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Global Value Chain and Misallocation: Evidence from South Korea*

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Abstract

Purpose – This paper empirically investigates the effect of a rise in the global value chain (GVC) on the industry-level efficiency of resource allocation (based on plant-level inefficiency measures) in Korea, with a focus on various channels through which a rise in the GVC can increase competition among firms and thus induce resources to be allocated more efficiently across firms.

Design/methodology – We empirically investigate the relationship between the industry-specific importance of GVC and the industry-level allocative inefficiency that is measured as the dispersion of the plant-level marginal revenue of capital (MRK) as in Hsieh and Klenow's (2009) influential model. We compute MRK dispersion for industries sorted by various characteristics that are closely related to firm/industry sensitivity to the GVC. In other words, we compute the average industry-level MRK dispersion for industries sorted by industry-specific importance of GVC and compute the difference between the two groups of industries (higher vs. lower than the median GVC); we also calculate the difference between industries sorted by industry-specific export (import) intensity. This is our difference-in-difference estimate of the MRK dispersion associated with the GVC for the export (import)-intensive industry versus the non-export (non-import)-intensive industry. This difference-in-difference estimate of the MRK dispersion conditional vs. unconditional on firm-level productivity is then calculated further (triple-difference estimate).

Findings – A rise in GVC is associated with a decrease in the MRK dispersion in the export-intensive industry compared to the non-export-intensive industry. The same is true for industries that rely heavily on imports versus those that do not (i.e., import intensive vs. non-intensive). Furthermore, the reduction in the MRK dispersion in the export-intensive industry associated with an increase in the GVC is disproportionately greater for high-productivity firms. In contrast, the negative relationship between GVC and MRK dispersion in the import-intensive industry is disproportionately smaller for high-productivity firms.

Originality/value – Existing studies focus on the relationship between GVC and aggregate output, exports, and imports at the country level. We investigate detailed firm/industry-level mechanisms that determine the relationship between GVC, trade, and productivity. Using the plant-level data in South Korea, we investigate how GVC is related to the cross-firm MRK dispersion, an important measure of allocative inefficiency, based on Hsieh and Klenow's (2009) influential economic theory. This is the first study to provide plant-level evidence of how GVC affects MRK dispersion. Furthermore, we examine how the relationship between GVC and MRK-dispersion varies across export intensity, import intensity, and firm-level productivity, providing insight into how GVC can affect firms' exposure to competition in the global market differently depending on market conditions and thus generate trade-related productivity gains.

Keywords: Allocative Efficiency, Dispersion of Marginal Revenue of Capital, Global Value Chain, Misallocation, Productivity

JEL Classifications: D12, F14, O53

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1. Introduction

The degree of international integration in the production of goods and services has substantially increased over time, resulting in a rise in the fragmentation of production chains throughout the world and a global value chain (GVC).[1] The determinants and consequences of the GVC have recently received considerable attention from researchers and practitioners (OECD, 2013; Koopman et al., 2014; Timmer et al., 2014; OECD, 2018; McKinsey Global Institute, 2019). However, how the GVC would affect the industry- and country-level productivity, especially via the channel of resource allocation across firms, is understudied, despite the importance of resource (mis)allocation in determining the industry and country-level aggregate productivity. A rise in the GVC can reduce the degree of resource misallocation by increasing the firms' exposure to global competition. Accordingly, we fill this gap by investigating how the GVC affects the degree of resource misallocation across firms, particularly its differential effects depending on firm/industry-level characteristics (e.g., industry-level export and import intensity, and firm-level productivity).

More specifically, using a Korean plant-level survey for manufacturing industries, we empirically investigate how the industry-level cross-firm allocative inefficiency is associated with the industry-specific importance of GVC. The industry-level allocative inefficiency can be measured as a dispersion, across firms in a given industry, of the marginal revenue of capital and labor, respectively (Hsieh and Klenow, 2009). The central idea is that, in the absence of any distortion (i.e., the same price of capital offered to all firms), the marginal revenue of capital (MRK) should be equalized across firms, and thus, the dispersion of MRK (across firms) should be zero. In Hsieh and Klenow's (2009) model, the dispersion of MRK is tightly (and inversely) related to allocative efficiency and affects aggregate productivity. We investigate how the cross-firm dispersion of MRK in the industry is related to the industry-specific importance of GVC.The theoretical motivation of our analysis is as follows: A high degree of fragmentation of global production chains implies a high degree of specialization/division of production across global production units. As a result, an increase in the importance of GVC can provide firms with both opportunities and challenges; in particular, it can increase a firm's exposure to competition and thus discipline firms to use resources more efficiently, generating productivity gains from trade.

Importantly, the effects of GVC on the firm/industry-specific gains from trade can be differential across firms/industries for the following reasons: Suppose the importance of GVC rises. First, a firm with the world-wide advantage in a specific production stage can access a larger market and hence is willing to use its production facilities that would not be otherwise used fully, labeled *export channel*. Second, by outsourcing less productive stages of production to foreign suppliers newly available because of a rise in GVC, a firm can concentrate on the more productive stages of production (i.e., increased degree of specialization); this would enable such a firm to overcome the overall productivity gap and compete more aggressively against the leading firm, labeled *import channel*. Both of these two channels are likely to increase a firm's exposure to competition.

Our sample, that is, the Korean plant-level survey for manufacturing industries, provides information on the plant-level annual sales and use of capital and labor, annually over 2000–

[1] The degree of GVC has, as illustrated in Fig. 2 in this paper, steadily increased over time since 2000, despite its moderate decline in the aftermath of the financial crisis of 2007—2008 and rebound thereafter (OECD, 2018; McKinsey Global Institute, 2019).

2014 (except for 2010, when the data are not collected). As in Chee and Jung (2015), who applied Hsieh and Klenow's (2009) model to the Korean data, we calculate the plant-level marginal revenue of capital (MRK), where "plant" and "firm" are used interchangeably in this paper. For a given (four-digit) industry and for a given sample year, we measure the dispersion of such plant-level MRK across firms as its cross-sectional standard deviation (or as its interquartile range). Meanwhile, industry-specific importance of GVC, a key explanatory variable, is measured as the contribution of foreign firms' value added to the industry's final output production, denoted as FVAD (Timmer et al., 2014; Los et al., 2015).

Our primary goal is to investigate how the dispersion of MRK in the industry is related to the industry-specific importance of GVC (again measured as FVAD). Furthermore, we want to examine whether the two channels (export and import channels) that connect the industry-specific FVAD to the industry's MRK dispersion are operative or not; to this end, we investigate whether the association between the industry-specific FVAD and the industry's MRK dispersion differs between export (import)-intensive industries and other industries. Furthermore, motivated by the finding in Chee and Jung (2015) that high-productivity firms tend to use capital less than the optimal, we investigate whether the export (import)-intensive industry's reduction in MRK dispersion associated with an increase in FVAD relative to that in other industries (i.e., difference-in-difference) is of magnitude disproportionately greater conditional on high-productivity firms than unconditional on productivity (i.e., triple-difference).

Our dependent variable (the industry-specific MRK dispersion) can be observed at the *industry* level. As a result, the number of sample observations (i.e., industries) for a given year is small, making regression analysis unsuitable for our purposes.

Our approach is as follows: We sort firms/industries according to various characteristics that are closely related to the driving forces discussed in our hypotheses; we investigate how the average of MRK dispersion of such characteristics-sorted firms/industries is related to the various combinations of characteristics (such as industry-level export- and import- intensity, and firm-level productivity). (We do this for a specific year, and the results are averaged across all sample years.) For example, we calculate how MRK dispersion differs between high-FVAD and low-FVAD industries, which is further differentiated between high- and low-export intensity industries (i.e., difference-in-difference estimate), to control for possible effects of other characteristics that may covary with FVAD. One advantage of our methodology is that we can examine whether specific mechanisms (e.g., export and import channels, respectively) are operative or not when determining the association between FVAD and MRK-dispersion.

