Product Scope Adjustment to the China Shock: Competition at Home and Abroad*

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Abstract

How does the rise of China affect the product scope of exporters that compete with Chinese firms both at home and abroad? Korean administrative plant-level data reveal that export competition in third markets, in addition to import penetration in the domestic market, contracts the product scope. Dissecting product scope adjustment further, we uncover that export competition dampens the creation of new products, whereas import penetration precipitates the destruction of existing products. Moreover, import-induced product destruction reallocates resources toward core products. We propose disproportionate importance of domestic market, a forward-looking aspect of product creation, and creative destruction as potential drivers.

Keywords: Creative Destruction; Export Competition; Import Penetration; Multi-Product Exporters; Product Churning; Product Scope

JEL Codes: D22; F14; F61; L10; L25

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1 Introduction

Since China's accession to the World Trade Organization (WTO) in 2001, the share of world manufacturing exports originating in China increased from 8.6% in 2006 to 13.6% in 2018. Imports from China increased in 204 out of 223 countries between 2006 and 2018, growing 162.4% on average, and China has been the largest exporter of goods in the world since 2009.[1] Around the world, consumers gain from international trade by purchasing cheaper made-in-China products, whereas firms and workers, especially in tradeable sectors, face increased competition from China.

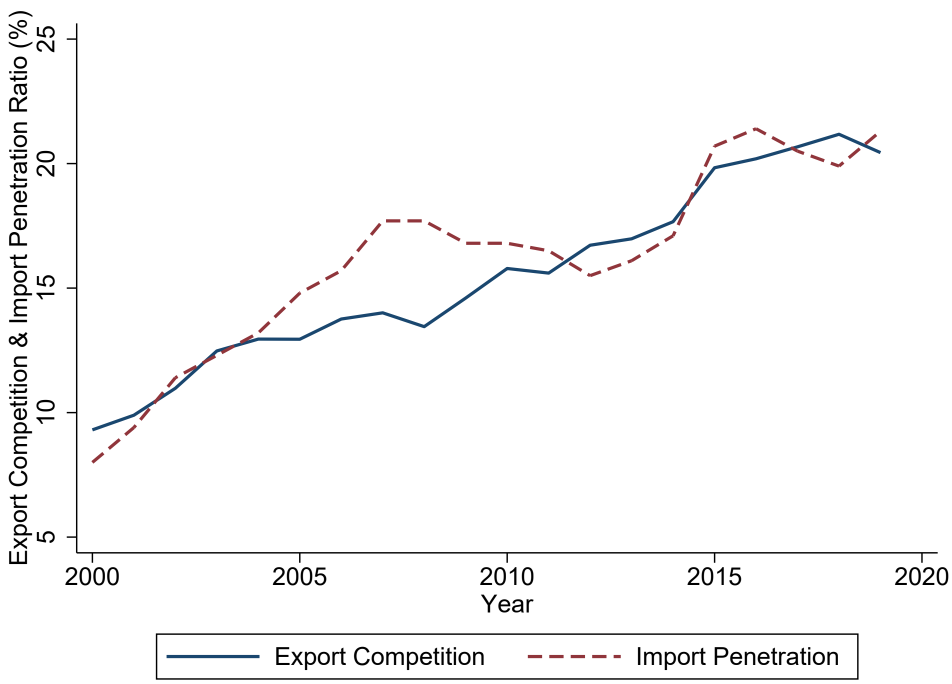
How do firms respond to competition with Chinese firms rising everywhere? In other words, how do firms respond to intensifying import penetration in the domestic market and to escalating third-market competition in export markets (henceforth, export competition) with Chinese competitors? The answers to this question are of great importance in this globalized world since competition with China is not just confined to the domestic market. Especially to firms that rely heavily on export markets, export competition with Chinese firms could be potentially as important as import penetration in their decision making.[2] However, despite its potential importance, export competition with China has been surprisingly under-explored.

We particularly think that the actual impacts of the China trade shock will be biased if researchers overlook the export market competition channel. In this article, we overcome this limitation in the literature by considering both the import penetration and the export competition channels in a unified framework; and revisit the China trade shock using

[1] *Source*: UN Comtrade.

[2] Two examples from the media to spotlight export competition with Chinese firms in exports markets: (i) "[C]hinese wind-turbine makers have grown big on the back of their rapidly growing home market. Now they want to expand abroad, putting further pressure on Western wind-turbine makers, [...] In February, they signed a letter from the Brussels-based WindEurope industry group to the European Commission warning that they were losing ground as Chinese manufacturers expand across Asia, South America, and Africa (The Wall Street Journal, May 14, 2022); (ii) [W]ho is ahead in the battle to be the leading shipbuilding country in the world? [...] Worldwide, Clarkson reported that [...] China holds nearly 40 percent of the backlog while South Korea has about a third of the global order book. Shipbuilders in the two countries will continue to compete for all the new orders, while they also seek to distinguish themselves with new technologies. (The Maritime Executive, Aug 11, 2021).

Figure 1: The China Trade Shock in Korea from 2000 to 2019



Notes: The raw data come from the UN Comtrade. Import penetration is defined as the share of Chinese goods in Korea's total imports. Export competition is defined as the weighted average of Chinese import penetration in each country. The weight is defined as the share of Korea's export value to each country to Korea's total export value.

South Korean manufacturing plants. Korea offers an ideal setting to study this research question for the following reasons:[3] (i) as a small open economy, the exposure to export competition with Chinese firms should be pervasive among Korean manufacturers; (ii) as a newly industrialized economy, the rise of Chinese firms should put substantially competitive pressure on Korean manufacturers whose technology levels are relatively close to those of Chinese competitors.[4] Indeed, Korean data suggest that export competition with China has continuously intensified highlighting its importance as shown in Figure 1.[5]

[3]Henceforth, throughout the paper, "Korea" is used to refer to the Republic of Korea (i.e., South Korea).

[4]di Giovanni et al. (2014) estimate that Korea is one of the top 10 most technologically similar countries to China.

[5]In Korea, the share of Chinese goods to total imported goods (import penetration) rose from 8.0 percent in 2000 to 21.3 percent in 2019. Over the same period, the average share of Chinese goods in Korea's export markets (export competition) increased from 9.3 percent in 2000 to 20.4 percent in 2019. Although these aggregate-level export competition and import penetration measures seem highly correlated over time, the correlation between *plant-level* export competition measure and import penetration measure we

Moreover, from Korean exporters' perspective, the recent return of protectionist policies against China (e.g., the US-China trade war) has directly affected the competition environments in their export destination countries. Without considering the export competition channel, it would be difficult to evaluate the impacts of economic policies, let alone trade policies, on domestic firms. Accordingly, a better understanding as to firms' adjustments to multi-faceted competition with Chinese firms in international trade will provide policymakers across the globe with better information in their decision making processes.

We pay particular attention to product scope adjustment of Korean manufacturing plants responding to both import penetration and export competition with China for three reasons. First, product creation and destruction are quite prevalent at the plant level. Our data show that 71.4% of Korean manufacturing plants engage in product switching activity,[6] and this prevalence is also commonly found in other countries (Bernard et al., 2010; Timoshenko, 2015). Second, since product scope adjustment implies the reallocation of resources within plants to their best use, what causes multi-product plants to adjust their product lines has important allocation implications. By taking advantage of the supply-driven, exogenous China trade shock, we are able to establish a causal inference on the product scope adjustment at the plant level in response to rising competition with China. Finally, because little is known about the impact of export competition with China, especially the differential impact of export competition and import penetration, exploring the product scope adjustment expands our understanding of the China syndrome. To our best knowledge, this article is the first such attempt to explore the differential impact of competition shocks at home and abroad on product switching behaviors.

To explore the impact of the China shock on the product scope adjustment, we construct the *plant-level* measures of import penetration and export competition with China

use throughout the paper is as low as -0.0067, underscoring the importance of distinguishing two types of competition that Korean plants faced during the period.

[6] Here, more specifically, product switching activity refers to the cases in which Korean manufacturing plants either dropped existing products or created new products between 2006 and 2018.

using the Mining and Manufacturing Survey (MMS) data from Statistics Korea, which include plant-product-level shipment information as disaggregate as 8-digit Korean Standard Industry Classification (KSIC). Specifically, we first define the *product-level* import penetration as the change in the share of imports from China relative to the size of domestic market, similar to the standard import penetration measure in the literature (Autor et al., 2013; Acemoglu et al., 2016; Autor et al., 2020a). Then, we compute the effective exposure of a multi-product plant to multiple product-level import penetration using the product-level shipment as a weight. Compared to the commonly used product-level (or industry-level) shocks, which typically rely on a single product with the largest shipment, our plant-level import penetration measures the effective level of competition that each plant experiences more precisely by considering all products that multi-product plants produce.

Advancing this approach further, we consider an extra dimension to construct the *plant-level* measure of export competition since exporters compete against Chinese exporters not only in their domestic market but also in their export markets: the new dimension — exporters can sell their products to multiple export destination countries. Specifically, we define the product-level export competition with China considering this new dimension building on Kang (2022) and compute the effective exposure of a multi-product plant to this product-level export competition using the product-level shipment similar to the import penetration measure. First, before accounting multiple export markets, we measure the *product-level* competition with China in each export destination country as the change in the share of imports from China relative to the imports from Korea and China in that country. Then, the effective exposure to the rise of competition with China in multiple export markets is computed as a weighted sum of these Chinese shares using the importance of each destination country to Korean exports as a weight to construct the product-level export competition with China. Finally, similar to the import penetration measure, we incorporate the plant-level shipment information to reflect all products that multi-product plants manufacture to capture a precise intensity of export competition each plant perceives at the plant level.[7]

Equipped with these two plant-level measures of the China trade shock, we examine the impact of the China shock on the product scope adjustment between 2006 and 2018.[8] The empirical evidence shows that Korean manufacturing plants reduce their scope of products facing more intense import penetration at home and, more importantly, export competition in third markets with China. However, the responses to the China shock are heterogeneous in that only exporting plants reduce their product line. We conjecture that there are two reasons for this observed pattern. First, since product switching activity requires substantial adjustment costs, exporters, who typically have more resources than non-exporters, can afford to engage in product restructuring behavior. Second, unlike non-exporters focusing on the domestic market, exporters are more likely to perceive competition in foreign markets as immediate threats because they are directly involved in exporting activity.

