Trade Liberalization and Product Dynamics within Firm: Role of Competition and Market Expansion

Jung Hur
Haeyeon Yoon

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School of Economics

University of Bristol
Priory Road Complex
Bristol
BS8 1TU
United Kingdom

University of Bristol
School of Economics

Trade Liberalization and Product Dynamics within Firm: Role of Competition and Market Expansion*

Jung Hur[†] Haeyeon Yoon[‡]

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Abstract

This study examines the impact of trade liberalization on firms' product mix, highlighting the distinct influences of tariff reductions on imports and exports. Using Korean firm-product data, we find that Korean firms narrow their product ranges and focus on selected items in response to increased competition from reduced import tariffs under the Korea-US Free Trade Agreement. Conversely, when tariffs on Korean exports decline, firms expand their product ranges and distribute their production more evenly across their products, benefiting from an enlarged market. This market expansion effect, however, is statistically significant only for firms in export-oriented industries that directly benefit from increased market reach. Moreover, we delve into firms' strategic decisions of changing their product mix by analyzing their choices to drop, add, or adjust the production of specific products. Our findings indicate that these decisions are primarily driven by the products' relative efficiency within the firm rather than by the magnitude of tariff changes. In adapting to trade dynamics, firms strategically reallocate resources towards more efficient products by dropping and reducing production of less efficient ones.

Keywords: Multiproduct firms, Product Mix, Trade liberalization, Tariff.
JEL classification: F10, F15, L11, L25

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[†]Department of Economics, Sogang University, ecsjhur@sogang.ac.kr

[‡]School of Economics, University of Bristol; Nam Duck Woo Economic Research Institute, haeyeon.yoon@bristol.ac.uk

1 Introduction

When countries enter into bilateral trade agreements, they agree to mutually lower tariff rates on imports and exports between them. For clarity in this paper, *import tariffs* are defined as duties imposed by a domestic country on goods imported from its trading partner, and *export tariffs* refer to duties imposed by the trading partner on goods exported from the domestic country.[1] The reduction of these tariffs has distinct impacts on domestic firms: lower import tariffs lead to increased domestic market competition by enabling foreign firms to offer more products at competitive prices, whereas reduced export tariffs expand the market reach of the domestic firms by allowing them to sell their products to foreign consumers at lower prices.

While a range of studies examined the product adjustment within firms in response to trade liberalization,[2] they focused on its net influence (Baldwin and Gu, 2009; Bernard et al., 2010, 2011). This approach risks missing critical insights into the underlying mechanisms driving the overall effect by overlooking the distinct impacts of reducing import and export tariffs. The previous studies could not distinguish between the effects of increased competition and market expansion, largely because the trade liberalization cases they used involved similar reductions in both import and export tariffs.[3]

To the best of our knowledge, this paper is the first to empirically distinguish between the effects of competition and market expansion by examining the strategic adjustments that firms make to their product portfolio under trade liberalization. This study underscores the distinct impacts of these two forces, specifically addressing how firms adapt to the challenges of increased competition and opportunities for market expansion. The Korea-US Free Trade Agreement (KORUS FTA), initiated in 2012, offers an ideal case for this analaysis, due to the differential changes in import and export tariffs. From 2011 to 2016, following the implementation of KORUS FTA, tariffs on goods exported from Korea to the US decreased by 2.22 percentage points, while tariffs on goods imported by Korea from the US experienced a more significant decrease of 11.42 percentage points.[4]

In our analysis, *product mix* includes both the range of products (extensive) and the distribution of output across these products (intensive aspect) within a firm's portfolio. It reflects

[1] In our empirical analysis, which focuses on Korean firms and the free trade agreement between Korean and the US, export tariffs refer to tariffs imposed on products exported from Korea to the US, while import tariffs refer to tariffs imposed on products imported to Korea from the US.

[2] Allanson and Montagna (2005); Bernard et al. (2011); Baldwin and Gu (2009); Goldberg et al. (2010); Iacovone and Javorcik (2010); Lopresti (2016); Mayer et al. (2014); Qiu and Zhou (2013).

[3] Baldwin and Gu (2009), Bernard et al. (2010), and Bernard et al. (2011) examine a case of the free trade agreement between Canada and the US where tariff cuts in the two countries are highly correlated. They use the sum of Canadian tariff reductions against imports from the US and US tariff reductions against exports from Canada.

[4] There exists a very weak and almost negligible linear relationship between the reductions in tariff rates on US imports and Korean imports. It is evidenced by the correlation coefficient of 0.06.

the diversity of manufactured products and the strategic distribution of production resources, as evident in the sales distribution of these products. Grasping these adjustments is crucial for understanding how firms respond to evolving economic environments, particularly in reaction to trade liberalization. Drawing on a model that incorporates multi-product firms and flexible manufacturing technology in an open economy framework (Eckel and Neary, 2010), this study examines how increased competition and market expansion affect firms' strategic decisions regarding their product mix.

Furthermore, this study goes beyond simply tracking the number of products (i.e. the variety of products) and their output distribution within firms; it investigates the strategic decisions driving these changes. We examine the specific products firms decide to drop, add, or adjust the production levels for, aiming to uncover the rationale behind these choices. Our analysis focuses on evaluating whether these strategic choices are mainly influenced by changes in tariff level on specific products or by their relative efficiency within the firm. This approach enhances our understanding of how firms strategically adapt to evolving trade environments.

Using Korean firm-product level data, we find two key insights into how trade liberalization affects firms' strategic decisions regarding their production mix. First, we find that changes in import and export tariffs impact firms' production mix in distinct ways. Specifically, (i) a reduction in import tariffs prompts firms to streamline their product range and concentrate on producing a select set of products. This strategic adjustment likely stems from the increased competition resulting from trade liberalization, which encourages firms to focus their resources on a more limited set of highly competitive products. However, (ii) the impact of export tariff reductions is not uniform across all firms. The benefits of market expansion arising from reduced export tariffs largely depend on a firm's engagement with exporting activities. This variance stems from the fact that not all firms experience market expansion following trade liberalization—the market size for firms focused solely on the domestic market remains unchanged, whereas it increases for firms involved in exports. We find that (iii) firms in export-oriented industries tend to diversify their product range and achieve a more balanced production distribution among their products in response to export tariff cuts. This suggests that broader market access allows firms to direct their resources towards products that, before the market expansion, were not profitable enough to justify production or expansion. Meanwhile, (iv) export tariff reductions do not have a significant effect on the product mix of firms in import-oriented industries.

Second, our analysis reveals that in making product churning decisions—such as whether to drop or add products, or to adjust their production levels—the key factor is the relative efficiency of the products within the firm, rather than changes in tariffs on those products. (i) Firms are more likely to drop less efficient products rather than those hurting from the largest reduction in import tariffs (or benefiting less from the smallest reduction in export tariffs). This indicates a preference for retaining more efficient products over those with more favorable tariff adjustments. Additionally, firms have the option to reallocate resources among their products without necessarily dropping or adding new ones. (ii) For products that remain in production, firms prioritize increasing output for those that demonstrate higher efficiency, regardless of any tariff changes affecting these products. Lastly, (iii) our analysis of newly added products shows that while they are initially less efficient than existing products,[5] they exhibit higher growth rates in both output and efficiency over time. This suggests a strategic shift in resources from less to more efficient products within firms under the trade liberalization.

The remainder of this paper is organized as follows. Section 2 introduces the theoretical framework. Section 3 describes the data and defines key variables for empirical analysis. Section 4 empirically analyzes the effects of trade liberalization on firms' product mix. Section 5 investigates firms' strategic choices in adjusting their product portfolio, specifically decisions to add, drop, or alter production levels. Section 6 concludes the paper.

2 Theoretical Framework

This section introduces a theoretical model to understand the effect of trade liberalization on firms' product range, focusing specifically on two distinct channels—competition and market-size effects. The theoretical framework builds on Eckel and Neary (2010),[6] which considers oligopolistic markets to isolate adjustment within firm from adjustment across firms within industry. There are two important features in the model—the cannibalization effect and flexible manufacturing technology. First, multi-product firms internalize demand linkages across products that they produce. In other words, if firms increase output of one product, it is highly likely that output of their other products will decrease. Second, firms have technologies that can be flexibly used for a range of their products, yet these are used most efficiently when making their core product. Inefficiency can be translated into higher marginal cost, which is proportional to the distance between a given product and the core product.[7]

[5]In this paper, the terms *continuing* and *existing product* are used interchangeably to refer to products that a firm continues to produce throughout the analysis period.

[6]There are several multi-product firm models based on monopolistic competitions where demand linkages and strategics behaviors are excluded (Allanson and Montagna, 2005; Bernard et al., 2011; Nocke and Yeaple, 2006).

[7]It also assumes a finite number of countries with fully integrated goods markets but without international factor mobility, alongside a continuum of identical industries, each characterized by an oligopolistic market structure.