We obtain the following findings. The dispersion of MRK is negatively associated with FVAD to a greater extent in the export-intensive industry than in the non-export-intensive industry on average over the sample period. The reduction (in percentage) in the standard deviation (interquartile range) of MRK associated with an increase in FVAD is greater in the export-intensive industry, by about 21 percentage point (pp) (about 12 pp), than in the non-export-intensive industry; this is our main difference-in-different estimate. These findings indicate that the export channel is operative: An increase in FVAD reduces the degree of resource misallocation by a factor that is disproportionately greater for the export-intensive industry. Our findings are robust to how the dispersion of MRK is measured: (i) standard deviation; and (ii) the interquartile range.

The same is also true for the comparison between industries differing in the import intensity: for the import-intensive industry, the dispersion of MRK is negatively associated with FVAD to a magnitude greater than for the non-import-intensive industry. For the import-intensive industry, the reduction in the standard deviation (interquartile range) of MRK associated with a rise in FVAD is greater, by 19 pp (25 pp), than for the non-import-intensive industry. These findings suggest that the import channel is also operative in propagating an increase in FVAD to the degree of resource misallocation.

We further examine how the magnitude of such a negative association between FVAD and MRK dispersion (conditional on the export (import) intensity being high) is different between a group of high-productivity firms and another group of all firms unconditional on productivity (i.e., triple-difference estimate). Interestingly, we find a substantial difference in this quantity between export- and import-intensive industries. The negative association between FVAD and MRK dispersion of the export-intensive industry (relative to that of the non-export-intensive industry) is of magnitude disproportionately greater for the high-productivity firms (than all firms unconditional on productivity) by 7 pp. This suggests that the export channel is operative mainly via high-productivity firms that are more likely to actively participate in the export.

By contrast, the negative association between FVAD and MRK dispersion of the import-intensive industry (relative to that of the non-import-intensive industry) is of magnitude disproportionately smaller for the high-productivity firms (than all firms unconditional on productivity) by 8.5 pp. This suggests that the import channel is operative mainly via low-productivity firms that are more likely to use the imported goods/services to compete against the leading firms in the industry.

Taken together, our findings suggest that a rise in the importance of the GVC could improve a country's productivity by reducing the degree of resource misallocation. This is due to the following reasons: Increased international integration in the production of goods and services would lead to greater specialization and division of production. Firms can focus on the production stage in which they have a competitive advantage by outsourcing other production stages to global suppliers. Thus, high-productivity firms can increase their exports to the global market, whereas low-productivity firms can compete with the leaders by importing high-quality components essential to their businesses; this would increase the degree of competition and thus discipline firms to use resources more efficiently. Importantly, we discover that the effects of increasing the industry-specific importance of GVC on the efficiency of resource allocation differ across industries/firms, implying that detailed market conditions should be taken into account, both by the government and by managers, in order to fully exploit the opportunities provided by the GVC.

The remainder of this paper proceeds as follows. Section 2 discusses the theoretical background, the model of the resource misallocation, how to measure GVC, hypotheses, and the methodology of empirical analysis. Section 3 presents the data and results. Section 4 concludes.

2. Theoretical Background and Model

2.1. Theoretical Background

We review the literature on the two topics: (i) measuring the GVC and (ii) misallocation of resources. We begin by reviewing the literature on measuring the GVC. To track the changes in competitiveness on the global value chains, many studies have attempted to develop a measure of international fragmentation. The seminal paper of Feenstra and Hansen (1999) first developed it by proposing a measure defined as the share of imported intermediate inputs in the value of all intermediate inputs used in a particular country, and providing simple information on the domestic and the foreign origin intermediate. Hummels et al. (2001) constructed alternative measures of the foreign content in a country's exports, also known as vertical specialization. Based on a country's input–output (IO) table, those papers fail to measure an economy's participation in cross-border production chains. Additionally, using gross output or exports may not be appropriate to gauge the value of the production activities conducted in each country. Henceforward, a burgeoning amount of literature has introduced alternative measures covering both international fragmentation within regions and global fragmentation across regions based on the GVC perspective (including bilateral trade) (see, e.g., Johnson and Noguera, 2012; Timmer et al., 2013, 2014; Wang et al., 2013; Koopman et al., 2014; Baldwin and Lopez-Gonzalez, 2015). On its relationship with productivity, Banh et al. (2020) explored the impact of GVC participation on productivity in Estonia and found that higher GVC participation at the industry level significantly boosts productivity at both the industry and the firm level. As an application to Korea, Chung (2016) concluded that Korea radically internationalized its production activities during the sample period, widening the gap between gross and value-added exports, based on GVC-related measures.

We turn to discuss the literature on misallocation of resources (Restuccia and Rogerson, 2008). In a seminal paper, Hsieh and Klenow (2007) introduced a simple framework based on the growth model to measure productivity losses by resource misallocation in manufacturing sectors in a sample of each country including the U.S., China, and India. They influence several applications to other countries have concluded that misallocation can be responsible for significant productivity losses (Benjamin and Meza, 2009; Sandleris and Wright, 2014; Hallward-Driemeier and Rijkers, 2013). Oberfield (2013) studied the relationship between productivity and misallocation in Chile during a crisis and concluded that both capital and labor misallocation could reduce productivity. Chen and Irarrazabal (2015) showed that Chile's banking reform has played a key role in the observed improvement in allocative efficiency after the 1982 financial crisis. Dai et al. (2016) explored whether factor misallocation will influence aggregate productivity of Portugal and came to the same conclusion that capital and labor misallocation would negatively affect the productivity. Inklaar et al.(2017) attempted to compare the role of gaps in misallocation in cross-country productivity differences and found that most countries would benefit from reducing the degree of resource misallocation to the level observed in the United States. Regarding capital market liberalization, recent literature has examined whether international capital inflows, such as FDI, influence domestic firms' productivity and misallocation (See Gopinath et al., 2017; Varela, 2017; Larrain and Stumpner, 2017).

2.2. The Baseline Model

In this section, we adopt the framework developed by Hsieh and Klenow (2009) ("HK" hereafter) to calculate the firm- and industry-level degree of resource misallocation. We extend the standard HK model of monopolistic competition with heterogeneous firms, by assuming that firms are grouped by GVC participation, which leads to changes in the input–output structure of production factors. There are two types (groups) of firms that differ in the degree of foreign value-added contribution to the production of the industry's final good output: large versus small contribution of value-added by foreign firms.

A representative firm produces a single final good Y in a perfectively competitive market. The gross output Y is produced by combining the output Y_s of S manufacturing industries using a Cobb-Douglas production technology:

$$Y = \prod_{s=1}^{S} Y_s^{\theta_s} \tag{1}$$

The industry share θ_s is defined by P_sY_s/PY, where $\sum_{s=0}^{S} \theta_s = 1$. P and P_s are the prices of Y and Y_s, respectively. Y is the numeraire, and hence its price is one: $P = 1$. Each industry output Y_s is produced by combining M_s number of differentiated goods Y_{si} using a CES technology with the elasticity of substitution between Y_{si} of σ:

$$\mathrm{Y_s} = \left(\sum_{i=1}^{M_s} \mathrm{Y_{si}}^{\frac{\sigma-1}{\sigma}}\right)^{\frac{\sigma}{\sigma-1}}. \tag{2}$$

The assumptions of free entry and monopolistic competition at the industry level imply inverse demand equations for each individual variety equal to: $P_{si} = Y_s^{\frac{1}{\sigma}} P_s (Y_{si})^{\frac{-1}{\sigma}}$. Each variety *si*'s production function is of Cobb-Douglas form:

$$Y_{si} = A_{si} K_{si}^{\alpha_s} L_{si}^{1-\alpha_s}, \tag{3}$$

where A_{si}, K_{si}, and L_{si} denote firm si's total factor productivity, capital stock, and labor, respectively. α_s is capital share and varies across industries *s* but not across firms within the same industry.[2] Firm si's profit is given by

$$\pi_{si} = (1-\tau_{Ysi}) P_{si} Y_{si} - W_s L_{si} - (1+\tau_{Ksi}) R_s K_{si}, \tag{4}$$

where W_s and R_s stand for the user costs of capital and labor, respectively. τ_{Ysi} and τ_{Ksi} are tax (subsidy) wedge of output and capital markets, respectively, which allow us to separately identify distortions that influence each market by measuring how various distortions affect a firm's profit. The output wedge τ_Y denotes any distortion that changes the marginal product of capital and labor by the same proportion. The capital market wedge τ_K denotes any distortion that raises the marginal product of capital relative to the marginal product of labor. A firm's profit maximization results imply that the firm's output price is a fixed markup over the marginal cost. The marginal revenues of capital and labor (labeled *MRK* and *MRL*, respectively) are given by the following[3]:

$$MRK_{si} \equiv \left(\frac{\sigma-1}{\sigma}\right) \alpha_s \frac{P_{si}Y_{si}}{K_{si}} = R_s \frac{1+\tau_{Ksi}}{1-\tau_{Ysi}},$$

$$MRL_{si} \equiv \left(\frac{\sigma-1}{\sigma}\right) (1-\alpha_s) \frac{P_{si}Y_{si}}{L_{si}} = W_s \frac{1}{1-\tau_{Ysi}} \tag{5}$$

[2] In the data, firm *i*' s variables are averaged at a four-digit industry level.