To better understand the product scope adjustment for exporters, equipped with the disaggregated datasets, we dissect the changes in the number of products into the creation of new products and the destruction of old products to explore the margin of adjustment. We find a stark contrast between the impacts of import penetration and export competition: (i) product creation declines only in response to tougher export competition; while in contrast (ii) product destruction increases only facing more intense import penetra-

[7]The most comparable, micro-level approaches, taking into account the multi-product dimension in measuring the China trade shock, has been done by Aghion et al. (2021) and Ding et al. (2022) at the firm level. They use firm-product-level information to compute the weighted sum of the China trade shock similar to our approach using French data and US data, respectively. However, Aghion et al. (2021) only focus on import penetration in the domestic market, and Ding et al. (2022) considers the increase of Chinese share of imports in a single market, Europe. In contrast, we consider all possible markets where competition with China occurs and directly compare the differential impact of import penetration and export competition to capture the complete effect of the China trade shock at the plant level.

[8]To identify the impact of the exogenous rise of China, we instrument the import penetration measure using other countries' imports from China as in Autor et al. (2013). In addition, we control the product-specific demand shock in a third-country that is common across exporters adopting Aghion et al. (2022). This mitigates a potential concern that the realized increase in Chinese exports to a third country (a core component of export competition measure) may include an increased demand from the third country, which is irrelevant to competition margin arising from China's supply-driven exports.

tion. Moreover, (iii) we find that import penetration increases the product specialization of plants, whereas export competition does not have such an impact. It seems that product specialization is more relevant to the destruction of existing products. As economists have rarely paid attention to export competition, the differential impact on the margin of product scope adjustment and its implications in the reallocation of resources add new finding to the literature.

In order to understand the mechanisms behind the increase in product destruction due to the import penetration, we notice a tendency that domestic market is more likely to serve as a core market for exporters. Since the domestic market is considered more essential due to the pecking order of exporters and the home bias in international trade, competitive pressure in the domestic market is more likely to threaten the survival of existing products. However, since export competition in non-core markets could be buffered by other markets including the domestic market, it does not necessarily lead to the drop of products from a plant's product portfolio. In other words, product destruction seems to happen only if the core market is under threats.

Turning to the decrease in product creation due to export competition, we focus on the forward-looking aspect of product creation activity. As tighter competition in export markets makes the introduction of new products more risky and/or less profitable, exporters react by decreasing the creation of new products that target export markets. This is especially relevant to Korean exporters because their domestic market is relatively small and thus export markets are crucial in their expansion in a forward-looking manner. Since export competition shrinks the effective size of export markets, it diminishes exporters' incentive to expand toward export markets by introducing new products to those markets. (Iacovone and Javorcik, 2010).

By the same logic, import penetration is expected to discourage new product creation targeting the domestic market. However, the insignificant impact of import penetration on product creation implies that there should be some countervailing forces. We speculate creative destruction as a potential explanation that offsets the downward pressure. More specifically, as the destruction of old products would release resources trapped in dropped products (Bloom et al., 2013), product creation becomes more affordable, and therefore increasing the creation of new products offsetting the discouraging impact. Indeed, our results show that non-exporters, who are more likely to be threatened by the deteriorating domestic market, increase new products facing the import penetration shock; to some degree, the result supports this creative destruction channel that we hypothesized.

Finally, to understand the allocation consequences of this product scope adjustment to the China shock, we examine how import penetration and export competition affect the product diversification of Korean exporting plants. We find that import penetration decreases the product diversification of plants, which means that resources are reallocated toward core products. This result is consistent with the robust prediction of theoretical models in the literature in that multi-product firms drop the least productive products and focus on products they have comparative advantage with facing adverse condition. In contrast, export competition with China does not have such an impact. In the absence of resource reallocation induced by product destruction, Korean exporting plants does not necessarily increase their product specialization at the plant level facing more intense export competition.[9]

[9] Indeed, this result is not surprising since it is ex-ante not clear how export competition affects product diversification of plants. First, even if plants concentrate their resources to the most competitive product in each export market, which results in stronger specialization at the plant-market level, since the most competitive product in each market could be different, specialization in each market may not lead to the specialization at the plant-level. Due to the differences between export destination countries, export competition may lead to non-trivial portfolio adjustment at the plant-level. Second, it is not clear how adding fewer new products affects the product diversification of plants. On the one hand, adding a new product could increase product diversification since there are more number of products with positive shipment share. On the other hand, a new product could dominate others if it incorporates a new technology, for instance, which increases product specialization instead.

1.1 Related Literature

Our study is related to two strands of literature in economics that have developed separately: (i) the China trade shock and (ii) multi-product firms. The unprecedentedly rapid growth of Chinese exports to the world after its accession to the WTO has sparked active research in the impacts of the China trade shock in a variety of contexts. Not only have economists investigated the impacts of import penetration from China on labor markets (Autor et al., 2013; Acemoglu et al., 2016; Choi and Xu, 2020), innovation (Autor et al., 2020a; Bloom et al., 2016), political outcomes (Autor et al., 2020b), but they also have expanded our understanding beyond its direct import penetration channel by exploring offshoring to China (Mion and Zhu, 2013), exporting to China (Feenstra et al., 2019), and input-output linkages related to Chinese intermediate inputs (Caliendo et al., 2019; Aghion et al., 2021; Ding et al., 2022). However, export competition with China around the world, along with its measurement, mechanisms, and consequences, has been underexplored.

There are some papers that examine the impact of competition with China in third markets. For instance, how an increase in US imports from China affects Mexican outcomes such as labor markets (Utar and Ruiz, 2013; Mendez, 2015; Robertson et al., 2020), firm activities (Iacovone et al., 2011, 2013), female bargaining power (Majlesi, 2016), migration (Majlesi and Narciso, 2018), and crime (Dell et al., 2019) have been studied. More recently, Ding et al. (2022) study the impact of an increase in Chinese share of imports in European markets on US firms' employment and sales.[10] However, all of these studies focus solely on one export market, the United States or Europe. To our best knowledge, the only exception is Kang (2022) who takes all export markets and the relative impor-

[10]Technically speaking, since Ding et al. (2022) examine the impact of the change in the Chinese share of imports in Europe on US firms, it can be understood as the impact of export competition with China in Europe on US firms. However, the authors rely on the change in Europe not because of Europe's importance as an export market but because of its exogeneity to US firms' decision. In contrast, we emphasize the importance of other countries as export markets explicitly by considering the share of Korean exports to each country and the exporting behavior of plants.

tance of each market into account to explore the innovation consequences of export competition with China using Korean patent data. In this paper, we build on Kang (2022) and extend further his measurement of export competition using the plant-product-level dataset, which allows us to measure the plant-level export competition with China more precisely, such as including the multi-product dimension.[11] Another difference is that while Kang (2022) focuses on new invention (or innovation), our topic of interest lies in the product scope adjustment. Importantly, we show that export competition and import penetration have different consequences on the product scope adjustment, highlighting the importance of distinguishing these two different shocks. Further, by studying the product scope adjustment, we bridge the China shock literature to another large literature investigating the product switching behavior of multi-product firms that has been developed in parallel.

Given that the significant share of sales (and exports) is accounted for by multi-product firms (Bernard et al., 2005, 2010), much attention has been paid to how multi-product firms respond to trade shocks both theoretically and empirically. Trade models robustly predict that multi-product firms drop the least efficient products and focus on core products facing more intense competition (Eckel and Neary, 2010; Bernard et al., 2010, 2011; Mayer et al., 2021). However, the empirical evidence is more nuanced. This churning effect is empirically supported in developed countries including U.S. (Bernard et al., 2011; Liu, 2010; Liu and Rosell, 2013), Canada (Baldwin and Gu, 2009), and France (Mayer et al., 2021). In contrast, Goldberg et al. (2010) show that dropping obsolete products rarely happens in India, suggesting the importance of frictions.[12]

[11] In a broader context, Lim et al. (2022) also consider competition in foreign markets and develop a theory of competitive cascades, which emphasizes a quality segment of the market. They investigate how scale and competition in a quality segment ahead/behind firms affect their innovation decisions. They capture competition in export markets at the product level, whereas our measure of export competition is specifically designed to capture competition with Chinese firms in export markets at the plant level.

[12] There have been a few studies to analyze the China shock from the perspective of a multi-product firm, while not focusing on product switching activity. Examples include firm-product technical efficiencies (Dhyne et al., 2017), product differentiation (Hombert and Matray, 2018), and employment (Hyun et al., 2022), to name a few. Different from this line of research, using Korean data, we focus on analyzing the impacts of the China trade shock on the plant-level product scope adjustment — both creation and

We add to this product switching literature in four meaningful ways. First, and most importantly, because we make the most of the supply-driven, exogenous China trade shock linking the China shock literature to the multi-product firms literature, our findings not only shed new light on these two separate lines of literature, but we are also able to establish *causal* relationships. Second, by differentiating the China trade shock into import penetration at home and export competition abroad, we are able to show the differential consequences of these two shocks on product churning behaviors at the plant level. That is, import penetration increases the destruction of existing products while export competition weakens the creation of new products. The differential impacts of import and export competition may give us a new way to think about why the existing empirical evidence has been mixed. Third, consistent with the (robust) predictions from trade models, we found that import penetration induces Korean plants to reallocate their resources towards core products. Interestingly, such a reallocation effect was not observed for the case of export competition, underscoring the importance of analyzing the two shocks separately. Fourth, exploring more countries with different economic environments, specifically Korea in this paper, will be a meaningful addition to the multi-product firms literature.

The rest of the paper proceeds as follows. Section 2 presents data and develops the measures of import penetration and export competition. Section 3 describes the empirical strategy and reports the main results. Section 4 further investigates the product scope adjustment. Section 5 discusses potential mechanisms. Section 6 concludes.

destruction. Our study investigates how efficiently a plant responds to the external shock by reallocating its resources within a plant. More importantly, we introduce the new concept of export competition with China in the global market and analyze its impact on the product scope adjustment at the plant level.

2 Data

2.1 Data Sources

Our primary dataset is the Mining and Manufacturing Survey (MMS) from Statistics Korea for the period between 2006 and 2018,[13] an annual plant-level panel survey.[14] The variables in the MMS include general information about plants activities such as shipments, employment, wage bills, value-added, and tangible capital. Importantly, the MMS also includes shipments of each 8-digit-level Korean Standard Industry Classification (KSIC) product that a plant manufactures. This disaggregate product-level shipment information allows us to analyze product switching behaviors of plants.[15] Moreover, this plant-product-level information is used to generate precise measures of import penetration and export competition with China that each plant faces during the sample period.

We supplement the MMS data with plant-level export information collected by Korea Customs Service (KCS).[16] The KCS data include plant IDs with a positive amount of export and the rank of some countries to which the plants export. By matching the two datasets, we are able to investigate differential responses between initial exporters and non-exporters to competition with Chinese firms, especially Korean exporters' competition with Chinese firms in other countries.

