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Import Variety and Productivity: Positive or Negative?*

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After heterogeneous firm trade models launched in the mid-2000s, the positive effect of import variety on productivity is well-established. However, using industry sectoral data for South Korean 16 regions from 2000 to 2017, this study explores heterogeneous productivity gains from import varieties across industry sectors and identifies negative productivity gains, especially in final consumption goods.

JEL Classification: F12, F14
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I. Introduction

The endogenous growth models in the early 1990s (Romer 1987, 1990; Grossman and Helpman, 1991; Aghion and Howitt, 1992) argued that international trade enhances the growth rate of productivity by the broader access to imported intermediate inputs. Halpern *et al*. (2015) and Broda *et al*. (2017) showed that productivity gains from intermediate or capital goods are significant.

The importance of import varieties used for final consumption goods in productivity has been accentuated by Melitz's (2003) model, where trade liberalization increases aggregate productivity through the reallocation of resources toward more productive firms. An expansion in import varieties forces inefficient domestic varieties to shrink or disappear, and domestic resources are redistributed toward more efficient domestic varieties.

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An extensive body of empirical studies has shown that an expansion of import variety leads to higher productivity. The self-selection effect was empirically demonstrated for Canada by Trefler (2004), analyzing the FTA with the US.. For the most impacted import-competing group of industries, labor productivity rose by 15%, with at least half coming from the exit and/or contraction of low productivity plants. Chen (2013) showed that Canadian productivity gained 0.74% as a result of trade variety growth. Export variety contributed 0.41%, and import variety contributed 0.33%. Broda *et al*. (2017) showed that, in a typical country, new imported varieties account for 10%–25% of its productivity growth. Alfaro and Chen (2018) found that selection and market reallocation account for most aggregate-productivity gains.

However, nascent literature has theoretically documented that reallocation (or self-selection) has little or no effect on productivity. Notably, Atkeson and Burstein (2010) argued that productivity improvements take a long time to pay off and have a little aggregate impact. Furthermore, we can propose a negative mechanism for the relationship between import variety and productivity, focusing on introducing new output varieties. In the opposite direction of the theoretical explanations by Feenstra and Kee (2008) and Feenstra (2018), the number of import product varieties (so-called extensive margin) rises with trade liberalization. However, the number of domestic production varieties falls because of import competition. Reducing domestically produced varieties may lower productivity based on the assumption of a concavity of production possibility frontiers.[1] Specifically, given that marginal production of factors is decreasing, producing fewer output varieties yields a smaller production gain than spreading production factors in producing more varieties. The disappearance of domestically produced outputs, holding the total of fixed inputs, lowers producers' and productivity revenue.

Thus, this study aims to explore a negative link between import variety and total factor productivity (TFP), using industry sectoral data for South Korea's 16 regions from 2000 to 2017. The translog regional GDP function is where trade varieties differ across regions and enter as price effects into the regional GDP equation (transformed into a relative regional productivity equation). Using industry share equations (domestic and corresponding import sectors) and a TFP equation with multiple sectors allows us to obtain heterogeneous productivity gains from import variety across industry sectors. We use the sectors classified by Harmonized Tariff System (HS) and Broad Economic Categories (BEC) for import and corresponding import sectors. The use of HS sectors may result in a mixture of positive and negative productivity effects of import varieties because the codes (goods) are

[1] Instead of the Ricardian world where all output varieties are produced with equal amounts of a single factor (labor), if we assume that output varieties are produced using several factors of production and with different factor intensities, the transformation curve will have the usual concave shape.

classified by what they are instead of their use. To distinguish productivity gains from import varieties used for intermediate inputs and final consumption goods, we explore BEC 6 sectors by the Bureau of Economic Analysis (BEA)'s end-use classification.

A key aspect of our finding is that productivity gains from import varieties are significantly varied across industries, and negative productivity gains are detected in final consumption goods. We find negative productivity gains from import varieties in HS and BEC sectors. The three HS sectors, *agriculture*, *textile and clothing*, and *machinery and transportation*, show negative effects of import varieties on the South Korean regional productivity. However, the results may be from an average effect and may not reflect a true effect. The three BEC sectors classified as final consumption goods, *foods and beverages*; *automotive vehicles, parts, and engines*; and *consumer goods*, show negative effects of import varieties on regional productivity. The newly imported varieties of final consumption goods may contract domestic counterparts and then hurt (revenue) productivity. Similar to the previous literature,[2] newly imported varieties in *industrial supplies and materials* and *capital goods* have boosted regional productivity.

We try to obtain the robustness of results through model specification, estimation methodology, and consistencies with the heterogeneous firm trade models. First, negative productivity gains are valid under our two nonlinear estimation systems. We use a baseline nonlinear estimation system with industry share equations (domestic sectoral shares and corresponding import shares) and a TFP equation. The translog regional GDP function is required to retain the homogeneity of degree one in endowments and prices and symmetry constraints on cross-equation prices. We implement another nonlinear system of industry share equations and an adjusted TFP equation to obtain the validity of the model restrictions and robustness of empirical findings. The negative productivity gains are still valid under the second nonlinear estimation system.

Second, the negative productivity gains are persistent after controlling for two econometric issues: endogeneity in the (adjusted) TFP equation and error correlations in share equations. Endogeneity could exist because TFP may affect export varieties (Melitz, 2003). The error terms of share equations would be correlated because the industries compete for the endowments (so-called Rybczynski theorem). In addition to a nonlinear OLS (NOLS) and a nonlinear seemingly unrelated regression (NSUR), we implement a nonlinear 3SLS (N3SLS) to cure the endogeneity problem and the SUR problem. The negative productivity gains in the three final consumption sectors are consistently detected under all of

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[2] Studies show that improved access to foreign inputs has increased firm productivity (Coe and Helpman, 1995; Coe, Helpman and Hoffmaister, 1997; Amiti and Konings, 2007; Kasahara and Rodrigue, 2008; Goldberg *et al*., 2010; Halpern *et al*., 2015).

the three estimators. Breusch and Pagan test and Hauseman test show that the N3SLS is the most preferred because the error correlations in the share equations are serious, and the endogeneity in the (or adjust) TFP equation is non-trivial.

Third, our estimates are consistent with the theoretical assumptions in Melitz (2003) and Feenstra (2010, 2018). Theoretically, the positive elasticity of the substitution between import varieties suggests that import varieties in a sector are used for final consumptions given a convex CES utility function. The negative elasticity suggests that import varieties in a sector are used for production given a concave transformation curve. In our study, the calculated elasticities of the final consumption goods are positive, and the calculated elasticities of the intermediate inputs are negative. Besides, we compare the calculated elasticities with priors, such as Broda and Weinstein (2006) for the US and Kang (2019) for South Korea. Many of the elasticities are close to those from the two former studies.

The rest of the paper is organized into four parts. Section 2 introduces industry share and TFP equations with trade varieties at a sub-national level. Section 3 presents data in use, testable industry share and TFP equations, and econometric issues with solutions. Section 4 reports the results of NOLS, NSUR, and N3SLS estimations for HS and BEC sectors and highlights the negative productivity gains from import varieties in South Korean regions. Section 5 concludes.

II. Regional Share and TFP Functions with Trade Varieties

We extend the framework by Kohli (2004), Feenstra and Kee (2008), and Chen (2013)[3] to the sub-national level to identify the relationship between trade variety and productivity in a multi-region multi-sector model. Suppose $R(r=1,\dots,R)$ regions exist, $N+1$ domestic sectors where $N(n=1,\dots,N)$ sectors are tradable and one sector $(n=N+1)$ is non-tradable, corresponding M import sectors and $K(k=1,\dots,K)$ endowment factors in a country. In turn, P_n^r is the aggregate price index for the domestic sector n, P_m^r is the aggregate price index for the import sector m, and V_k^r is the endowment for factor k. The translog form of a region's GDP function is described as follows:

$$\ln GDP_t^r = \alpha^r + \beta_t + \sum_{n=1}^{N+1} \alpha_n \ln P_{nt}^r + \sum_{m=1}^{M} \alpha_m \ln P_{nt}^r + \sum_{k=1}^{K} \beta_n \ln V_{kt}^r$$

[3] Diewert (1974) and Kohli (1978) initially suggested the translog GDP (or revenue) function considering a number of production factors and outputs and the prices of production factors as well as outputs. It was extended from the translog functional form of costs based on the theories of index numbers (Feenstra, 2015).

$$+\frac{1}{2}\sum_{i=1}^{N+1}\sum_{j=1}^{N+1}\gamma_{ij}\ln P_{it}^{r}\ln P_{jt}^{r}+\frac{1}{2}\sum_{i=1}^{M}\sum_{j=1}^{M}\gamma_{ij}\ln P_{it}^{r}\ln P_{jt}^{r}$$
$$+\frac{1}{2}\sum_{i=1}^{K}\sum_{j=1}^{K}\delta_{ij}\ln V_{it}^{r}\ln V_{jt}^{r}+\sum_{n=1}^{N+1}\sum_{m=1}^{M}\gamma_{nm}\ln P_{nt}^{r}\ln P_{mt}^{r}$$
$$+\sum_{n=1}^{N+1}\sum_{k=1}^{K}\theta_{nm}\ln P_{nt}^{r}\ln V_{kt}^{r}+\sum_{m=1}^{M}\sum_{k=1}^{K}\mu_{nm}\ln P_{nt}^{r}\ln V_{kt}^{r}, \quad (1)$$

where α^{r} is the region fixed effect and β_{t} is the time fixed effect.