[3] "Marginal revenue of capital (labor)" in this paper corresponds to "marginal revenue product of capital (labor)" in Hsieh and Klenow (2009).

Equation (5) allows us to estimate the two types of wedges of production factor markets given gross output, input costs and parameters— σ and α_s. To measure the allocative inefficiency of each factor market in real terms, we compare the value of the marginal product of a production factor (i.e., marginal revenue of capital) of a firm si with its (weighted) average across firms in the industry s. The weighted averages of the marginal revenue of capital and labor, respectively, in industry s are written as follows[4]:

$$\overline{MRK_s} \equiv \frac{R_s}{\sum_{i=1}^{M_s}\left(\frac{1-\tau_{Ysi}}{1+\tau_{Ksi}}\right)\frac{P_{si}Y_{si}}{P_sY_s}} \text{ and } \overline{MRL_s} \equiv \frac{W_s}{\sum_{i=1}^{M_s}(1-\tau_{Ysi})\frac{P_{si}Y_{si}}{P_sY_s}}. \tag{6}$$

Notice that the average values are weighted by revenue, $P_{si}Y_{si}$. Using industry s price deflators, we identify how many production input factors more (or less) allocated to a firm si compared to the corresponding industry-level average. That is, the allocative inefficiency of capital and labor markets is measured as $MRK_{si}/\overline{MRK_s}$ and $MRL_{si}/\overline{MRL_s}$, respectively. Similarly, we measure improvement in the firm's productivity in real terms, total factor quantity productivity (TFP), by using $TFP_{si}/\overline{TFP_s}$. It indicates how many units of output a firm can produce by using one unit of mix of production factors. Firm si's productivity TFP_{si} is defined as follows:

$$\mathrm{TFP_{si}} = \mathrm{A_{si}} = \frac{\mathrm{Y_{si}}}{\mathrm{K_{si}^{\alpha_s}L_{si}^{1-\alpha_s}}}. \tag{7}$$

The average of$\mathrm{TFP_{si}}$ in industry s, denoted by $\overline{TFP_s}$, is defined as[5]:

$$\overline{TFP_s} = \overline{A_s} = \left(\sum_{i=1}^{M_s} A_{si}^{\sigma-1}\right)^{\frac{1}{\sigma-1}} = \left(\sum_{i=1}^{M_s} TFP_{si}^{\sigma-1}\right)^{\frac{1}{\sigma-1}}. \tag{8}$$

2.3. Measuring the Global Value Chain Participation

We discuss the industry-specific importance of GVC. As in the baseline model of GVC (Los et al., 2015), firm si's output Y_{si} is linked to the GVC networks: input factors in the production of Y_{si} can be supplied through international production chains over the world. Firm si's production pattern is determined by the GVC structure of industry s to which firm si belongs. We compute the value-added in Korea and the value added abroad in each production stage by exploiting international input–output tables that cover the world economy. The model enables us to calculate the industry-level contribution of foreign value added (FVAD), measuring the degree to which production in foreign countries contributes to the production of final goods in the given industry in Korea; we use FVAD as our measure of the industry-specific importance of GVC, determining the industry-specific exposure of firm si to competition against other firms.

First, we must define and measure the degree of fragmentation of production chains between one country and the rest of the world. For this purpose, we adopted the decom-

[4] For a technical reason discussed in Hsieh and Klenow (2009) and its subsequent errata, the industry-level average of MRK is actually the reciprocal of the weighted average of the firm-level MRK. For more details, see discussion in Hsieh and Klenow (2009) and its subsequent errata.

[5] For procedures to derive the results in (8) from (7), see pages 5–6 in Chee and Jung (2015) and page 1410 in Hsieh and Klenow (2009).

position strategy suggested by Timmer et al. (2014) and Los et al. (2015). This is based on the world input–output tables (WIOTs), an outcome of the World Input–Output Database (WIOD) project that develops the accounting model frameworks to understand the degree of global integration. WIOTs track the trade flow of intermediate and final goods across countries and industries. Fig. 1 illustrates the structure of WIOTs.

Fig. 1. The structure of the world input–output tables (WIOTs).

	Intermediate use (S columns per country)			Final use (C columns per country)			Total
	1	⋯	N	1	⋯	N	
S industries, country 1	Z^{11}	$Z^{1.}$	Z^{1N}	F^{11}	$F^{1.}$	F^{1N}	X^{1}
⋯	$Z^{.1}$	$Z^{..}$	Z^{N}	$F^{.1}$	$F^{..}$	F^{N}	$X^{\cdot}$
S industries, country 1	Z^{N1}	$Z^{N.}$	Z^{NN}	F^{N1}	$F^{N.}$	F^{NN}	X^{N}
Value added	$(w^{1})'$	⋯	$(w^{N})'$				
Output	$(X^{1})'$	⋯	$(X^{N})'$				

Note: Z^{ij} refers to the intermediate sales from the i-th row to the j-th column, F^{ij} the final sales from the i-th row to j-th final demand category (macroeconomics totals), w^{j} the value added by j-th column's industry, X^{i} the total output of the i-th row's industry.

The WIOTs illustrated in Fig. 1 provides information on how much the good produced in the *i-th* industry-country pair (denoted by i-th row in the table) is used by j-th industry-country pair (denoted by j-th column in the table). Thus, for the *i-th* row in the table, adding up across all of the j-th industry-country column yields X^{i}, the total use of the good produced by the *i-th* industry-country pair.

More specifically, there are N countries. Each country is made up of S industries and C categories of final demand. Consider a value chain, which consists of activities in industries $\mathrm{s} = 1, \dots, \mathrm{S}$ in each country $\mathrm{n} = 1, \dots, \mathrm{N}$. For the choice of a specific final output matrix F of dimension $(SN \times CN)$, the final output is obtained by multiplying F (a final demand block) by a CN summation vector e.

By using the Leontief inverse, we measure the value added contribution in all tiers of both domestic and international suppliers. The $(SN \times SN)$-matrix A contains intermediate input coefficients, which are made by dividing the cells of the columns with intermediate by their total production. That is, $\mathrm{A} = \mathrm{Z}\hat{x}^{-1}$, where $\hat{x}$ is a diagonal matrix converted from the column vector x indicating domestic industry gross output (the last "Total" column in table of Fig. 1). Z is an intermediate-input block. The $(s_1 n_1, s_2 n_2)$ element of the matrix A gives the intermediate inputs produced by the industry s_1, the country n_1, required by per unit of gross output of (s_2, n_2). Similarly, the (SN)-vector v is obtained by $\mathrm{v}' = \mathrm{w}'\hat{x}^{-1}$, and represents the value added per unit of gross output. Let $\hat{\mathrm{v}}$ denote a diagonal matrix of the vector with value added over gross output ratios, for each country-industry. Notice that the elements of an SN vector $\hat{\mathrm{v}}Fe$ represent value-added generated in the final stage and are equal to zero for all industries other than (s, n). (For detailed discussion, see the appendix in Los et al. (2015).)