To capture rising competition with Chinese firms, we use international trade flows data, which are originally sourced from the United Nations Commodity Trade Statistics Database (UN Comtrade). The UN Comtrade provides standardized official trade statis-

[13] The sample period starts in 2006 because the disaggregated product-level shipment information is available from 2006 for this project. Admittedly, the information is available even before 2006 from Statistics Korea. However, we were able to get access to the restricted product-level information as early as 2006. Additionally, we can identify the value, but not the quantity, of a product.

[14] Before 2008, the survey collected plant-level information from plants hiring at least 5 employees. However, the survey criteria were changed in 2008, and it then reports only plants with at least 10 employees. As the datasets of 2006 and 2007 contain plants hiring 5-9 employees, we drop the plants with 5-9 employees in 2006 and 2007 to make it consistent across years.

[15] Hur and Yoon (2018) also used the MMS dataset, over the period 2008-16 to investigate the impact of US-Korea FTA on Korean firms' product churning and dynamics.

[16] The KCS database is confidential. Permission to use the dataset through purchase was arranged between the authors and KCS.

tics reported by countries reflecting 99 percent of world merchandise trade. It covers over 200 reporting countries and more than 6,000 different products at the 6-digit Harmonized System (HS) product level. We match the 6-digit HS product code in UN Comtrade to the product code in the MMS data, which is reported at the 8-digit Korean Standard Industry Classification (KSIC) product level, by using the 5-digit Industrial Statistics Analysis System (ISTANS) product code developed and managed by Korean Institute for Industrial Economics and Trade (KIET).[17] More specifically, we retrieve bilateral UN Comtrade data from the ISTANS website,[18] which converts a 6-digit HS product to a 5-digit ISTANS product. Then, we link the 8th revision and the 10th revision KSIC codes in the MMS data to 5-digit ISTANS codes using the concordance table provided by KIET. Through this procedure, we can construct consistent product codes that enable us to assign trade shocks to plant-level shipment information in a precise manner. Appendix A and Appendix B describe the data and matching process more in detail.

2.2 Measuring Plant-Level Trade Shocks

Equipped with the detailed datasets, we measure *plant-level* competition with China's rising share of manufacturing products in the world from two perspectives: i) import penetration at home and ii) export competition in third markets. Typically, the China trade shock is defined at the industry- or region-level import penetration in a domestic market (Autor et al., 2013; Acemoglu et al., 2016). However, in such measures, it would be difficult to answer the product adjustment mechanism (i.e., our main research question) in response to the China shock because plants, not industries or regions, ultimately adjust a product portfolio. Hence, we depart from measuring the China shock at the industry- or region-level, but gauge competition with China at the more disaggregated level, i.e., the plant level. Moreover, taking advantage of the plant-product-level dataset, which shows

[17] KIET is an affiliate of Korean Ministry of Trade, Industry, and Energy.
[18] http://www.istans.or.kr.

the composition of each plant's shipments by product, we further incorporate the multi-product dimension when measuring competition with China.

Import Penetration More specifically, we compute the weighted sum of import penetration in each product at the plant level, where the weight is defined as a product's share of total shipments in each plant. Combining this detailed multi-product feature at the plant level, import penetration for a plant i between 2006 and 2018 is defined as follows:

$$\Delta IP_{i,06-18} = \sum_k \frac{y_{ik,06}}{y_{i,06}} \frac{\Delta M^{CNtoKR}_{k,06-18}}{Y_{k,06}}, \tag{1}$$

where $y_{ik,06}$ is plant i's shipment of product k in 2006, $y_{i,06}$ is the total shipment of plant i in 2006, $Y_{k,06}$ is the total Korean shipment of product k in 2006, and $\Delta M^{CNtoKR}_{k,06-18}$ is the change in Korea's total imports of product k from China between 2006 and 2018.

The import penetration in equation (1) may yield endogeneity issues to establish causality if unobserved error terms simultaneously affect the import penetration and the outcome variable (i.e., omitted variable bias). Also, the outcome variable may impact the import penetration (i.e., reverse causality). To mitigate such endogeneity concerns, similar to the methodology adopted in the literature in (Autor et al., 2013; Acemoglu et al., 2016), we construct an instrument variable as follows:

$$\Delta IPO_{i,06-18} = \sum_k \frac{y_{ik,06}}{y_{i,06}} \frac{\Delta M^{CNtoOTH}_{k,06-18}}{Y_{k,06}}, \tag{2}$$

where $\Delta M^{CNtoOTH}_{k,06-18}$ is the change in other countries' imports of product k from China between 2006 and 2018.[19]

[19] In practice, we use Japan's total imports of product k from China between 2006 and 2018 as in Choi and Xu (2020).

Export Competition In addition to measuring import penetration at the plant level, in this paper, we depart from the existing studies by considering export market competition with China in third markets.[20] For instance, suppose that Korean firms export a certain product to a third country. In the same product market in the third country, if Chinese firms start to penetrate the third-country product market, then the Korean firms will face competitive pressures, just as they encounter rising competition from Chinese firms in Korea. We think this export market competition is particularly important for firms relying heavily on export markets and/or that are similar to Chinese competitors in terms of the level of production technology. In this regard, export market competition with China is expected to be another competition margin to Korean firms in addition to import penetration from China in their domestic market. However, to our best knowledge, only few studies have investigated competition with China in export markets despite its potential importance.[21]

To gauge export market competition with China, we build on the export competition measure originally developed in Kang (2022) who uses the weighted sum of competition in third countries. By using a more disaggregated dataset at the plant-product level in this paper, we construct export market competition with China for a plant i between 2006 and 2018 as follows:

$$\Delta XC_{i,06-18} = \sum_k \frac{y_{ik,06}}{y_{i,06}} \sum_S \frac{X_{k,06}^{KRtoS}}{\sum_{S'} X_{k,06}^{KRtoS'}} \frac{\Delta X_{k,06-18}^{CNtoS}}{X_{k,06}^{CNtoS} + X_{k,06}^{KRtoS}}, \quad (3)$$

[20] Here, third markets (or countries) refer to any countries other than China and Korea. Note that export competition defined in this paper is clearly different from an export shock as a result of the new market opportunities used in Dauth et al. (2014), Feenstra et al. (2019), and Choi and Xu (2020). In these papers, instead of capturing competition, the export shock measures foreign demand shocks that drive exports from Germany, the US, and Korea, respectively. Note further that it is also different from competition induced by positive export demand shock as in Aghion et al. (2022). In their paper, increased demand in export markets attracts the entry of firms, which intensifies competition between domestic firms. However, our export competition focuses on competition between Korean exporters and Chinese exporters in third markets, mostly driven by the Chinese spectacular export growth.

[21] Exceptions include Utar and Ruiz (2013), Mendez (2015), and Robertson et al. (2020), where they study the impacts of US imports on Mexican labor market. However, all of them consider only one export market competition, i.e., the US. To our best knowledge, Kang (2022) is the only exception that incorporates all export markets when measuring export competition with China.

where S (or S') refers to a third country other than China and Korea. $X^{KRtoS}_{k,06}$ and $X^{CNtoS}_{k,06}$ are Korea's total exports and China's total exports of product k to third country S in 2006, respectively. $\Delta X^{CNtoS}_{k,06-18}$ is the change in China's total exports of product k to third country S between 2006 and 2018.

The measure in equation (3) is constructed as a weighted sum of the change in China's share in total imports from China and Korea in a third market between 2006 and 2018 using two weights: (i) the share of each product k for plant i; and (ii) the importance of each market S to Korea. More specifically, it takes into account plant i's reliance on product k, the importance of market S for Korea's total exports of product k,[22] and the growth of China's total exports of product k to market S. We normalize the change in China's total exports in each third country with the total imports from China and Korea in the third country to emphasize the substitution between the two countries in market S. Notice that time variation of this measure comes only from China's total exports to third country S, which is irrelevant with the behavior of Korean plant i. Accordingly, we consider this measure of export competition itself as an exogenous shock.

Controlling for Export-Market Demand Shock While China's tremendous export growth to third countries during the sample period seems to be driven by internal supply shocks and falling global trade barriers (Autor et al., 2013), one may still argue that third-market (or export-market) demand shocks are included in the realized China's exports to third countries. Here, the third-market demand shock has subtle implications for Korean plants' competition with Chinese firms in third markets. The third-market demand shock

[22] The reliance on market S for Korean export product k is the key component that delineates between an instrument for import penetration in equation (2) and export competition in equation (3). For some reason Korean firms export a product k to a particular country S relatively more than country S'. This relationship may originate from fixed costs associated with the entry into a new export market, including information costs, regulation barriers, and setting up distributional channels, all of which are specific to each export market. Hence, Korean firms' export destination markets can differ across products. After this weight is combined with China's total exports of product k to market S, the export competition measure then captures competition with Chinese firms in third markets, which is different from import penetration at home.

that is common across exporters can increase the demands for products of Korean plants. However, at the same time, if the third-market demand shock induces Chinese products relative to Korean products, then it still increases competitive pressure for Korean plants in a third market. Therefore, in order to rule out the pure demand shock, irrelevant to a competition margin arising from China's supply-driven exports, it would be important to purge away the product-specific demand shock in a third country that is common across exporters.

To do so, we adopt a measure developed by Aghion et al. (2022), which captures the change in export market size at the plant level:

$$\Delta Xsize_{i,06-18} = \sum_k \frac{y_{ik,06}}{y_{i,06}} \sum_S \frac{X_{k,06}^{KRtoS}}{\sum_{S'} X_{k,06}^{KRtoS'}} \frac{\Delta M_{k,06-18}^{S\setminus KR}}{M_{k,06}^{S\setminus KR}}, \tag{4}$$

where $M_{k,t}^{S\setminus KR}$ denotes total imports of product k in country S that are not from Korea in year t. The last growth term captures the product k-specific demand shock in country S that is common across exporters. Therefore, $\Delta Xsize_{i,06-18}$ captures each plant i's exposure to this growth considering the two weights used in constructing export competition, analogous to equation (3). Across all specifications, we control the growth of export market size (or product-specific demand shock), and thus export competition now exploits the competition effect with China in third markets.[23]

2.3 Measuring Plant-Level Product Scope Adjustment

We aim to explore how competition with China both in the domestic market and export markets affects resource allocation within a plant through product switching behaviors. Since more intense competition imposes downward pressure on profits, one of the natu-

[23] If imports from China increase in product k in market S, there are three possible scenarios. First, imports in product k in country S increase more than imports from China. Second, imports in product k in country S do not change but those from China increase. Third, country S decreases imports of k despite its imports from China increases. By controlling the change in total imports in product k in country S, we utilize the increase in Chinese exports to country S in a relative manner.

ral responses to escape from competition is to reallocate resources toward products with less fierce competition. To examine whether competition with China incurs such product churning consequences, following Bernard et al. (2010), we measure the change in the number of products (either at the 5-digit level or the 8-digit level). In addition, we decompose the change in the number of products into the creation of new products and the destruction of existing products to analyze whether the margin of adjustment differs by the type of competition.