To ensure the translog regional GDP function is homogeneous of degree in prices, we impose symmetry, $\gamma_{ij}=\gamma_{ji}(i$ and $j=1,\ldots,N+M+1)$, and the requirements are

$$\sum_{n=1}^{N+1}\alpha_{n}+\sum_{m=1}^{M}\alpha_{m}=1,\ \sum_{k=1}^{K}\beta_{k}=1,$$
$$\sum_{i=1}^{N+1}\gamma_{in}+\sum_{m=1}^{M}\gamma_{mn}=0, n=1,\ldots,N+1,\ \sum_{j=1}^{M}\gamma_{mj}+\sum_{n=1}^{N+1}\gamma_{mn}=0, m=1,\ldots,M.$$

To ensure that the translog regional GDP function is homogeneous of degree one in endowments, we impose symmetry $\delta_{ij}=\delta_{ji}(i$ and $j=1,\ldots,N+M+1)$, and the requirements are

$$\sum_{n=1}^{N+1}\theta_{nk}+\sum_{m=1}^{M}\mu_{mk}=0, k=1,\ldots,K,\ \sum_{j=1}^{K}\delta_{kj}=0, k=1,\ldots,K.$$

The share equations of the domestic sector n and import sector m are equal to the derivative of $\ln GDP_{t}^{r}$ with respect to $\ln P_{nt}^{r}$ and $\ln P_{mt}^{r}$,

$$S_{nt}^{r}=\alpha_{n}+\sum_{j=1}^{N+1}\gamma_{nj}\ln P_{nt}^{r}+\sum_{k=1}^{K}\theta_{nj}\ln V_{nt}^{r},\quad n=1,\ldots,N+1, \quad (2)$$
$$S_{mt}^{r}=\alpha_{m}+\sum_{j=1}^{M}\gamma_{mj}\ln P_{mt}^{r}+\sum_{k=1}^{K}\mu_{nj}\ln V_{mt}^{r},\quad m=1,\ldots,M. \quad (3)$$

Differencing the translog regional GDP and share equations concerning those of the whole nation (∗), equations (1), (2), and (3) are rewritten as

$$\ln\left(\frac{G_{t}^{r}(P_{t}^{r},V_{t}^{r})}{G_{t}^{*}(P_{t}^{r},V_{t}^{r})}\right)=\alpha_{0}^{r}+\beta_{0t}+\sum_{n=1}^{N+1}\frac{1}{2}(S_{nt}^{r}+S_{nt}^{*})\ln\left(\frac{P_{nt}^{t}}{P_{nt}^{*}}\right)$$
$$+\sum_{m=1}^{M}\frac{1}{2}(S_{mt}^{r}+S_{mt}^{*})\ln\left(\frac{P_{mt}^{t}}{P_{mt}^{*}}\right)+\sum_{k=1}^{K}\frac{1}{2}(S_{kt}^{r}+S_{kt}^{*})\ln\left(\frac{P_{kt}^{t}}{P_{kt}^{*}}\right) \quad (4)$$

$$S_{nt}^{r}-S_{nt}^{*}=\sum_{j=1}^{N}\gamma_{nj}\ln\left(\frac{P_{nt}^{r}}{P_{nt}^{*}}\right)+\gamma_{nN+1}\ln\left(\frac{P_{N+1t}^{r}}{P_{N+1t}^{*}}\right)+\sum_{k=1}^{K}\theta_{nk}\ln\left(\frac{V_{kt}^{r}}{V_{kt}^{*}}\right) \quad (5)$$

$$S_{mt}^{r}-S_{mt}^{*}=\sum_{j=1}^{M}\gamma_{mj}\ln\left(\frac{P_{mt}^{r}}{P_{mt}^{*}}\right)+\gamma_{mN+1}\ln\left(\frac{P_{N+1t}^{r}}{P_{N+1t}^{*}}\right)+\sum_{k=1}^{K}\mu_{mk}\ln\left(\frac{V_{kt}^{r}}{V_{kt}^{*}}\right), \tag{6}$$

where the relative GDP (expenditure) of region r depends on the region fixed effect (α_0^r), which reflect exogenous technology differences across regions, the time fixed effects ($\beta_{0,t}$), which are equal across regions, the relative prices of regionally produced sectors weighted by their shares, the relative prices of imported sectors weighted by their shares, and the relative endowments weighted by shares.

We use the exact price index with new export varieties to map trade variety term in the regional GDP function based on Melitz (2003) and Feenstra and Kee (2008). The ratio of region r's CES aggregate price index of varieties in the import sector $m(=1,\ldots,M)$ to the whole nation ($*$) is given as

$$\ln\left(\frac{P_{mt}^{r}}{P_{mt}^{*}}\right)=\frac{1}{(1-\sigma_m)}\ln\left(\frac{\lambda_{mt}^{r}}{\lambda_{mt}^{*}}\right), \tag{7}$$

where σ_m is the elasticity of substitution between varieties in import sector m. Following the spirit of Feenstra (1994) and Hummels and Klenow (2005), the relative regional import variety to the whole nation ($*$) is measured by

$$\frac{\lambda_{mt}^{r}}{\lambda_{mt}^{*}}\equiv\frac{\sum_{j\in J_{mt}^{r}}(p_{mjt}^{*}\cdot q_{mjt}^{*})}{\sum_{j\in J_{mt}^{*}}(p_{mjt}^{*}\cdot q_{mjt}^{*})}, \tag{8}$$

where $p_{mjt}^{*}(q_{mjt}^{*})$ is the import price (quantity) for variety j in import sector m, year t, and the whole nation $*$. Region r imports J_{mt}^{r} set of product varieties, and the whole nation imports J_{mt}^{*} set of product varieties in import sector m at time t. The relative import variety (so-called the extensive margin) changes over time or across regions only because of changes in the varieties imported by region r.

Regarding the exact export price index, the ratio of region r's CES aggregate price index of domestically produced varieties in sector n to the whole nation $*$ is given by

$$\ln\left(\frac{P_{nt}^{r}}{P_{nt}^{*}}\right)=\rho_n w_{nxt}^{r}\ln\left(\frac{\lambda_{nxt}^{r}}{\lambda_{nxt}^{*}}\right), \tag{9}$$

where $\rho_n=(\sigma_n-1)/\theta_n\sigma_n$, σ_n is the elasticity of the substitution between export varieties in sector n and θ_n is the Pareto parameter representing the dispersion of productivity. w^r_{nxt} is the export share of sector n in region r. Similar to import variety, we measure the relative export variety as follows:

$$\frac{\lambda^r_{nxt}}{\lambda^*_{nxt}} \equiv \frac{\sum_{j \in J^r_{nxt}} (p^*_{nxjt} \cdot q^*_{nxjt})}{\sum_{j \in J^*_{nxt}} (p^*_{nxjt} \cdot q^*_{nxjt})} \tag{10}$$

Inserting equations (7) and (9) into the differenced share equations (5) and (6) and introducing a time fixed effect and an error term yield

$$S^r_{nt} - S^*_{nt} = \beta_{0t} + \sum_{j=1}^{N+1+M} \gamma_{nj} \rho_n w^r_{nxt} \ln\left(\frac{\lambda^r_{nxt}}{\lambda^*_{nxt}}\right) + \gamma_{nN+1} \ln\left(\frac{P^r_{N+1t}}{P^*_{N+1t}}\right)$$
$$+ \sum_{k=1}^{K} \theta_{nk} \ln\left(\frac{V^r_{kt}}{V^*_{kt}}\right) + \varepsilon^r_{nt} \tag{11}$$

$$S^r_{mt} - S^*_{mt} = \beta_{0t} + \sum_{j=1}^{M+N+1} \gamma_{mj} \frac{1}{(1-\sigma_m)} \ln\left(\frac{\lambda^r_{mt}}{\lambda^*_{mt}}\right) + \gamma_{mN+1} \ln\left(\frac{P^r_{N+1t}}{P^*_{N+1t}}\right)$$
$$+ \sum_{k=1}^{K} \mu_{mk} \ln\left(\frac{V^r_{kt}}{V^*_{kt}}\right) + \varepsilon^r_{mt} . \tag{12}$$

Inserting equations (7) and (9) into the differenced GDP function (4) and moving the factor endowments and non-tradable prices to the left yield,

$$\ln\left(\frac{G^r_t(P^r_t, V^r_t)}{G^*_t(P^*_t, V^*_t)}\right) - \sum_{k=2}^{K} \frac{1}{2}(S^r_{kt} + S^*_{kt}) \ln\left(\frac{V^r_{kt}}{V^*_{kt}}\right)$$
$$-\frac{1}{2}(S^r_{N+1t} + S^*_{N+1t}) \ln\left(\frac{P^r_{N+1t} / P^r_t}{P^*_{N+1t} / P^*_t}\right) \equiv TFP^r_t$$
$$= \alpha^r_0 + \beta_{0t} + \sum_{n=1}^{N} \frac{1}{2}(S^r_{nt} + S^*_{nt}) \rho_n w^r_{nxt} \ln\left(\frac{\lambda^r_{nxt}}{\lambda^*_{nxt}}\right)$$
$$+ \sum_{m=1}^{M} \frac{1}{2}(S^r_{mt} + S^*_{mt}) \frac{1}{(1-\sigma_m)} \ln\left(\frac{\lambda^r_{mt}}{\lambda^*_{mt}}\right) + \varepsilon^r_t . \tag{13}$$

The left-hand side of equation (13) can be interpreted as the total factor productivity (TFP) difference between region r and the whole nation $*$ with an adjustment for non-trade goods prices. The relative TFP of region r depends on a region fixed effect, a time fixed effect, the relative export variety, and the relative import variety.