The Leontief inverse $(I - A)^{-1}$ gives information on value-added contributions in all tiers of suppliers. The total contribution of value-added g on the GVC networks can be calculated as follows:

$$g = \sum_{k=1}^{\infty} g^{k} = \hat{\mathrm{v}}(I - A)^{-1}(Fe) \tag{9}$$

where g indicates an $(S \times N)$-vector of value-added created by the GVC networks. The vector g contains the matching value-added contributions $VA(k)(s,n)$ by country k in production for each (s,n). Next, we derive the final output value of the product of (s,n), $FINO(s,n)$ by aggregating value-added contributions, $VA(k)(s,n)$, of all countries.

$$FINO(s,n) = \sum_k VA\,(k)(s,n). \tag{10}$$

Using $FINO(s,n)$, we can calculate the sum of value-added contributions by foreign countries other than the country-of-completion n, defined as foreign value-added (*FVA*):

$$FVA(s,n) = \sum_{k \neq n} VA\,(k)(s,n) = FINO(s,n) - VA(n)(s,n). \tag{11}$$

We define the contribution of foreign countries to the final output value (i.e., value-added share generated outside the country-of-completion), labeled *FVAD*, as the following:

$$FVAD(s,n) = FVA(s,n)/FINO(s,n). \tag{12}$$

We use *FVAD* as a measure of the industry-specific importance of GVC[6], as $FVAD$ increases with the degree of international fragmentation; $FVAD$ is zero if all value added is generated domestically. *FVAD* is based on the value added in each production stage: the gross output at the end of the stage minus the intermediate inputs in that stage.[7]

2.4. Hypothesis

Recent studies that assess the degree of resource misallocation in Korea's manufacturing industries are the motivation of the present study. Using the Korean data, Chee and Chung (2015) find that (i) capital distortions are more important than labor and output distortions in explaining potential aggregate productivity/efficiency gains and (ii) high-productivity firms tend to use less capital than the optimal: a high level of dispersion in MRK conditional on high-productivity firms. According to Oh (2016), the MRK dispersion is primarily due to subsidies to unproductive small-sized establishments. Despite the importance of GVC networks and trade in shaping Korea's business environment, how the allocative efficiency is related to GVC networks has received little attention. We aim to fill this void in this paper.

More specifically, we explore the main hypothesis that GVC can increase a firm's exposure to competition and hence discipline firms to use resources more efficiently, thereby improving the allocative efficiency. The reason is as follows: A high degree of the fragmentation of production chains throughout the world means a high degree of specialization/division of production across production units around the globe; therefore, it provides (domestic) firms with both opportunities and challenges.

First, a firm with the world-wide advantage in a specific production stage can access the larger market and hence be willing to use its production facilities that would not be otherwise used fully, labeled *export channel*. Second, by outsourcing less productive stages of production via GVC, a firm can concentrate on the more productive stages of production (i.e., increased

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[6] The value-added share generated inside the country-of-completion n is defined as follows: $DVAD(s,n) = 1 - FVAD(s,n)$.

[7] Therefore, it does not suffer from double-counting problems encountered in the case of using the gross output rather than value added.

degree of specialization); this would enable such a firm to overcome the overall productivity gap and compete more aggressively against the leading firm, labeled *import channel*. These two channels are likely to increase a firm's exposure to competition so that the degree of an industry's dependence on GVC can reduce the industry's degree of resource misallocation (e.g., dispersion of MRK). Therefore, the higher the industry's export (import) intensity, the greater the magnitude of the reduction in MRK-dispersion associated with a rise in GVC. This is the main hypothesis.

Hypothesis 1*: GVC increases the degree of competition among firms and hence reduces the extent to which resources (i.e., capital) are misallocated across firms: that is, FVAD negatively affects the dispersion of MRK. In particular, the effect of GVC on the dispersion of MRK is of magnitude that is disproportionately greater in the export (import) intensive industry than in other industries.*

Motivated by the findings of Chee and Chung (2015), we also examine whether the association between GVC and the dispersion of MRK is disproportionately greater conditional on high-productivity firms. For instance, in the case of the export channel discussed above, we expect that among exporting firms, the high-productivity firm would have the stronger incentive and capability to use the opportunities offered by a rise in GVC than the low-productivity firm does.

Hypothesis 2*: The differential effect of GVC on export (import)-intensive industry's MRK dispersion is of magnitude disproportionately greater for high-productivity firms.*

Using a distribution of micro-level firm data, we examine the hypotheses above for the export-intensive and import-intensive firms, relative to other firms, and unconditional and conditional on firm-level productivity, respectively.

2.5. Methodology

This paper's primary goal is to empirically examine how the variation in the industry-level degree of resource misallocation (e.g., dispersion of MRK across firms) is associated with the variation of the industry-specific importance of GVC (measured as FVAD). Note that our dependent variable is a dispersion of MRK at the industry level (across firms within a given industry) and thus observable at the *industry* level. As a result, the number of sample observations (i.e., industries) for a given year is small. Hence, regression analysis is not appropriate for our needs.

Our approach is as follows: We categorize industries based on various characteristics (e.g., export intensity), which are closely related to the driving forces discussed in our hypotheses. We investigate how the average MRK-dispersion of such sorted industries is related to the characteristics used to sort them. For example, we compare how the dispersion of MRK differs between high- and low-FVAD industries, which is further differentiated between high- and low-export intensity industries (i.e., difference-in-difference estimate) to control for the effects of other characteristics that may covary with FVAD. Our method allows us to investigate whether specific mechanisms (e.g., differential effect for export-intensive industries versus non-export-intensive industries) are operative when determining the association between FVAD and MRK-dispersion.

We calculate differences in industry-level dispersion of MRK between various groups of industries (sorted by export (import)-intensity, FVAD, and productivity, respectively) for a given sample year, which are then averaged across sample years. For example, we compute differences in MRK-dispersion between high- and low-FVAD industries, as well as their differences between export-intensive and non-export-intensive industries (i.e., difference-in-difference).

Industries are categorized as follows: We calculate the median of FVAD and export intensity for a given year, and then classify whether an industry's FVAD is greater than the median of FVAD or not; we do the same for export intensity.

By doing so, we have four groups of industries sorted by FVAD and export intensity for a given year. Similarly, by replacing the export intensity with the import intensity, we also classify (for a given year) an industry into the four groups of industries sorted by FVAD and import intensity. Table A in the appendix lists the characteristics used in sorting industries.

We can further sort firms by firm-level productivity $\log(A_{si}/\overline{A_s})$: above and below the median of $\log(A_{si}/\overline{A_s})$ for a given year. This would yield eight groups of industries sorted by FVAD, export (import) intensity, and productivity.

3. Empirical Results

3.1. The Data

Our primary data source to measure allocative inefficiency at the firm level is the Census on Establishments of Mining and Manufacturing Sectors from the Statistics of Korea, which covers all establishments (with at least ten employees) that are doing business activities in mining and manufacturing industries in Korea. We choose the sample period of 2000–2014 for establishments to avoid measurement errors in the age information of each establishment or firm in the earlier sample period. The unit of observation in our sample is a business establishment. In the final sample, from 2000 to 2014, 209,259 observations correspond to average 36,152 different establishments per year. The dataset includes gross output, value added, consumption of intermediate inputs, labor costs (wages and benefits including social security contributions), number of employees, the book values of tangible fixed assets, inventory, and date of foundation.

We use gross output as a firm output Y_{si}. Capital stock is an average of the beginning- and the end-of-the-year values of tangible fixed assets. Labor is measured as worker compensation labor cost including social benefits, to capture labor quality.[8] For the industry-level factor share, we use a yearly factor share averaged at the two-digit industry level, where the factor share is defined as the ratio of the input factor to the value added. Before measuring allocative inefficiency, we trim the 1% tails of $\log(A_{si}/\overline{A_s})$ across industries.

The secondary data source to measure FVAD is WIOTs. We obtain industrial value-added for all countries from the WIOT's 2016 release; this version of the WIOTs covers 43 countries and 56 industries (19 manufacturing and 33 service industries) covering the period from 2000 to 2014. The industrial definition used in the WIOT is more aggregated than that in the KSIC9. We sum up the Census on Establishments of Mining and Manufacturing Sectors according to Chung (2016), and then merged the two datasets.[9]

[8] The data on worker compensation include both the salaries and other labor costs such as pension contributions or fringe benefits.

[9] For the industry classification in the WIOT and corresponding KSIC9, refer to the appendix of Chung

Export intensity is measured as the ratio of the value of final goods exported (to foreign countries) to the final output value of product of (s, n) by summing rows of WIOTs. Similarly, import intensity is measured as the ratio of the value of intermediate inputs imported from abroad to the final output value of (s, n) by summing columns of WIOTs.