More formally, the change in the number of products in response to competition with China at the plant level can be attributed to two different margins in a dynamic setting as follows:

$$\Delta N_{i,06-18} = C_{i,18} - D_{i,18}, \tag{5}$$

where $\Delta N_{i,06-18}$ is the change in the number of products that plant i manufactures between 2006 and 2018; $C_{i,18}$ is the number of new products for plant i added between 2006 and 2018; $D_{i,18}$ is the number of existing products for plant i discarded between 2006 and 2018.[24]

For instance, suppose that plant A producing one KSIC-5-digit product, Electronic Integrated Circuits (32112) in 2006, exited the market between 2006 and 2018; while plant B producing three KSIC-5-digit products, Electronic Integrated Circuits (32112), Apparatuses for Switching, Protecting Electrical Circuits Used in Power Distribution Systems (31201), and Wire Telecommunication Apparatuses (32201) in 2006, switched to produce two KSIC-5-digit products, Electric Lamps and Bulbs (28410) and Ballasts for Lamps (28113), in 2018. Then, the changes in the number of products are -1 for both plants A and B, respectively, which does not reveal the different product switching behaviors between the two plants. However, by decomposing the change in the number of products

[24]In practice, the number of products of exiting plants is set to be zero to take into account the exit of plants during the sample period. To put it another way, we are able to capture the extensive margin adjustment. In contrast, although there are plants that entered the market during the sample period, we disregard these plants because the measures of the trade shock cannot be defined for them.

into product creation and product destruction, we are now able to distinguish how the two plants responded differently. To be specific, the numbers of product creation are 0 for plant A and 2 for plant B, whereas the numbers of product destruction are 1 for plant A and 3 for plant B, respectively.

In addition, to investigate whether this product switching activity results in the reallocation of resources across products within plants, we use the Entropy index of product diversification (or specialization) following Baldwin and Gu (2009). The change in the Entropy index of plant i between 2006 and 2018 is defined as follows:

$$\Delta E_{i,06-18} = \sum_{k}^{N_{i,18}} s_{ik,18} ln(1/s_{ik,18}) - \sum_{k}^{N_{i,06}} s_{ik,06} ln(1/s_{ik,06}), \tag{6}$$

where $s_{ik,t}$ denotes plant i's shipments share of product k at time t; $N_{i,t}$ refers to the total number of products of plant i at time t. The measure of product diversification $E_{i,t}$ is, by construction, zero when only a single product is produced and is maximized at $ln(N_{i,t})$ when shipments are evenly spread across $N_{i,t}$ distinct products. In this regard, a negative value of $\Delta E_{i,06-18}$ implies that plant i specialized its product composition between 2006 and 2018.[25]

2.4 Summary Statistics

Table 1 shows the mean, standard deviation, and the number of observations for the key variables used in the analysis. We categorize plants in the sample based on their exporting status in 2006 and thus the summary statistics are presented as the full sample, exporters, and non-exporters, respectively. There are 27,969 manufacturing plants in our sample (11,604 plants are exporters; 16,365 plants are non-exporters).[26] Among the total manufacturing plants in the sample in 2006, 13,341 plants (6,144 exporters; 7,197 non-exporters)

[25]Note that the product diversification measure, $E_{i,t}$, is defined only for surviving plants.

[26]We drop the mining sector from the MMS, which covers both the mining and the manufacturing sector.

remained in the sample in 2018.[27] To put in another way, the survival rate between 2006 and 2018 is 47.7 percent for entire plants (52.9 percent for exporters; 44.0 percent for non-exporters). Note that the survival rate is about 9 percentage points higher for exporters than non-exporters.

Panel A of Table 1 presents variables related to product scope adjustment. Columns (1), (2), and (3), i.e., the full sample, show that on average the number of products that each plant produces decreases by 0.638 between 2006 and 2018. This change is due to the destruction of old product by 0.812, which is partly offset by the creation of new product by 0.174. The comparison between exporting plants and non-exporting plants reveals that exporting plants engage more actively in both product creation and product destruction than non-exporting plants do (see columns (4) through (9)). Exporters drop 0.024 more product and create 0.064 more product than non-exporters between 2006 and 2018. Combining product creation and destruction, the number of products decreases by 0.615 for exporters and by 0.655 for non-exporters, respectively. The measure of product diversification ($\Delta Entropy$) also reveals that exporters (-0.027) reallocate resources towards core products more than non-exporters (-0.011) do conditional on survival.

Noticeably, while non-exporting plants appear to engage more actively in product switching behavior by just looking at the change in the number of products, the opposite is true in that product turnover in terms of both product creation and product destruction has been more prevalent for exporters. This is the reason why it would be important to separate the product creation from the product destruction when we investigate plant-level product scope adjustment.

Panel B of Table 1 also shows that exporters and non-exporters are heterogeneous. On average, exporting plants produce more, have more capital, hire more employees, generate more value-added, and are older than non-exporting plants in 2006. That is, exporters tend to have more resources than non-exporters, and the differences are quite

[27] This means that the rest 14,628 plants (5,460 exporters; 9,168 non-exporters) had stopped operation and exited the market between 2006 and 2018.

Table 1: Summary Statistics

Sample:	1. Full			2. Exporters			3. Non-Exporters		
	Mean	SD	OBS	Mean	SD	OBS	Mean	SD	OBS
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Panel A. Dependent Variables									
$\Delta\#\ of\ Products$	-0.638	0.795	27,969	-0.615	0.875	11,604	-0.655	0.733	16,365
$\#\ of\ Dropped\ Products$	0.812	0.699	27,969	0.826	0.766	11,604	0.802	0.647	16,365
$\#\ of\ New\ Products$	0.174	0.450	27,969	0.211	0.503	11,604	0.147	0.407	16,365
$\Delta Entropy$	-0.018	0.270	13,341	-0.027	0.294	6,144	-0.011	0.248	7,197
Panel B. Control Variables									
Log production value	15.447	1.338	27,968	15.873	1.435	11,603	15.145	1.175	16,365
Log capital	13.946	1.800	27,911	14.403	1.853	11,583	13.621	1.688	16,328
Log employment	3.362	0.886	27,969	3.677	1.010	11,604	3.139	0.705	16,365
Log value-added	14.476	1.269	27,793	14.902	1.366	11,526	14.175	1.101	16,267
Age	10.615	9.223	27,969	12.587	10.208	11,604	9.217	8.173	16,365
$\Delta Xsize$	0.106	0.278	27,969	0.085	0.276	11,604	0.120	0.279	16,365
Panel C. Competition Measures and Instrument									
ΔIP	0.118	0.280	27,969	0.141	0.294	11,604	0.102	0.268	16,365
ΔXC	0.317	0.661	27,969	0.305	0.659	11,604	0.325	0.663	16,365
ΔIPO	0.144	0.521	27,969	0.176	0.605	11,604	0.122	0.450	16,365

Notes: The table presents mean and standard deviation (SD) of the main variables used in the empirical analysis. OBS denotes the number of observations. The sample is restricted to the manufacturing sector. Δ refers to the change between 2006 and 2018. In Panel A, the number of products is measured at the KSIC-5-digit level. $\Delta Entropy$ is a measure of product diversification, which is defined only for surviving plants. In Panel B, all variables except $\Delta Xsize$ are measured at the plant level in 2006. In Panel C, ΔXC is divided by 10 to make it comparable to ΔIP.

noticeable in magnitude. The measure of export market size implies that Korean plants experience positive product-specific demand shock on average.

Panel C of Table 1 presents variables related to the China trade shock during the sample period. On average, import penetration along with its instrument and export competition at the plant level all increase during the sample period. This is true for both exporters and non-exporters. Consistent with the broader measures of import penetration and export competition defined at the country level (i.e., Korea) shown in Figure 1, plant-level measures of the China trade shocks increase between 2006 and 2018.

3 Main Results

3.1 Empirical Strategy

We relate plant-level changes in the number of products to changes in plant-level exposures to both Chinese import penetration and export competition in third-country markets. The regression equation is as follows:

$$\Delta N_i = \alpha + \beta_1 \Delta IP_i + \beta_2 \Delta XC_i + \gamma \Delta Xsize_i + \delta X_i + \psi_{IND(i)} + \varepsilon_i, \quad (7)$$

where i indicates plant and IND denotes industry. The sample period is between 2006 and 2018. The dependent variable, ΔN_i, is the change in the number of products that plant i produces between 2006 and 2018. ΔIP_i (ΔXC_i) is import penetration (export competition) for a plant i between 2006 and 2018. To control the product-specific, export-market demand shock that each plant perceives, we include $\Delta Xsize_i$ as a control variable. To account for plant-level heterogeneity, we add X_i, a vector of plant-level control variables in 2006. Industry fixed effects $\psi_{IND(i)}$ are included at the 4-digit level where industry denotes to which plant i's product with the largest shipment value belongs in 2006.

Our coefficients of interest are β_1 and β_2. The first coefficient, β_1, denotes the impact of Chinese import penetration on plant-level outcomes; the second coefficient, β_2, captures the impact of export competition with China on plant-level outcomes. To identify the causal effect of rising competition with China on product switching behavior, we employ a two-stage least-squares (2SLS) strategy that accounts for the potential endogeneity issue. More specifically, the endogenous variable ΔIP_i is instrumented by ΔIPO_i to capture the supply-driven, exogenous component of Chinese imports. The export competition variable, ΔXC_i, gauges the supply-driven, exogenous component of China's rising comparative advantage and falling trade costs. To further ensure that ΔXC_i measures export competition in third markets, we control $\Delta Xsize_i$, which captures product-specific demand shock. Estimates are weighted by the number of employees in each plant in 2006. Standard errors are clustered at the firm level to account for potential correlations across plants.

3.2 The First-Stage Relationship

Before presenting the main estimation results in equation (7), we check whether there is a sufficient degree of association between the endogenous explanatory variable (ΔIP_i) and the instrument (ΔIPO_i). Table 2 shows the first-stage estimation results. In column (1), we regress the endogenous variable ΔIP_i on the instrument ΔIPO_i and control variables along with industry fixed effects; in column (2), we include ΔXC_i additionally as a regressor. All coefficients of ΔIPO_i are positive and statistically significant at the one percent level across columns. The Kleibergen-Paap F-statistics against the null of weak identification is 255.32 for column (1) and 255.51 for column (2), both of which are well above the Stock and Yogo critical values. Therefore, we reject the null hypothesis that the instrument is irrelevant in the first-stage regression.