Equations (11), (12), and (13) are our baseline estimation equations, which will be extended to an applicable version in the next section. In this study, our interest coefficient represents the effect of relative import variety $(\lambda^r_{mt}/\lambda^*_{mt})$ on the regional TFP (TFP^r_t). However, the coefficient cannot be identified from the regressing of the TFP equation because of the cross-equation restrictions on γ_{mj} and $1/(1-\sigma_m)$ (in the export side, ρ_n and γ_{mj}) and their multiplicative nature. γ_{mj} represents the price effect of the relative import variety of sector m on the share of sector j. If $m=j$, γ_{mj} is the own price effect, which should be negative for imports to reflect the downward-sloping demand curves. We need to apply a nonlinear estimation system for the share and TFP equations. The optimal estimates for these parameters are derived by minimizing the variance-covariance matrix of the residuals in the full system of regression equations.

III. Empirical Strategy

3.1. Trade Variety in South Korea

We use South Korean regional trade data at the 10-digit Harmonized Tariff System (HS) from 2000 to 2017, obtained from the *Korea Trade Association*'s database. A variety of traded goods is defined as a region-partner pair, following the definition of Armington (1969).[4] The dataset covers the export and import data of 16 regions in South Korea: Busan, Chungbuk, Chungnam (including Sejong metropolitan city), Daegu, Daejon, Gangwon, Gwangju, Gyeongbuk, Gyenggi, Gyeongnam, Incheon, Jeju, Jeonbuk, Jeonnam, Seoul, and Ulsan.

First, we aggregate up regional trade data into HS 7 sectors: *agriculture* (HS 01–24), *chemical and plastic* (HS 28–40), *mineral products and metals* (HS 25–27, 68–71, and 72–83), *raw material* (HS 41–49), *textiles and clothing* (HS 50–67), *machinery and transportation* (HS 84 and 86–89), and *electronics* (HS 85). Second, given that the productivity gains from intermediate or capital goods are more significant (Halpern *et al.*, 2015; Broda *et al.*, 2017)[5], we need to classify trade goods into BEC 6 sectors by the *BEA*'s end-use classification: *food and beverages*; *industrial supplies*

[4] In an ideal world, one has to define a specific model produced by a firm as a variety, for example, Samsung Galaxy S20 and Apple Iphone11 as different varieties of mobile phones. However, in empirical studies focusing on industrial and national trades covering longer time spans, however, a variety is usually defined as an importer-exporter pair because of data limitation.

[5] Feenstra (2010) provided a theoretical simplification of the efficiency gains from new inputs and outputs. On the case of new inputs with a CES production function with the elasticity of substitution between varieties greater than one, an introduction of a new input enhances TFP. On the case of new outputs with a concave transformation function, the creation of a new output variety (holding fixed the total level of inputs) can be expected to raise the value of output, raising productivity.

and materials; *capital goods*; *automotive vehicles, parts, and engines*; and *consumer goods*.[6] The two sectors, *industrial supplies and materials* and *capital goods*, are classified as intermediate inputs. The three sectors, *food and beverages*; *automotive vehicles, parts, and engines*; and *consumer goods*, are classified as final consumption goods.

Table 1 describes the summary statistics of the regional export and import varieties for BEC 6 sectors,[7] measured by equations (10) and (8). In the upper part, we show the measure of export varieties (so-called the extensive margin of exports). The export varieties of all the six sectors have significantly increased over the period. In particular, the mean value of export variety in *consumer goods* is 0.63 in 2000 and 0.78 in 2017. A typical region in South Korea exported 63% of the total number of *consumer goods* in 2000 and 78% in 2017. The average annual growth rate of *consumer goods* is 8.42% per year, which means that the export variety has increased by 4.99 times over the period.

The lower part shows the summary statistics of import varieties. Let us first focus on the final consumption goods: *foods and beverages*; *automotive vehicles, parts, and engines;* and *consumer goods*. The expanse of new import variety in *consumer goods* has been impressive. The mean value of import variety in *consumer goods* is 0.60 in 2000 and 0.81 in 2017. A typical region in South Korea imported 60% of the total number of *consumer goods* in 2000 and 81% in 2017. The average annual growth rate of *consumer goods* is 7.46% per year, which means that the import variety has increased by 3.91 times over the period. The import varieties of *food and beverages* and *automotive vehicles, parts, and engines* have increased by 2.50 and 3.38 times. For the two sectors categorized as the end-use of intermediate inputs, the import varieties of *industrial supplies and materials* and *capital goods* have increased by 1.77 and 2.29 times over the period. Table 1 highlights the expansion of the import varieties of all the BEC sectors, used for the final consumption goods and intermediate inputs. It is also confirmed by Appendix Table 1, reporting the summary statistics over the export and import varieties of HS 6 sectors.

[6] The author uses the correlation table of HS-SITC-BEC by the *UN Trade Statistics* to convert the values of HS sectors to those of BEC.

[7] The summary statistics of the regional export and import varieties for HS 7 sectors are reported in Appendix Table 1.

[Table 1] Summary Statistics of Trade Varieties for BEC Sectors

		Food and beverage	Industrial supplies and materials	Capital goods	Automotive vehicles, parts, and engines	Consumer goods	Other goods
Export variety	Mean value (2000)	0.43	0.46	0.52	0.56	0.63	0.40
	Mean value (2017)	0.64	0.57	0.65	0.68	0.78	0.51
	Annual growth rate (2000–2017)	3.90	3.34	5.25	4.79	8.42	2.16
	Variety (2017)/ Variety (2000)	3.02	2.72	3.44	4.14	4.99	1.42
Import Variety	Mean value (2000)	0.38	0.44	0.56	0.57	0.60	0.30
	Mean value (2017)	0.62	0.53	0.69	0.72	0.81	0.45
	Annual growth rate (2000–2017)	4.13	3.36	3.52	5.07	7.46	2.62
	Variety (2017)/ Variety (2000)	2.50	1.77	2.29	3.38	3.91	1.75

Notes: Author's calculation based on the data from the *Korea Trade Association*'s database. The export and import varieties for South Korean 16 regions are measured by equations (10) and (8), respectively. Variety (2017)/ Variety (2000) = exp(average growth rate*17).

3.2. Data and Estimation Equations

The regional real GDP, value-added shares for HS 7 sectors and BEC 6 sectors,[8] and endowment data (capital, labor, and land) are obtained from the *Korean Statistical Information Service (KOSIS)*. To construct the sectoral and import shares for HS 7 sectors and BEC 6 sectors, we compare the regional value-added and import value of these 14 sectors (12 sectors) to the corresponding regional GDP. Labor is the population in each region. Capital is constructed from real investment, which is obtained by deflating each region's gross regional capital formation with a regional GDP deflator. Given the prices of non-traded goods, we use the average house sale price index, education expenditure index, and health care price index. The balanced panel dataset covers South Korea's 16 regions from 2000 to 2017. Given that each equation has 288 observations, the total system has 4,320 observations for HS 7 sectors and 3,744 observations for BEC 6 sectors.

Therefore, based on the availability of data in use, our first estimation system is

[8] To obtain value-added shares for each HS and BEC sectors, the author uses a matching table between the KOSIC 2017 codes and HSK (2007) provided by the *Industrial Statistics Analysis System*.

rewritten as follows:

$$S^r_{nt} - S^*_{nt} = \beta_t + \sum_{j=1}^{N+M+1} \gamma_{nj} \rho_n w^r_{nxt} \ln\left(\frac{\lambda^r_{nxt}}{\lambda^*_{nxt}}\right) + \gamma_{n8} \ln\left(\frac{P^r_{8t}}{P^*_{8t}}\right) + \sum_{k=1}^{3} \pi_{nk} \ln\left(\frac{V^r_{kt}}{V^*_{kt}}\right) + \varepsilon^r_{nt} . \tag{14}$$

$$S^r_{mt} - S^*_{mt} = \beta_t + \sum_{j=1}^{N+M+1} \gamma_{mj} \frac{1}{(1-\sigma_m)} \ln\left(\frac{\lambda^r_{mt}}{\lambda^*_{mt}}\right) + \gamma_{n8} \ln\left(\frac{P^r_{8t}}{P^*_{8t}}\right) + \sum_{k=1}^{3} \pi_{mk} \ln\left(\frac{V^r_{kt}}{V^*_{kt}}\right) + \varepsilon^r_{mt} \tag{15}$$

$$TFP^r_t = \alpha^r + \beta_t + \sum_{n=1}^{N} \frac{1}{2}(S^r_{nt} + S^*_{nt}) \rho_n w^r_{nxt} \ln\left(\frac{\lambda^r_{nxt}}{\lambda^*_{nxt}}\right) + \sum_{m=1}^{M} \frac{1}{2}(S^r_{mt} + S^*_{mt}) \frac{1}{(1-\sigma_m)} \ln\left(\frac{\lambda^r_{mt}}{\lambda^*_{mt}}\right) + \varepsilon^r_t , \tag{16}$$

where n and $m = 1,\ldots,7$ for HS sectors, n and $m = 1,\ldots,6$ for BEC sectors, and $r = 1,\ldots,16$. We will regress the panel data for 14 (12) sectoral share equations with a time fixed effect and a TFP equation with region and time fixed effects. The relative regional TFP depends on the relative export and import varieties of industry sectors.

3.3. Econometric Issues and Solutions

First, we will implement an iterative nonlinear OLS (NOLS) regression for our system of sectoral share equations and a TFP equation. However, three potential econometric issues arise: error correlation, endogeneity, and model specification (homogeneity constraints on the GDP function). First, the errors of the 14 share equations may be correlated. The domestic production sectors may compete for endowments. The domestic production sectors and import sectors may also be correlated because an increase in an import sector's share may influence other domestic production sectors (the so-called Rybczynksi effect). If true, a seemingly unrelated regression (SUR) is highly desirable (Zellner, 1962).

Second, export variety could be endogenous because regions with higher productivity may produce more export varieties (Melitz, 2003; Feenstra and Kee, 2008). Ignoring the problem of endogeneity may cause the estimates to be biased. We will use a nonlinear two-stage least square (N2SLS) method to derive unbiased estimates with sufficient and valid instrumental variables (IVs). We will also use the iterative nonlinear three-stage least square (N3SLS) regression suggested by Feenstra and Kee (2008) because the N3SLS is a mixture of SUR and N2SLS estimations.