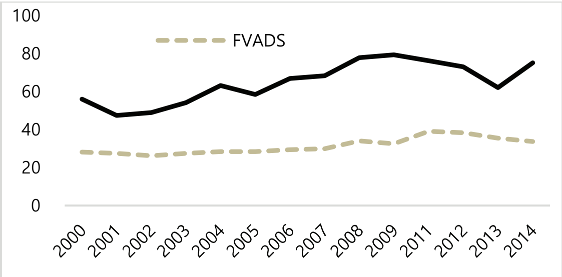
Table 1 presents the descriptive statistics of key variables, $\log(MRK_{si}/\overline{MRK_s})$, $\log(MRL_{si}/\overline{MRL_s})$, $\log(A_{si}/\overline{A_s})$, FVAD, export intensity, and import intensity. Fig. 2 plots the trend of FVAD and aggregate total factor productivity (TFP) gains. We compute the aggregate TFP gains by using the equation (15) in Hsieh and Klenow (2009): it is the ratio of efficient TFP to observed TFP, where efficient TFP refers to the potential TFP that would be realized if distortions (i.e., MRK dispersion and MRL dispersion) are eliminated from the economy. Fig. 2 shows that FVAD is highly correlated with aggregate TFP gains. (Their correlation coefficient is 0.753.) Efficiency gains would be disproportionately greater for the industry depending more on GVC. As such, when GVC rises, we investigate which industry's efficiency gain would be greater.

Table 1. Descriptive Statistics of Key Variables, 2003–2014.

Variable	Observation	Average	Median	Std Dev.	Min	Max
$\log(MRK/\overline{MRK})$	762,961	0.5969	0.3730	1.2851	−3.2469	7.2124
$\log(MRL/\overline{MRL})$	762,961	−0.2164	−0.2382	0.5094	−4.4279	5.0852
TFP: $\log(A/\bar{A})$	762,961	−1.070	−1.080	1.076	−6.205	3.070
FVAD (%)	270	33.1	29.8	12.9	17.8	85.1
Export Intensity (%)	270	20.8	17.6	14.4	1.3	63.9
Import Intensity (%)	270	22.5	18.3	15.2	10.0	85.7

Source: Authors' calculation using WIOT's 2016 release and Census on Establishments of Mining and Manufacturing Sectors, the Statistics of Korea.

Fig. 2. Trend of FVAD and Model-Implied Aggregate TFP Gains (Unit: %)



Note: FVAD (dashed line) measures the extent to which the foreign firm's contribution to the production of the final good is important relative to that of a domestic firm. TFP gains (solid line) refer to the aggregate productivity gains of counterfactually removing resource misallocation (i.e., zero dispersion of MRK) as in equation (15) in Hsieh and Klenow (2009).

Source: Authors' calculation using WIOT's 2016 release and Census on Establishments of Mining and Manufacturing Sectors, provided by the Statistics of Korea.

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3.2. Results

This section discusses our main results. For the reason discussed earlier, we calculated the difference in MRK-dispersion between an industry with a higher FVAD (than the median) and that with a lower FVAD (than the median), especially the difference between the export-intensive (import-intensive) industries and other industries (i.e., difference-in-difference). Moreover, we also examine how the magnitude of the reduction in MRK-dispersion associated with a rise in FVAD is different between a group of high-productivity firms and all firms unconditional on productivity.[10]

Table 2 shows the MRK dispersion for industries sorted by FVAD and export intensity (import intensity) on average over the sample years. More specifically, for a given sample year, we sort firms/industries and calculate the average industry-level dispersion of MRK across industries for the given portfolio of sorted industries (results for each year are presented in Tables BE in the appendix), and the average over the sample years is presented in Table 2. In particular, the column headed "% Diff (3)" provides the percentage change in the dispersion of MRK.

Table 2. FVAD and MRK Dispersion: Export (Import)-Intensive versus Other Industries, 2003–2014

Industry Characteristic	SD of MRK			IQR of MRK		
	Less FVAD (1)	More FVAD (2)	% Diff (3) = 100*[(2)–(1)]/(1)	Less FVAD (4)	More FVAD (5)	% Diff (6) = 100*[(5)–(4)]/(4)
Panel A: Export Intensity, For All Firms						
High	1.303	1.184	−9.187	1.732	1.491	−13.942
Low	1.282	1.437	11.794	1.700	1.673	−1.594
High–Low			−20.981			−12.348
Panel B: Export Intensity, Conditional on High-Productivity Firms						
High	1.181	1.105	−6.412	1.739	1.545	−11.035
Low	1.156	1.409	21.483	1.679	1.934	14.470
High–Low			−27.895			−25.504
Panel C: Import Intensity, For All Firms						
High	1.429	1.296	−9.529	2.067	1.561	−24.164
Low	1.263	1.367	9.005	1.698	1.707	0.446
High–Low			−18.534			−24.610
Panel D: Import Intensity, Conditional on High-Productivity Firms						
High	1.205	1.240	2.383	1.764	1.695	−3.992
Low	1.171	1.294	12.433	1.713	1.826	7.707
High–Low			−10.050			−11.699

Note: This table presents, on average over the sample years of 2003–2014, dispersion of MRK for industries sorted by FVAD and export intensity (import intensity), respectively. "SD" refers to the standard deviation, "IQR" the interquartile range (i.e., difference between 75th percentile and 25th percentile). The row headed "High–Low" presents the difference-in-difference estimate of the association between FVAD and dispersion of MRK.

Source: Authors' calculation using WIOT's 2016 release and Census on Establishments of Mining and Manufacturing Sectors, the Statistics of Korea. Observations in 2010 are missing because the census was not conducted in 2010.

[10] In this paper, we do not discuss the dispersion of MRL much because the dispersion of MRL is likely to be subject to measurement errors due to the poor data on labor costs (Chee and Jung, 2015).

We obtained the following findings. The dispersion of MRK is negatively associated with an increase in FVAD (i.e., the difference in MRK-dispersion between the high- and low-FVAD industries) to a greater magnitude in the export-intensive industry than in the non-export-intensive industry. More specifically, as shown in Panel A of Table 2, the reduction (in percentage) in the standard deviation (interquartile range) of MRK associated with an increase in FVAD is greater in the export-intensive industry, by about 21 pp (about 12 pp), than in the non-export-intensive industry. These findings imply that the export channel, which connects an increase in FVAD to a decrease in the degree of resource misallocation, is operational: a rise in GVC provides a disproportionately greater incentive to export-intensive firms to use resources efficiently than to non-export-intensive firms.

The same is true when comparing industries that differ in their import intensity: in the import-intensive industry, the MRK dispersion is negatively associated with an increase in FVAD to the extent greater than in the non-import-intensive industry. More specifically, Panel C of Table 2 shows that the reduction in the standard deviation (interquartile range) of MRK associated with an increase in FVAD is greater in the import-intensive industry, by about 19 pp (about 25 pp), than in the non-import-intensive industry. These findings suggest that the import channel is also at work in linking an increase in FVAD to a reduction in the degree of resource misallocation: an increase in GVC provides import-intensive firms with a disproportionately greater incentive to use resources efficiently than non-import-intensive firms.

Furthermore, we investigate how the magnitude of such a negative relationship between FVAD and the MRK dispersion (conditional on the export- and import-intensity industry) differs between a group of high-productivity firms and the other group of all firms unconditional on productivity. In this comparison, we discover a significant difference between export- and import-intensive industries.

For example, the negative relationship between FVAD and the MRK dispersion in the export-intensive industry (relative to the non-export-intensive industry) is disproportionately greater for high-productivity firms (than for all firms unconditional on productivity), by about 7 pp (13 pp) in the case where the MRK dispersion is measured as the standard deviation (interquartile range) of MRK.