Table 2: First-Stage Results

	Dependent Variable: ΔIP_i	
	(1)	(2)
ΔIPO_i	0.498***	0.498***
	(0.031)	(0.031)
ΔXC_i		0.009**
		(0.004)
1st stage F-statistics	255.32	255.51
Observations	27,735	27,735

Notes: All models include plant-level control variables (i.e., log production value, log employment, log value-added, log capital, age, $\Delta Xsize$) and ISTANS 4-digit industry level fixed effects. Standard errors are clustered at the firm level. All estimates are weighted by the number of employees of each plant in 2006. The first-stage F-stats refers to Kleibergen-Paap F-statistics. *** p<0.01, **p<0.05, * p<0.1.

3.3 2SLS Results

Having established the relevance condition of our instrumental variable strategy, we now present the second-stage results that identify the impact of import penetration and export competition on the product scope at the plant level. Table 3 shows the 2SLS estimation results. We begin by estimating equation (7) with the import penetration channel only using a OLS method. The OLS coefficient of column (1) is -0.345 and is statistically significant at the 5 percent level, revealing that there is a negative correlation between import penetration and the number of products at the plant level. In column (2), we estimate the same empirical specification as in column (1), but using a 2SLS method where we instrument ΔIP_i with ΔIPO_i. The 2SLS coefficient of column (2) is -0.833 and is still statistically significant at the 5 percent level.[28] The statistically significant 2SLS estimate allows us to establish a *causal* relationship. Quantitatively, a one standard deviation increase in import penetration is predicted to reduce the number of products by 0.233 at the plant level.[29]

Table 3: Product Churning, Import Penetration, and Export Competition

	Dependent Variable: $\Delta Number\ of\ Products_i$				
Estimation Method:	OLS	IV	OLS	OLS	IV
	(1)	(2)	(3)	(4)	(5)
ΔIP_i	-0.345**	-0.833**		-0.334**	-0.820**
	(0.136)	(0.360)		(0.133)	(0.357)
ΔXC_i			-0.345***	-0.340***	-0.217**
			(0.119)	(0.119)	(0.101)
1st stage F-statistics		255.32			255.51
Observations	27,735	27,735	27,735	27,735	27,735

Notes: All models include plant-level control variables (i.e., log production value, log employment, log value-added, log capital, age, $\Delta Xsize$) and ISTANS 4-digit industry level fixed effects. Standard errors are clustered at the firm level. All estimates are weighted by the number of employees of each plant in 2006. Columns (2) and (5) report the 2SLS results instrumenting ΔIP_i with ΔIPO_i. The rest columns report the OLS results. The first-stage F-stats refers to Kleibergen-Paap F-statistics. *** p<0.01, **p<0.05, * p<0.1.

Turning to the export competition channel, in column (3), we begin by relating the

[28] Comparing the two estimates, the OLS estimate appears to be biased towards zero.

[29] A one standard deviation increase in import penetration is equal to 0.280 (see Table 1). Hence, the treatment effect is calculated as follows: -0.833 $\times$ 0.280 = -0.233.

export competition shock and the number of products without the import penetration channel. The coefficient of -0.345 is statistically significant at the 1 percent level. Quantitatively, a one standard deviation increase in export competition is predicted to reduce the number of products by 0.228 at the plant level.[30] While the product churning effect has been investigated in the context of import penetration in *domestic markets*, to our knowledge, the finding that *export competition* decreases the number of products is new to the international trade literature. To further explore the robustness of the export competition channel, in column (4), we use both the import penetration variable and the export competition variable and perform an OLS regression. The results are barely changed, relative to the specifications in columns (1) and (3), respectively.

Finally, in our most preferred specification, we perform a 2SLS regression, including both the import penetration and the export competition variables. Column (5) shows that both import penetration from China and export competition with China in third countries decrease the number of products. Both coefficients are statistically significant. Quantitatively, a plant that experiences a one standard deviation higher import penetration from China decreases the number of product it produces by 0.230. Similarly, a plant facing a one standard deviation higher export competition with China decreases the number of product it produces by 0.143. When the mean value of the change in import penetration (0.118) and export competition (0.317) in Table 1 are considered, these coefficients imply that the average plant (in terms of import penetration and export competition) decreases 0.097 product and 0.069 product facing stronger import penetration and export competition, respectively. Since the number of product decreases by 0.638 during the sample period on average, these results suggest that more intense import penetration from China and more fierce export competition with China in third markets explain 26.0% of the change in the product scope of the average plant that experiences the average levels of

[30] A one standard deviation increase in export competition is equal to 0.661 (see Table 1). Hence, the treatment effect is calculated as follows: -0.345 $\times$ 0.661 = -0.228.

import penetration and export competition.[31]

All in all, we confirm two channels of product churning at the plant level: i) import penetration in domestic markets; ii) export competition in third markets.[32] Put another way, Korean manufacturing plants respond to competition with China by reducing the number of products they manufacture to escape from competition. This core finding is not only consistent with the results in the literature (Bowen and Wiersema, 2005; Liu, 2010) such that plants reallocate their resources to more efficient products facing negative import penetration shocks, but it also sheds new light on the unexplored channel through which plants reshuffle a product portfolio in response to export competition shocks.[33]

4 Dissecting the Product Scope Adjustment

In order to better understand the responses of Korean manufacturing plants facing more intense competition with Chinese firms at home and abroad, we dissect the product scope adjustment further. First, we examine the heterogeneity between plants by focusing on the exporting status to explore which plants are more likely to engage in product churning behaviors. Second, we decompose the change in the number of products into the creation of new product and the destruction of existing product to analyze the margin of adjustment at the plant level. Third, we examine whether the product churning behavior leads to product specialization or product diversification.

4.1 Exporters versus Non-Exporters

While our core results of product churning in Section 3.3 are based on all Korean manufacturing plants, we expect to see differential adjustment patterns across exporters and

[31] The following back-of-the-envelope calculation is used to quantify the importance of competition with China in decreasing the number of products at the plant level: (0.097+0.069) / 0.638 = 0.260.

[32] The first channel is traditional, whereas the second channel is new in the literature.

[33] Appendix C shows that analysis at a more disaggregate (8-digit KSIC) level yields qualitatively similar results.

non-exporters for several reasons.[34] First, exporters tend to have more resources than non-exporters as shown in Panel B of Table 1. That is, on average, exporters are bigger than non-exporters in terms of production value, capital, employment, and value-added; exporters are also in general older than non-exporters (Bernard et al., 2007). This may allow exporters to respond more actively to competitive shocks, including both import penetration and export competition, since product churning requires costs, which include R&D investment, market investigation efforts, and time, all of which make it harder for plants with fewer resources, such as non-exporters, to adjust their product scope. Therefore, exporters are expected to engage in more active product churning behaviors.

Second, exporters and non-exporters may perceive competitive pressures in third markets differently. More specifically, regarding export competition with China, Korean exporters are expected to be more susceptible to export competition because they are directly involved in exporting activity amid rising competition with Chinese products in third markets. In contrast, the export competition may have little effect on non-exporters since they do not participate directly in export markets.[35] In this regard, we expect that exporters respond stronger to export competition than non-exporters do.

In Table 4, we estimate equation (7) across exporters in Panel A and non-exporters in Panel B.[36] In column (5) of Panel A., the most preferred specification, the two coefficients of our interest are both negative and statistically significant. That is, both import penetration from China and export competition with China in third countries decrease the number of products for Korean exporters. Quantitatively, a one standard deviation increase in import penetration from China is associated with the decrease in the number of products by 0.352. Similarly, a one standard deviation increase in export competition

[34] Hereafter, exporters refer to plants that export in 2006.

[35] In other words, for non-exporters, export competition in third markets can be perceived as a competitive threat—competition that has not occurred directly but has the potential to occur.

[36] The Kleibergen-Paap F-statistics against the null of weak identification are 356.66 for column (2) of Panel A, 353.64 for column (5) of Panel A, 61.85 for column (2) of Panel B, and 61.81 for column (5) of Panel B, all of which are well above the Stock and Yogo critical values. Therefore, the relevance conditions are all satisfied.

Table 4: Exporters, Non-Exporters, and Competition with China

	Dependent Variable: $\Delta Number\ of\ Products_i$				
Estimation Method:	OLS	IV	OLS	OLS	IV
	(1)	(2)	(3)	(4)	(5)
Panel.A. Exporters					
ΔIP_i	-0.576***	-1.337**		-0.547**	-1.199**
	(0.222)	(0.600)		(0.217)	(0.558)
ΔXC_i			-1.117***	-1.097***	-1.613**
			(0.332)	(0.327)	(0.728)
1st stage F-statistics		356.66			353.64
Observations	11,503	11,503	11,503	11,503	11,503
Panel.B. Non-Exporters					
ΔIP_i	0.036	-0.041		0.035	-0.041
	(0.075)	(0.177)		(0.075)	(0.177)
ΔXC_i			0.016	0.016	0.011
			(0.023)	(0.023)	(0.027)
1st stage F-statistics		61.85			61.81
Observations	16,226	16,226	16,226	16,226	16,226

Notes: All models include plant-level control variables (i.e., log production value, log employment, log value-added, log capital, age, $\Delta Xsize$) and ISTANS 4-digit industry level fixed effects. Standard errors are clustered at the firm level. All estimates are weighted by the number of employees of each plant in 2006. Columns (2) and (5) report the 2SLS results instrumenting ΔIP_i with ΔIPO_i. The rest columns report the OLS results. The first-stage F-stats refers to Kleibergen-Paap F-statistics. *** p<0.01, **p<0.05, * p<0.1.

with China is associated with the decrease in the number of products by 1.063. Relative to the benchmark case using all plants, the magnitudes of both are higher for exporters.[37]

When the mean value of the change in import penetration (0.141) and export competition (0.305) for exporters in Table 1 are considered, these coefficients imply that the average exporting plant (in terms of import penetration and export competition) decreases 0.169 product and 0.492 product facing stronger import penetration and export competition, respectively. Since the number of product decreases by 0.615 during the sample period on average for exporters, these results suggest that more intense import penetration from China and more fierce export competition with China in third markets explain

[37] To be specific, the magnitude is 1.5 (7.4, respectively) times higher in the case of import penetration (export competition, respectively).