2.1 Consumer Preferences and Demand

Each consumer consumes differentiated products from a single industry which maximizes her utility function. The utility function from industry j is:

$$u(j) = a\int_0^K q(k)dk - \frac{1}{2}\mathrm{b}\left[(1-e)\int_0^K q(k)^2dk + e\left(\int_0^K q(k)dk\right)^2\right]. \quad (1)$$

The utility function depends on each consumer's level of consumption on product k, $q(k)$. K measures the degree of differentiated product available in an industry. K increases as more differentiated products are produced in an industry. The parameters a, b, and e are assumed to take non-negative values and be identical for all consumers. Product differentiation is measured by e whose value is between 0 and 1. If $e = 0$, the products are heterogeneous and demand for each product is completely independent of other products. As the value of e increases, the degree of product differentiation decreases.[8]

Considering all industries, each consumer then maximizes the upper tier of utility function which is the sum of the utility from industry j:

$$U[u(j)] = \int_0^1 u(j)dj, \quad (2)$$

where $j \in [0,1]$, under the budget constraint $\int_0^1\int_0^K p(k)q(k)dkdj \leq I$. The budget constraint indicates that the sum of consumer's expenditure on product k, $p(k)\cdot q(k)$, across industries can not exceed the individual income I.

Individual inverse demand functions for product k can be derived as

$$\lambda p(k) = a - b\left[(1-e)q(k) + e\int_0^K q(k)dk\right], \quad (3)$$

where the parameter λ is the Lagrange multiplier which indicates the marginal utility of income. To derive the aggregate demands, this model assumes that each of n number of identical countries has L number of consumers, all with identical preferences for product k. Based on these, we can derive a inverse world market demand function for product k as

$$p(k) = \frac{a}{\lambda} - \frac{b}{\lambda nL}\left[(1-e)x(k) + e\int_0^K x(k)dk\right], \quad (4)$$

where $x(k)$ is the market demand for product k in a given industry. In a closed economy, n takes the value of one. When a country has a bilateral trade agreement with another country, the value of n increases to two. Trade liberalization affects the demand function that firms in

[8]Two extreme cases where the parameter e takes the value of 0 or 1 are ruled out.

the domestic country face.[9]

2.2 Production Technology

Each firm has a technology that characterizes a core competence and flexible manufacturing. Firms have a core product whose efficiency is the highest within firms. Flexible technology allows firms to produce multiple products with different efficiencies across products within firms. The technology, while used most efficiently on the core product, operates less efficiently on others. The efficiency of product k in firm i can be measured by its marginal cost, $c_i(k)$. The marginal cost of the core product, $c_i(0)$, is the lowest across products within firms, increasing as the distance between product k to the core product grows: $c_i(0) < c_i(1) < \cdots < c_i(k)$. Assuming a linear case, the marginal cost for firm i to produce k^{th} product can be described as

$$c_i(k) = c_i(0) + \eta k, \ \eta > 0. \ (5)$$

Firms determine their product range based on the the marginal cost of each product. Firms drop a product when it becomes unprofitable due to external shocks. On the other hand, they may introduce a new product if it promises to be a profitable venture. Referring to equation (5), the core product is the final item that firms would drop. It infers that the efficiency of dropped or added products is comparatively lower than that of the core product. If a firm produces product k, it means that the firm produces a range of products from 0 to k, $\theta(k)$. The product range of firm i can be simply described as θ_i. The profit for firm i who produces $\theta(k)$ range of products can be described as

$$\pi_i = \int_0^{\theta_i} \left[p_i(k) - c_i(k)\right] x_i(k) dk - F, \ (6)$$

where F is the fixed cost of the firm.

2.3 Optimal Product Range

Based on the previous demand and supply linkage settings, we now examine the optimal product range of firms. We suppose a single-stage Cournot game where all firms simultaneously choose the product range and the quantity of each product which maximize their profits. The product range which will maximize firm i's profits satisfies the following condition:

$$\frac{\partial \pi_i}{\partial \theta_i} = \left[p_i(\theta_i) - c_i(\theta_i)\right] x_i(\theta_i) = 0. \ (7)$$

[9] For convenience, λ is set to 1. When interpreting nominal variables in general equilibrium, this nominalization needs to be considered.

In order to maximize the profit, firm i would choose its product range so that either $p_i(\theta_i) - c_i(\theta_i) = 0$ or $x_i(\theta_i) = 0$. Considering the optimal output of each product for profit maximization,[10] the first case needs to be ruled out, which indicates that the profit of the product located the farthest from the core product cannot be zero. This requires that the quantity of the marginal product should be zero, $x_i(\theta_i) = 0$. Considering the optimal output of each product k,[11] the product range maximizing the profit of firm i should satisfy the following condition:

$$c_i(\theta_i) = \frac{a}{\lambda L} - \frac{b}{\lambda n L} e(X_i + Y), \ (8)$$

where X_i is the total output of firm i, $X_i \equiv \int_0^{\theta_i} x_i(k)dk$, and Y is the industry output. Under the symmetric Cournot oligopoly case, the industry output can be measured as $Y = nmX_i$, where m is the number of firms in each country. Figure 1 shows the optimal product range of firm i. It illustrates that firm i first starts produce its core product with the marginal cost $c_i(0)$. The farther a product is from the core product, the higher the marginal cost of producing that product. The firm will keep expanding its product range and stop adding more products on their portfolio when the marginal cost of producing the lastly added product is equal to the value of right-hand side of equation (8). θ_i is the product range that maximizes the profit of firm i.

[Insert Figure 1]

2.4 Effect of Trade liberalization

This subsection focuses on how a firm modifies its optimal product range in response to trade liberalization. The trade liberalization affects the product range of firms via two different channels—(i) increased competition and (ii) expanded market size. In general, while the increase in competition represents an unfavorable shock for domestic firms, the market expansion acts as a favorable one.

As a country completely opens its markets, foreign firms enter the domestic market and export their products at more competitive price. The reduction on tariffs levied on goods from foreign firms leads to increased competition for domestic firms. This has a similar effect of an increase in the number of firms, m, that each country has. As the number of competitors that a domestic firm faces increases from $m-1$ to $nm-1$, the total output X of a domestic firm decreases.[12] Firms reduce the output of each product uniformly, so the marginal product is

[10] The condition of product k's quantity maximizing firm i's profit: $\frac{\partial \pi_i}{\partial x_i(k)} = p_i(k) - c_i(k) - \frac{b}{\lambda c L}[(1-e)x_i(k) + eX_i] = 0$.

[11] $x_i(k) = (\frac{a}{\lambda L} - c_i(k) - \frac{b}{\lambda n L} e(X_i + Y))/2\frac{b}{\lambda n L}(1-e) = 0$

[12] X decrease less than proportionally to the increase in m, resulting in an increase in Y.

expected to drop due to the increased competition. Therefore, the increased competition leads to a reduction in domestic firms' product range.

As a result of mutual tariff reductions with their trading partners, domestic firms also can sell their products to foreign consumers at lower trade costs. Even if in a country where its market has already been partially opened, the market size of domestic firms is still expected to grow as the tariff cuts enable them to sell products to overseas consumers at a lower price than before. Since trade liberalization means the number of countries that a country trades with increases, it has the same effect of an increase in the number of consumers that each country has. So, the market expansion effect can be represented by increasing L to nL, leading to alterations in the right-hand side of equation (8). Due to the increased number of consumers, $\frac{b}{\lambda nL}$ decreases. At the same time, as firms sell products more, the total outputs of firm X_i and industry Y will increase. The product range of firms does not change because of equiproportionate decrease in $\frac{b}{\lambda nL}$ and increase in $(X_i + Y)$. [13]

Combining the two distinct effects, the net effect of trade liberalization is to increase the total output of continuing products while reducing the product range of firms. Firms would likely increase the output of products aligned with their core competencies, while decreasing the output of products with lower efficiencies or dropping those products.

The effects of trade liberalization on product range can vary among between in export- and import-oriented industries. First, the market expansion effect is notably significant for firms engaged in exporting, while the competition effect applies to both export-oriented and domestic-focused firms. This suggest that trade liberalization may have a limited impact on the market size of firms that exclusively focus on the domestic market. Thus, the market expansion effect will operate primarily in export-oriented industries where most domestic firms are involved in exporting either directly or indirectly. Second, trade liberalization's role in stimulating economies of scale is particularly crucial for small countries. By broadening market access, these countries can overcome the limitations of their domestic markets, allowing firms to increase production volumes and achieve cost efficiencies.

Accordingly, we modify the marginal cost equation of product k of firm i following trade liberalization by incorporating external economies of scale, represented as

$$c_i(k) = c_i(0) + \eta k - \mu Y,\ \mu \geq 0. \ (9)$$

In export-oriented industries, μ has a positive value, while in import-oriented industries, μ is zero. Using equation (9) with (7), the first-order condition with respect to product range can

[13] Proposition 2 in Eckel and Neary (2010).

be re-written as[14]

$$c_i(\theta_i) = \frac{a}{\lambda} - \frac{b}{\lambda n L} e(X_i + Y) + \mu Y. \quad (10)$$

The increase in the threshold, as shown on the right-hand side of equation (10), raises the likelihood of turning an unprofitable product into a profitable one. A decrease in export tariffs cause the threshold's horizontal line in Figure 1 to shift upwards, reflecting the inclusion of external economies of scale, μ. This upward shift expands firm i's product range from θ_i to θ_i^{μ}, driven by market expansion and enhanced economies of scale. Therefore, in response to reductions in export tariffs, firms are anticipated to expand their product ranges, especially in industries where increases in output and economies of scale are expected. The significance of economies of scale is particularly pronounced when smaller economies initiate trade with larger ones.