However, to cure an endogeneity problem, we need to find enough valid IVs to replace endogenous variables correlated to export variety but not regional productivity. Eaton and Kortum (2002) and Melitz (2003) provided some trade costs variables, such as tariffs, transport costs, and distance, as instruments. However, given that all of the South Korean 16 regions confront the same rates of tariff against exports and the same distance between each region to its export destinations, we will use some IVs concerning transport costs and supply-related variables, including exogenous IV variables, such as endowments, non-traded good price, and time fixed effects. As IVs concerning transport costs, we will use the ratio of paved roads to total roads and the dummy for international airports and ports. Concerning supply-related variables, we choose the ratio of regional internet users to regional population and lagged regional patent. We collect the data on IVs from the KOSIS.

We implement an OLS estimation linking export varieties to all of the suggested IV and exogenous variables because the OLS estimation will determine the effectiveness of the excluded IVs and the overall fitness of all of the IVs.[9] Table 2 shows the effects of the IVs on the regional export varieties in BEC 6 sectors.[10] For example, paved roads (the ratio of paved roads relative to total roads) positively impact the export varieties of all the BEC sectors, which means that it may reduce transport costs in those sectors. The endowment controls, such as capita/land, labor/land, and land, positively impact the export varieties of some sectors. The R-square ranges from 0.74 to 0.92, which means that all of the IVs significantly explain the variation of the relative export varieties.

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[9] The OLS result is straightforward and not different to the first stage estimation of the non-linear 2- and 3-stage least squares, which involves regressing the derivatives of each equation with respect to the parameters of the system on all the instruments and exogenous variables. Differentiating (16) with respect to ρ_n, we obtain $(S^r_{nt}+S^*_{nt})w^r_{nxt}\ln(\frac{\lambda^r_{nxt}}{\lambda^*_{nxt}})$, which is the export varieties, times the average share of region r and sector n, and export share of the sector. The regression only uses export variety $\ln(\frac{\lambda^r_{nxt}}{\lambda^*_{nxt}})$ as a dependent variable, which allows us to identify the partial relationships between export variety and the trade cost variables.

[10] The OLS result linking the export varieties of HS 6 sectors is not reported here. All of the R-squares are above 0.79, denoting that the IVs preserve most of the variation of the export varieties.

[Table 2] Effects of IVs on Export Varieties (OLS)

Independent variables	Dependent variables: Export variety					
	Food and beverage	*Industrial suppliers and Materials*	*Capital goods*	*Automotive vehicles parts and engines*	*Consumer goods*	*Other goods*
Paved Road	0.23* (0.11)	0.38*** (0.07)	0.72*** (0.19)	0.66* (0.34)	0.33** (0.10)	0.27* (0.13)
Dummy (Airport or Port)	−0.14 (0.08)	0.24** (0.03)	0.10* (0.03)	0.27** (0.08)	0.19** (0.05)	0.11 (0.16)
Internet	0.12 (0.08)	0.27** (0.11)	−0.25 (0.16)	0.22* (0.13)	0.34*** (0.06)	0.20* (0.08)
Lagged Patent	−0.15 (0.18)	0.26 (0.29)	0.31** (0.07)	0.43*** (0.09)	0.36** (0.11)	0.32** (0.08)
Capital/Land	0.32* (0.14)	0.16** (0.07)	0.50*** (0.09)	0.36** (0.08)	0.24** (0.07)	0.28* (0.13)
Labor/Land	0.52** (0.19)	0.30 (0.42)	0.27 (0.30)	0.44** (0.13)	0.51*** (0.15)	0.27* (0.12)
Land	0.64** (0.24)	−0.42 (0.19)	−0.29 (0.22)	0.17 (0.27)	0.35* (0.16)	−0.13 (0.22)
Non-traded good price	0.05* (0.02)	−0.12** (0.03)	0.21* (0.09)	−0.28 (0.17)	0.11 (0.07)	0.25* (0.09)
Time fixed effect	Yes	Yes	Yes	Yes	Yes	Yes
R-square	0.82	0.86	0.79	0.88	0.92	0.74

Notes: *, **, and *** indicate significance at 90%, 95%, and 99% confidence levels respectively, and white-robust standard errors are in parentheses.

Third, even if our results from the previous specification and estimation methods would be significant, we need to examine the homogeneity constraints on endowment and prices and the symmetry constraints on cross-equation prices. For each of the share equations, homogeneity constraints on prices and endowments are imposed. The homogeneity constraint on endowments is imposed in the GDP function but not the homogeneity constraint on prices because of the possible measurement errors in non-traded good prices. To check that the TFP equation is homogeneous of degree one in prices and endowments, we can adjust the TFP equation (16) by following Feenstra and Kee (2018). The non-traded share $-\frac{1}{2}(S_{8t}^r + S_{8t}^*)$ is rewritten $\frac{1}{2}\sum_{n=1}^{7}(S_{nt}^r - S_{nt}^*)-1$ to test that the TFP equation is homogeneous of degree one in prices.

$$\ln\left(\frac{G_t^r(P_t^r,V_t^r)}{G_t^*(P_t^*,V_t^*)}\right)-\sum_{k=1}^{3}\frac{1}{2}(S_{kt}^r+S_{kt}^*)\ln\left(\frac{V_{kt}^r}{V_{kt}^*}\right)$$
$$-\left(\frac{1}{2}\sum_{n=1}^{7}(S_{nt}^r+S_{nt}^*)-1\right)\ln\left(\frac{P_{N+1t}^r/P_t^r}{P_{N+1t}^*/P_t^*}\right)$$

$$=\alpha_0^r+\beta_{0t}+\sum_{n=1}^{7}\frac{1}{2}(S_{nt}^r+S_{nt}^*)\rho_n w_{nxt}^r \ln\left(\frac{\lambda_{nxt}^r}{\lambda_{nxt}^*}\right)$$

$$+\sum_{m=1}^{7}\frac{1}{2}(S_{mt}^r+S_{mt}^*)\frac{1}{(1-\sigma_m)}\ln\left(\frac{\lambda_{mt}^r}{\lambda_{mt}^*}\right)+\varepsilon_t^r \tag{17}$$

We move $\ln(\frac{P_{N+1t}^r/P_t^r}{P_{N+1t}^*/P_t^*})$ to the right of equation (17) and introduce the coefficient η_1. In testing $\hat{\eta}_1=1$, the TFP equation is homogeneous of degree one in prices. We test whether the TFP equation is homogeneous of degree one in endowments. the weighted endowments in equation (17) is rewritten as

$$-\sum_{k=1}^{3}\frac{1}{2}(S_{kt}^r+S_{kt}^*)\ln\left(\frac{V_{kt}^r}{V_{kt}^*}\right)=\frac{1}{2}(S_{Lt}^r+S_{Lt}^*)\ln\left(\frac{l_t^r}{l_t^*}\right)$$

$$-\left(1-\frac{1}{2}(S_{Lt}^r+S_{Lt}^*)-\eta_2\right)\ln\left(\frac{k_t^r}{k_t^*}\right)-\ln\left(\frac{T_t^r}{T_t^*}\right),$$

where $\ln l_t^r \equiv \ln(L_t^r/T_t^r)$ and $\ln k_t^r \equiv \ln(K_t^r/T_t^r)$. We move $-\eta_2\ln(\frac{k_t^r}{k_t^*})$ and $-\ln(\frac{T_t^r}{T_t^*})$ to the right and introduce the coefficient η_3 on the latter term. $\hat{\eta}_3=1$ is that the TFP equation is homogeneous of degree one in endowments.

To implement the homogeneity tests, we define an adjusted TFP as

$$Adj.TFP_t^r=\alpha^r+\beta_t+\sum_{n=1}^{7}\frac{1}{2}(S_{nt}^r+S_{nt}^*)\hat{\rho}_n w_{nxt}^r\ln\left(\frac{\lambda_{nxt}^r}{\lambda_{nxt}^*}\right)$$

$$+\sum_{n=1}^{7}\frac{1}{2}(S_{mt}^r+S_{mt}^*)\frac{1}{(1-\hat{\sigma}_m)}\ln\left(\frac{\lambda_{mt}^r}{\lambda_{mt}^*}\right)+\hat{\eta}_1\ln\left(\frac{P_{8t}^r/P_t^r}{P_{8t}^*/P_t^*}\right)$$

$$-\hat{\eta}_2\ln\left(\frac{k_t^r}{k_t^*}\right)+\hat{\eta}_3\ln\left(\frac{T_t^r}{T_t^*}\right)+\varepsilon_t^r \quad . \tag{18}$$

The corresponding share equations are rewritten as follows:

$$S_{nt}^r-S_{nt}^*=\beta_t+\sum_{j=1}^{7}\hat{\gamma}_{nj}\hat{\rho}_n w_{nxt}^r\ln\left(\frac{\lambda_{nxt}^r}{\lambda_{nxt}^*}\right)+\hat{\phi}_n\ln\left(\frac{k_t^r}{k_t^*}\right)+\hat{\phi}_n\ln\left(\frac{T_t^r}{T_t^*}\right)+\varepsilon_{nt}^r \tag{19}$$

$$S_{mt}^r-S_{mt}^*=\beta_t+\sum_{j=1}^{7}\hat{\gamma}_{mj}\frac{1}{(1-\sigma_m)}\ln\left(\frac{\lambda_{mt}^r}{\lambda_{mt}^*}\right)+\hat{\phi}_m\ln\left(\frac{k_t^r}{k_t^*}\right)+\hat{\phi}_m\ln\left(\frac{T_t^r}{T_t^*}\right)+\varepsilon_{mt}^r \tag{20}$$

We will regress the panel data for share equations (19) and (20) and an adjusted TFP equation (18). Given cross equation restrictions on the coefficients and their multiplicative nature, we need to use a nonlinear system estimation to estimate the share equations (19) and (20) and the adjusted TFP equation (18). The share equation's homogeneity constraints on prices and endowments are imposed. The TFP equation's homogeneity constraints on endowments are imposed, but the TFP equation's homogeneity constraints in prices are not imposed because of the potential measurement errors in non-traded good prices. The symmetry constraints on the cross-price effects are also imposed on the whole system of equations.