134% of the change in the product scope of the average plant that experiences the average levels of import penetration and export competition.[38] To put it another way, the China trade shock can account for more than 100% of the total product churning effect for Korean exporters.[39]

In column (5) of Panel B., the most preferred specification, the two coefficients are statistically indistinguishable from zero, indicating stronger competition with China does not result in statistically meaningful product churning activities for non-exporting Korean manufacturing plants in the sample. It appears that product churning effects are mostly driven by exporters than non-exporters.

4.2 Product Creation and Destruction

Because only exporters respond to increased competition from China at home and abroad, we now zoom in on the product scope of exporters. Thanks to the detailed plant-product-level datasets, we are able to track 5-digit product composition at the plant level in a consistent manner between 2006 and 2018. Hence, in order to understand the margins of adjustment at the plant level better, we decompose the change in the number of products into (i) the creation of new products and (ii) the destruction of existing products. That is, we repeat the analysis with two new dependent variables – the number of new products and the number of dropped products, respectively, between 2006 and 2018.

Table 5 shows the estimation results. In Panel A, the product creation margin results are presented; in Panel B, the product destruction margin results are presented. In column (5) of Panel A, the preferred specification, the coefficient of import penetration is statistically insignificant, while the coefficient of export competition is statistically significant at the one percent level. The coefficient of export competition is -0.641, indicating that a

[38]The following back-of-the-envelope calculation is used to quantify the importance of competition with China in decreasing the number of products at the plant level: (0.169+0.492) / 0.615 = 1.34.

[39]Appendix C shows that analysis at a more disaggregate (8-digit KSIC) level yields qualitatively similar results.

Table 5: Product Creation and Product Destruction

Estimation Method:	OLS	IV	OLS	OLS	IV
	(1)	(2)	(3)	(4)	(5)
Panel.A. Dependent Variable: $Number\ of\ New\ Products_{i,06-18}$					
ΔIP_i	-0.140**	-0.169		-0.129**	-0.114
	(0.066)	(0.205)		(0.065)	(0.200)
ΔXC_i			-0.408***	-0.404***	-0.641***
			(0.118)	(0.117)	(0.246)
Panel.B. Dependent Variable: $Number\ of\ Dropped\ Products_{i,06-18}$					
ΔIP_i	0.437**	1.168**		0.418**	1.085**
	(0.196)	(0.479)		(0.192)	(0.445)
ΔXC_i			0.709**	0.693**	0.972
			(0.288)	(0.285)	(0.614)
1st stage F-statistics		356.66			353.64
Observations	11,503	11,503	11,503	11,503	11,503

Notes: All models include plant-level control variables (i.e., log production value, log employment, log value-added, log capital, age, $\Delta Xsize$) and ISTANS 4-digit industry level fixed effects. Standard errors are clustered at the firm level. All estimates are weighted by the number of employees of each plant in 2006. Columns (2) and (5) report the 2SLS results instrumenting ΔIP_i with ΔIPO_i. The rest columns report the OLS results. The first-stage F-stats refers to Kleibergen-Paap F-statistics. *** p<0.01, **p<0.05, * p<0.1.

one standard deviation increase in export market competition is predicted to reduce the number of new products by 0.422 at the plant level.

The product destruction margin results stand in striking contrast to the product creation margin results. In column (5) of Panel B, the preferred specification, the coefficient of import penetration is statistically significant at the five percent level, while the coefficient of export competition is statistically insignificant. The coefficient of import penetration is 1.085, indicating that a one standard deviation increase in import penetration is predicted to destruct the number of existing products by 0.319 at the plant level.

These results indicate that product creation and product destruction are differently affected by each type of shock (see Table 7). The product creation responds to export competition with China in third countries, whereas import penetration does not affect the product creation at the plant level. However, product destruction increases as import penetration from China escalates, whereas export competition does not impact the product destruction decision of plants.

4.3 Product Diversification

The previous results indicate that exporting plants adjust their product scope facing more intense competition with China at home and abroad through the increased product destruction and the decreased product creation. In order to understand the product scope adjustment to competition with China to the fullest, we examine whether and how this product scope adjustment is accompanied by the reallocation of their resources. Specifically, we investigate how the China trade shock affects the product diversification of plants.

Given that import penetration leads to the destruction of old products, we expect import penetration to decrease product diversification[40] at the plant level for two reasons. First, resources previously used for dropped products would be reallocated to other products that plants have comparative advantage. Indeed, this is consistent with the robust prediction by the theoretical models of multi-product firms in the literature (Eckel and Neary, 2010; Bernard et al., 2010, 2011; Mayer et al., 2021). Second, since tougher competition makes less efficient products less profitable, firms reallocate resources away from their periphery products to their core products.[41] Indeed, dropping an old product is an example of reallocating resources away from the old product to other products.

In contrast, the impact of export competition on product diversification is ex-ante not clear. First, since export competition does not lead to the destruction of old products, the reallocation of resources previously allocated to dropped products would not happen. Second, similar to the import penetration in the domestic market, tougher competition in each export market may result in the concentration toward products with compara-

[40] This is equivalent to an increase in product specialization

[41] This adjustment at the intensive margin is emphasized by Mayer et al. (2014) and Mayer et al. (2021).

tive advantages in each export destination. However, we speculate that this logic may not necessarily apply to the cases in export competition. If a plant's most competitive product in each export market is different,[42] then heightened competition in each export destination may reshuffle the plant's product portfolio in a non-trivial way. Third, it is ambiguous as to how production creation would affect product diversification or product specialization. On the one hand, adding a new product could increase product diversification because the share of new product among plant's shipments is positive; On the other hand, it is possible that adding a new product could result in specializing in the new product.

Table 6: Product Diversification

	Dependent Variable: $\Delta Entropy_{i,06-18}$				
Estimation Method:	OLS	IV	OLS	OLS	IV
	(1)	(2)	(3)	(4)	(5)
ΔIP_i	-0.256***	-0.222*		-0.254***	-0.206*
	(0.084)	(0.115)		(0.083)	(0.109)
ΔXC_i			-0.056	-0.047	-0.147
			(0.106)	(0.104)	(0.142)
Observations	6,107	6,107	6,107	6,107	6,107
1st stage F-stats		161.31			159.11

Notes: All models include plant-level control variables (i.e., log production value, log employment, log value-added, log capital, age, $\Delta Xsize$) and ISTANS 4-digit industry level fixed effects. Standard errors are clustered at the firm level. All estimates are weighted by the number of employees of each plant in 2006. Columns (2) and (5) report the 2SLS results instrumenting ΔIP_i with ΔIPO_i. The rest columns report the OLS results. The first-stage F-stats refers to Kleibergen-Paap F-statistics. *** p<0.01, **p<0.05, * p<0.1.

In Table 6, we estimate equation (7) using the change in the Entropy index defined in (6) as a dependent variable. For all specifications, the import penetration coefficients are negative and statistically significant, whereas the export competition coefficients are statistically indistinguishable from zero. These results indicate that import penetration

[42] The Spearman rank correlation between a firm's global product rank and a firm's product rank in each destination is 0.68 in France (Mayer et al., 2014) and 0.860 in Brazil (Arkolakis et al., 2021), indicating this possibility.

decreases the product diversification of plants, which is equivalent to the increase in product specialization, whereas export competition does not necessarily lead to the change in product diversification or specialization. Reallocation of resources toward core products, or product specialization, seems more relevant with import penetration-induced product destruction.[43]

Table 7: Summary of the Results

	Number of Products (1)	Product Creation (2)	Product Destruction (3)	Product Diversification (4)
Import Penetration	(−)	·	(+)	(−)
Export Competition	(−)	(−)	·	·

Collectively, the results indicate that product creation, product destruction, and resulting product diversification are differently affected by each type of shock (see Table 7). These distinct impacts of import penetration and export competition on different margins of adjustment at the plant level are noticeable findings from at least two perspectives. First, partly due to data limitation, it would have been difficult to decompose the product churning effect into product creation, product destruction, and product diversification. Second, more importantly, economists have paid little attention to the role of export competition in product churning effects. Therefore, our results can shed new light on the literature.

5 Exploring Mechanisms

The natural follow-up question is then *why* import penetration and export competition have different adjustment consequences on product creation and product destruction margins across exporters. Since product diversification is closely related to import penetration-induced destruction of existing products, we focus on why product destruction and creation respond to different shocks.

[43] Appendix D shows qualitatively similar results using more disaggregate (8-digit KSIC) level data.

5.1 Survival Threats

With respect to product destruction, plants may drop their products only if competition pressure is large enough for the survival of the product. In this regard, from the perspective of our empirical evidence in Table 5, stronger import penetration in a domestic market appears to be associated with threats to the survival of products whereas export competition in third markets does not. We illuminate two possible phenomena that can potentially explain this difference: (i) a pecking order of exporters and (ii) home bias in international trade.

It is well documented in the literature that even exporters rely heavily on their domestic markets. For instance, using French firm-level data, Eaton et al. (2011) document that French firms rely more on their domestic market compared to the ideal reliance. In a dynamic setting, Iacovone and Javorcik (2010) found that firms enter foreign markets with a single variety that is already sold in the domestic market before they expand showing the importance of the domestic market. Based on this empirical evidence, a standard monopolistic competition framework like Melitz (2003) and the multi-product model like Mayer et al. (2014) also impose a structure that firms sell in their domestic market first because the profits earned from foreign markets should be large enough to cover exporting costs.[44] The well-known home bias in international trade (Armington, 1969; McCallum, 1995) could strengthen this tendency. When home bias exists, Korean products would be less substitutable with Chinese products in their domestic market than in their export markets. As an effective import barrier, this home bias in consumer preferences makes firms' reliance on the domestic market higher. As a result, the domestic market is more likely to be the core market of firms even for exporters.

Consistent with this literature, we observe a similar implied pattern of a pecking order among Korean manufacturing firms using an auxiliary dataset, the Survey of Business

[44]Exporting costs including fixed costs, transportation costs, tariffs, and non-tariff trade barriers make the unit profits from export markets smaller than those from domestic markets.

Table 8: Exports-to-Sales Ratio of Manufacturing Firms in 2006

	Mean	SD	p10	p25	Median	p75	p90	OBS
Exports-to-Sales Ratio	0.162	0.261	0	0	0.013	0.224	0.600	5,142
Exports-to-Sales Ratio (Exporters)	0.283	0.291	0.009	0.041	0.167	0.455	0.771	2,951

Notes: This table summarizes the exports-to-sales ratio of firms in the Survey of Business Activity (SBA) matched to the Mining, and Manufacturing Survey (MMS). Exporters are defined as firms with positive exports in 2006. SD, p10, p25, p75, and p90 indicate the standard deviation, the tenth percentile, the twenty-fifth percentile, the seventy-fifth percentile, and the ninetieth percentile, respectively, of the exports-to-sales ratio in 2006.