3 Data and Variables

In this section, we introduce the data and methodology used to examine the effects of trade liberalization on firms' product mix. We describe how we measure changes in a firm's product mix and changes in export and import tariffs at the firm level.

3.1 Data and Statistics

We use three data sets for our analysis. The main data is the Mining and Manufacturing Survey (MMS) of Statistics Korea. Statistics Korea annually publishes the MMS that surveys plants with at least 10 employed workers in mining and manufacturing sectors. It provides detailed information on input and output information plants such as number of employees, value of fixed tangible asset, material costs, sales, and value added. The MMS also contains plant-product information—all products that each plant produces and output of each product.[15] In general, closing a production line of a product is not decided by the plant level but the firm level. We aggregate the plant-product data into the firm-product data using the identification number of firms to which plants belong.[16] Considering that the KORUS FTA was initiated in March 2012, we use data from 2011 and 2016 to examine the changes in the product mix resulting from the trade liberalization.[17]

[14] Product k's output which maximizes firm i's profit is $x_i(k) = [\frac{a}{\lambda L} - c_i(k) - \frac{b}{\lambda c L}(e-\mu)(X_i+Y)]/2\frac{b}{\lambda c L}(1-e)$.

[15] Products are defined by the eight-digit Korean Standard Industrial Classification (KSIC) code.

[16] We can identify the products manufactured and their corresponding total production output at the product-firm level. However, the data do not include information on which products are exported or what proportion of total production is exported. Nonetheless, the data set sufficiently addresses primary questions of this paper: how firms adjust their product mix in response to the import and export tariff reductions, and which products are most often dropped or see significant production cuts.

[17] 2008 and 2013 data are also utilized for conducting the placebo test and analyzing newly added products.

To capture the effects of increased competition in the domestic market and expanded market size of domestic firms, this paper uses two distinct sets of tariff data: (i) Korean tariff data obtained from the Korea Customs Service[18] and (ii) US tariff data sourced from the US International Trade Commission[19]. The effect of increased competition is captured by changes in Korean tariff rates on imports from the US. A reduction in Korean tariff rates on US imports enhances American firms' access to the Korean market, increasing the presence of US products and intensifying the competition faced by Korean firms. On the other hand, the effect of expanded market size is captured by changes in US tariff rates on imported goods from Korea. A decrease in US tariff rates on Korean imports allows Korean firms to offer their products in the US market at more competitive prices, leading to an expansion of their customer base.

[Insert Figure 2]

To differentiate between the market-size and competition effects in our analysis, it is crucial for the changes of export and import tariffs to be asymmetric. We analyze the change in import and export tariff rates between 2011 and 2016 under the KORUS FTA. The average tariff rate on Korean goods exported to the US—referred to as the export tariff—was 2.44 percent in 2011 and decreased to 0.22 percent in 2016. Conversely, the average tariff rate on US goods imported into Korea—the import tariff—was 12.4 percent in 2011, dropping to 1.07 percent in 2016. Across both periods, the export tariff rates exceed the import tariffs. In other words, on average, Korea's trade protection level against US imports was higher than that of the US against Korean imports. After the FTA, reduction in import tariff rates is substantial, at 11.33 percentage points, which is significantly larger than the decline in export tariff rates of 2.22 percentage points. Figure 2 is a scatter plot illustrating the import and export tariff changes on separate axes. It emphasizes the asymmetrical changes by demonstrating the limited correlation between the two sets of tariff changes. Notably, the correlation coefficient between the changes in the two tariffs stands at 0.06.

[Insert Table 1]

The KORUS FTA is expected to have significant effects on Korea, given that difference in tariff rates between Korea and the US, which initially was 10.05 percentage points, narrows to 0.85 percentage points. Furthermore, considering that the US ranks as Korea's second-largest export destination and third-largest import source, the impact of the trade liberalization is particularly noteworthy for Korean firms. To assess how Korean trade evolved before and after the FTA with the US, we analyzed aggregated trade figures and the number of traded

[18] The Korea tariff on US imports is based at eight-digit Harmonized System of Korea (HSK) code.

[19] The US tariff on Korean imports is based at eight-digit Harmonized Tariff Schedule of the United States (HTS-US) code.

products in 2011 and 2016.[20] Table 1 presents Korea's trade with its top three export and import partners in 2011, as well as its entire global trade. Notably, Korean exports to the US showed the most substantial increase, both in terms of value and the variety of products, highlighting potential effects of the KORUS FTA on Korean export. While imports from the US to Korea decreased by 3% following the KORUS FTA, this reduction should not be seen as an indication of diminished trade relations or importance between the two countries. In fact, this decrease was significantly smaller than the 23% decline in Korea's overall imports during the same period. The slight decrease in imports from the US, despite a much larger decrease in Korea's total imports, suggests that the FTA facilitated a relative increase in trade activity between the two nations. In addition, Korea experienced the largest increase in the number of products imported from the US among its top three import sources.

3.2 Variables

To measure changes in firms' product mix, we begin by defining the product range. This paper quantifies the product range based on the variety of products a firm manufactures. Changes in the number of products indicate shifts at the extensive margin resulting from trade liberalization. However, the effects of trade liberalization go beyond the extensive margin to include the intensive margin, such as changes in the production of continuing products. To capture these intensive aspects of product mix, we use a diversification index as a second measure. Following Baldwin and Gu (2009), we calculate an entropy index which measures product diversification within firm as

$$Diversification_{it} = \sum_{k=1}^{K} share_{ikt} \cdot log(\frac{1}{share_{ikt}}), \quad (11)$$

where $share_{ikt}$ is the proportion of product k's output within the total output of firm i which produces K number of products in year t. This index can capture the distribution of product's output within firms. The index increases when a firm diversifies its product mix—either by adding more products or by increasing the output share of existing products that already have a large output share without changing the total number of products. Using the number of products and the diversification index, we can examine how firms modify their product mix extensively and intensively in response to tariff change.

We, now, calculate a tariff change applied to firms. A firm-specific tariff change considers both the relative importance of products within firm and the difference in tariff change across

[20]The data on the trade value and the number of trade products between Korea and other countries were obtained from the International Trade Centre, accessed as of August 2020. The products are categorized according to the six-digit HS codes.

products.[21] The firm-specific tariff rate change is defined as the output-weighted average of import or export tariff changes applied to firm i between 2011 and 2016. This is calculated as follows:

$$\triangle imptariff_i = \sum_k share_{ik2011} \cdot \triangle imptariff_k, \quad (12)$$

$$\triangle exptariff_i = \sum_k share_{ik2011} \cdot \triangle exptariff_k, \quad (13)$$

where $share_{ik2011}$ is the output share of product k in firm i in 2011. $\triangle imptariff_k$ and $\triangle exptariff_k$ represent the change in import and export tariff rates for product k between 2011 and 2016, respectively.[22]

Our variable provides a more accurate representation of the tariff changes that firms actually experience, compared to another method that simply average the tariff changes across all products within firms. By recognizing that not all products are of equal importance to a firm, this approach ensures that tariff changes on main products are appropriately weighted to reflect their greater impact on the firm's overall tariff rate, unlike uniform changes on peripheral products.

The mean and standard deviation of import tariff change of firm i, $\triangle imptariff_k$, are -10.9 percentage points and 15.7 percentage points. The mean and standard deviation of export tariff rate change, $\triangle exptariff_k$, are much smaller at -2.1 percentage points and 2.8 percentage points.[23] The summary statistics indicate that, on average, firms experience a larger reduction in import tariffs, and these changes exhibit greater dispersion among firms compared to export tariffs. This suggests a wider range of effects on the import side of trade and the level of competition that Korean firms face.

[21] For the empirical analysis, it is necessary to convert the product codes utilized in the tariff rate data, which are coded in HTS-US and HS classification, to the product codes used in the main data, KSIC. Specifically, for export tariff rates, we align the six-digit HTS-US codes with the corresponding five-digit KSIC codes through a concordance list of HS and KSIC codes. We note that in our regressions, product churning (dropping and adding) is defined at eight-digit of KSIC. However, for the US tariff rates that correspond to the Korean products, we could not match them at that level, because the KSIC and the HTS-US are quite different at the eight-digit codes. We had to aggregate the tariff rates at the most disaggregated level, which is the six-digit of HTS-US. These are well-matched to five-digit codes of KSIC through the Harmonized System (HS) codes. Therefore, using the concordance list between HS and KSIC, we can finally match the six-digit HTS-US code to the five-digit KSIC code. For the import tariff rates we directly match HS and KSIC codes. Then, the weighted tariff rates is measured at the five-digit KSIC level.

[22] We calculate the six-digit weighted average export and import tariff rates by using the eight-digit tariff rates along with trade value data (Bernard et al., 2011).