IV. Empirical Results

4.1. Effect of Import Variety on TFP

First, we use the nonlinear system of share equations (14) and (15) and the TFP equation (16) for HS sectors. Table 3 only reports the estimated coefficients of the regional productivity equation because of a space limitation.[11] The upper part of Table 3 shows the estimates of $\hat{\rho}_n$ representing the effects of regional export varieties on the regional TFP. Except for *mineral products and metals* under the N3SLS estimation, all the estimated coefficients are positive and significant, which indicates that increasing export varieties in the 7 HS industries has positive and significant effects on the South Korean regional TFP.[12] *Electronics* sectors contribute the most to the regional productivity, followed by *machinery and transportation* sectors. Export variety in each industry is different across the South Korean regions because the most productively produced products are exported. The difference in export variety across regions induces a price difference in regional GDP functions, which increases the share of exported varieties. Having more domestic varieties to produce enables producers to allocate the productive factors more efficiently. Thus, the regional TFP of South Korea rises.

In the lower part of Table 3, the principal interest is the coefficient $1/(1-\hat{\sigma}_m)$ representing the effect of regional import variety on the regional TFP for 7 HS sectors. The signs of coefficients in import varieties are different across the sectors.

[11] Given a limitation in space to report all of trade varieties' price effects on industry shares, we only report the case of the second non-linear system, BEC sectors, and N3SLS in Appendix Table 2. Theoretically, the own price effects are expected to be positive of exports because of the upward-sloping supply curves and negative for imports caused by the downward-sloping demand curves.

[12] The first empirical identification of the link between export variety and productivity has been found by Feenstra et al. (1999) for South Korea and Taiwan, and by Funke and Ruhwedel (2001) for OECD and East Asian countries. Feenstra and Kee (2008) showed that the increase in export variety accounts for a 3.3% average productivity growth in 48 countries from 1980-2000, using the monopolistic competition model augmented with endogenous technology. Kang (2017) showed that increasing export variety in South Korea has a positive impact on regional productivity over the period 2000-2015.

In two sectors, the coefficient is positive and significant: *chemical and plastics* and *electronics*, which are consistent with the prediction by Melitz (2003) model and some evidence (Trefler, 2006; Broda and Weinstein, 2017). However, shown in bold-face, three sectors show negative and significant coefficients: *agriculture*, *textile*

[Table 3] Effects of Trade Variety on TFP by HS Sectors

Independent variables		NOLS	NSUR	N3SLS
Export variety	*Agriculture*	0.112* (0.042)	0.173* (0.022)	0.135*** (0.013)
	Chemical and plastics	0.207*** (0.033)	0.242*** (0.062)	0.433*** (0.102)
	Mineral products and metals	0.084* (0.050)	0.132* (0.024)	-0.106 (0.011)
	Raw material	0.201** (0.061)	0.321** (0.083)	0.235* (0.097)
	Textiles and clothing	0.146** (0.050)	0.340** (0.094)	0.433*** (0.061)
	Machinery and transportation	0.574*** (0.058)	0.543*** (0.069)	0.606*** (0.064)
	Electronics	0.704*** (0.081)	0.802*** (0.058)	0.698*** (0.093)
Import variety	*Agriculture*	**-0.302***** **(0.029)**	**-0.227***** **(0.032)**	**-0.191***** **(0.044)**
	Chemical and plastics	0.650*** (0.047)	0.583*** (0.054)	0.399*** (0.051)
	Mineral products and metals	0.204 (0.177)	0.322 (0.207)	0.104 (0.165)
	Raw material	0.040* (0.021)	0.117* (0.427)	-0.060 (0.124)
	Textiles and clothing	**-0.243**** **(0.098)**	**-0.177**** **(0.052)**	**-0.260***** **(0.066)**
	Machinery and transportation	**-0.521***** **(0.103)**	**-0.455***** **(0.113)**	**-0.379***** **(0.081)**
	Electronics	0.432*** (0.108)	0.518*** (0.124)	0.237*** (0.041)
R-square		0.941	0.930	0.948
Breusch and Pagan Test (p-value)			0.001	
Hausman Test (p-value)				0.007

Notes: The table shows the point estimates of $\hat{\rho}_n$, which denotes the effect of export variety on the TFP, and $1/(1-\hat{\sigma}_m)$, which denotes the effect of import variety on the TFP. Only the year-fixed effect is included for the share equations, and both region fixed and time-fixed effects are included for the TFP equation. The total system has 288 observations per equation and 4,320 observations in the total system. *, **, and *** indicate significance at 90%, 95%, and 99% confidence levels, respectively. White-robust standard errors are in parentheses.

and clothing, and *machinery and transportation*. The different signs of coefficients may suggest that a significant fraction of import varieties in the latter three sectors may be used as final consumption goods rather than intermediate inputs. To investigate the argument, we need to repeat the estimation process by using BEC 6 sectors, categorized as the end-use of goods.

With the above test, we believe that import variety negatively affects productivity for some industries. As said in the preceding section, the NOLS estimation may yield inefficient or biased estimates because of error correlation and simultaneity. First, to check the issue of the error correlation between share equations, we simply compare the estimates of NOLS and NSUR and test for the zeros in the off-diagonal error covariance matrix. Overall, the sizes of the NOLS coefficients are quite different from those of the NSUR coefficients, which implies that the residuals of the sectoral share equations have strong correlations. A reliable test for the correlation of error terms should be done to retain the results of NSUR. To test the correlation of error terms, we test for the zeros in the off-diagonal error covariance matrix, using Breusch and Pagan test. The p-value (0.001) is significantly below a threshold ($p < 0.05$), and the null hypothesis of homoskedasticity is rejected. The residuals of the share equations have a strong correlation. The share equations are dependent, providing support for using a SUR estimation. The estimates of NSUR are more reliable than those of NOLS.

Second, endogeneity may be a problem in the (adjusted) TFP equation. We need to decide which between NOLS or N3SLS is more reliable by Hausman Test (Hausman, 1978) to test for potential endogeneity. If the endogeneity is so serious, N3SLS is naturally superior to NOLS. The p-value of the statistic is 0.007, which means we reject the null hypothesis of no endogeneity. The estimates of N3SLS are more unbiased rather than those of NOLS. After all, for our first nonlinear estimation system and HS sectors, the N3SLS is the most preferred because of the two issues of error correlation in the share equations and endogeneity in the TFP equation.

Regarding BEC 6 sectors classified by the end-use of a good, Table 4 reports the effect of trade varieties on the regional TFP from NOLS, NSUR, and N3SLS, respectively. The top half presents the $\hat{\rho}_n$ for each estimator. All the estimates are positive. The expansion of export variety in each BEC sector contributes to regional productivity. The industry, *automotive vehicles, parts, and engines*, contributes the most to the regional productivity because of an increase in export variety. The bottom half presents the coefficient $1/(1-\hat{\sigma}_m)$. Three industries, *food and beverage*; *automotive vehicles, parts, and engines*; and *consumer goods*, have negative effects of import varieties on the regional productivity. Those industries are considered as final consumption goods in BEA's end-use classification. *Industrial supplies and materials,* and *capital goods,* considered as the intermediate inputs, show a negative correlation between import variety and TFP. Greater access to import variety in intermediate inputs leads to higher TFP. However, import variety in final consumption goods leads to lower TFP. Similar to Halpern *et al*. (2015) and Broda *et al*. (2017), imported intermediate inputs have positive effects on productivity. However, this study finds that imported final consumption goods have negative effects on productivity (so called negative productivity effects). The newly imported varieties for final consumption force the less efficient domestic varieties to shrink or disappear, and the contractions of the corresponding sectors' shares hurt the productivity.

[Table 4] Effects of Trade Variety on TFP by BEC Sectors

Independent Variables		NOLS	NSUR	N3SLS
Export variety	*Foods & Beverages*	0.203* (0.087)	0.177** (0.052)	0.309** (0.102)
	Industrial supplies & Materials	0.330** (0.073)	0.510* (0.272)	0.442** (0.149)
	Capital goods	0.532*** (0.174)	0.506*** (0.161)	0.732*** (0.233)
	Automotive vehicles, parts, and engines	0.772*** (0.105)	0.834*** (0.217)	0.847** (0.305)
	Consumer goods	0.633*** (0.047)	0.564*** (0.106)	0.388*** (0.073)
	Other goods	0.063 (0.084)	0.212 (0.175)	−0.027 (0.160)
Import variety	*Food and beverage*	**−0.282* (0.140)**	**−0.148** (0.036)**	**−0.295** (0.027)**
	Industrial supplies & materials	0.153*** (0.008)	0.302** (0.0132)	0.433*** (0.083)
	Capital goods	0.770*** (0.068)	0.463*** (0.117)	0.657*** (0.160)
	Automotive vehicles, parts, and engines	**−0.233*** (0.018)**	**−0.253*** (0.046)**	**−0.241** (0.090)**
	Consumer goods	**−0.542*** (0.075)**	**−0.663** (0.081)**	**−0.421*** (0.074)**
	Other goods	0.041 (0.199)	−0.002 (0.015)	0.115 (0.032)
R-square		0.970	0.972	0.966
Breusch and Pagan Test (p-value)			0.002	
Hausman Test (p-value)				0.003

Notes: The table shows the point estimates of $\hat{\rho}_n$, which denotes the effect of export variety on the TFP , and $1/(1-\hat{\sigma}_m)$, which denotes the effect of import variety on the TFP. Only the year-fixed effect is included for the share equations, and region fixed and time-fixed effects are included for the TFP equation. The total system has 288 observations per equation and 3,744 observations. *, **, and *** indicate significance at 90%, 95%, and 99% confidence levels respectively. White-robust standard errors are in parentheses.