Activity (SBA).[45] While our main dataset does not allow us to examine whether or not a domestic market is the core market for Korean manufacturing plants, firms in the SBA matched to the subset of our data suggest that the reliance on the domestic market is quite substantial as shown in Table 8. In 2006, the average ratio of export sales over total sales is 0.162 (0.283) for matched firms (exporters), which shows that the domestic market is relatively more important. In addition, strengthening this importance of the domestic market, the median exports-to-sales ratio of 0.013 (0.167) and the seventy-fifth percentile of 0.224 (0.455) indicate that there are only a small number of matched firms (exporters) who are heavily export-oriented. Furthermore, since firms in the SBA are not matched to small plants in our sample that are likely to rely less on export markets, the overall reliance on the domestic market could be even larger.

This disproportionate reliance on the domestic market, together with the findings in the literature, supports that a domestic market is more seemingly considered as a core market for exporters. Accordingly, import penetration in the domestic market is more likely to threaten the core market from an exporter's perspective, which then induces the exporting plants to discard the products that are affected by rising competitive pressures in the domestic market (core market).

In contrast, even when export competition in the non-core market (periphery markets)

[45] SBA covers firms employing at least 50 full-time employees and reporting a capital stock value of at least 300 million Korean won (about 267,869 USD using the 2010 exchange rate). More detailed information about the SBA can be found in Appendix A.

leads exporters to scale down their production, it does not necessarily force them to drop their products completely because other markets, including its domestic market, could buffer the adverse shock. In other words, since a plant can sell its products to multiple markets, even if a stronger competition in one of the export markets forces the plant to stop selling to that country, the plant may continue selling its products in other countries. In contrast, more intense competition in the core domestic market that penetrates the *home bias* could not be buffered by export markets. In other words, export competition would be considered as a *restructuring threat*, whereas import penetration would be perceived as a *survival threat*.

5.2 Risks of New Product Addition

With regard to product creation activity, plants would introduce new products only if they are expected to generate sufficient profits. Essentially, introducing new products is a forward-looking behavior under uncertainty (Albornoz et al., 2012; Ruhl and Willis, 2017; Eaton et al., 2021), which requires additional costs such as an innovation cost or a fixed cost of production (Bernard et al., 2010, 2011; Eckel and Neary, 2010; Qiu and Zhou, 2013; Mayer et al., 2021; Arkolakis et al., 2021).

From this point of view, our empirical evidence in Table 5 indicates that as tighter competition in export markets makes the introduction of new products more risky and/or less profitable, exporters react by decreasing product creation activity. In other words, as Korean exporters engage in product creation targeting export markets, deteriorating condition in foreign export markets leads to the decrease in new product addition. This is especially relevant for Korean exporters, aiming to achieve economies of scale, because they should rely on a large market size but Korean domestic market is relatively smaller than other bigger markets. Hence, foreign markets are crucial in their expansion in a *forward-looking manner*. Therefore, as export competition shrinks the effective size of export markets, it diminishes exporters' incentive to expand in export markets by introducing new products to those markets. (Iacovone and Javorcik, 2010).

5.3 Creative Destruction

Similar to export competition, more intense competition in the domestic market could also prevent plants from creating new products. However, the insignificant impact of import penetration on product creation implies that there should exist some countervailing forces that offset the discouraging impact. We speculate the *creative destruction* as a potential driver that could offset the downward pressure. More specifically, by dropping existing products under survival threats, plants are able to release their resources trapped in the old products (Bloom et al., 2013). As a result, investing on product creation becomes more affordable. Moreover, as reallocating the best inputs used for the old products, the expected profits of new products become larger than keeping existing products. Therefore, the downward pressure of import penetration on product creation could be offset by the creative destruction activity. Importantly, since this creative destruction is associated with the destruction of old products, it appears to happen in conjunction with import penetration, which threats the survival of existing products.

Table 9: Product Creation of Non-exporters

	Dependent Variable: $Number\ of\ New\ Products_{i,06-18}$				
Estimation Method:	OLS	IV	OLS	OLS	IV
	(1)	(2)	(3)	(4)	(5)
ΔIP_i	0.145***	0.181**		0.146***	0.182**
	(0.049)	(0.077)		(0.049)	(0.077)
ΔXC_i			-0.026**	-0.027***	-0.027**
			(0.011)	(0.011)	(0.013)
Observations	16,226	16,226	16,226	16,226	16,226
1st stage F-stats		61.85			61.81

Notes: All models include plant-level control variables (i.e., log production value, log employment, log value-added, log capital, age, $\Delta Xsize$) and ISTANS 4-digit industry level fixed effects. Standard errors are clustered at the firm level. All estimates are weighted by the number of employees of each plant in 2006. Columns (2) and (5) report the 2SLS results instrumenting ΔIP_i with ΔIPO_i. The rest columns report the OLS results. The first-stage F-stats refers to Kleibergen-Paap F-statistics. *** p<0.01, **p<0.05, * p<0.1.

If this creative destruction force is at work, we expect that the effect would be relatively more pronounced for non-exporters than exporters because non-exporters are more likely to perceive import penetration as a surviving threat. Table 9 confirms the hypothesis, showing that the impact of import penetration on non-exporters' product creation is positive and statistically significant for all specifications.[46] Quantitatively, in column (5), the preferred specification, a one standard deviation increase in import penetration from China is associated with the increase in the number of new products by 0.049.

Interestingly, column (5) also shows that the impact of export competition on the product creation activity is negative and statistically significant. This implies that Korean non-exporting plants decrease the creation of new products targeting export markets in a forward-looking manner since competition with China intensifies in potential export markets. Quantitatively, a one standard deviation increase in export competition with China is associated with the decrease in the number of existing products by 0.018. As non-exporters are indirectly exposed to export competition, the magnitude of response is smaller than that of exporters.[47]

In summary, since import penetration is a survival threat to the core market, it leads to the destruction of existing products. This destruction of products could encourage the creation of new products, which offsets negative impact of competition on product creation. In contrast, since export competition does not necessarily threaten the survival of products, creative destruction does not seem to operate, and product creation declines facing tougher competition in export markets.

[46]Note that we do not find such positive impacts of product creation in response to import penetration in the case of exporters. Please refer to Panel A of Table 5.

[47]Note that the impact of a one standard deviation increase in export competition on product creation for exporters was associated with the decrease in product creation by 0.422. The magnitude for exporters is 23.4 times higher than the case of non-exporters. Please refer to Panel A of Table 5.

6 Conclusion

We explore how Korean manufacturing plants adjust their scope of products in response to rising competition with China not only in the domestic market but also in the export markets using detailed product shipment and export information. Equipped with the exogenous measure of export competition and the instrument variable for the measure of import penetration, we find causal evidence that export competition with China, in addition to import penetration from China, reduce the product scope of plants between 2006 and 2018, particularly for exporters. Importantly, we also show that export competition and import penetration affect the different margins of adjustment in that export competition decreases product creation and import penetration increases product destruction, both of which contribute to the contraction of product scope. Finally, we show that Korean plants reallocate their resources toward core products facing more intense import penetration from China. Equipped with the precise measures of import penetration from China and export competition with China, we show not only the importance of the understudied export competition but also its different impact from import penetration.

We advance our understanding on the China shock and the multi-product firm literature by uncovering the product scope adjustment of Korean manufacturing plants in response to export competition and import penetration exploiting the rise of China as an example. Our study can be extended to many interesting directions to deeper understand the product scope adjustment behavior of firms/plants and export competition more clearly.

For instance, further research is warranted to understand the underlying mechanisms both theoretically and empirically. We speculate a core-periphery market structure of exporting plants arising from a pecking order of exporters and home bias as a potential explanation for the differential impacts of export competition and import penetration. However, admittedly, the suggestive evidence does not rule out other potential mechanisms.

In order to establish a robust causal link between product switching activity and competition shocks, more evidence from different environments is required. The shock of interest does not need to be confined to the China trade shock; the country of interest does not need to be limited to Korea. For instance, the enlargement of the European Union (EU) in 2004 and 2007, which accompanied a rapid growth of exports from new member states to existing EU member countries (Dauth et al., 2014), could have intensified export competition with firms from East European countries in European markets as in Kang (2022). Since high-quality microdata are available in many countries and this question has been rarely explored, we regard this strand of extension fruitful.

There are other potential extensions from our study. The impact of export competition and import penetration on other outcome variables such as employment could also be interesting to investigate whether, how, and why two competition shocks have different implications. Finally, while we focus on the within-firm reallocation in response to competition shocks, it would also be intriguing to examine between-firm reallocation consequences in response to two different shocks.

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Appendix

Appendix A. Detailed Dataset Descriptions

Mining and Manufacturing Survey (MMS)

The Mining and Manufacturing Survey (MMS) is a survey dataset focusing on Korean plants operating in the mining or manufacturing sector. Since 1967, Statistics Korea annually publishes the MMS dataset based on the survey that covers, on average, 70,000 plants hiring 10 or more employees (5 or more employees before 2008) in the mining or manufacturing sector and investigates the economic variables of those plants. For consistency between datasets over time, we drop samples hiring 5 to 9 employees in the MMS 2006 dataset. The MMS consists of two datasets: (i) the MMS industrial dataset and (ii) the MMS product dataset.

The MMS industrial dataset includes general information about plant-level variables such as the industry code, opening year, employment, wage bills, production value, value-added, and tangible capital. The MMS gives us the identification numbers (ID) of plants and the ID of a firm to which the plants belong.

The MMS product dataset is made up of *confidential* plant-product-level data. Every product produced by a plant is defined at the Korean Standard Industrial Classification (KSIC) 8-digit-product level. This product dataset provides shipment data at each plant-product level. By dropping the last three digits of a KSIC product code, we are able to construct KSIC 5-digit-product-level shipment data by adding shipments of 8-digit-level products that are in the same 5-digit code. Furthermore, the MMS product dataset reports all 8-digit products that each plant produces in the mining or manufacturing sector. So we can count the number of 5- or 8-digit products that a single plant makes and thus generate the number of product data of any plant.

Equipped with the sets of plant-level information, we are able to construct dependent variables which are the focus of our study (i.e., the number of products, the number of dropped products, the number of new products, and the Entropy index). Furthermore, using industry information and other plant-level characteristics, we are able to construct industry-level fixed effects and to control for plant-level heterogeneity such as age and size.

Survey on Business Activity (SBA)

The Survey on Business Activity (SBA) is another annual survey dataset from Statistics Korea. This survey covers 13,000 or more firms in a year since 2006. The SBA includes information about firm-level economic activities in Korea, especially the activities of large firms which hire 50 or more employees in a year. The SBA also includes the ID of a firm that can be matched with the firm in the MMS dataset, allowing us to match the two datasets.

