of other non-metallic mineral products	359
12	Manufacture of tobacco products	6	24	Manufacture of basic metals	612
13	Manufacture of textiles, except apparel	431	25	Manufacture of fabricated metal products, except machinery and furniture	884
14	Manufacture of wearing apparel, clothing accessories and fur articles	346	26	Manufacture of electronic components, computer; visual, sounding and communication equipment	1,689
15	Manufacture of leather, luggage and footwear	104	27	Manufacture of medical, precision and optical instruments, watches and clocks	475
16	Manufacture of wood and of products of wood and cork; except furniture	71	28	Manufacture of electrical equipment	796
17	Manufacture of pulp, paper and paper products	223	29	Manufacture of other machinery and equipment	1,439
18	Printing and reproduction of recorded media	145	30	Manufacture of motor vehicles, trailers and semitrailers	1275

Table B. (Continued)

	classification	No. of firms		classification	No. of firms
19	Manufacture of coke, briquettes and refined petroleum products	42	31	Manufacture of other transport equipment	281
20	Manufacture of chemicals and chemical products; except pharmaceuticals and medicinal chemicals	712	32	Manufacture of furniture	123
21	Manufacture of pharmaceuticals, medicinal chemical and botanical products	287	33	Other manufacturing	147

Table C. List of Sector Used in the Analysis and the Number of Companies by Sector

	EX1		EX2	
	(3) Coeff. (s.e.)	(4) Coeff. (s.e.)	(3) Coeff. (s.e.)	(4) Coeff. (s.e.)
ln(ratio_ export)	0.2192 *** (0.0410)	-	0.0390 (0.0333)	
ln(ratio_ import)	- 0.0000 (0.0062)	-	- 0.0078 (0.0058)	
ln(export)	-	0.7322 *** (0.0164)		0.6506 *** (0.0167)
ln(import)	-	- 0.0093 * (0.0053)		- 0.0015 (0.0051)
ln(employ)	- 0.0523 ** (0.0240)	- 0.6127 *** (0.0241)	- 0.0773 ** (0.0249)	- 0.5933 *** (0.0256)
ln(K/L)	- 0.0757 *** (0.0153)	- 0.1424 *** (0.0133)	- 0.0398 ** (0.0158)	- 0.1329 *** (0.0142)
ln(average wage)	0.1391 *** (0.0123)	0.0823 *** (0.0107)	0.1009 *** (0.0112)	0.0551 *** (0.0010)
Number of obs / firms	8,338 / 2,358		8,416 / 2,691	
Obs per group				
min	1		1	
avg	3.5		3.1	
max	14		14	
R-squared				
within	0.0630	0.3041	0.0484	0.2544
between	0.0001	0.4055	0.0006	0.4360
overall	0.0000	0.3844	0.0001	0.4444
Model Statistics				
F-value	F(2,357, 5,941) = 4.06	F(2,357, 5,941) = 3.69	F(2,690, 5,687) = 4.07	F(2,690, 5,687) = 3.67
Prob>F	0.0000	0.0000	0.0000	0.0000

Table C. (Continued)

EX3		EX4		EX5	
(3)	(4)	(3)	(4)	(3)	(4)
Coeff. (s.e.)	**Coeff. (s.e.)**	**Coeff. (s.e.)**	**Coeff. (s.e.)**	**Coeff. (s.e.)**	**Coeff. (s.e.)**
- 0.0310	-	- 0.0278 *	-	- 0.0127 **	-
(0.0248)		(0.0143)		(0.0045)	
- 0.0005	-	0.0080	-	- 0.0075	-
(0.0056)		(0.0050)		(0.0048)	
-	0.4915 ***	-	0.2484 ***		0.0183 ***
	(0.0160)		(0.0119)		(0.0045)
-	0.0126 **	-	0.0256 ***		0.0175 ***
	(0.0052)		(0.0048)		(0.0047)
- 0.1419 ***	- 0.4689 ***	- 0.1608 ***	- 0.3619 ***	- 0.3019 ***	- 0.3318 ***
(0.0247)	(0.0249)	(0.0247)	(0.0252)	(0.0245)	(0.0249)
- 0.0638 ***	- 0.1104 ***	- 0.0552 ***	- 0.8420 ***	- 0.0594 ***	- 0.0629 ***
(0.0152)	(0.0141)	(0.0146)	(0.0140)	(0.0129)	(0.0129)
0.0879 ***	0.0582 ***	0.0603 ***	0.0377 ***	0.0765 ***	0.0749 ***
(0.0110)	(0.0102)	(0.0110)	(0.0106)	(0.0112)	(0.0112)
8,464 / 2,929		8,482 / 2,999		8,501 / 2,902	
Obs per group					
1		1		1	
2.9		2.8		2.9	
14		14		14	
R-squared					
0.0665	0.2106	0.0605	0.1407	0.0761	0.0796
0.0048	0.3823	0.0079	0.1944	0.0201	0.0077
0.0065	0.3664	0.0093	0.1625	0.0236	0.0108
Model Statistics					
F(2,928, 5,495) = 4.22	F(2,928, 5495) = 3.51	F(2,998, 5445) = 4.27	F(2,998, 5,445) = 3.37	F(2,901, 5,559) = 3.90	F(2,901, 5,559) = 3.62
0.0000	0.0000	0.0000	0.0000	0.0000	0.0000