[23] For surviving firms between 2011 and 2016 in our data

4 Optimizing Product Mix under Trade Liberalization

4.1 Empirical Strategies

Our primary focus lies in understanding how firms alter their product mix as a reaction to the heightened competition and the broadened market resulting from trade liberalization. Using the firm-product data, we examine how Korean firms response to import and export tariff cuts under KORUS FTA. The main regression model is:

$$\triangle y_{ij} = \alpha_0 + \alpha_1 \triangle imptariff_i + \alpha_2 \triangle exptariff_i + \alpha_3 \triangle IP_j + X'_{i2011}\beta + e_{ij}. \quad (14)$$

y_{ijt} is the number of products produced by firm i in industry j in year t (or the diversification index). The difference of y_{ijt} , $\triangle y_{ij}(= y_{ij2016} - y_{ij2011})$, captures how firms adjust their product mix before and after the KORUS FTA. The change in the number of products measures the extensive margin, while that of diversification index accounts for the intensive margin. To distinguish the two channels of trade liberalization—competition and market-size effects, we introduce changes in import and export tariff. The output-weighted import tariff change of firm i, $\triangle imptariff_i$ is to measure the competition effect on firm i between 2011 and 2016, while the output-weighted export tariff change of firm i, $\triangle exptariff_i$ is to evaluate the market-size effect.

We employ a first difference model to control time-invariant firm characteristics. We additionally include a pre-KORUS FTA firm characteristic vector, X_{i2011}, including the natural logarithm of age, age squared, total factor productivity,[24] and total number of workers, along with dummy variables for firms that export and produce multiple products in 2011. Considering that competition from countries other than the US can also influence a firm's product range, we further account for industry-level market competition not related to the KORUS FTA. $\triangle IP_j = \triangle(\frac{M_j}{M_j+Q_j})$ captures the change of import penetration rate of industry j between 2011 and 2016, where M_j is an aggregated import value excluding the US, and Q_j is an aggregated total sale at four-digit industry j to which firm i belongs. Firm-level cluster standard error are employed.

4.2 Competition *vs* Market Expansion

Table 2 presents how Korean firms adjust their product mix in response to export and import tariff reductions under the KORUS FTA. The columns (1)-(3) of Table 2 illustrate how the firms

[24] Value-added total factor productivity is measured by the Cobb-Douglas production function with a two-thirds labour share in 2011.

adjust the number of their products in response to tariff changes. The coefficients associated with the import tariff reduction variable exhibit positive values and statistical significance. This finding suggests that Korean firms decrease the number of products by approximately 0.775 in response to import tariff cuts.[25] The reduction in import tariffs encourages foreign firms to enter the domestic market, thereby intensifying market competition. Faced with increased competition, domestic firms may find it less profitable to continue producing marginally profitable products. As a result, this competition effect leads to a decrease in the overall number of products produced by a firm.

[Insert Table 2]

The results in columns (4)-(6) reveal that firms exhibit a tendency to allocate more resources towards a set of specific products when import tariffs decrease. When confronted with heightened competition, firms may strategically concentrate on their core products by shifting resources from peripheral products (Liu, 2010; Wiersema and Bowen, 2008). To gain more a comprehensive understanding of this finding, we analyze the products that firms drop or decrease their production in Section 4.2.

While the reduction in import tariffs poses an adverse trade shock to domestic firms, the decrease in export tariffs can be considered as a favorable shock, attributed to market size expansion. Our analysis of export tariff reductions, as shown in Table 2, reveals that the coefficients for this variable are negative, as expected for the effect of market expansion. Yet, they are not statistical significant. This puzzling result leads us to investigate two potential reasons that could explain this unexpected findings regarding the market-size effect.

First, there is the possibility of an expanded range of exported products. However, this would not affect the overall variety of products if the newly exported items are already part of production. In many cases, newly exported products have a history of being produced for the domestic market (Iacovone and Javorcik, 2010; Mayer et al., 2014).

Second, it is important to note that not all firms benefit from market expansion due to trade liberalization. Firms engaged in export activities primarily experience expanded market-reach under the FTA. However, firms that exclusively serve domestic customers do not see an expansion in their market size; instead, they remain confined to the domestic market. Considering these dynamics, drawing definitive conclusions at this stage is premature. Thus, we will further explore how export tariff reductions influence firms' strategies in contexts with potential for market growth in the next subsection.

[Insert Table 3]

[25] $0.775 = 0.071(in\, column\,(1)) \cdot 10.9$, where 10.9 is the mean decrease of import tariff, expressed in percentage points, during the study period.

Our main findings in 2 show how firms adjust their product mix in response to the trade liberalization, which led to increased competition and expanded market size. However, there is a concern that these adjustments in product range and diversification were initiated prior to the FTA, independent of the tariff changes between Korea and the US.To address this concern, we examine a placebo effect in Table 3 by regressing changes in product range and diversification indexes between 2008 and 2011 on the tariff changes from 2011 to 2016. We find that changes in both import and export tariffs do not show any significant effects, indicating no pre-existing trends in firms' product mix adjustments prior to the trade liberalization.

4.3 Further Analysis: Market Expansion Effect

Given that trade liberalization does not uniformly result in market expansion for all firms and can introduce external economies of scale in a small open economy, we categorize firms into two groups: those in industries where Korea has a comparative advantage and those in industries without the comparative advantage. To evaluate Korea's comparative advantage relative to the US, we use the revealed comparative advantage (RCA).[26] This approach identifies industries where Korea has a comparative advantage. In this paper, industries in which Korea demonstrates a revealed comparative advantage over the US are termed *export industries*, whereas others are classified as *import industries*. The rationale for this classification, rather than distinguishing firms simply as exporters or non-exporters, stems from two considerations: (i) a significant proportion of non-exporters actually engage in export activities indirectly,[27] and (ii) even non-exporting firms within export-oriented industries can benefit from trade liberalization via the external economies of scale. Accordingly, we expect the market expansion effect and the advantages of economies of scale to be most pronounced among firms within export industries.

[Insert Table 4]

We apply the same regression model outlined in equation (14) to two sub-samples. Table 4 shows the regression results for each group. Panel A of Table 4 displays the results for firms in export industries where the market-size effect channel can be operative. The coefficients of export tariff changes become statistically significant, and the magnitude of the effect is

[26] $RCA_{KOR,j} = \frac{Exp_{KOR,j}/\sum_j Exp_{KOR,j}}{Exp_{US,j}/\sum_j Exp_{US,j}}$, where $Exp_{KOR,j}$ is the exports of industry j by Korea, $Exp_{US,j}$ is the exports of industry j by the US, $\sum_j Exp_{KOR,j}$ is the total exports by Korea, and $\sum_j Exp_{US,j}$ is total exports by the US. When $RCA_{KOR,j} \geq 1$, it indicates that Korea has a revealed comparative advantage in industry j over the US.

[27] Even though they export indirectly, they are classified as non-exporting firms in the data because their direct export volume is zero. This phenomenon is underscored by the 2016 Survey on the Actual Conditions of Small and Medium Enterprises (SMEs) and Startups: among SMEs identifying themselves as exporters, either directly or indirectly, only about 14.7% engage in direct exports. Consequently, the vast majority, approximately 85.3%, participate in export activities indirectly, frequently without generating direct export revenue.

considerably larger than previously observed in Table 2. Specifically, the results in column (2) indicate that Korean firms in export industries, on average, increase the number of their products by 2.191 in response to export tariff cuts under the KORUS FTA.[28] Furthermore, firms tend to allocate their production more evenly across products in response to export tariff reductions. This empirical evidence highlights the differential impacts of increased competition and market expansion resulting from trade liberalization on firms' product mix.

The coefficients of import tariff change variable in Panel A of 4 remain positive, although the magnitude of effect slightly diminishes. The impact of competition on firms within export industries is anticipated to be less marked compared to those focusing primarily on the domestic market. Notably, before the FTA, the import tariff rates for export industries stood at 7.70 percent, compared to 13.99 percent for import industries in 2011. This suggests that even before the KORUS FTA, export industries faced lower import tariffs and, consequently, were exposed to higher competition pressures already than other industries.

We now turn our focus to the second group—firms in industries without a comparative advantage over the US. As shown in Panel B of Table 4, these firms in import industries do not benefit from the market-size effect due to the FTA. In scenarios where the market-size effect is absent but the competition effect persists, reductions in import tariffs lead to a decrease in both the range of products and the level of product diversification. In contrast, reductions in export tariffs do not yield statistically significant outcomes, as we expected.

5 Product Churning Strategies: Drop, Add and Adjust

To deepen our understanding of the findings from the previous analysis, this section investigates the specific products that firms decide to drop, add, or increase production of during trade liberalization. We investigate which factors influence these decisions—the magnitude of tariff changes on products or the relative efficiency of products within firms. Our investigation is structured into four parts: (i) defining the efficiency of products, (ii) comparing dropped products with those that are retained, (iii) analyzing changes in production levels among continuing products, and (vi) tracing the efficiency and production trends of newly added products over time.

5.1 Measuring Firm-Product Efficiency

Measuring the efficiency of products is crucial for our analysis. However, accurately evaluating product efficiencies at the firm-product level is a common challenge across studies due to the

[28] $2.191 = -1.378 (in\, column\, (2)\, of\, Panel\, A) \cdot -1.59$, where the average export tariff change for firms in export industries is -1.59.

absence of detailed input data for each product.[29] Our data provides output information for each product but lacks specific input data at the firm-product level, such as how much labor and capital are allocated to manufacture each product within firms. To overcome this challenge, we adopt three proxies for firm-product efficiency: (i) efficiency measured by the multiproduct production function, (ii) the product's output share, and (iii) relative size of the product within firms.

