# Within-Firm Responses to Import Competition: Quality Upgrading and Exporting in the Peruvian Apparel Industry*

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**Abstract**

Since China entered the WTO in 2001, the Peruvian apparel industry has been considerably affected by the dramatic inflow of Chinese garments. Unlike neighboring countries, the industry was able to keep afloat by firm-level responses that led to unprecedented growth in exports, driven by sales of high-quality apparel. While firm-level responses to import competition are now a well-established empirical fact in the economic literature, few papers have provided a precise mechanism by which they occur. This paper is one of the first to show that both quality upgrades and increases in export activity can be direct outcomes of import competition, and quantify their importance.

To capture both responses, I build and estimate a structural dynamic equilibrium model that hinges on the redeployment of less mobile factors when firms are exposed to import competition. If firms are highly exposed to import competition in the domestic market, within-firm factor reallocation results in an increase in exporting activity. Considering richer foreign markets have a higher taste for quality, firms will tend to export high-quality apparel. I use the estimated model to analyze: (1) whether firms' ability to escape competition by moving across products and destinations proved key for Peruvian firms' success, and (2) the effect on welfare and industry growth of commonly used trade policies such as tariffs. I find that allowing firms to re-optimize their product mix alleviates negative trade shocks by raising annual industry sales by as much as 17.5%. Moreover, even though raising import tariffs by 15% can expand the domestic industry's revenues and employment by 5%, it would do so with an annual 7% reduction in consumer welfare –US$ 133 millions. In contrast, alternative policies that cut the up-front costs of exporting high-quality in half would achieve the same objectives at no cost for consumers.

**JEL classification**: F1, F14, O14, O24, O54.

**Keywords**: International Trade, Quality Upgrading, Competition.

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# 1 Introduction

Understanding the effects of globalization and import competition on industry performance constitutes a fundamental economic and policy question. Even more so today, as governments and policy makers in the developing world are deeply concerned about the potential pervasive effects of the rise of low-wage countries such as China and India, and where tariffs or other measures to block imports and protect domestic industries have become the norm.

While there are a large number of studies on international trade that deal with this issue, they have mainly emphasized the across-firm effect of trade, i.e., changes coming from the reallocation of factors and selection effects across firms within an industry.[1]. However, recent literature has highlighted the importance of taking reactions that occur at the firm level into account.[2] Although the existence of these within-firm responses is now well-established,[3] the precise mechanism by which they occur, as well as their magnitudes and policy implications remain unclear. In this paper, I focus on how import competition leads to sizable within-firm responses of quality upgrading of the product mix and an increase in exporting activity.

I examine these responses by analyzing the reaction of Peruvian apparel firms to the surge of Chinese import competition following China's accession to the World Trade Organization, an industry that I have unique firm-level production data on. My setting is well-suited to measure these within-firm responses, since I am able both to measure export behavior, and also to directly observe a measure of quality, and thus avoid relying on potentially biased proxies, such as unit prices.[4] Specifically, given the apparel production process, final output quality is predominantly determined by material quality, which, in turn, can be identified in the data. Taking this into consideration, along with the fact that in Peru there is a clear hierarchy of material quality, given the co-existence of high-quality Pima cotton and low-quality synthetic and man-made fabrics, the Peruvian apparel industry provides a context to effectively identify high- and low-quality production.

As other Latin-American countries, since 2001, the Peruvian apparel industry has been considerably affected by the dramatic inflow of Chinese garments. Unlike neighboring countries, the industry has kept afloat. Despite the lack of government intervention and even though it has lost a considerable share of the domestic market to Chinese imports, the Peruvian apparel industry has remained standing. In fact, in 2012, the Peruvian apparel industry

[1] For instance, see Melitz (2003), Bernard et al. (2003), and Tybout (2003)

[2] Pavcnik (2002) found that one third of all productivity gains following Chilean trade liberalization were associated with reactions within the firm.

[3] Recent literature has found that firms exposed to trade tend to innovate more (Bloom et al. (2015)), change their range of products (Iacovone et al. (2012), Melitz et al. (2015)), upgrade skills (Mion and Zhu (2013)), and upgrade product quality (Fernandes and Paunov (2013)).

[4] For an extensive discussion on this point see Schott (2004).

became the second largest manufacturing industry in the country, making up 7 percent of Peruvian gross domestic product, and directly accounting for more than 50 percent of formal employment in the manufacturing sector. One of the main reasons behind the industry's survival has, in fact, been firm-level responses to import competition. These responses have led to an unprecedented growth in exports, driven by sales of high-quality apparel.[5] Following the exposure to higher Chinese import competition, Peruvian firms have not only exported up to 32 percent more, but have also included more products in their export bundle, and have been more likely to survive in the export market. Most of this effect, however, has been concentrated in sales and products of garments made of high-quality Peruvian Pima cotton. Together, these effects account for approximately 30 percent of the total exports observed over the 2001-2012 period.

To shed light on the precise mechanism, I have built a theoretical framework that hinges on the redeployment of less mobile factors towards high-quality products when firms are exposed to import competition. Consider that some factors are used in the production of all goods. Intuitively, if import competition is tougher for the domestic market, it is optimal to reallocate less mobile or specific productive factors from the local to foreign markets. This generates an increase in exports Moreover, if the domestic country is a small open economy, it is more profitable to sell high-quality goods in wealthier foreign markets that have more of a taste for high-quality garments. This, in turn, leads firms to upgrade quality.[6] Therefore, unlike recent models of quality upgrading and trade, in my model, within-firm responses are a direct outcome of competition at the final good level, rather than to easier access to imported high-quality inputs due to trade liberalizations.[7]

Next, I have extended the previous literature by structurally estimating a dynamic model to understand the importance of the mechanism and the effect of several policy measures. To my knowledge, no other paper has been able to quantify these within-firm responses. The estimation is done in two stages, where I first solve for firms' static profits and then estimate the dynamic parameters using conditional choice probability techniques, and a general equilibrium model is fully solved for the policy experiments.