More specifically, the difference in the change in the standard deviation (interquartile range) of MRK associated with an increase in FVAD (from low to high values) between the export-intensive industry and the non-export-intensive industry is −20.98 pp (−12.35 pp), reported in Panel A of Table 2, for all firms (unconditional on the productivity), while the counterpart conditional on high-productivity firms is −27.90 pp (−25.50 pp), reported in Panel B of Table 2. Thus, the reduction in MRK-dispersion associated with a rise in FVAD for the export-intensive industry (relative to that for the non-export-intensive industry) is of magnitude disproportionately greater for the high-productivity firms (than for all firms unconditional on productivity). This finding suggests that the export channel is operative mainly via high-productivity firms that are more likely actually to participate in the export.

By contrast, for the comparison between the import-intensive and non-import-intensive industries, the negative association between FVAD and MRK-dispersion of the import-intensive industry (relative to that of the non-import-intensive industry) is of magnitude disproportionately *smaller* for the high-productivity firms (than for all firms unconditional on productivity), by about 8.5 pp (13 pp) when the MRK dispersion is measured as the standard deviation (interquartile range) of MRK. More specifically, the difference in the change in the standard deviation (interquartile range) of MRK associated with a rise in FVAD (from low to high values) between the import-intensive industry and the non-import-intensive industry is −18.53 pp (−24.61 pp), reported in Panel C of Table 2, for all firms (unconditional on productivity), while the counterpart conditional on high-productivity firms is −10.05 pp (−11.70 pp), reported in Panel D of Table 2. Thus, the import-intensive industry's MRK-dispersion reduction associated with a rise in FVAD (relative to that of the non-import-intensive industry) is disproportionately smaller for the high-productivity firms (than for all firms unconditional on productivity). This finding suggests that the import channel is operative mainly via low-productivity firms that are more likely to actually use the imported goods/services to compete against the leading firm.

Taken together, our findings suggest that a rise in GVC (measured as FVAD) would provide the opportunities to improve a country's productivity by reducing the degree of resource misallocation for the reason as follows: The increased degree of international integration in the production of goods and services means an increased degree of specialization and division of production. Firms can focus on the production stage in which they have their competitive advantages, by outsourcing other production stages to suppliers over the world. This would increase the degree of competition and, hence, discipline firms to use resources more efficiently, reducing the MRK dispersion. Importantly, the magnitude of such an effect depends on the characteristics of firms/industries. More specifically, high-productivity firms can increase their exports to the world market, while the low-productivity firms can compete with the leading firms by importing the high-quality components essential to their businesses.

As a result, in the export-intensive industry, the effect of an increase in GVC on resource allocation improvement would be disproportionately greater for high-productivity firms (than for low-productivity firms), whereas in the import-intensive industry, it would be disproportionately greater for low-productivity firms. GVC can benefit some businesses while harming others. Our findings also indicate that there are asymmetric effects of efficiency between firms of different sizes, as firm size is highly correlated with firm productivity.

4. Conclusion

This study investigates how the industry-level MRK dispersion, which represents the degree of resource misallocation across firms, is related to the industry-level importance of GVC. Using the plant-level survey for manufacturing industries, we calculate the difference in the average dispersion of MRK between industries with high versus low importance of GVC, of which difference between export (import)-intensive versus non-export (import)-intensive industries is calculated. These difference-in-difference estimates show that GVC is negatively associated with the MRK-dispersion of the export (import)-intensive industry in comparison to the non-export (import)-intensive industry. Furthermore, we find that the negative association between GVC and the MRK-dispersion of the export-intensive industry (relative to the non-export-intensive industry) is disproportionately greater for high-productivity firms (than for firms unconditional on productivity). The import-intensive industry, on the other hand, exhibits the opposite pattern: the negative association between GVC and the import-intensive industry's MRK-dispersion (relative to the non-import-intensive industry) is disproportionately smaller for high-productivity firms.

Our findings suggest that an increase in the importance of GVC could improve a country's productivity by reducing the degree of resource misallocation. The greater the degree of international integration in the production of goods and services, the greater the degree of specialization and division of production. Firms can focus on the production stage where they have a competitive advantage by outsourcing other production stages to suppliers all over the world, increasing competition and thus playing the role of disciplining firms, reducing resource misallocation. Surprisingly, the magnitude of such an effect would vary by industry and firm, depending on the export and import intensity in shaping their business environment.

Our findings are based on firm- and industry-level analysis, whereas previous findings were based on industry- and country-level analysis. As a result, our paper shed light on the detailed similarities and differences in the challenges and opportunities presented by an increase in GVC across firms with varying productivity and export (import) intensity. More specifically, our findings suggest that in response to an increase in GVC, a firm with a global advantage in a specific production stage can access the larger market and thus be willing to use production facilities that would not otherwise be fully utilized, labeled *export channel*. Importantly, we discover that the export channel operates primarily through high-productivity firms, which are more likely to participate in exports.

Our findings also indicate that an increase in GVC provides firms with the opportunity to outsource less productive stages of production to foreign suppliers via GVC while concentrating on more productive stages of production (i.e., increased degree of specialization); this will enable the firm to overcome the overall productivity gap and compete more aggressively against the leading firm, labeled *import channel*. We discover that the import channel operates primarily through low-productivity firms, which are more likely to use imported goods/services to compete with the leading firms.

Our findings suggest the following business and policy implications: GVC can benefit some businesses while harming others. Our findings also imply, though this is not explicitly addressed in this paper, that there are asymmetric effects of efficiency between firms of different sizes, as firm size is highly correlated with firm productivity. Furthermore, our findings shed light on the design of export-related policies. It is worth noting that, among export-oriented firms, an increase in GVC would provide firms with differential benefits of technological improvement investment: for example, high-productivity firms would benefit more from technological improvement investment (due to their access to a larger global market) than low-productivity firms. As a result, export promotion policies should be designed to provide more assistance to firms that are more likely to benefit from their participation in GVC.

It would be interesting to investigate how an increase in GVC affects firm-level decisions about specializing versus offshoring a variety of production stages, as well as quantify such effects on firm- and aggregate-level productivity. We will save it for later.

References

Baldwin, R. and J. Lopez-Gonzalez (2015), "Supply-Chain Trade: A Portrait of Global Patterns and Several Testable Hypotheses," *The World Economy*, 38 (11), 1682–1721.

Banh, H. T., P. Wingender and C. A. Gueye (2020), *Global Value Chains and Productivity: Micro Evidence from Estonia* (IMF working paper 2020117).

Benjamin, D. and F. Meza, (2009), “Total factor productivity and labor reallocation: the case of the Korean 1997 crisis,” *B.E. Journal of Macroeconomics*, 9(1), 1–41.

Chung, Sung-Hoon (2016), “Korea’s Participation in Global Value Chains: Measures and Implications,” *KDI Journal of Economic Policy*, 38(4), 45-76.

Chee, Chung-Gu and Won-Suk Chung (2015), *Allocative Efficiency and Total Factor Productivity in the Korean Manufacturing sector* (Discussion Paper Series BOKDP No. 2015-2), Bank of Korea.

Chen, K. and A. Irarrazabal (2015), “The Role of Allocative Efficiency in a Decade of Recovery,” *Review of Economic Dynamics*, 18(3), 523-550.

Dias, D. A., C. R. Marques and C. Richmond (2016), “Misallocation and productivity in the lead up to the Eurozone crisis,” *Journal of Macroeconomics*, 49, 46-70.

Feenstra, R. C. and G. H. Hanson (1999), “The Impact of Outsourcing and High-Technology Capital on Wages: Estimates for the United States, 1979–1990.” *The Quarterly Journal of Economics*, 114(3), 907–940.

Gopinath, G., S. Kalemli-Ozcan, L. Karabarbounis and C. Villegas-Sanchez (2017), “Capital allocation and productivity in south Europe,” *The Quarterly Journal of Economics*, 132(4), 1915-1967.

Hallward-Driemeier, M. and B. Rijkers (2013), “Do Crises Catalyze Creative Destruction? Firm-level Evidence from Indonesia,” *The Review of Economics and Statistics*, 95(1), 1788–1810.

Hsieh, C. and P. Klenow (2009), “Misallocation and Manufacturing TFP in China and India,” *The Quarterly journal of Economics*, 124(4), 1403-1448.

Hummels, D., J. Ishii and K. Yi (2001), “The Nature and Growth of Vertical Specialization in World Trade,” *Journal of International Economics*, 54(1), 75-96.