The first efficiency index is estimated by following Dhyne et al. (2017)'s multiproduct production function:

$$ln(y_{ikt}) = \alpha_0^k + \alpha_1^k ln(l_{it}) + \alpha_2^k ln(k_{it}) + \alpha_3^k ln(m_{it}) + \alpha_4^k ln(y_{i-kt}) + v_{ikt}, \quad (14)$$

where y_{ikt} is the output of product k in firm i in year t.[30] l_{it}, k_{it}, and m_{it} are the labor, capital, and material inputs of firm i in time t.[31] In multiproduct firms, the output of product k depends on not only firm i's inputs but also other products' outputs. The estimation aggregates the output of all other products in firm i excluding those of product k in year t, y_{i-kt}. v_{ikt} is composed of the specification error, n_{ikt}, and the efficiency shock, w_{ikt}. We estimate the multiproduct production function and obtain the residuals, which serve as the firm-product efficiencies denoted as $MPEff_{ikt}$. In the process of estimation, we first pool observations at the three-digit level, since the number of observations at eight-digit level is insufficient for the estimation. To manage the between-industry price differences, we divide product output based on the industry price indices from the Bank of Korea.

According to the models of Diewert (1973) and Lau (1976), the output of product k is non-decreasing in the input factors holding the output of other products$-k$ constant and non-increasing in the sales of other products holding the input factors constant. Table 5 and 6 summarize the results of the top 10 three-digit goods according to the number of firm-product observations in 2011 and 2016, respectively. The estimation results show that all the coefficients have the correct signs. That is, all the coefficients of the input factors are positive, whereas those of the sales of other products are negative.[32]

[29] Due to the lack of data on variable inputs by products within firms, the previous empirical studies could not estimate efficiency level of products. Instead, they used firms' product sales-weighted productivity, firm sales, and the length of time that a firm has produced a product (Bernard et al., 2010); firms' product sales-weighted capital intensity (Ma et al., 2014); and firms' relative product sales shares (Liu, 2010).

[30] Dhyne et al. (2017) estimates the quantity based efficiency, but this paper use the revenue-based efficiency. There are concerns of using sales-based productivity. Hence, it would be better to check whether our results are robust with quantity-based productivity (De Loecker et al., 2016; Dhyne et al., 2017). However, only product's output variable is available in the our data. In other worlds, the quantity based variables are not available in our estimation. Since we use a product's sales as the output variable, we divide output by the output price index to control the price effect on the sales.

[31] We use the total wage for l_i, tangible fixed assets for k_i, and material input for m_i of firm i.

[32] It implies that as the sales of other products increase the proportion of input factors to product k decreases.

[Insert Table 5]

[Insert Table 6]

The second firm-product efficiency proxy is the output share of product k in firm i in year t, $Share_{ikt} = \frac{q_{ikt}}{\sum_{k=1}^{K} q_{ikt}}$, where q_{ikt} represents the output of product k in year t at firm i who produces K number of different products. This proxy operates on the assumption that the share of product output is proportionate to the efficiency of products within firms (Bernard et al., 2010, 2011; Liu, 2010). It suggest that firms produce far more their core products than peripheral products.

The last efficiency proxy involves measuring the relative product size, $Relative\ Share_{ikt} = \frac{q_{ikt}}{\frac{1}{K}\sum_{k=1}^{K} q_{ikt}}$ (Bernard et al., 2010). If the second proxy indicates the overall importance of a product, this last proxy offers a evaluation of how significantly a product deviates from the average.

5.2 Dropping Products

To better understand their decision-making processes we analyze the characteristics of products that are dropped from firms' portfolios, using the three efficiency indexes and tariff changes variables. The regression model is is defined as follows:

$$Dropped_{ik} = \alpha_0 + \beta_1 \triangle imp\,tariff_k + \beta_2 \triangle exp\,tariff_k + \beta_3 Efficiency_{ik2011} + \delta_i + \eta_k + e_{ik}. \quad (15)$$

$Dropped_{ik}$ is a dummy variable which takes the value of 1 if product k is produced by firm i in 2011, but is no longer in production by 2016. The dummy variable for continuing products has the value of 0. Import tariffs change, $\triangle imp\,tariff_k$, and export tariffs change, $\triangle exp\,tariff_k$, of product k between 2011 and 2016 are included in the model. $Efficiency_{ik2011}$ is the efficiency of product k within firm i in 2011, captured by three different proxies—$MP\,Eff_{ik2011}$, $Share_{ik2011}$, and $Relative\ Share_{ik2011}$. δ_i is the firm fixed effect to control time-invariant firm characteristics. η_k is the product fixed effect to control for product characteristics that are common across firms. Firm-level cluster standard error are employed.

[Insert Table 7]

Table 7 presents which products that firms drop after the FTA. Column (1) shows that the choice of firms to discontinue production of a particular product is not influenced by tariff changes of that product. Instead, that decision depends on the product's relative efficiency within firm. The negative coefficient of the firm-product efficiency variable, estimated by the multi-product production function in column (2), suggests that products with lower efficiency are more likely to be dropped from a firm's product lineup during trade liberalization. The findings in columns (3) and (4), utilizing different efficiency indexes, yield similar results. This implies that firms are more inclined to discontinue their marginal product rather than the core one, even when the core product experiences the largest reduction in import tariffs and the marginal product sees the smallest reduction within the product set.

5.3 Adjusting Output of Continuing Products

Resource reallocation within firm goes beyond dropping products; it also encompasses adjustments within the continuing product portfolio. We further examine whether firms tend to change production of products based on tariff changes or efficiency levels. The regression model to investigating this aspect is as follows:

$$\triangle Output_{ik} = \alpha_0 + \alpha_1 \triangle imp\,tariff_k + \alpha_2 \triangle exp\,tariff_k + \alpha_3 Efficiency_{ik2011} + \delta_i + \eta_k + e_{ik}. \quad (16)$$

$\triangle Output_{ik}$ is the growth rate of either the output or the output share of product k in firm i between 2011 and 2016.[33] $Efficiency_{ik2011}$ is the efficiency of product k in firm i in 2011. $\triangle imp\,tariff_k$ and $\triangle exp\,tariff_k$ are import and export tariff rate change of product k between 2011 and 2016, respectively. Firm fixed effect, product fixed effect, and firm-level cluster standard error are employed. The sample is limited to products that were produced in both 2011 and 2016.

[Insert Table 8]

Even for continuing products, resource reallocation within firms is primarily influenced by product efficiency rather than changes in tariffs. The positive coefficients of the product efficiency variables in Table 8 indicate that firms tend to increase production of more efficient products over less efficient ones. Insights from Table 7 and 8 suggest trade liberalization prompts firms to reallocate resources not just by dropping the least efficient products but also by scaling down production of less efficient ones while keeping them in their portfolio. In other words, firms shift their resources from less to more efficient products in response to trade liberalization. This decision to reallocate resources is influenced more by the relative efficiency of the products within the firm than by the size of import and export tariff changes affecting them.

[33]The growth rate of output is quantified as the logarithmic difference in a product's output between 2011 and 2016. Similarly, the growth rate of output share is calculated by dividing the change in a product's output between 2011 and 2016 by the mean value of the product's output over these two periods.

5.4 Adding New Products

[Insert Table 9]

Lastly, we delve into the analysis of the products that firms decide to incorporate into their portfolio following the FTA. As anticipated by the theoretical model, Table 9 reveals that the products added by firms tend to exhibit lower efficiency compared to the existing products within those firms. This indicates that the efficiency of the most recently added product is generally lower than that of the existing products within the same firm. To gain deeper insights into the nature of the products that firms choose to add, we trace the output and efficiency of the newly introduced products.[34] Our analysis aims to track the growth patterns of products introduced between 2011 and 2013, which is represented as

$$\triangle X_{ik} = \alpha_0 + \alpha_1 Added_{ik} + \delta_i + \eta_k + e_{ik}. \quad (17)$$

$\triangle X_{ik}$ is the increase in efficiency or the growth in output of product k in firm i between 2013 and 2016. $Added_{ik}$ is a dummy variable which takes a value of 1 if product k in firm i is added between 2011 and 2013; it is set to 0 for products that exist in both periods. Firm fixed effect, product fixed effect, and firm-level cluster standard error are employed.

[Insert Table 10]

The coefficients estimated for $Added_{ik}$ in column (1)-(3) of Table 10 suggest that newly introduced products demonstrate a faster efficiency growth compared to the existing products upon entering production. Furthermore, as indicated in column (4), the output of added products grows at a faster rate than that of existing products. This suggests that although the initial efficiency level of added products might be lower than that of existing ones, they display a steeper growth. In other words, firms tend to add products with substantial growth potential.