It is important to note that the existence of scarce but critical resources, such as Pima cotton, has been key to Peruvian firm success. In fact, the ability of firms to switch to more

[5] Similar cases of adjustment are found in the footwear industry in Bangladesh, and the U.S. valve industry (Bartel at al. (2007)), among others.

[6] Specifically, the framework embeds two well-established empirical regularities in the trade literature into a general equilibrium model of heterogeneous multi-product firms. First, firms do not consider that markets are segmented when making production decisions. Among other productive factors, firms use some specialized or less mobile shared factors across products and therefore, the decision to produce one particular good also depends on the production decisions for all goods sold by the firm (Bloom et al. (2013), Bloom et al. (2014)). Second, preferences are non-homothetic across countries, which mean that richer countries spend more on high-quality goods relative to less wealthy ones, as in Fieler (2011)).

[7] Among several, important examples of this in the literature are Amiti and Konnings (2007), Kugler and Verhoogen (2012), and Eslava et al. (2015).

profitable products and markets has proven to have far-reaching economic and social effects. For example, when I evaluate the impact of increasing switching costs, by either raising the cost of the high-quality input or the up-front costs of changing products, I find sizable effects on industry performance. Concretely, firms' ability to upgrade quality and sell in the export market can increase average annual industry sales, firm-level profits and industry employment by as much as 17.5, 16.4 and 17.7 percent. This fact can help explain the varying worldwide responses of apparel industries to Chinese export growth, assuming that other countries have higher costs to access key inputs or export markets.

This contrasts sharply with the effect of the preferred response of Latin American governments to Chinese growth: raising import tariffs. While additional import tariffs of 15 percent can help expand the domestic industry's revenues and employment by 5 percent, it would do so with an annual 7 percent reduction in consumer welfare–equivalent to US$ 133 million per year. In contrast, alternative policies that that cut up-front costs of exporting high-quality goods in half can achieve the same objectives at no cost to consumers.

The results of this paper stress the importance for governments to reconsider and redirect the set of trade policies aimed at supporting their industries. In particular, they propose using policy measures that eliminate market failures that increase firms' cost of switching products and entering foreign markets, rather than the introduction of additional inefficiencies. These types of policy measures include initiatives promoting firm mobility in the product or industry space, such as reducing import tariffs on high-quality inputs, strengthening supply chain relationships, decreasing transport costs, and fostering export promotion initiatives. Moreover, in a more general sense, the model speaks to the literature on product diversification, the search for niche markets and even industry diversification as efficient firm-level responses to import competition.

The remainder of this paper is organized as follows. Section 2 describes the data. In Section 3, I present the key facts about the Peruvian apparel industry that guides both the reduced-form evidence provided in Section 4 as the theoretical model detailed in Section 5. I structurally estimate the model in Section 6 and evaluate the impact of relevant policies in Section 7. Section 8 concludes.

## 2 Data

I study the upgrade in quality and the increase in exports by Peruvian firms following an increase of Chinese import competition. In order to investigate these responses, I rely on a unique firm-product level dataset that allows me to observe product mix quality decisions as well as changes in exporting activity. This analysis is based on firm-level production data spanning from 2000-2012.[8]

My primary sources are the Peruvian customs data and the Peruvian Economic Survey (EEA). I select firms engaged in the production of apparel, either classified under CIIU (*Clasificación Industrial Internacional Uniforme*) rev.3. codes 1810 and 1730, or firms classified elsewhere but exporting apparel products under chapters 61 and 62 of the HTS (Harmonized Tariff Schedule) code.

Peruvian customs data is collected by the Peruvian Customs Authority (SUNAD), and corresponds to all daily registrations of exports and imports of apparel, apparel machinery, and textiles between 2000 and 2012. For each transaction, the data includes firm tax ID, US$ value of the shipment, quantity, units, HTS code at the 10-digit level, a detailed description of the product and its composition, and destination or origin country, among other variables. Data from the EEA spans from 2007 to 2012. It consists in a representative sample of the Peruvian manufacturing industry and provides information about net sales, material and labor expenditures, value added, and capital stock, among others.[9] I bring together these datasets by using the information on the tax ID of Peruvian firms (*Registro Único de Contribuyentes* - RUC).

In addition, I complement this firm-level dataset with measures of annual aggregate expenditure and price indices by both product and destination market, as well as additional aggregate industry characteristics. For the domestic market, I construct these measures by aggregating the data of my main dataset at the product and year level. For the foreign market, I use aggregate imports, exports and prices at the product level for the United States based on information from the United States Office of Textiles and Apparel (OTEXA), and the United Nations Commodity Trade Statistics database (COMTRADE).

This detailed information on products exported by each firm allows me to determine whether Peruvian firms are exporting high or low quality goods. Importantly, the disaggregation of the export data at the 10-digit HTS code level allows me to observe both the type of apparel product (i.e. pants, t-shirts or shirts) and also the material composition of the product (i.e. cotton, fur and leather, synthetic). Because apparel quality is directly related to the quality of materials used in production, the particular use of a high-quality material would be associated with production of high-quality final goods, and vice-versa. For the Peruvian case, high-quality products are classified as exported clothes made of high-quality Peruvian cotton, and low-quality goods are cataloged as exported clothes made of synthetic

[8]For a more detailed description of the data and variable definitions see Appendix F.

[9]For medium and large firms in the manufacturing sector, the National Economic Survey is effectively a census, because all firms are surveyed.

and man-made fibers. Thus, this dataset allows me to use an observed measure of quality in the analysis, rather than a potentially biased quality proxy, such as unit values. An extensive discussion of quality definition is given in Section 3.2.

## 3 The Peruvian Apparel Industry: Key Facts

This section presents key facts about the Peruvian apparel industry and its status following the increase in Chinese import competition in 2001. These facts will be important to keep in mind, since they will ultimately motivate the focus on quality upgrading and exporting as responses to import competition, as well as the modeling of the production activity in the industry.