Similar to the MMS industrial dataset, the SBA dataset provides abundant information, such as employment, the number of plants a firm owns, tangible and intangible assets, sales, and profits of firms in Korea. In addition, the dataset contains financial statements and the number of patents. Furthermore, this dataset gives firm-level export data. Using the SBA dataset, we are also able to construct an export-to-sales ratio of each exporting firm in the SBA, which allows us to gauge the reliance on the foreign export market at the firm level.

Plant-Level Export Status Data

The plant-level export status data is a non-public dataset maintained by the Korean Customs Service (KCS). The KCS Export Status Dataset annually investigates exporting status of all plants operating in Korea. This dataset includes the ID of plants exporting a positive amount of products. Note that in the MMS dataset, we cannot identify whether each plant in the manufacturing sector is an exporter or not. However, thanks to the information of the MMS dataset plant ID identical to the ID in the KCS Export Status Dataset, under the special arrangement between the authors and KCS, we are able to identify whether a plant in the MMS dataset is an exporting plant in each year (especially the year 2006—the initial year of our analysis).

Appendix B. Matched Dataset Construction Process

Since we utilize several datasets from different sources, such as Statistics Korea, Korean Customs Service, and UN Comtrade, we need to construct a consistent, matched dataset containing essential plant-level information. For consistency, we use two data points in 2006 and 2018. Here, we provide detailed descriptions of data cleaning processes.

Product Data Matching Process

After 2006, Statistics Korea revised the KSIC two times: (i) the 8th revision to the 9th revision (from 2008); (ii) the 9th revision to the 10th revision (from 2017). Hence, we must match each product code in each revision of KSIC in a consistent manner because there were much diversification and integration in product classification throughout the revisions.

For example, when *N (N>1)* different classes in the 8th revision converge to one class in the 10th revision, tracking the original 8th revision class of the new 10th revision class is impossible. Therefore, we are not able to distinguish whether this convergence is an exact product destruction process or not. On the other hand, if one class in the 8th revision diverges to *M (M>1)* classes in the 10th revision, it is also unable to confirm whether this divergence is a process of product creation or not. Hence, a direct matching between the 8th revision and the 10th revision of KSIC cannot provide accurate information on product dynamics in the manufacturing sector.

In order to overcome this limitation, we use an ISTANS 5-digit product code as an intermediary between the KSIC 8th and the KSIC 10th revision at the 5-digit product code level. Since each 5-digit code in each KSIC revision is matched to an ISTANS 5-digit code through injective mapping, we are able to link the 8th revision with the 10th revision via the ISTANS product classification because the ISTANS classes cover the whole KSIC classes without the loss of critical product level difference. As a result, we can use a KSIC 5-digit and an ISTANS 5-digit product codes almost interchangeably throughout the paper.

Furthermore, based on this matching process, we are also able to track product creation and destruction at the plant level. Without the consistent product classification compatible with both 2006 and 2018 datasets, we can only measure the plant-level difference in the number of products between 2006 and 2018. However, we are capable of counting the exact product creation and the product destruction in a plant with the robust product classification matching process that we built in our paper. Consequently, we are able to construct variables containing information about the number of product creations or destruction taking place in each plant between 2006 and 2018 in a consistent manner.

Baseline Matched Dataset Construction Process

Since all our datasets utilize the same product classification, the ISTANS 5-digit product classification, we first match our MMS product datasets and UN Comtrade product-level import and export data through the ISTANS product codes. Our primary explanatory variables, ΔIP and ΔXC, and instrument, ΔIPO, are built upon equation (1), (2), and (3) and the merged dataset including UN Comtrade data and the MMS plant-product level shipment data. In addition, as we mentioned in the "Product Data Matching Process", we can use KSIC 5-digit codes and ISTANS 5-digit codes interchangeably. Then, we are able to make our primary dependent variables, $\Delta Number\ of\ Products$, the Number of Product Creation, and the Number of Product Destruction, at the ISTANS-5-digit level for every plant in our MMS datasets.

Next, we combine MMS industrial dataset containing plant-level variables with our merged dataset through plant IDs that the MMS industrial and product dataset share. We now have dependent, explanatory, and instrumental variables, and plant-level control variables such as age, employment, tangible capital, value-added, and production value in a single dataset. We also have a code of industry and a firm ID to which each plant belongs. Furthermore, since the KCS export status dataset and the MMS dataset share the identical plant ID, we can exploit plant-level export status for estimating different effects across exporting and non-exporting samples by merging the KCS and the MMS dataset through a plant ID.

Appendix C. Product Adjustment at the 8-digit-KSIC Level

Equipped with our data that classify product as disaggregate as the 8-digit-KSIC level, we examine how plants adjust their product scope in response to stronger import penetration and export competition at the 8-digit-product level. By doing so, we are able to capture more detailed product switching activities that may not be captured at the 5-digit level. We conjecture that the product scope adjustment of plants is more prevalent at the 8-digit level than at the 5-digit level. At the same time, we expect the number of products to decrease facing both import penetration and export competition shocks, consistent with our main analysis at the 5-digit level.

Table C.1: Product Churning at the 8-digit-KSIC level and Competition

	Dependent Variable: $\Delta Number\ of\ Products_i$				
Estimation Method:	OLS	IV	OLS	OLS	IV
	(1)	(2)	(3)	(4)	(5)
ΔIP_i	-0.595*	-1.209*		-0.578*	-1.189*
	(0.303)	(0.655)		(0.299)	(0.648)
ΔXC_i			-0.515***	-0.507***	-0.347***
			(0.188)	(0.187)	(0.172)
1st stage F-statistics		255.32			255.51
Observations	27,735	27,735	27,735	27,735	27,735

Notes: All models include plant-level control variables (i.e., log production value, log employment, log value-added, log capital, age, $\Delta Xsize$) and ISTANS 4-digit industry level fixed effects. Standard errors are clustered at the firm level. All estimates are weighted by the number of employees of each plant in 2006. Columns (2) and (5) report the 2SLS results instrumenting ΔIP_i with ΔIPO_i. The rest columns report the OLS results. The first-stage F-stats refers to Kleibergen-Paap F-statistics. *** p<0.01, **p<0.05, * p<0.1.

Table C.1 shows how Korean manufacturing plants change the number of products facing competition with China at the 8-digit-product level. Both import penetration coefficients and export competition coefficients are negative and statistically significant at the 10 percent level in all specifications, confirming that plants contract their scope of product facing stronger competition with China even at the 8-digit product level in line with the main results at the 5-digit product level. Moreover, all coefficients are larger than those in

Table 3 in absolute value, reflecting the extra product switching activities captured at the 8-digit level. For instance, column (5), preferred specification, implies that a plant that experiences one standard deviation stronger import penetration shock (export competition shock) reduces the number of 8-digit product it produces by 0.333 (0.229), which is larger than reduction of the number of 5-digit product by 0.230 (0.143).

Table C.2: Product Churning by Exporting Status at the 8-digit-KSIC level

	Dependent Variable: $\Delta Number\ of\ Products_i$				
Estimation Method:	OLS	IV	OLS	OLS	IV
	(1)	(2)	(3)	(4)	(5)
Panel.A. Exporters					
ΔIP_i	-0.982*	-2.006*		-0.940*	-1.784*
	(0.510)	(1.128)		(0.501)	(1.057)
ΔXC_i			-1.608**	-1.523***	-2.601**
			(0.508)	(0.497)	(1.211)
1st stage F-statistics		356.66			353.64
Observations	11,503	11,503	11,503	11,503	11,503
Panel.B. Non-Exporters					
ΔIP_i	0.095	0.080		0.093	0.080
	(0.092)	(0.193)		(0.092)	(0.193)
ΔXC_i			0.028	0.028	0.024
			(0.028)	(0.028)	(0.032)
1st stage F-statistics		61.85			61.81
Observations	16,226	16,226	16,226	16,226	16,226

Notes: All models include plant-level control variables (i.e., log production value, log employment, log value-added, log capital, age, $\Delta Xsize$) and ISTANS 4-digit industry level fixed effects. Standard errors are clustered at the firm level. All estimates are weighted by the number of employees of each plant in 2006. Columns (2) and (5) report the 2SLS results instrumenting ΔIP_i with ΔIPO_i. The rest columns report the OLS results. The first-stage F-stats refers to Kleibergen-Paap F-statistics. *** p<0.01, **p<0.05, * p<0.1.

Similar to the main analysis at the 5-digit-product level, plants in the sample are partitioned into exporters and non-exporters in order to examine whether product switching activities are more pronounced on exporting plants at the 8-digit-product level. Table C.2 shows the results in accordance with the main analysis at the 5-digit level. The coefficients in Panel A, which show the responses of exporting plants, are negative and significant at the 10 percent level in all columns. Again, all coefficients are larger in absolute value than corresponding coefficients in the 5-digit-product analysis analogous to the results in Table C.1. Quantitatively speaking, the coefficients in column (5) of Panel A mean that an exporting plant that experiences one standard deviation stronger import penetration (export competition) reduces the number of 8-digit-products it produces by 0.524 (1.714), which is larger than the reduction of 5-digit-product by 0.352 (1.063) in the main analysis.

Panel B of Table C.2 shows that both import penetration coefficients and export competition coefficients are statistically indistinguishable from zero in all columns. Consistent with the main results, stronger competition with China does not result in statistically meaningful product churning activities for non-exporting Korean manufacturing plants in the sample.

Appendix D: Product Diversification at the 8-digit-KSIC Level

Table D.1: Product Diversification of Exporters at the 8-digit-KSIC level

	Dependent Variable: $\Delta Entropy_i$				
Estimation Method:	OLS	IV	OLS	OLS	IV
	(1)	(2)	(3)	(4)	(5)
ΔIP_i	-0.288**	-0.354*		-0.287**	-0.329*
	(0.123)	(0.197)		(0.122)	(0.186)
ΔXC_i			-0.039	-0.029	-0.232
			(0.127)	(0.125)	(0.183)
Observations	6,107	6,107	6,107	6,107	6,107
1st stage F-stats		161.31			159.11

Notes: All models include plant-level control variables (i.e., log production value, log employment, log value-added, log capital, age, $\Delta Xsize$) and ISTANS 4-digit industry level fixed effects. Standard errors are clustered at the firm level. All estimates are weighted by the number of employees of each plant in 2006. Columns (2) and (5) report the 2SLS results instrumenting ΔIP_i with ΔIPO_i. The rest columns report the OLS results. The first-stage F-stats refers to Kleibergen-Paap F-statistics. *** p<0.01, **p<0.05, * p<0.1.