6 Conclusion

Trade liberalization impacts firms' product mix by operating through two fundamental channels. First, as a result of import tariff cuts, domestic firms face heightened competition when foreign counterparts gain access to their domestic market. Second, at the same time, export tariff reductions offer these domestic firms the opportunity to expand their reach by selling their products to foreign consumers. The theoretical framework suggests that each of these channels has a distinct effect on firms' product range. However, previous empirical papers study only

[34] Here, we set the year for the added products as 2013, the year after the KORUS FTA started in 2012.

the aggregate impact of trade liberalization on product adjustment within firm, since they are unable to disentangle these channels due to the identical changes in import and export tariff rates.

This paper distinguishes between these two channels and investigates their unique impacts on firm's product mix adjustment. Unlike in other cases of trade liberalization, the KORUS FTA has led to significant asymmetry in changes to and import and export tariff rates. This study finds two major results. First, firms distinctly adjust their product mix, both extensively intensively, in response to reductions in import and export tariffs. As import tariffs decrease, firms tend to narrow their product range and focus on a select few products due to increased competition. Conversely, in response to export tariff reductions, firms expand their product range and distribute their production more evenly across their products, thanks to the expanded market. This effect of export tariff cuts is only observed in industries where the market-size effect can come into play.

Second, further examination of firms' decisions to drop, add, decrease, or increase production shows that these decisions are primarily driven by the relative efficiency of products within firm, rather than tariffs change on products. The findings indicate that firms strategically adjust their product mix by reallocating resources from less efficient products to more efficient ones. The empirical results match theoretical expectations, showing that products which are dropped or added typically have lower efficiencies compared to those that are continued within the same firms. However, the products that are added experience a quicker growth in both efficiency and output once they are brought into production. As well as dropping and adding products, firms also reshape their product mix by decreasing the output of continuing products that exhibit relatively lower efficiency compared to other continuing products within the same firm.

This study contributes to the literature by thoroughly examining how trade liberalization affects firms through both market-size and competition effects, highlighting their distinct influences. This paper not only documents the outcomes of firms' decisions on production levels but also examines the decision-making processes, exploring the reasons behind their choices to drop, add, or adjust production. Our analysis helps to better understand the strategies firms use to adapt to changing trade environments. However, our study is limited by the available data, which does not fully allow us to separate the changes in product mix for exports from those for domestic sales. This limitation points to an area for future research to explore more deeply.

References

Allanson, P. and C. Montagna (2005). Multiproduct firms and market structure: An explorative application to the product life cycle. *International Journal of Industrial Organization 23*(7-8), 587–597.

Baldwin, J. and W. Gu (2009). The impact of trade on plant scale, production-run length and diversification. In *Producer Dynamics: New Evidence from micro data*, pp. 557–592. University of Chicago Press.

Bernard, A. B., S. J. Redding, and P. K. Schott (2010). Multiple-product firms and product switching. *American Economic Review 100*(1), 70–97.

Bernard, A. B., S. J. Redding, and P. K. Schott (2011). Multiproduct firms and trade liberalization. *The Quarterly Journal of Economics 126*(3), 1271–1318.

De Loecker, J., P. K. Goldberg, A. K. Khandelwal, and N. Pavcnik (2016). Prices, markups, and trade reform. *Econometrica 84*(2), 445–510.

Dhyne, E., A. Petrin, V. Smeets, and F. Warzynski (2017). Multi product firms, import competition, and the evolution of firm-product technical efficiencies. Technical report, National Bureau of Economic Research.

Diewert, W. E. (1973). Functional forms for profit and transformation functions. *Journal of Economic theory 6*(3), 284–316.

Eckel, C. and J. P. Neary (2010). Multi-product firms and flexible manufacturing in the global economy. *The Review of Economic Studies 77*(1), 188–217.

Goldberg, P. K., A. K. Khandelwal, N. Pavcnik, and P. Topalova (2010). Multiproduct firms and product turnover in the developing world: Evidence from india. *The Review of Economics and Statistics 92*(4), 1042–1049.

Iacovone, L. and B. S. Javorcik (2010). Multi-product exporters: Product churning, uncertainty and export discoveries. *The Economic Journal 120*(544), 481–499.

Lau, L. J. (1976). A characterization of the normalized restricted profit function. In *The Hamiltonian Approach to Dynamic Economics*, pp. 131–163. Elsevier.

Liu, R. (2010). Import competition and firm refocusing. *Canadian Journal of Economics/Revue canadienne d'économique 43*(2), 440–466.

Lopresti, J. (2016). Multiproduct firms and product scope adjustment in trade. *Journal of International Economics 100*, 160–173.

Ma, Y., H. Tang, and Y. Zhang (2014). Factor intensity, product switching, and productivity: Evidence from chinese exporters. *Journal of International Economics 92*(2), 349–362.

Mayer, T., M. J. Melitz, and G. I. Ottaviano (2014). Market size, competition, and the product mix of exporters. *American Economic Review 104*(2), 495–536.

Nocke, V. and S. Yeaple (2006). Globalization and endogenous firm scope.

Qiu, L. D. and W. Zhou (2013). Multiproduct firms and scope adjustment in globalization. *Journal of International Economics 91*(1), 142–153.

Wiersema, M. F. and H. P. Bowen (2008). Corporate diversification: The impact of foreign competition, industry globalization, and product diversification. *Strategic Management Journal 29*(2), 115–132.

Figure 1: Optimal Product Range

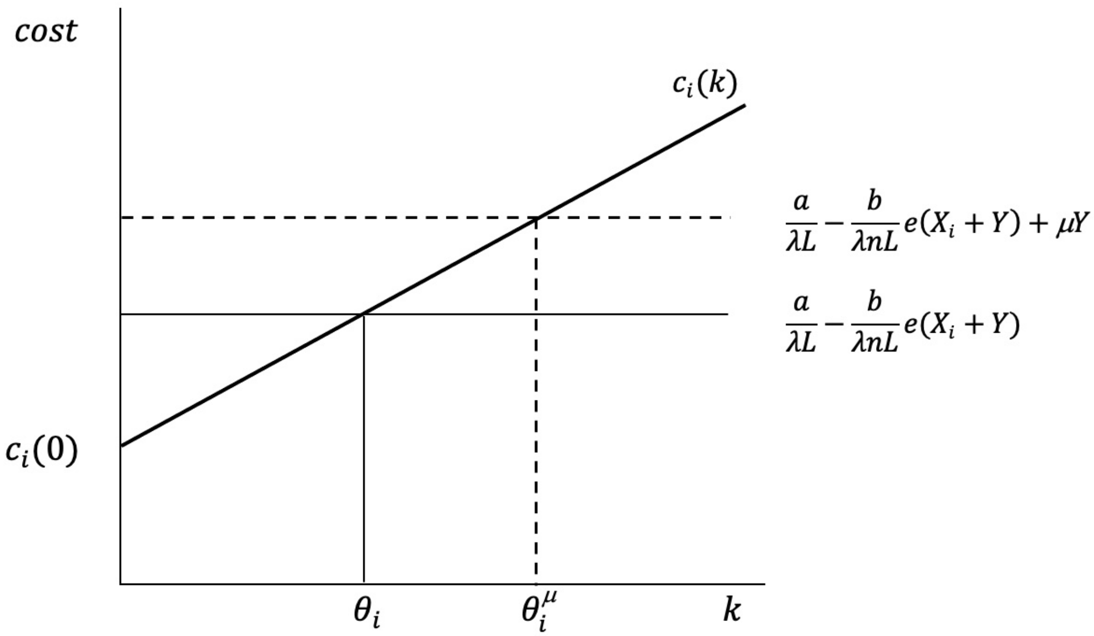
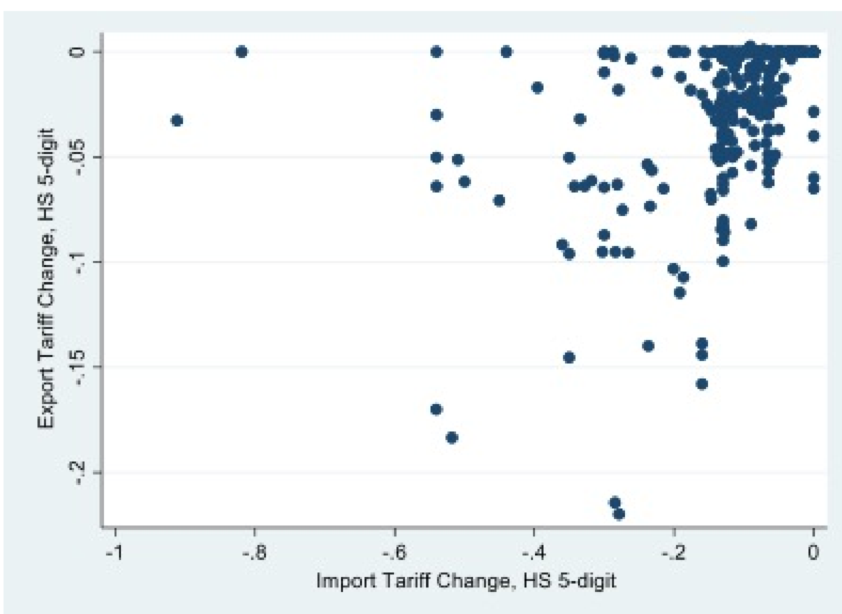


Figure 2: Product Tariff Change between 2011 and 2016



Notes: Import tariff is the tariff on goods from US to Korea. Export tariff is the tariff on goods from Korea to US.