### 3.1 The Apparel Industry

Peru is a country with a strong history of textile and apparel production. The Peruvian apparel industry is made up of many micro and small firms that coexist with a few medium and large enterprises. However, the latter concentrate more than 50% of domestic sales and almost all international sales.[10] Their flagship products correspond to basic garments, such as t-shirts and shirts, and almost all firms produce more than one type of garment. In the export market, trade is dominated by the United States. To a lesser extent, Peruvian firms also export to Venezuela, Colombia, Chile and Italy.

Apparel production in Peru is not different from the production of apparel elsewhere. Broadly, it follows a sequential process for most products.[11] Firms begin the process with a specific amount of fabric and, given the specifications of the product (i.e., pants, t-shirts or shirts), the fabric is cut and pieces are sent to the next station. Pieces are put together by seamstresses and moved again to another area to include add-ons such as buttons and labels. Finally, garments are packed and shipped. While the process is labor intensive, labor remains specialized to tasks and not to materials or products. The same is true for a large fraction of the machinery, as it can be used indistinctly for producing different pieces of apparel, for instance, synthetic or cotton fabrics. Finally, the fabric requirements by product do not vary, regardless of specific fabric being used. For instance, whether the fabric is cotton, nylon or any other man-made fiber, one square meter is required for a small size t-shirt, two for a pair of trousers, and so on.

Traditionally, Peruvian production was destined for the domestic market. From the late

[10]For instance, in 2012, the number of firms in the industry was 16,143 where 16,022 (99.2%) firms corresponded to micro firms (15243) and small firms (779).

[11]Exceptions include knitted products or garments made with fur or leather.

seventies to early nineties, the Peruvian apparel industry was centered in the capital city of Lima (Ponce (1994)), with sales almost completely concentrated locally. According to Ponce (1994), in the nineties, the textile-apparel sector was only competitive in the early stages of production, i.e., yarn spinning and cloth weaving, due to the superior quality of Peruvian cotton, but not in apparel manufacturing.[12]

However, in less than 15 years, the Peruvian apparel industry has experienced a large transformation. From 1994 to 2012, annual production has increased 43% and apparel has become the second largest manufacturing industry in the country. By 2010, this industry directly accounted for more than 50% of formal manufacture employment and 7% of the gross domestic product.[13] Interestingly, most of the growth came during the 2000s. Apparel exports have more than doubled in this period, and currently account for the majority of exports in the textile sector[14], significantly contributing to the overall export dynamic of Peru.[15]

### 3.2 Quality

As explained in Section 3.1, due to the particularities of the apparel production process, the quality of a garment can be directly associated with the quality of the materials used on its production. Because fabrics are by far the most important material in apparel production, final product quality is ultimately defined by fabric quality.

In this regard, the Peruvian clothing apparel industry differs from others in developing countries. Peruvian natural fibers, such as Alpaca and Peruvian cotton, are widely known for their high quality. For instance, Peru's most important cotton varieties, Pima and Tangüis, are characterized by extra-long and long staple fibers, respectively. To put this in context, Pima compares favorably with Egyptian cotton, while Tangüis rivals Ambard cotton from Sudan, Giza 47 and 68 from Egypt, and Acala from the United States.

Compared to other cottons and synthetic or man-made fibers, the main advantages of Pima cotton are its superior staple length, remarkable strength, excellent dyeing properties, and increased durability and lifespan of textile and apparel products.[16] For instance, its

[12]To put these statistics in context, Peru had a period of economic stagnation from 1975-92, where income per capita fell by 32% and returned to the 1960 level. Since 1974, inflation has been above 10%, reaching an historical high in 1990 with 7650%. Moreover, Peru was experiencing a time of terror, due to a civil war against the Shining Path, a terrorist organization. After the 1990 elections, several measures were taken by the Alberto Fujimori administration. First, trade was liberalized, lowering import tariffs from an average of 63% in 1985 to 16% in 1994. Moreover, strict tax policies increased revenues from 1% of GDP in 1989 to 11.1% of GDP in 1994. Furthermore, in 1992, the head of the Shining Path, Abimael Guzman, was captured, which led to a more secure investment scenario for Peruvian firms. Finally, the new president reorganized the government and drastically reduced the public sector and subsidies.

[13]The total formal employment in the manufacturing sector is 7% of the total formal employment. The apparel sector represents 4.7% of formal national employment (53,000 workers).

[14]The textile sector includes apparel, fabrics, textile fibers and accessories.

[15]By 2011, approximately 15% of non-traditional exports corresponded to apparel.

[16]Pima cotton is classified under extra-long 1-3/8" staple length. Moreover, because of its fineness, more fibers can be spun into a yarn of a given count, which enhances the feel and softness, drapeability and brilliant color of the fabric. It thus provides

strength and uniformity measurements are considerably higher than those of upland cotton, the largest cotton crop produced in the United States and one of the most important in the world.

The largest Pima cotton producers are the United States, Australia and Peru. However, Pima cotton production only accounts for 8% of worldwide cotton production. Thus, apparel production that uses this high-quality input might not be seen frequently in several countries. Even within mayor cotton consumers such as China, Pima cotton apparel is rare. In particular, this is because China has established import quotas on foreign cotton to favor their national farmers, despite the fact that Chinese national crops are considerably lower in quality.

The fact that output and material quality are directly linked, and that there are clear differences in material quality in Peru, allows me to categorize high- and low-quality apparel. Specifically, an apparel product is classified as high-quality if the garments are made of Pima cotton fabric, and as low-quality if they are produced with fabrics made out of other cottons, synthetic or man-made fibers. Notably, given the level of disaggregation of exported products at the 10-digit HTS code level, I am able to observe these distinctions in my data. For an extensive list of the HTS codes associated with cotton, synthetic and man-made apparel, see Appendix G.