Similar to the case of HS sectors in Table 3, the results of NSUR are more efficient than those of NOLS because the cross-correlation in share equations is non-trivial (the p-value of Breusch and Pagan test, 0.002, is significantly less than 0.05). For an endogeneity issue, we also implement the Hausman test. We reject the null hypothesis of no endogeneity (the p-value is 0.003). We need to retain the results from the N3SLS under our first nonlinear system of estimation. Even when we use the BEC sectors, the error correlations among the share equations and endogeneity in the TFP equation are still non-trivial.

4.2. Effect of Import Variety on Adjusted TFP

To acquire the validity of the model constraints and robustness of empirical findings, we implement another nonlinear system of share equations (14) and (15) and the adjusted TFP equation (18). The top part of Table 5 reports $\hat{\rho}_n$ representing the effect of export variety on the adjusted TFP for 7 HS sectors. The estimates by the NOLS, NSUR, and N3SLS are reported in the columns. Under all three estimation methods, four sectors, *chemical and plastics*, *textiles and clothing*, *machinery and transportation*, and *electronics,* have significant positive effects of export varieties on the adjusted TFP.

Regarding our coefficients of import variety, the middle part of Table 5 reports $1/(1-\hat{\sigma}_m)$ representing the effect of import variety on the adjusted TFP. Different signs of productivity gains are shown from import varieties across industry sectors even on first acquaintance. The import varieties in *agriculture*, *textile and clothing*, and *machinery and transportation* negatively affect the adjusted TFP in Korean regions, whereas the import varieties in *chemicals and plastics* and *electronics* have positive effects on the adjusted TFP. The imports in *agriculture*, *textile and clothing*, and *machinery and transportation* may force the less efficient varieties to disappear. Producing fewer varieties yields a smaller production gain than spreading production factors in producing more varieties.

The bottom part of Table 5 reports the effects of the control variables on the adjusted TFP. Besides, the estimated coefficients associated with non-traded goods and relative land prices imply an observance or violation of the homogeneity constraints on prices and endowments. The coefficients of the prices of non-traded goods are significantly less than one (0.387, 0.255, and 0.293), which indicates a violation of the homogeneity assumption on prices.[13] The homogeneity assumption may be because the price of non-traded goods is poorly measured. Unlike the model and empirical finding by Feenstra and Kee (2008), the coefficients of the capital-

[13] The violation of the homogeneity constraint in prices in the adjusted TFP equation does not affect the rest of the estimations because we did not impose it (Feenstra and Kee, 2008; Chen, 2011, 2013).

[Table 5] Effects of Trade Variety on 'Adjusted' TFP by HS Sectors

Independent Variables		NOLS	NSUR	N3SLS
Export variety	*Agriculture*	0.088* (0.042)	0.084 (0.056)	0.122 (0.140)
	Chemical and plastics	0.674*** (0.065)	0.455*** (0.090)	0.384*** (0.070)
	Mineral products and metals	0.021* (0.010)	0.005 (0.053)	-0.002 (0.001)
	Raw material	0.201** (0.061)	0.092 (0.173)	0.254* (0.097)
	Textiles and clothing	0.146** (0.050)	0.277** (0.078)	0.220*** (0.051)
	Machinery and transportation	0.559*** (0.058)	0.623*** (0.067)	0.506*** (0.064)
	Electronic	0.422*** (0.061)	0.274*** (0.035)	0.574*** (0.044)
Import variety	*Agriculture*	**-0.124**** **(0.029)**	**-0.202*** **(0.069)**	**-0.156***** **(0.024)**
	Chemical and plastics	0.425*** (0.047)	0.491*** (0.072)	0.399*** (0.051)
	Mineral products and metals	0.014 (0.273)	-0.020 (0.065)	0.016 (0.026)
	Raw material	0.240* (0.098)	0.07 (0.130)	0.196 (0.177)
	Textiles and clothing	**-0.328**** **(0.089)**	**-0.438***** **(0.073)**	**-0.250***** **(0.056)**
	Machinery and transportation	**-0.411***** **(0.041)**	**-0.257***** **(0.032)**	**-0.201***** **(0.028)**
	Electronics	0.364*** (0.080)	0.473*** (0.073)	0.502*** (0.072)
Non-traded good price		0.387** (0.042)	0.255** (0.067)	0.293*** (0.050)
Capital/land		-0.242** (0.055)	0.133*** (0.032)	0.231** (0.057)
Relative land		0.801*** (0.159)	0.543** (0.200)	0.744*** (0.162)
R-square		0.865	0.847	0.884
Breusch and Pagan test (p-value)			0.002	
Hauseman test (p-value)				0.0283

Notes: The first column shows the point estimates of $\hat{\rho}_n$, which denotes the effect of export variety on the adjusted TFP, and the second column shows the point estimates $1/(1-\hat{\sigma}_m)$, which denotes the effect of import variety on the 'adjusted' TFP. Region fixed and year fixed effects are included. A total of 288 observations per equation and 4,320 observations in the total system. *, **, and *** indicate significance at 90%, 95%, and 99% confidence levels, respectively, and White-robust standard errors are in parentheses.

land ratio from the NSUR and N3SLS's are positive. The coefficient from the NOLS is −0.242, which implies that the estimated share of land in Korean regional GDP is approximately 24.2%. The coefficients of the relative land are close to one (0.801, 0.543, and 0.744), which indicates an observance of the homogeneity assumption on endowments.

We need to decide which estimator is more reliable by Breusch and Pagan test and Hausman test. The p-value of the Breusch and Pagan test is 0.002, which is below 0.05. The cross-correlation in share equations is non-trivial, and the NSUR is more efficient. Given that the p-value of the Hausman test is 0.0283, we reject the null hypothesis that the regressors are exogenous. Export varieties are endogenous in explaining productivity. The estimates from the N3SLS have to be taken. The coefficients of non-traded good price are less than one, which means a violation of the homogeneity assumption on price, possibly because of measurement errors in non-traded good prices. The coefficients of relative land are close to one, which means satisfaction of the homogeneity assumption on endowments.

Table 6 reports $\hat{\rho}_n$ and $1/(1-\hat{\sigma}_m)$ for BEC 6 sectors. The top part reports the effects of export varieties for each industry in the row. All the four estimates, except for *other goods*, are significant and positive over the NOLS, NSUR, and N3SLS. The expansion in export variety of *consumer goods* contributes the most to the regional productivity growth, whereas export variety in *food and beverage* contributes the least.

The middle part shows the effects of import varieties for each industry in the row. From NOLS to N3SLS, the import varieties of *industrial supplies and materials* and *capital goods*, which are classified as intermediate inputs, have positive effects on the adjusted TFP. Conversely, the import varieties in *food and beverage*; *automotive vehicles, parts, and engines*; and *consumer goods*, classified as final consumption goods have negative effects on the adjusted TFP. An increase in import variety in *consumer goods* harms most the regional productivity.

The bottom part of Table 6 reports the effects of control variables and homogeneity constraints in the adjusted TFP equation. Similar to HS sectors, the coefficients of the prices of non-traded goods are significantly less than one (0.245, 0.472, and 0.261), whereas the coefficients of the relative land are close to one (0.725, 0.803, and 0.712). Homogeneity constraint on prices is violated, but homogeneity constraint on endowment is observed. Unexpectedly, all the coefficients of the capital-land ratio are shown to be positive.

The p-value of the Breusch and Pagan test is 0.001, which is below 0.05. The share equations are dependent. We reject the null hypothesis that the regressors are exogenous because the p-value of the Hausman test is low (0.030). In the first and second nonlinear systems of estimation, the estimates from N3SLS are superior to the rest of estimators.

[Table 6] Effects of Trade Variety on Adjusted TFP by BEC Sectors

Independent variables		NOLS	NSUR	N3SLS
Export variety	*Food and beverage*	0.218** (0.070)	0.164** (0.062)	0.161** (0.053)
	Industrial supplies and materials	0.301*** (0.063)	0.311*** (0.059)	0.181*** (0.021)
	Capital good	0.385** (0.093)	0.437** (0.96)	0.462*** (0.052)
	Automotive vehicles, parts, and engines	0.792*** (0.080)	0.466*** (0.040)	0.573*** (0.039)
	Consumer goods	0.592*** (0.076)	0.577*** (0.089)	0.874*** (0.083)
	Other goods	–0.201 (0.177)	0.037 (0.202)	–0.076 (0.204)
Import variety	*Food and beverage*	**−0.206* (0.099)**	**−0.314** (0.122)**	**−0.128** (0.047)**
	Industrial supplies and materials	0.484*** (0.075)	0.660*** (0.093)	0.733*** (0.083)
	Capital goods	0.924*** (0.193)	0.583*** (0.237)	0.657*** (0.160)
	Automotive vehicles, parts, and engines	**−0.399*** (0.104)**	**−0.392*** (0.155)**	**−0.247** (0.090)**
	Consumer goods	**−0.782*** (0.068)**	**−0.599*** (0.070)**	**−0.602*** (0.074)**
	Other goods	−0.199 (0.173)	0.202 (0.170)	0.214 (0.131)
Non-traded good price		0.245** (0.067)	0.472*** (0.045)	0.261** (0.060)
Capital/Land		0.212*** (0.042)	0.307* (0.150)	0.157** (0.062)
Relative land		0.725* (0.284)	0.803** (0.249)	0.812** (0.205)
R-square		0.879	0.846	0.893
Breusch and Pagan test (p − value)			0.001	
Hausman test (p-value)				0.037

Notes: The first column shows the point estimates of $\hat{\rho}_n$, which denotes the effect of export variety on the adjusted TFP. The second column shows the point estimates $1/(1-\hat{\sigma}_m)$, which denotes the effect of import variety on the adjusted TFP. Region fixed and year fixed effects are included. The total system has 288 observations per equation and 3,744 observations. *, **, and *** indicate significance at 90%, 95%, and 99% confidence levels, respectively. White-robust standard errors are in parentheses.