Inklaar, R., A. A. Lashitew and M. P. Timmer (2017), “The Role Of Resource Misallocation In Cross-Country Differences In Manufacturing Productivity,” *Macroeconomic Dynamics*, 21(3), 733-756.

Johnson, R. C. and G. Noguera (2012), “Accounting for Intermediates: Production Sharing and Trade in Value Added,” *Journal of International Economics*, 86(2), 224-236.

Koopman, R., Z. Wang and S. J. Wei (2014), “Tracing Value-Added and Double Counting in Gross Exports,” *American Economic Review*, 104(2), 459-494.

Larrain, M. and S. Stumpner (2017), “Capital account liberalization and aggregate productivity: The role of firm capital allocation,” *The Journal of Finance*, 72(4), 1825–1858.

Los, B., M. P. Timmer and G. J. de Varies (2015), “How Global Are Global Value Chains? A New Approach to Measure International Fragmentation,” *Journal of Regional Science*, 55(1), 66-92.

McKinsey Global Institute (2019), *Globalization in transition: The future of trade and value chains*.

Oberfield, E. (2013), “Productivity and misallocation during a crisis: Evidence from the Chilean crisis of 1982,” *Review of Economic Dynamics*, 16(1), 110-119.

Oh, Ji-Yoon (2016), “Misallocation and Manufacturing TFP in Korea,” *KDI Journal of Economic Policy*, 38(3), 37-52.

OECD (2013), *Interconnected Economies: Benefitting from Global Value Chains*, OECD Publishing.

OECD (2018), *The changing nature of international production: Insights from Trade in Value Added and related indicators*, OECD Publishing.

Restuccia, D. and R. Rogerson, (2008), "Policy distortions and aggregate productivity with heterogeneous establishments,” *Review of Economic Dynamics*, 11(4), 707–720.

Sandleris, G. and M.L.J. Wright, (2014), “The costs of financial crises: resource misallocation, productivity and welfare in the 2001 Argentine crisis,” *Scandinavian Journal of Economics*, 116(1), 87–127.

Timmer, M. P., B. Los, R. Stehrer and G. J. de Varies (2013), “Fragmentation, Incomes and Jobs. An Analysis of European Competitiveness,” *Economic Policy*, 28(76), 613-661.

Timmer, M. P., A. A. Erumban, B. Los, R. Stehrer and G. J. de Varies (2014), "Slicing Up Global Value Chains," *Journal of Economic Perspective*, 28(2), 99-118.

Varela, L. (2017). "Reallocation, competition, and productivity: Evidence from a financial liberalization episode," *The Review of Economic Studies*, 85(2), 1279–1313.

Wang, Z., S. Wei and K. Zhu (2013), *Quantifying International Production Sharing at the Bilateral and Sector Level* (NBER Working Paper, 19677).

Appendix

Table A lists variables/characteristics: how they are constructed at either firm- or industry-level and the criteria by which the characteristics are classified as either "high" or "low" (relative to their median values). Such variables/characteristics and criteria are calculated for a given year. Tables B–E present the detailed results for each sample year, of which averages are reported in Table 2 in the main text.

Table A. Variables/Characteristics and Criteria to Classify Industries

Variable/ Characteristic	Firm/ Industry	Definition	Criteria
Panel A: Variables			
MRK	Firm	Marginal revenue of capital. See equation (5).	NA
Dispersion of MRK (I): SD of MRK	Industry	Benchmark measure of the industry-specific dispersion of MRK across firms: Standard deviation of MRK.	NA
Dispersion of MRK (II): IQR of MRK	Industry	Alternative measure of the industry-specific dispersion of MRK across firms: Interquartile range (i.e., difference between 75th percentile and 25th percentile) of MRK.	NA
Panel B: Characteristics by which firms/industries are sorted			
FVAD	Industry	Ratio of foreign value added to the industry-country pair's final good output. It measures the industry-specific importance of the global value chain. See equation (12).	Median
Export intensity	Industry	Ratio of ratio of the value of final goods exported (to foreign countries) to the final output value for a given industry.	Median
Import intensity	Industry	Ratio of the value of intermediate inputs imported from abroad to the final output value for a given industry.	Median
Productivity (TFP)	Firm	Log of the ratio of the firm-level total factor productivity (TFP) to the industry's average: $\log(A_{si}/\overline{A_s})$. See equation (7) for A_{si} and (8) for $\overline{A_s}$. "High-Productivity" dummy is set to one if the firm's productivity is above the median across firms for a given industry. Statistics conditional on high-productivity firms are calculated for firms with "High-Productivity" dummy set to one.	Median

Table B. FVAD and MRK Dispersion: Export-Intensive versus Other Industries

Year	Industry: Export-Intensive	SD of MRK			IQR of MRK		
		Less FVAD (1)	More FVAD (2)	% Diff (3) = 100*[(2)–(1)]/(1)	Less FVAD (4)	More FVAD (5)	% Diff (6) = 100*[(5)–(4)]/(4)
2003	Yes	1.142	1.044	−8.531	1.562	1.355	−13.224
	No	1.116	1.195	7.126	1.550	1.452	−6.285
2004	Yes	1.161	1.044	−10.065	1.571	1.346	−14.326
	No	1.157	1.257	8.647	1.601	1.505	−6.002
2005	Yes	1.199	1.064	−11.272	1.639	1.371	−16.356
	No	1.208	1.293	7.071	1.651	1.574	−4.640
2006	Yes	1.215	1.117	−8.040	1.605	1.418	−11.646
	No	1.299	1.308	0.708	1.842	1.570	−14.754
2007	Yes	1.264	1.150	−9.042	1.686	1.437	−14.730
	No	1.290	1.335	3.513	1.751	1.602	−8.514
2008	Yes	1.336	1.186	−11.206	1.790	1.504	−15.992
	No	1.264	1.407	11.263	1.650	1.619	−1.903
2009	Yes	1.352	1.189	−12.072	1.846	1.493	−19.120
	No	1.299	1.442	10.982	1.665	1.700	2.097
2011	Yes	1.378	1.268	−7.934	1.779	1.569	−11.821
	No	1.359	1.549	13.980	1.745	1.733	−0.665
2012	Yes	1.397	1.280	−8.381	1.813	1.581	−12.772
	No	1.341	1.590	18.556	1.714	1.757	2.491
2013	Yes	1.442	1.337	−7.315	1.871	1.655	−11.544
	No	1.388	1.691	21.864	1.757	1.898	8.033
2014	Yes	1.445	1.341	−7.196	1.895	1.671	−11.835
	No	1.384	1.744	26.023	1.774	1.998	12.611
Avg	Yes	1.303	1.184	−9.187	1.732	1.491	−13.942
	No	1.282	1.437	11.794	1.700	1.673	−1.594
	Yes–No			−20.981			−12.348

Note: This table presents, for a given year, dispersion of MRK for the four groups of industries sorted by FVAD and export intensity, respectively. "SD" refers to the standard deviation, "IQR" the interquartile range (i.e., difference between 75th percentile and 25th percentile). The row headed "Avg" for the column "Year" presents the results on average over the sample years. The last row headed "Yes–No" presents the difference between export-intensive industries (corresponding to "Yes") and non-export-intensive industries (corresponding to "No"): that is, the difference-in-difference estimate of the association between FVAD and dispersion of MRK.

Source: Authors' calculation using WIOT's 2016 release and Census on Establishments of Mining and Manufacturing Sectors, the Statistics of Korea. Observations in 2010 are missing because the census was not conducted in 2010.