However, even with this level of detail, the HTS codes will not differentiate among types of cotton. Thus, a concern arises if Peruvian firms are producing using non-Pima cottons. In order to correctly classify high-quality goods, I use a particular trade policy established in 1993. As it happens, from 1995 to the present, Peruvian exporters entitled to receive a drawback over the net exported FOB value when using national products as raw materials for their production. This special treatment includes, among others, apparel production with Pima cotton. In the customs data, given that I can observe duties and reimbursements, I am able to check whether Peruvian exporters, in fact, used this high-quality input, and thus can effectively categorize them as either exporting high- or low-quality clothes. In reality, most of Peruvian firms that export cotton apparel use Peruvian cotton.[17]

excellent dyeing properties and assures the durability of the fabric.

[17] At this point, I only observe product disaggregation for the export market. However, the EEA has a module on main products and main inputs used by firms. Unfortunately, this information is self-reported by the firm and thus their categories are not yet standardized. Future work aims to merge this data and establish this same categorization for the domestic market as well.

### 3.3 Import Competition

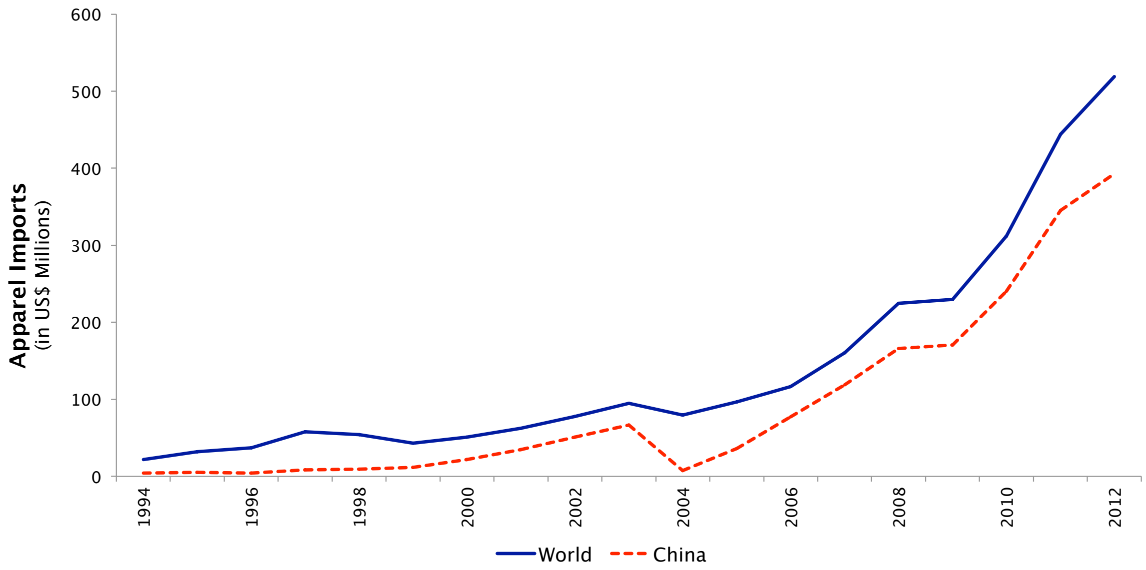
Since China entered the World Trade Organization (WTO) in 2001, the Peruvian apparel industry has faced a surge of Chinese import competition.[18] Figure 1 shows Perus total apparel imports from 1994 to 2012, and confirms how competition has intensified in the domestic market beginning in early 2000s, mainly due to Chinese apparel imports.

Apparel imports originating in China have risen steadily, so that they now greatly exceed apparel imports from any other potential foreign competitor in the Peruvian market.[19] In less than ten years, the value of Chinese imported apparel has quintupled. In addition, on average, Chinese clothes entered the country with prices 50% lower than Peruvian clothes and clothes from other countries. Consequently, the domestic market share of Peruvian manufacturers has decreased over time. In terms of value, Chinese apparel imports accounted for only 12% of the Peruvian market in 2000, while by 2011, their share had risen to 30%. In terms of units, the figure is even more striking. By 2011, China consolidated itself as the main supplier to the Peruvian market, both in weight units and in the number of clothes, with 50% and 57% of the market, respectively.

The situation is no different from the main export destinations of Peruvian apparel such as the United States. Not only is China's share of total U.S. apparel imports crowding out the share of imported apparel from many other countries but, as occurred in Peru, Chinese clothes exported to the American market are priced below the unit price offered by most other apparel exporters, including Peruvians.

[18] Undoubtedly, China's export growth in the last decade constitutes a striking exogenous increase in import competition. Since China entered the WTO, it has multiplied its total exports 7.7 times, and, in particular, has increased its apparel exports by 458%; growth rates that far exceed the export growth of other large low-wage countries. Not surprisingly, by 2009, China had become the largest exporter in the world. Moreover, Chinese exports have not only targeted high-income countries, but also medium and low-income markets, with Peru being no exception.

[19] The decrease of Chinese imports in 2004 and 2005, as along with the increase in their prices, was due to the temporary 200-day tariffs imposed by the Peruvian government in December 2003.