4.3. Comparisons

For the plausibility of our findings, the estimates are consistent with theoretical assumptions in Melitz (2003) and Feenstra (2010). We cannot identify the elasticities for export varieties because the elasticity of substitution between export varieties cannot be separated $\hat{\sigma}_n$ from the estimated $\hat{\rho}_n(=\sigma_n - 1)/\theta_n\sigma_n)$. However, all of $\hat{\rho}_n$ are between 0 and 1, which is an assumption in Melitz (2003). We can calculate the elasticities of substitution between import varieties from the coefficients, $1/(1-\hat{\sigma}_m)$. Table 7 reports implied elasticities of import sectors in the estimates from the adjusted TFP and N3SLS. Positive elasticity $(\hat{\sigma}_m > 1)$ suggests that import varieties in a sector are used for final consumptions given a convex CES utility function. The implied import elasticities of *food and beverage* and *consumer goods* are 8.81 and 3.48, respectively, greater than unity. The two BEC sectors are generally categorized as the end-use of final consumption. The negative elasticity $(\hat{\sigma}_m < 0)$ suggests that import varieties in a sector are used for production given a concave transformation curve. The implied import elasticities of *industrial supplies and materials* and *capital goods* are –0.36 and –0.52, respectively, which are less than unity. These sectors are generally categorized as the end-use of intermediate inputs. Overall, our estimates are comparable with the theoretical predictions, except for *automotive vehicles, parts, and engines*. This sector is categorized as a final consumption goods in BEC classification and includes a large fraction of intermediate inputs, such as automotive parts and engines.

[Table 7] Implied Sigmas of Import Variety $(\hat{\sigma}_m)$

HS Sectors		BEC Sectors	
Agriculture	7.41	*Foods and beverages*	8.81
Chemical and plastics	–1.50	*Industrial suppliers and materials*	–0.36
Mineral products and metals	–61.5	*Capital goods*	–0.52
Raw material	–4.10	*Automotive vehicles, parts, and engines*	–3.04
Textile and clothing	5.00	*Consumer goods*	3.48
Machinery and transportation	5.97	*Others goods*	–3.67
Electronics	–0.99		

Notes: The author calculates the elasticities of the substitution between import varieties from the coefficients, $1/(1-\hat{\sigma}_m)$, obtained from the adjusted TFP equation and N3SLS estimation. The industry sectors with elasticities greater than one (a convex utility function) are used for final consumption. In contrast, the industry sectors with elasticities less than one (a concave transformation curve) are used for intermediate inputs.

Another way to acquire plausibility is by comparing the estimates with priors. Unlike the case of South Korea, Broda and Weinstein (2006) estimated the elasticities of substitution between import varieties for approximately 30,000 goods from the US official import statistics. They showed that industries with more goods that are classified as differentiated are more likely to have low elasticities of substitution and vice versa. Similar to Broda and Weinstein (2006), the import elasticities for *agriculture* and *food and beverage*, where varieties are relatively homogeneous (less differentiated), are greater than those for *machinery and* *transportation* and *consumer goods*, where varieties are relatively differentiated. Fortunately, a comparable study for South Korea is found. Recently, Kang (2019) estimated the elasticities of substitution between varieties using Korean trade data from 1993 to 2013. The mean elasticity of substitution between import varieties is 7.75 over the 4,438 import elasticities in the HS 10 digit level. The implied elasticities of substituting *food and beverage* and *consumer goods*, classified as final consumption goods, are 8.81 and 3.48, respectively. The aggregated elasticities of this study are comparable with the mean value of the import elasticities. Considering the consistencies with the theoretical predictions and priors, our estimates are plausible.

IV. Conclusion

This study has attempted to investigate a negative effect of import varieties on productivity, based on the hypothesis that newly imported varieties of final consumption goods may crowd out the corresponding domestic varieties, hurting industry share (revenue) and productivity. Having less domestic varieties enables producers to allocate the production resource less efficiently, which yields a smaller production gain. We have used the translog regional GDP function by allowing for multiple industry sectors and trade varieties. Estimating the industry share equations simultaneously with the GDP equation (transformed to become relative regional productivity equation) allows us to identify different effects of import varieties on productivity across industry sectors.

We find the negative productivity gains from import varieties by using the panel data of South Korean 16 regions from 2000 to 2017. To distinguish productivity effects of imports by intermediate goods and final consumption goods, we implement the estimation procedure for BEC 6 sectors by the BEA's end-use classification. The signs and magnitudes of the productivity gains from import varieties are significantly different across industries. The import varieties in *food and beverage*; *automotive vehicles*; *parts, and engines*; and *consumer goods*, which are classified as final consumption goods, negatively affect the regional TFP. An increase in import variety in *consumer goods*, a typical final consumption industry, harms regional productivity. Similar to the previous literature arguing a positive relationship between imported inputs and productivity, we find that the import varieties of industrial supplies and materials and capital goods, classified as intermediate inputs, have positive effects on the TFP of the South Korean regions. Our work is complementary to the literature focusing on the gains from trade varieties.

Let us close with a remainder: our finding of the negative productivity gains from import variety does not imply that aggregate or average productivity gains are worse off because of alternative sources of productivity gains from newly imported varieties of intermediate inputs and from self-selection (and resource reallocation) effect in the final consumption goods. Furthermore, negative productivity gains would take a tiny fraction of the overall gains from increased import variety, including consumer welfare gains (Broda and Weinstein, 2006).

[Appendix Table 1] Summary Statistics of Trade Variety for HS 7 Sectors

		Agriculture	Chemical and plastics	Mineral products and metals	Raw material	Textiles and clothing	Machinery and transportation	Electronics
Export variety	Mean value (2000)	0.46	0.55	0.40	0.54	0.63	0.64	0.57
	Mean value (2017)	0.68	0.72	0.55	0.63	0.74	0.61	0.78
	Annual growth rate (2000−2017)	3.85	5.72	2.68	7.64	2.39	3.74	10.2
	Variety (2017)/ Variety (2000)	2.05	3.15	1.54	3.84	1.73	2.32	5.41
Import variety	Mean value (2000)	0.44	0.63	0.41	0.37	0.62	0.65	0.68
	Mean value (2017)	0.52	0.75	0.46	0.43	0.68	0.79	0.75
	Annual growth Rate (2000–2017)	2.58	3.84	1.83	1.92	3.27	7.49	4.05
	Variety (2017)/ Variety (2000)	1.69	2.36	1.21	1.28	2.11	4.41	2.63

Note: Author's calculation based on the data from the *Korea Trade Association*'s database. The export and import varieties for South Korean 16 regions are measured by equations (10) and (8), respectively. Variety (2017)/Variety (2000) = exp (average growth rate*17).

[Appendix Table 2] Coefficients of Share Equations from Adjusted TFP Equation, BEC Sectors, and N3SLS