Table 1: Value and Number of Imported and Exported Products

Exported to	US	China	Japan	World
Value of exports				
2011	56,421	134,185	39,679	555,208
2016	66,757	124,432	24,356	495,465
Growth	18%	-7%	-39%	-11%
Number of exported products				
2011	3,047	3,646	3,375	4,514
2016	3,318	3,721	3,283	4,646
Growth	9%	2%	-3%	3%
Imported from	US	China	Japan	World
Value of imports				
2011	44,814	86,430	68,319	524,405
2016	43,396	86,962	47,454	406,059
Growth	-3%	1%	-31%	-23%
Number of imported products				
2011	4,013	4,236	3,900	4,863
2016	4,141	4,314	3,924	4,955
Growth	3%	2%	1%	2%

Notes: Data from the International Trade Centre. Unit of trade value is expressed in US dollars (in millions). Products are defined by the six-digit HS codes.

Table 2: Effect of Tariff Reductions on Product Mix

	(1)	(2)	(3)	(4)	(5)	(6)
	$\triangle number\ of\ products$			$\triangle diversification$		
$\triangle imp\,tariff$	0.071***		0.075**	0.031**		0.031**
	(0.036)		(0.037)	(0.013)		(0.014)
$\triangle exp\,tariff$		-0.098	-0.187		-0.022	-0.059
		(0.400)	(0.407)		(0.093)	(0.094)
$ln(TFP)$	-0.0002	0.0003	-0.0004	-0.003	-0.003	-0.003
	(0.008)	(0.008)	(0.008)	(0.003)	(0.003)	(0.003)
$ln(L)$	-0.087***	-0.087***	-0.087***	-0.041***	-0.041***	-0.041***
	(0.013)	(0.013)	(0.013)	(0.004)	(0.003)	(0.004)
$ln(Age)$	-0.008***	-0.008***	-0.008***	-0.003***	-0.003***	-0.003***
	(0.002)	(0.002)	(0.002)	(0.001)	(0.001)	(0.001)
$ln(Age^2)$	0.0001	0.0001	0.0001	0.00003***	0.00003***	0.00003***
	(0.0001)	(0.0001)	(0.0001)	(0.00001)	(0.00001)	(0.00001)
$Export$	-0.040***	-0.041***	-0.041***	-0.007*	-0.007*	-0.007*
	(0.012)	(0.012)	(0.012)	(0.004)	(0.004)	(0.004)
$Multiproduct$	0.715***	0.715***	0.716***	0.320***	0.321***	0.321***
	(0.015)	(0.015)	(0.015)	(0.006)	(0.006)	(0.006)
$\triangle IP$	0.069	0.071	0.104	-0.028	-0.030	-0.017
	(0.458)	(0.462)	(0.463)	(0.182)	(0.183)	(0.184)
$Constant$	0.296***	0.285***	0.293***	0.139***	0.135***	0.138***
	(0.048)	(0.050)	(0.049)	(0.011)	(0.011)	(0.011)
$Observation$	23,797	23,797	23,797	23,796	23,796	23,796
$R-squared$	0.154	0.154	0.154	0.219	0.218	0.219

Notes: The dependent variable in column (1)-(3) is the change in the number of eight-digit KSIC products produced by firm $i$between 2011 and 2016, and that of column (4)-(6) is the change in the product diversification of firm i. $\triangle imp\ tariff$ is the change in firm i's specific import tariff rate between 2011 and 2016. $\triangle exp\ tariff$ is the change in firm i's specific export tariff rate between 2011 and 2016. TFP is firm i's value-added total factor productivity measured by the Cobb–Douglas production function with a two-thirds labor share in 2011. L is the number of permanent workers and Age is the age of firm i in 2011. *Export* and *Multiproduct* are dummy variables that take the value of 1 if firm i exports and produces more than two products in 2011, respectively; otherwise, they are 0. $\triangle IP$ is the change in import penetration between 2011 and 2016 in the four-digit-level industry j to which firm i belongs. Numbers in parentheses are robust standard errors. ***, **, and * indicate statistical significance at the 1%, 5%, and 10% levels, respectively.

Table 3: Placebo Effect

	(1)	(2)	(3)	(4)	(5)	(6)
	$\triangle number\,of\,products_{08-11}$			$\triangle diversification_{08-11}$		
$\triangle imp\,tariff$	0.028		0.024	-0.001		-0.001
	(0.035)		(0.036)	(0.012)		(0.012)
$\triangle exp\,tariff$		0.210	0.180		-0.006	-0.005
		(0.395)	(0.404)		(0.096)	(0.097)
$ln(TFP)$	-0.012	-0.012	-0.012	0.001	0.001	0.001
	(0.009)	(0.009)	(0.009)	(0.002)	(0.002)	(0.002)
$ln(L)$	-0.085***	-0.085***	-0.085***	-0.027***	-0.027***	-0.027***
	(0.016)	(0.016)	(0.016)	(0.003)	(0.003)	(0.003)
$ln(Age)$	-0.009***	-0.009***	-0.009***	-0.004***	-0.004***	-0.004***
	(0.002)	(0.002)	(0.002)	(0.001)	(0.001)	(0.001)
$ln(Age^2)$	0.0001	0.0001	0.0001	0.0001***	0.0001***	0.0001***
	(0.0001)	(0.0001)	(0.0001)	(0.00001)	(0.00001)	(0.00001)
$Export$	-0.020*	-0.020*	-0.020*	-0.003	-0.003	-0.003
	(0.011)	(0.011)	(0.011)	(0.004)	(0.004)	(0.004)
$Multiproduct$	0.330***	0.330***	0.330***	0.168***	0.168***	0.168***
	(0.016)	(0.016)	(0.016)	(0.006)	(0.006)	(0.006)
$\triangle IP$	0.536	0.500	0.510	0.050	0.050	0.051
	(0.357)	(0.361)	(0.361)	(0.146)	(0.146)	(0.147)
$Constant$	0.272***	0.273***	0.275***	0.065***	0.065***	0.065***
	(0.058)	(0.058)	(0.058)	(0.011)	(0.011)	(0.011)
$Observation$	20,456	20,456	20,456	20,456	20,456	20,456
$R-squared$	0.046	0.046	0.046	0.074	0.074	0.074

Notes: The dependent variable in column (1)-(3) is the change in the number of eight-digit KSIC products produced by firm $i$between 2008 and 2011, and that of column (4)-(6) is the change in the product diversification of firm i. $\triangle imp\ tariff$ is the change in firm i's specific import tariff rate between 2011 and 2016. $\triangle exp\ tariff$ is the change in firm i's specific export tariff rate between 2011 and 2016. TFP is firm i's value-added total factor productivity measured by the Cobb–Douglas production function with a two-thirds labor share in 2011. L is the number of permanent workers and Age is the age of firm i in 2011. *Export* and *Multiproduct* are dummy variables that take the value of 1 if firm i exports and produces more than two products in 2011, respectively; otherwise, they are 0. $\triangle IP$ is the change in import penetration between 2011 and 2016 in the four-digit-level industry j to which firm i belongs. Numbers in parentheses are robust standard errors. ***, **, and * indicate statistical significance at the 1%, 5%, and 10% levels, respectively.

Table 4: Effect of Tariff Reductions on Product Mix; Export and Import Industries

	(1)	(2)	(3)	(4)	(5)	(6)
	$\triangle number\,of\,products$			$\triangle diversification$		
Panel A: Firms in Export industries						
$\triangle imp\,tariff$	0.036		0.062**	0.012		0.021**
	(0.025)		(0.028)	(0.009)		(0.009)
$\triangle exp\,tariff$		-1.378*	-2.183***		-0.481*	-0.752***
		(0.748)	(0.852)		(0.264)	(0.290)
$Observation$	8,486	8,486	8,486	8,486	8,486	8,486
$R-squared$	0.183	0.183	0.184	0.245	0.245	0.245
Panel B: Firms in Import industries						
$\triangle imp\,tariff$	0.062*		0.061*	0.027**		0.027**
	(0.035)		(0.036)	(0.013)		(0.013)
$\triangle exp\,tariff$		0.132	0.060		0.063	0.031
		(0.449)	(0.457)		(0.099)	(0.100)
$Observation$	15,311	15,311	15,311	15,311	15,311	15,311
$R-squared$	0.139	0.139	0.139	0.203	0.203	0.203

Notes: The sample of Panel A consists of firms in industries where Korea has a comparative advantage with the US. The same of Panel B consists of firms in industries where Korean has not a comparative advantages. The dependent variable in column (1)-(3) is the change in the number of eight-digit KSIC products produced by firm $i$between 2011 and 2016, and that of column (4)-(6) is the change in the product diversification of firm i. $\triangle imp\ tariff$ is the change in firm i's specific import tariff rate between 2011 and 2016. $\triangle exp\ tariff$ is the change in firm i's specific export tariff rate between 2011 and 2016. TFP, L, Age, Age^2, $Export$, $Multiproduct$, $\triangle IP$, and industry dummies are included in the regression, but not reported in the tables. Numbers in parentheses are robust standard errors. ***, **, and * indicate statistical significance at the 1%, 5%, and 10% levels, respectively.