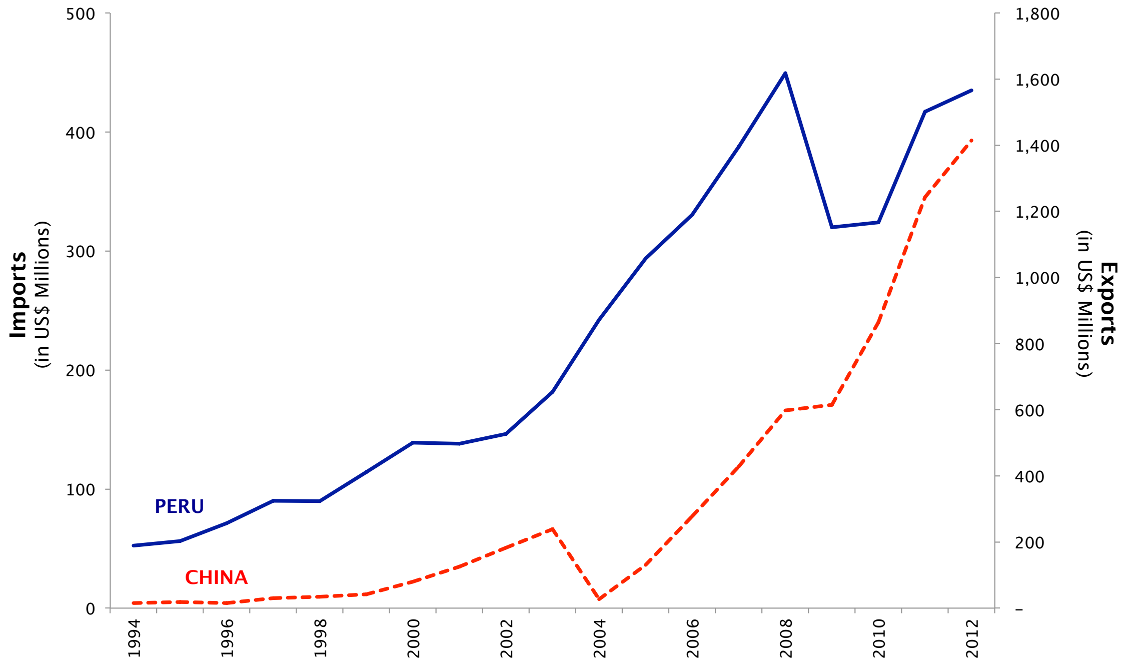

Source: Peruvian customs data.

**Figure 1: Apparel Imports from Peru by Origin**

This rapid Chinese growth cast doubt on domestic producers and the government about the future of the industry, and raised the question of whether additional policies aiming at protecting it from China's growth were appropriate. Indeed, over the past decade, domestic producers have promoted several initiatives for protectionism without further success.[20]

Despite these facts and the lack of government intervention, the Peruvian apparel industry has kept afloat. Figure 2 shows Chinese imports of apparel in the primary axis and Peruvian exports of apparel in the secondary axis, both in millions of US$. While import competition is significantly increasing in the domestic market during the 2000s, Peruvian firms have found a way to cope with this negative shock by exporting. This reaction is significant: exports went from 56% of total Peruvian apparel sales in 2000 to 71% in 2008. In fact, even though Peruvian manufacturers have lost a considerable share of their domestic market, Peruvian apparel exporters have managed to increase their participation in the U.S. market from 0.5% in 1996 to 1.5% by the end of 2011, the largest share of any South American country.

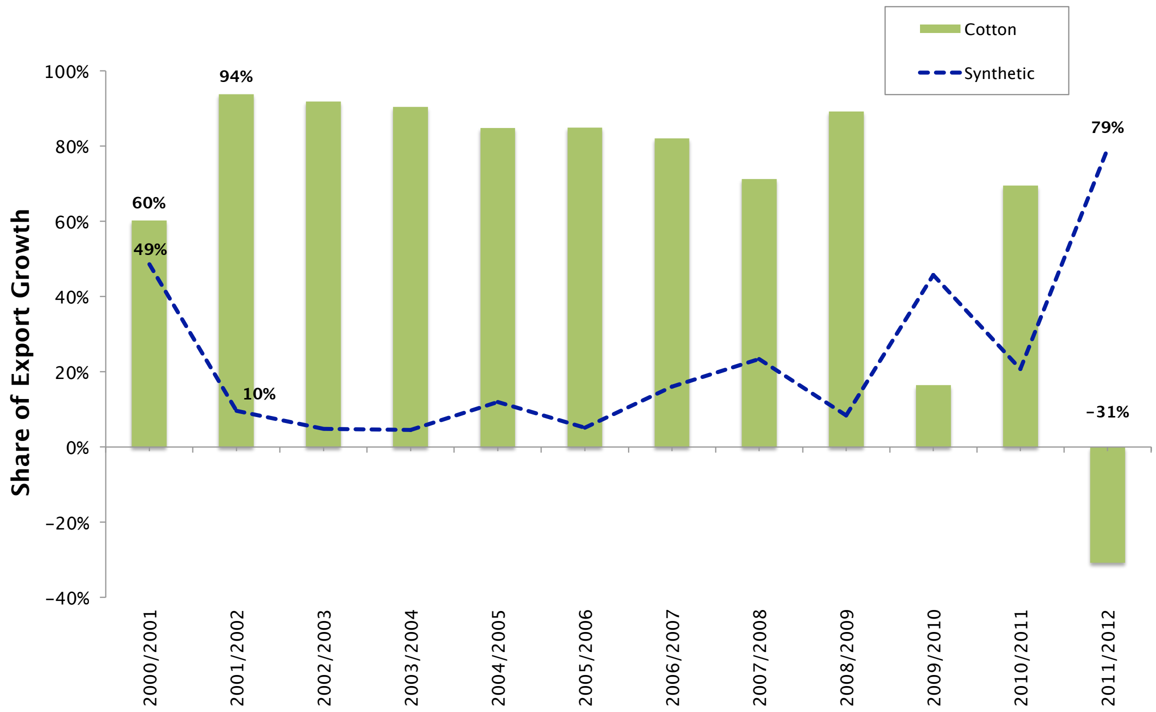
[20]For instance, on October 2003, the Peruvian National Society of Industries (SNI) signed a petition to the Peruvian Antitrust Agency (INDECOPI) requiring the creation of temporary tariffs for apparel imports originating in China. Responding to this request, on December 2003, the Peruvian government imposed provisional tariffs for 200 calendar days on Chinese apparel imports appearing on 106 HTS classifications while it conducted an investigation. Ultimately, the additional tariffs were eliminated. More recently, the government initiated its own investigation of price dumping by Chinese apparel importers. As a result, in December 2013, the Peruvian government found evidence that damage to the domestic industry had taken place between 2009 and2011, and imposed additional tariffs. Other Latin American countries have raised the same concerns about Chinese competition. To date, Argentina, Colombia and Venezuela are among the Latin American countries that adopted definitive tariffs on Chinese apparel imports very early in the century. Noticeably, none of these countries had a domestic apparel industry as large as the Peruvian one.