Table C. FVAD and MRK Dispersion: Import-Intensive versus Other Industries

Year	Industry: Import-Intensive	SD of MRK			IQR of MRK		
		Less FVAD (1)	More FVAD (2)	% Diff (3) = 100*[(2)–(1)]/(1)	Less FVAD (4)	More FVAD (5)	% Diff (6) = 100*[(5)–(4)]/(4)
2003	Yes	1.209	1.083	−10.376	1.754	1.394	−20.567
	No	1.126	1.285	14.046	1.539	1.463	−4.965
2004	Yes	1.240	1.087	−12.294	1.817	1.407	−22.565
	No	1.151	1.420	23.423	1.551	1.544	−0.451
2005	Yes	1.301	1.124	−13.623	1.877	1.454	−22.546
	No	1.189	1.448	21.788	1.610	1.626	0.981
2006	Yes	1.348	1.164	−13.668	1.932	1.469	−23.940
	No	1.226	1.448	18.148	1.632	1.596	−2.212
2007	Yes	1.374	1.194	−13.143	1.980	1.491	−24.702
	No	1.257	1.479	17.716	1.666	1.698	1.878
2008	Yes	1.377	1.303	−5.372	1.968	1.547	−21.392
	No	1.311	1.275	−2.745	1.725	1.795	4.040
2009	Yes	1.491	1.323	−11.242	2.017	1.574	−21.996
	No	1.330	1.290	−3.029	1.770	1.708	−3.497
2011	Yes	1.564	1.421	−9.133	2.122	1.629	−23.204
	No	1.366	1.345	−1.530	1.756	1.849	5.290
2012	Yes	1.589	1.444	−9.143	2.401	1.657	−30.987
	No	1.379	1.344	−2.516	1.776	1.814	2.100
2013	Yes	1.605	1.539	−4.075	2.365	1.761	−25.552
	No	1.142	1.356	18.761	1.813	1.780	−1.831
2014	Yes	1.620	1.576	−2.746	2.504	1.794	−28.353
	No	1.418	1.347	−5.001	1.839	1.904	3.573
Avg	Yes	1.429	1.296	−9.529	2.067	1.561	−24.164
	No	1.263	1.367	9.005	1.698	1.707	0.446
	Yes–No			−18.534			−24.610

Note: This table presents, for a given year, dispersion of MRK for the four groups of industries sorted by FVAD and import intensity, respectively. "SD" refers to the standard deviation, "IQR" the interquartile range (i.e., difference between 75th percentile and 25th percentile). The row headed "Avg" for the column "Year" presents the results on average over the sample years. The last row headed "Yes–No" presents the difference between import-intensive industries (corresponding to "Yes") and non-import-intensive industries (corresponding to "No"): that is, the difference-in-difference estimate of the association between FVAD and dispersion of MRK.

Source: Authors' calculation using WIOT's 2016 release and Census on Establishments of Mining and Manufacturing Sectors, the Statistics of Korea. Observations in 2010 are missing because the census was not conducted in 2010.

Table D. FVAD and MRK Dispersion: Export-Intensive versus Other Industries, Conditional on High-Productivity Firms.

Year	Industry: Export-Intensive	SD of MRK			IQR of MRK		
		Less FVAD (1)	More FVAD (2)	% Diff (3) = 100*[(2)–(1)]/(1)	Less FVAD (4)	More FVAD (5)	% Diff (6) = 100*[(5)–(4)]/(4)
2003	Yes	1.017	0.969	−4.672	1.494	1.373	−8.079
	No	0.986	1.148	16.437	1.428	1.457	2.045
2004	Yes	1.026	0.960	−6.385	1.477	1.340	−9.301
	No	1.025	1.213	18.326	1.521	1.544	1.518
2005	Yes	1.056	0.987	−6.598	1.547	1.399	−9.593
	No	1.079	1.255	16.313	1.615	1.666	3.126
2006	Yes	1.095	1.040	−4.988	1.620	1.456	−10.127
	No	1.129	1.278	13.199	1.689	1.743	3.161
2007	Yes	1.129	1.070	−5.199	1.672	1.529	−8.553
	No	1.137	1.283	12.857	1.686	1.766	4.727
2008	Yes	1.202	1.096	−8.837	1.783	1.517	−14.916
	No	1.130	1.378	21.870	1.598	1.890	18.270
2009	Yes	1.208	1.093	−9.536	1.814	1.561	−13.983
	No	1.175	1.394	18.704	1.664	1.961	17.871
2011	Yes	1.268	1.188	−6.363	1.835	1.621	−11.637
	No	1.249	1.546	23.787	1.742	2.125	21.959
2012	Yes	1.292	1.200	−7.091	1.880	1.683	−10.477
	No	1.221	1.589	30.080	1.750	2.172	24.147
2013	Yes	1.343	1.265	−5.830	1.991	1.754	−11.897
	No	1.295	1.687	30.235	1.878	2.412	28.490
2014	Yes	1.353	1.285	−5.039	2.016	1.758	−12.820
	No	1.290	1.735	34.501	1.895	2.537	33.849
Avg	Yes	1.181	1.105	−6.412	1.739	1.545	−11.035
	No	1.156	1.409	21.483	1.679	1.934	14.470
	Yes–No			−27.895			−25.504

Note: This table presents, for a given year, dispersion of MRK for the four groups of industries sorted by FVAD and export intensity, respectively, conditional on high-productivity firms. "SD" refers to the standard deviation, "IQR" the interquartile range (i.e., difference between 75th percentile and 25th percentile). The row headed "Avg" for the column "Year" presents the results on average over the sample years. The last row headed "Yes–No" presents the difference between export-intensive industries (corresponding to "Yes") and non-export-intensive industries (corresponding to "No"): that is, the difference-in-difference estimate of the association between FVAD and dispersion of MRK.

Source: Authors' calculation using WIOT's 2016 release and Census on Establishments of Mining and Manufacturing Sectors, the Statistics of Korea. Observations in 2010 are missing because the census was not conducted in 2010.

Table E. FVAD and MRK Dispersion: Import-Intensive versus Other Industries, Conditional on High-Productivity Firms.

Year	Industry: Import-Intensive	SD of MRK			IQR of MRK		
		Less FVAD (1)	More FVAD (2)	% Diff (3) = 100*[(2)–(1)]/(1)	Less FVAD (4)	More FVAD (5)	% Diff (6) = 100*[(5)–(4)]/(4)
2003	Yes	1.005	1.000	−0.498	1.505	1.410	−6.281
	No	1.008	1.308	29.739	1.467	1.642	11.988
2004	Yes	1.043	0.992	−4.881	1.498	1.363	−9.064
	No	1.024	1.466	43.172	1.487	1.841	23.875
2005	Yes	1.089	1.039	−4.599	1.583	1.468	−7.277
	No	1.057	1.499	41.813	1.553	1.939	24.908
2006	Yes	1.126	1.082	−3.898	1.578	1.520	−3.657
	No	1.101	1.508	36.871	1.638	2.047	24.973
2007	Yes	1.127	1.106	−1.934	1.641	1.566	−4.572
	No	1.128	1.501	33.047	1.667	2.188	31.256
2008	Yes	1.146	1.260	9.940	1.669	1.679	0.617
	No	1.182	1.074	−9.113	1.735	1.668	−3.822
2009	Yes	1.244	1.267	1.881	1.674	1.724	2.963
	No	1.197	1.106	−7.617	1.761	1.689	−4.094
2011	Yes	1.369	1.386	1.257	2.094	1.855	−11.426
	No	1.259	1.192	−5.323	1.801	1.737	−3.592
2012	Yes	1.366	1.415	3.565	2.036	1.889	−7.230
	No	1.270	1.201	−5.388	1.833	1.759	−4.015
2013	Yes	1.363	1.523	11.728	2.050	2.020	−1.434
	No	1.324	1.205	−9.005	1.947	1.805	−7.279
2014	Yes	1.379	1.568	13.653	2.076	2.148	3.454
	No	1.328	1.176	−11.427	1.956	1.772	−9.416
Avg	Yes	1.205	1.240	2.383	1.764	1.695	−3.992
	No	1.171	1.294	12.433	1.713	1.826	7.707
	Yes–No			−10.050			−11.699

Note: This table presents, for a given year, dispersion of MRK for the four groups of industries sorted by FVAD and import intensity, respectively, conditional on high-productivity firms. "SD" refers to the standard deviation, "IQR" the interquartile range (i.e., difference between 75th percentile and 25th percentile). The row headed "Avg" for the column "Year" presents the results on average over the sample years. The last row headed "Yes–No" presents the difference between import-intensive industries (corresponding to "Yes") and non-import-intensive industries (corresponding to "No"): that is, the difference-in-difference estimate of the association between FVAD and dispersion of MRK.

Source: Authors' calculation using WIOT's 2016 release and Census on Establishments of Mining and Manufacturing Sectors, the Statistics of Korea. Observations in 2010 are missing because the census was not conducted in 2010.