Independent variables		Dependent variables											
		Domestic share in						Import share in					
		F&B	I&M	Cap	Auto	Con	Oth	F&B	I&M	Cap	Auto	Con	Oth
Export variety of	F&B	**0.083**** **(0.026)**	-0.004 (0.015)	-0.005 (0.038)	0.042 (0.060)	0.087** (0.024)	-0.106 (0.149)	0.048 (0.060)	-0.006 (0.011)	0.004* (0.001)	-0.093 (0.117)	-0.009* (0.004)	0.017 (0.025)
	I&M	-0.164 (0.083)	**0.037** **(0.028)**	0.048 (0.027)	0.157** (0.039)	0.066 (0.073)	0.027 (0.040)	-0.052* (0.024)	0.093* (0.046)	-0.004 (0.005)	0.037 (0.026)	0.233** (0.059)	-0.093** (0.041)
	Cap	0.022 (0.075)	0.078** (0.023)	**0.240***** **(0.046)**	0.073** (0.020)	-0.082 (0.105)	-0.094 (0.057)	-0.073 (0.106)	0.070* (0.032)	0.057** (0.019)	0.130** (0.061)	-0.058* (0.027)	0.037 (0.043)
	Auto	0.194* (0.077)	0.115** (0.350)	0.401** (0.136)	**0.372*** **(0.147)**	0.407 (0.288)	0.021* (0.010)	0.038* (0.015)	-0.043** (0.018)	0.127** (0.055)	-0.073*** (0.021)	0.019 (0.035)	-0.036* (0.017)
	Con	0.032** (0.011)	-0.446 (0.370)	0.051* (0.023)	-0.009 (0.014)	**0.216***** **(0.038)**	0.065** (0.021)	0.042** (0.013)	0.004 (0.007)	-0.042*** (0.008)	0.006 (0.014)	0.030** (0.013)	-0.047** (0.016)
	Oth	-0.005 (0.020)	0.106 (0.177)	-0.003 (0.048)	0.083* (0.040)	-0.032 (0.053)	**0.112**** **(0.030)**	-0.018* (0.008)	-0.007 (0.013)	-0.028** (0.009)	-0.094 (0.049)	-0.063 (0.038)	0.090 (0.100)
Import variety of	F&B	0.064 (0.108)	-0.004 (0.011)	0.008 (0.047)	0.064* (0.030)	0.071** (0.025)	0.029 (0.033)	**-0.063** **(0.044)**	-0.044 (0.036)	0.006* (0.003)	-0.072* (0.036)	-0.035* (0.017)	-0.064 (0.042)
	I&M	-0.021 (0.107)	0.061 (0.104)	0.027* (0.013)	0.153* (0.077)	-0.006 (0.017)	-0.070* (0.036)	-0.058 (0.042)	**0.207** **(0.095)**	-0.403 (0.216)	0.036** (0.011)	-0.407* (0.200)	-0.027 (0.016)
	Cap	0.064** (0.025)	0.057* (0.023)	-0.277 (0.030)	0.084* (0.037)	0.135* (0.058)	0.072 (0.041)	0.006** (0.002)	-0.081 (0.057)	**-0.031*** **(0.014)**	-0.066 (0.053)	0.083* (0.040)	0.074 (0.049)
	Auto	-0.044 (0.107)	0.047* (0.023)	0.026* (0.011)	1.064** (0.325)	0.037 (0.070)	0.304* (0.099)	-0.047 (0.061)	0.052** (0.020)	0.049*** (0.010)	**0.067*** **(0.022)**	-0.094 (0.077)	-0.008* (0.003)
	Con	0.064 (0.055)	-0.206 (0.114)	0.188 (0.205)	0.304 (0.329)	-0.116* (0.440)	-0.327* (0.138)	0.034*** (0.007)	-0.047*** (0.008)	-0.020* (0.011)	-0.061* (0.028)	**-0.041**** **(0.012)**	0.016** (0.007)
	Oth	-0.043 (0.037)	0.023 (0.028)	-0.009 (0.016)	0.036* (0.017)	0.007 (0.014)	-0.042 (0.057)	0.039 (0.035)	0.104 (0.096)	0.096 (0.105)	-0.037** (0.014)	-0.601* (0.294)	**-0.002** **(0.032)**
Capital/Land		0.064*** (0.016)	0.118** (0.036)	0.206*** (0.004)	0.197*** (0.009)	0.200** (0.805)	0.206** (0.673)	0.046*** (0.12)	0.068*** (0.014)	0.138*** (0.027)	0.041*** (0.005)	0.082** (0.325)	0.035** (0.011)
Relative land		0.148** (0.040)	-0.025 (0.037)	0.011 (0.072)	0.044* (0.023)	0.135** (0.036)	-0.062 (0.109)	-0.095 (0.042)	-0.147*** (0.036)	0.047 (0.038)	-0.036** (0.012)	-0.094** (0.031)	-0.061* (0.029)
R-square		0.475	0.563	0.578	0.651	0.582	0.534	0.517	0.528	0.662	0.554	0.673	0.470

Notes: Columns 1 to 6 report $\hat{\gamma}_{nj}$, which are the partial price effects on the share of domestic sectors because of the changes of export and import varieties in rows. Columns 7 to 12 report $\hat{\gamma}_{nj}$, which are the partial price effects on the share of import sectors because of the changes of export and import varieties in rows. *, **, and *** indicate significance at 90%, 95%, and 99% confidence levels, respectively. White-robust standard errors are in parentheses.

References

Aghion, P. and P. Howitt (1992), "A Model of Growth through Creative Destruction," *Econometrica*, Vol. 60, No. 2, 323–351.

Alfaro, L. and M. Chen (2018), "Selection and Market Reallocation: Productivity Gains from Multinational Production," *American Economic Journal: Economic Policy*, Vol. 10, No. 2, 1–38.

Amiti, M. and J. Konings (2007), "Trade Liberalization, Intermediate Inputs, and Productivity:

Evidence from Indonesia," *American Economic Review*, Vol. 97, 1611–1638.

Arkolakis, C., S. Demidova, P. Klenow and A. Rodriguez-Clare (2008), "Endogenous Variety and the Gains from Trade," *American Economic Review*, Vol. 98, No. 2, 444–450.

Armington, P. (1969), "A Theory of Demand for Products Distinguished by Place of Production," *IMF Staff Papers*, Vol. 26, 159–178.

Atkeson, A. and A. Burstein (2010), "Innovation, Firm Dynamics, and International Trade," *Journal of Political Economy*, Vol. 118, No. 3, 433–484.

Baldwin, R. and R. Forslid (2010), "Trade Liberalization with Heterogeneous Firms," *Review of Development Economics*, Vol. 14, No. 2, 161–176.

Blonigen, B. and A. Soderbery (2010), "Measuring the Benefits of Foreign Product Variety with an Accurate Variety Set," *Journal of International Economics*, Vol. 82, No. 2, 168–180.

Broda, C. and D. Weinstein (2006), "Globalization and the Gains from Variety," *Quarterly Journal of Economics*, Vol. 121, No. 2, 541-585.

Broda, C., J. Greenfield, and D. Weinstein (2017), "From Groundnuts to Globalization: A Structural Estimate of Trade and Growth," *Research in Economics*, Vol. 71, No. 4, 759–783.

Chen, B. (2011), "Export Variety, Revenue, and Productivity in China," *Review of International Economics*, Vol. 19, No. 2, 341–355.

Chen, B. (2013), "Trade Variety and Productivity in Canada," *Review of Development Economics*, Vol. 17, No. 3, 414–429.

Coe, D. and E. Helpman (1995), "International R&D Spillovers," *European Economic Review*, Vol. 39, 859–887.

Coe, D., E. Helpman and A. Hoffmaister (1997), "North-South R&D Spillovers," *Economic Journal*, Vol. 107, No. 440, 134–149.

Diewert, W. (1974), "Functional Forms for Revenue and Factor Requirements Functions," *International Economic Review*, Vol. 15, No. 1, 119–130.

Eaton, J. and S. Kortum (2002), "Technology, Geography, and Trade," *Econometrica*, Vol. 70, No. 5, 1741–1779.

Feenstra, R. (1994), "New Product Varieties and the Measurement of International Prices," *American Economic Review*, Vol. 84, No. 1, 157–177.

Feenstra, R., D. Madani, T. Yang and C. Liang (1997), "Testing Endogenous Growth in

South Korea and Taiwan," *Journal of Development Economics*, Vol. 60, 317–341.

Feenstra, R. and H. Kee (2008), "Export Variety and Country Productivity: Estimating the Monopolistic Competition Model with Endogenous Productivity," *Journal of International Economics*, Vol. 74, No. 2, 500–514.

Feenstra, R. (2010), "Product Variety and the Gains from International Trade," Zeuthen Lecture Book Series. The MIT Press. Cambridge.

Feestra, R. (2015), Advanced International Trade: Theory and Evidence, Second Edition. Princeton University Press.

________ (2018), "Alternative Sources of the Gains from International Trade: Variety, Creative Destruction, and Markups," *Journal of Economic Perspectives*, Vol. 32, No. 2, 25–46.

Funke, M., and R. Ruhwedel (2001), "Product Variety and Economic Growth: Empirical Evidence for the OECD Countries," *IMF Staff Papers*, Vol. 48, No. 2, 225–242.

Goldberg, P., A. Khandelwal, N. Pavcnik and P. Topalova (2010), "Imported Intermediate Inputs and Domestic Product Growth: Evidence from India," *Quarterly Journal of Economics*, Vol. 125, No. 4, 1727–1767.

Grossman, G. and E. Helpman (1991), Innovation and Growth in the Global Economy, Cambridge, MA. MIT Press.

Halpern, L., M. Koren, and A. Szeidl (2015), "Imported Inputs and Productivity," *American Economic Review*, Vol. 105, No. 12, 3660–3703.

Hummels, D. and P. Klenow (2005), "The Variety and Quality of a Nation's Exports," *American Economic Review*, Vol. 95, No. 2, 704–723.

Kang, K. (2017), "Identifying the Dispersion of the Pareto Productivity Distribution in International Trade," *Economics Letters*, Vol. 161, 108–111.

________ (2019), "The Adjustment Effect of the Extensive Margin on the Terms of Trade during Economic Crises," *Economics Letters*, Vol. 176, 5–8.

Kasahara, H. and J. Rodrigue (2008), "Does the Use of Imported Intermediates Increase Productivity? Plant-Level Evidence," *Journal of Development Economics*, Vol. 87, 106–118.

Kohli, U. (2004), "Real GDP, Real Domestic Income, and Terms-of-Trade Changes," *Journal of International Economics*, Vol. 62, No. 1, 83–106.

Melitz, M. (2003), "The Impact of Trade on Intra-industry Reallocations and Aggregate Industry Productivity," *Econometrica*, Vol. 71, No. 6, 1695–1725.

Romer, P. (1987), "Growth Based on Increasing Returns Due to Specialization," *American Economic Review*, Vol. 77, No. 2, 56–62.

________ (1990), "Endogenous Technological Change," *Journal of Political Economy*, Vol. 98, No. 5, 71–102.

Trefler, D. (2004), "The Long and Short of the Canada-U.S. Free Trade Agreement," *American Economic Review*, Vol. 94, No. 4, 870–895.

수입다양성과 생산성: 양(+) 혹은 음(−)인가?*

강 기 천**

초 록 이질적 기업무역 모형이 등장한 2000년대 중반 이후에, 수입다양성이 생산성에 양(+)의 영향을 미친다는 것은 부인할 수 없는 사실로 받아지고 있다. 그러나 본 연구는 2000-2017 기간 한국의 지역산업 데이터를 이용하여, 수입다양성에서 얻는 생산성 효과가 산업별로 이질적이고, 특히 최종재 산업에서는 생산성에 음(−)의 영향을 미친다는 사실을 제시한다.

핵심 주제어: 수입다양성, 생산성, 음(-)의 생산성 효과
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