Source: Peruvian customs data.

**Figure 2: Peruvian Exports of Apparel**

Most notably, even though there has been an increase in exports of all types of products, export growth is mostly the result of the increase in exports of Peruvian high-quality cotton apparel. Figure 3 shows that while from 2000 to 2001, export growth was roughly divided evenly between sales of cotton and sales of synthetic apparel, since 2001, export growth has been predominantly driven by export growth of cotton apparel only. With the exception of the period that corresponds to the financial crisis of 2008, this pattern clearly emerges after China's accession to the WTO.




Source: Peruvian customs data.

**Figure 3: Composition of Export Growth by Product**

Additionally, as firms export more of these higher quality products, they also shifting their product mix towards these goods. On average, 38% of the firms that do not export any cotton products will likely include at least one over the next year, whereas 9.8% will shift towards exporting cotton products exclusively. On the contrary, only 5% of the firms exporting at least one cotton product will stop exporting cotton altogether and shift towards only synthetic apparel exports.

These results are also consistent with two pieces of anecdotal evidence. On one hand, the Peruvian government dismissed the generalization of provisional tariffs in 2004, because it found Peruvian firms did not suffer substantial damages from the increase in Chinese apparel imports. According to INDECOPI, at the same time that Chinese imports increased to satisfy domestic demand, domestic producers only slightly increased their domestic sales, while largely increasing exports, especially those related to cotton products. Thus, the increase of Chinese imports did not represent a significant threat to the domestic industry, since it opened a path to export more and more" (INDECOPI (2004)). However, considering the 2009-2011 period, INDECOPI demonstrated that domestic producers were indeed affected by Chinese competition (INDECOPI (2012)). The main reason is that during these years, domestic producers saw the possibility of directing their production to foreign markets reduced, due to the economic crisis faced by their main trading partners.[21] Thus, it seems that both the government and firms recognized that the impact of import competition depended heavily on the ability of firms to cope with the situation by producing and exporting Peruvian cotton clothes.

# 4 Empirical Evidence: Quality-Upgrading and Exports Increase

Considering the evidence highlighted in the previous section, the question arises: did import competition drive the increase in exports and the upgrade in quality. This section presents empirical evidence of the existence of within-firm responses to import competition that match the aggregate patterns discussed in Section 3. First, I describe the measure of firm-level Chinese import competition to be used in the analysis. Second, I estimate the impact of firm-level import competition on several measures of firm performance in the export market. By examining the reaction of Peruvian apparel manufacturers to Chinese import competition, I find that import competition leads exporting Peruvian firms to upgrade quality and increase their exports in terms of both greater quantities and new products.

## 4.1 Measuring Firm-Level Exposure to Import Competition

In order to capture responses within the firm to import competition, I first need to construct a measure of Chinese import competition at the firm-level. Consider a firm $j$ in year $t$ selling product $p \in P$. Chinese import competition affects firm $j$ by its import penetration rates in the particular products this firm produces. If Chinese import penetration is high in all products sold by the firm, firm $j$ will be largely exposed. Conversely, if Chinese import penetration rates are low for the products firm $j$ sells, this firm will be considerably less exposed to competition from Chinese products. Variation in firm-level exposure to import competition exists, then, because different firms produce different bundles of goods.[22]

Let $Comp_{jt}$ be the firm-level measure of import competition at period $t$ taking values between 0 and 1. This measure includes the firm-level variation previously mentioned by aggregating Chinese import penetration rates to the firm level, using export shares of the products sold by a firm as weights such that,

$$Comp_{jt} = \sum_{p} \frac{x_{jpt}}{x_{jt}} ImpPen_{pt} \tag{1}$$

where $ImpPen_{pt}$ refers to Chinese import penetration on apparel product $p$ at the 10-digit

[21] According to INDECOPI, with the financial crisis of 2008 and 2009, the largest American firms not only reduced their demand but also required faster delivery times (90 to 45 days), turning their demand to closer partners in Central America.

[22] Similar measures have been used in the empirical literature by Iacovone et al. (2012) and Melitz (2015).

HTS level (i.e., the share of Chinese imports on total imports by product), $x_{jpt}$ denotes exports of firm $j$ of product $p$, and $x_{jt}$ represents total exports of firm $j$; all of them measured at period $t$.

Two caveats are in order. First, if firms respond to import competition by changing their product bundle, there is a concern of endogeneity of exported products or exported market shares. Second, disaggregation at the product level is only observed for the export market. Therefore, this means that the analysis will be done with exporters only and also implicitly assumes that firms keep the same structure of production and product shares, whether they sell domestically or abroad.

In order to alleviate the first concern, I follow Melitz (2015) and modify the measure so that the shares and product bundle will be fixed to those that I first observe for the firm in the data, whereas the import penetration measure will move over time. Thus, the competition measure will be redefined as $Comp_{jt} = \sum_p \frac{x_{jpt_0}}{x_{jt_0}} ImpPen_{pt}$, where $x_{jpt_0}$ are now exports of firm $j$ of product $p$ at time $t_0$ and, $x_{jt}$ corresponds to total exports of firm $j$ in period $t_0$. Even with this adjustment, $x_{jpt_0}$ and $x_{jt}$ may still be the result of responses to import competition for firms that appear in the customs data after 2000, and thus endogenous. To account for this, as a robustness check, I examine whether the main effects hold when I consider only firms existing in my sample since 2000, for which the initial bundle and export shares may not have been affected by Chinese import competition. I find that the main qualitative results are unchanged.[23]

In regards to the second concern, exporters in my data account for approximately 70% of Peruvian apparel industry sales, making them a representative sample of the Peruvian industry. However, it is true that import competition might drive some firms to export and thus, there would be selection in my sample driven by the variable of interest. In this case, I also follow the previously mentioned strategy, and ascertain whether the main effects hold for the 2000 panel.[24]

[23]See Appendix H for robustness checks.