Table 5: Estimation Results of Multiproduct Production Function at Three-Digit Industry Level in 2011

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
	General Purpose Machinery	Plastic Products	Special-Purpose Machinery	Other Metal Products	Parts for Motor Vehicles	Other Food Products	Electrical Equipment	Other Chemical Products	Structural Metal Products	Cement, Lime, and Plaster
l	0.149***	0.348***	0.284***	0.291***	0.251***	0.349***	0.091**	0.119**	0.207***	0.742
	(0.027)	(0.025)	(0.033)	(0.023)	(0.040)	(0.061)	(0.040)	(0.053)	(0.035)	(0.052)
k	0.072***	0.042***	0.050***	0.072***	0.109***	0.0001	0.055***	0.040	0.087***	0.046**
	(0.012)	(0.012)	(0.015)	(0.010)	(0.021)	(0.027)	(0.016)	(0.028)	(0.016)	(0.021)
m	0.680***	0.647***	0.594***	0.652***	0.614***	0.693***	0.718***	0.755***	0.713***	0.752***
	(0.017)	(0.016)	(0.019)	(0.014)	(0.025)	(0.042)	(0.026)	(0.030)	(0.022)	(0.029)
y_{-k}	-0.147***	-0.146***	-0.158***	-0.131***	-0.136***	-0.212***	-0.144***	-0.181***	-0.146***	-0.136***
	(0.004)	(0.003)	(0.004)	(0.003)	(0.005)	(0.009)	(0.005)	(0.007)	(0.005)	(0.007)
Obs.	2,471	2,430	2,228	1,968	1,521	1,188	1,164	1,145	1,024	940

Notes: ***, **, and * indicate statistical significance at the 1%, 5%, and 10% levels, respectively.

Table 6: Estimation Results of Multiproduct Production Function at Three-Digit Industry Level in 2016

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
	General Purpose Machinery	Plastic Products	Special-Purpose Machinery	Other Metal Products	Parts for Motor Vehicles	Other Food Products	Other Chemical Products	Electrical Equipment	Structural Metal Products	Cement, Lime, and Plaster
l	0.537***	0.722***	0.684***	0.583***	0.424***	0.467***	0.303***	0.522***	0.515***	0.284***
	(0.032)	(0.028)	(0.033)	(0.029)	(0.049)	(0.062)	(0.060)	(0.046)	(0.046)	(0.067)
k	0.062***	0.068***	0.057***	0.084***	0.233***	0.098***	0.165***	0.081***	0.145***	0.119***
	(0.015)	(0.014)	(0.016)	(0.013)	(0.029)	(0.034)	(0.031)	(0.021)	(0.022)	(0.028)
m	0.393***	0.324***	0.312***	0.397***	0.363***	0.398***	0.479***	0.342***	0.405***	0.560***
	(0.020)	(0.016)	(0.019)	(0.016)	(0.028)	(0.042)	(0.029)	(0.030)	(0.025)	(0.037)
y_{-k}	-0.151***	-0.140***	-0.155***	-0.131***	-0.154***	-0.188***	-0.161***	-0.145***	-0.139***	-0.153***
	(0.004)	(0.004)	(0.004)	(0.004)	(0.006)	(0.010)	(0.008)	(0.006)	(0.007)	(0.008)
Obs.	2,253	2,461	2,306	1,991	1,729	1,257	1,218	1,181	1,044	960

Notes: ***, **, and * indicate statistical significance at the 1%, 5%, and 10% levels, respectively.

Table 7: Characteristics of Dropped Products

	(1)	(2)	(3)	(4)
$\triangle imp\,tariff$	0.019	0.015	0.020	0.018
	(0.046)	(0.046)	(0.049)	(0.045)
$\triangle exp\,tariff$	-0.419	-0.493	-0.563	-0.560
	(0.908)	(0.888)	(0.900)	(0.901)
$MPEff$		-0.058***		
		(0.007)		
$Share$			-0.246***	
			(0.030)	
$Relative\,share$				-0.077***
				(0.010)
$Constant$	0.947***	1.087***	1.088***	1.182***
	(0.206)	(0.214)	(0.209)	(0.215)
$FirmFE$	Yes	Yes	Yes	Yes
$ProductFE$	Yes	Yes	Yes	Yes
$Observation$	39,152	39,152	39,152	39,152
$R-squared$	0.848	0.854	0.853	0.853

Notes: The dependent variable is 1 if a product is produced by a firm in 2011 but not produced in 2016 and it takes 0 if a product is produced both in 2011 and 2016. Three proxies are used to capture the firm-product efficiency—$MPEff$, *Share*, and *Relative share*. All the columns include product and firm dummy variables. Numbers in parentheses are standard errors clustered at the firm level. ***, **, and * indicate statistical significance at the 1%, 5%, and 10% levels, respectively

Table 8: Among Continuing Products

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
		Growth of Output				*Growth of Output Share*		
$\triangle imptariff$	0.052	0.044	0.046	0.004	0.050	0.041	0.044	0.001
	(0.182)	(0.163)	(0.184)	(0.175)	(0.181)	(0.163)	(0.183)	(0.174)
$\triangle exptariff$	0.899	0.816	1.002	2.201	0.975	0.890	1.075	2.317
	(4.272)	(3.703)	(4.286)	(3.919)	(4.310)	(3.772)	(4.325)	(3.983)
$MPEff$		0.319***				0.325***		
		(0.038)				(0.038)		
$Share$			1.530***				1.570***	
			(0.138)				(0.140)	
$Relative\ share$				0.061				0.059
				(0.041)				(0.043)
$Constant$	0.872	0.219	0.802	-0.533	0.855	0.189	0.786	-0.586
	(0.143)	(0.446)	(1.282)	(0.351)	(1.657)	(0.612)	(1.516)	(0.420)
$FirmFE$	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
$ProductFE$	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
$Observation$	19,563	19,563	19,563	19,563	19,563	19,563	19,563	19,563
$R-squared$	0.780	0.833	0.781	0.832	0.557	0.662	0.558	0.633

Notes: The sample consists of continuing products produced both in 2011 and in 2016. *Growth of Output* in columns (1)-(3) are measured by the log differences of product's output between 2011 and 2016. *Growth of Output Share* in columns (5) and (6) are measured by the product's output changes between 2011 and 2016 divided by the mean of the two periods' values. Three proxies are used to capture the firm-product efficiency—$MPEff$, *Share*, and *Relative share*. All the columns include product and firm dummy variables. Numbers in parentheses are standard errors clustered at the firm level. ***, **, and * indicate statistical significance at the 1%, 5%, and 10% levels, respectively.

Table 9: Characteristics of Added Products

	(1)	(2)	(3)	(4)
$\triangle imp\,tariff$	0.007	0.004	0.009	0.010
	(0.044)	(0.043)	(0.042)	(0.043)
$\triangle exp\,tariff$	0.003	0.093	0.060	-0.024
	(0.995)	(0.971)	(0.969)	(0.984)
$MPEff$		-0.047***		
		(0.006)		
$Share$			-0.203***	
			(0.028)	
$Relative\,share$				-0.068***
				(0.010)
$Constant$	0.837***	0.890***	0.922***	0.991***
	(0.192)	(0.190)	(0.189)	(0.192)
$FirmFE$	Yes	Yes	Yes	Yes
$ProductFE$	Yes	Yes	Yes	Yes
$Observation$	38,404	38,404	38,404	38,404
$R-squared$	0.825	0.829	0.829	0.829

Notes: The dependent variable is 1 if a product is not produced by a firm in 2011 but started to be produced in 2016 and it takes 0 if a product is produced both in 2011 and 2016. Three proxies are used to capture the firm-product efficiency—$MPEff$, *Share*, and *Relative share*. All the columns include product and firm dummy variables. Numbers in parentheses are standard errors clustered at the firm level. ***, **, and * indicate statistical significance at the 1%, 5%, and 10% levels, respectively

Table 10: Growth of Added Products

	(1)	(2)	(3)	(4)
	$\triangle MPEff$	$\triangle Share$	$\triangle Relative\, share$	$\triangle Output$
$Added$	0.194**	0.064***	0.154***	0.229***
	(0.082)	(0.018)	(0.058)	(0.087)
$Constant$	-0.516	0.007	-0.056	-0.272
	(0.853)	(0.265)	(0.819)	(0.928)
$FirmFE$	Yes	Yes	Yes	Yes
$ProductFE$	Yes	Yes	Yes	Yes
$Observation$	26,871	26,878	26,878	26,878
$R-squared$	0.639	0.039	0.036	0.606

Notes: Dependent variables are the change of $MPEff$,*Share*, *Relative share*, and *Output* of product k in firm i between 2013 and 2016. *Added* is 1 if a product is not produced by a firm in 2011 but started to be produced in 2013 and it takes 0 if a product is produced both in 2011 and 2016. All the columns include product and firm dummy variables. Numbers in parentheses are standard errors clustered at the firm level. ***, **, and * indicate statistical significance at the 1%, 5%, and 10% levels, respectively.