[24]In addition, it is likely that the set of products offered in the export market is similar or even smaller than the bundle produced for the domestic one, given the empirical evidence of existing fixed and iceberg costs of exporting. That is, firms tend to sell most of their production in the domestic market and only sell their core products abroad, because there are additional per period costs to export them. However, it is not clear why the products left out would be necessarily more affected by import competition or, in which way, as these products modify the weights used in the analysis. If it is the case that the measurement error in the import competition measure $Comp_{jt}$ is random, then coefficients will be biased downwards, and the resulting effect should consider a lower bound of the true effects of import competition. Nevertheless, to provide additional evidence, I compare a firm competition index from the 2007-2012 National Economic Survey, where firms declared their main products, with the index for these firms constructed with the customs data, and find a high level of correlation. We can therefore expect the index to effectively capture the relative exposure of these firms to Chinese competition.

### 4.2 Reduced-Form Evidence

With a firm-level measure of import competition in hand, I am interested in examining whether it had some impact on firms' product mix quality and export activity. This section directly relates the firm-level measure of import competition previously described to these within-firm responses.

The main specification takes the following form,

$$y_{jt} = \beta_0 + \beta_1 Comp_{jt-1} + \delta_t + \mu_j + \epsilon_{jt} \quad (2)$$

where $y_{jt}$ denotes the outcome of interest for firm $j$ at time $t$, $Comp_{jt-1}$ refers to the firm-level competition measure at $t-1$, $\delta_t$ represents year fixed effects, and $\mu_j$ indicates firm fixed effects.[25]

A potential concern for this estimation is that import penetration from Chinese apparel is correlated with demand shocks in Peru, and thus, does not represent an exogenous increase on import competition. Under those circumstances, the OLS coefficients might understate the true impact if export performance of Peruvian firms is positively correlated with unobserved demand shocks in the domestic market. Thus, in order to uniquely identify the supply-driven component of import competition, I adopt an instrumental variable (IV) strategy following Autor et al. (2013) and instrument Chinese import penetration rates in Peru with Chinese import penetration rates in other similar Latin American countries.[26] The main idea behind this instrument is that the common component between these variables is the result of Chinese exogenous export growth, rather than the response to specific local demand shocks. Moreover, to account for positively correlated demand shocks between these countries, I include year fixed effects, so that they control for common unobserved annual trends.

In specification (2), the main focus is on whether higher exposure to import competition had any effect on exporting and quality upgrading. I estimate these effects at the intensive margin where $y_{jt}$ will denote firm total exports, firm exports by product type, average export per product, and number of products exported by a firm in total and by type. Products are defined at the 10-digit HST level. Additionally, for the extensive margin, I consider variables such as dummy variables, taking value 1 if the firm has included a new product, either from high- or low-quality, and dummy variables taking value 1 if the firm has stopped exporting.

Table 1 shows summary statistics for the main outcomes of interest and the firm-level

[25]Given that import penetration and total exports are variables constructed by aggregating daily observations to the annual level, I use $Comp_j$ at $t-1$ instead than $t$ in order to capture only responses to past increases of import competition, rather than potential misleading correlations with past and future values.

[26]The countries used in the analysis are Argentina, Brazil, Bolivia, Chile, Colombia and Ecuador.

competition measure. In terms of size and number of products, Peruvian firms tend to be largely heterogeneous, with a considerably skewed size distribution. Moreover, on average, Peruvian exporters sell substantially more cotton than synthetic apparel, both in terms of export values and number of products. Finally, there is ample variation on the firm-level competition measure, from firms that have not been exposed to import competition to fully exposed exporters.

| **Variables** | **Mean** | **Std. Dev.** | **1% Perc.** | **Median** | **99% Perc.** | **Obs** |
|---|---|---|---|---|---|---|
| Firm-level Exports *(Thousands of US$)*: | | | | | | |
| Total Apparel | 1,478.7 | 6,745.5 | 21.0 | 182.4 | 31,372.2 | 9,015 |
| Cotton Apparel | 1,296.8 | 6,486.6 | 0.0 | 107.1 | 30,189.5 | 9,015 |
| Synthetic Apparel | 106.5 | 623.8 | 0.0 | 1.3 | 1,609.5 | 9,015 |
| Number of Products (sold by a firm): | | | | | | |
| Total Apparel | 13 | 13 | 1 | 10 | 64 | 9,015 |
| Cotton Apparel | 8 | 8 | 0 | 6 | 34 | 9,015 |
| Synthetic Apparel | 3 | 4 | 0 | 1 | 22 | 9,015 |
| Firm-level Import Competition | 0.45 | 0.28 | 0.00 | 0.51 | 0.92 | 9,015 |

Table 1: Summary Statistics

I start by showing the estimates for the intensive margin under the IV strategy in Table 2. All outcome variables are expressed in logs. Three main results emerge from this analysis. First, firms are, on average, increasing their total exports (10.4%) and their exported number of products (13%) following an increase of one standard deviation of Chinese import competition. Second, similar to what is observed at the aggregate level, this effect is mainly concentrated in cotton apparel. In fact, as shown in Column (2), both exports of cotton, as well as the number of cotton products sold, increases by 14% as a result of an increase of a standard deviation of Chinese import competition. On the contrary, as shown in Columns (3) and (6), the effect on the level of exports of synthetic clothes is negative and non-significant. Finally, given this movement in total exports and in the number of products of cotton and synthetic clothes, it is not surprising that average exports per product are not significantly impacted.

| | Intensive Margin | | | | | |
|---|---|---|---|---|---|---|
| | (1) | (2) | (3) | (4) | (5) | (6) |
| | **Exports** | **Cotton Exports** | **Synthetic Exports** | **Number of Products** | **Number of Cotton Products** | **Number of Synthetic Products** |
| $\text{Comp}_{jt-1}$ | 0.372*** | 0.494*** | 0.160 | 0.456*** | 0.494*** | 0.184* |
| | (0.125) | (0.157) | (0.254) | (0.085) | (0.090) | (0.111) |
| Firm FE | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |
| Year FE | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |
| F-Stat | 904.94 | 876.40 | 578.96 | 904.04 | 876.40 | 578.96 |
| Hansen J-Stat | 6.94 | 4.74 | 3.54 | 2.72 | 2.69 | 3.36 |
| Obs | 5,477 | 5,004 | 2,899 | 5,477 | 5,004 | 2,899 |
| R-squared | 0.055 | 0.031 | 0.081 | 0.020 | 0.019 | 0.020 |
| N. Firms | 1,178 | 1,091 | 731 | 1,178 | 1,091 | 731 |

*Notes*: Clustered standard errors at the firm-level in parentheses. F-Stat refers to the Cragg-Donald Wald F-statistic and corresponds to a week identification test. Hansen J-statistics denotes the over-identification test of all instruments. All outcome variables are expressed in logs.

Table 2: Reduced-Form Evidence: Average Effects on Intensive Margin

Additionally, Table 3 presents the estimates for the extensive margin following the same IV strategy. First, Column (7) shows that firms are 7.6% less likely to quit exporting following an increase in one standard deviation of Chinese import competition. Second, estimates in Columns (8)-(10) suggest that import competition encourages firms to introduce products that otherwise would probably not have been exported, had the competition increase not taken place. The effect remains: one standard deviation increment in import competition increases the probability of exporting a new product by 3.5%, but the marginal effect is only significant for the introduction of new cotton products (4%).

In sum, firms respond to domestic Chinese import competition by exporting and quality upgrading at the intensive and extensive margin, as evidenced by the increases in total exports and in the number of exported goods, with a particular emphasis on cotton products, the increase in the probability of survival in the export market and the introduction of new export products. These results are consistent with previous empirical findings, such as Liu (2012), Iacovone and Jarvorick (2010) and Iacovone et al. (2012). Considering my estimates, back-of-the-envelope calculations show that Chinese import competition accounted for approximately 30% of cumulative exports during the 2000-2012 period. Thus, these correspond to sizable within-firm responses to import competition.

| | Extensive Margin | | | |
|---|---|---|---|---|
| | (7) | (8) | (9) | (10) |
| | **Exit Exporting** | **New Product** | **New Cotton Product** | **New Synthetic Product** |
| $\text{Comp}_{jt-1}$ | -0.273*** | 0.124*** | 0.147*** | 0.076 |
| | (0.040) | (0.045) | (0.054) | (0.055) |
| Firm FE | ✓ | ✓ | ✓ | ✓ |
| Year FE | ✓ | ✓ | ✓ | ✓ |
| F-Stat | 643.34 | 904.94 | 904.94 | 904.94 |
| Hansen J-Stat | 6.94 | 4.74 | 3.54 | 2.72 |
| Obs | 4,781 | 5,477 | 5,477 | 5,477 |
| R-squared | 0.055 | 0.031 | 0.081 | 0.020 |
| N. Firms | 1,059 | 1,178 | 1,178 | 1,178 |

*Notes*: Clustered standard errors at the firm-level in parentheses. F-Stat refers to the Cragg-Donald Wald F-statistic and corresponds to a week identification test. Hansen J-statistics denotes the over-identification test of all instruments. All outcome variables are dummy variables.

Table 3: Reduced-Form Evidence: Average Effects on Extensive Margin

Moreover, in order to rule out other potential confounding effects, I perform several robustness checks detailed in Appendix H. Specifically, I examine potential issues coming from the passage of bilateral trade agreements with major export partners, as well as biases due to sample selection and endogeneity of first period bundle. In all of these cases, the main results still hold.

In order to broadly understand what triggers this reaction, three additional facts are also worth mentioning. Table 4 shows the impact of import competition on factors' usage, as well as on average unit price at the firm-level. First, overall, firms do not seem to be altering their number of employees or investment in capital, measured as imports of machinery, in response to higher exposure to import competition. Surprisingly, this occurs despite the fact that these firms are selling more to the export market and increasing their number of products. This can thus be explained as import competition possibly driving exports and quality upgrades through the reallocation of productive factors across products within the firm.

Second, import competition might be affecting the firm through their productive decisions, and therefore it would effect firms' unit prices. Here, it might seem surprising that, even when firms switch towards higher quality products, average unit prices decrease as a consequence of larger exposure to import competition. Similar results are found regardless of firm size. However, if we consider a reallocation mechanism of productive factors within the firm, these effects remain consistent with quality upgrades to the product mix.

| | **Additional Facts** | | |
|---|---|---|---|
| | (1) | (2) | (3) |
| | **Labor** | **Imports of Machinery** | **Unit Prices** |
| $\text{Comp}_{jt-1}$ | -0.000 | 0.262 | -0.097** |
| | (0.629) | (0.071) | (0.048) |
| Firm FE | ✓ | ✓ | ✓ |
| Year FE | ✓ | ✓ | ✓ |
| F-Stat | 126.68 | 579.99 | 904.94 |
| Hansen J-Stat | 1.98 | 0.61 | 3.84 |
| Obs | 555 | 507 | 5,477 |
| R-squared | 0.038 | 0.346 | 0.198 |
| N. Firms | 89 | 145 | 1,178 |

*Notes*: Unit prices are calculated as the weighted average of unit prices at the 10-digit HTS code level where weights are given by the export share of the product. In turn, unit prices at the 10-digit HS code level are calculated dividing total imports over quantity imported of pieces of clothing. Labor refers to the number of employees at the firm-level. Both unit prices and labor are in logs. Labor and imports of machinery estimations use the merge customs data with EEA database from 2007-2009.

Table 4: Reduced-Form Evidence: Additional Facts

So far, these results have indicated the existence and relevance of responses to import competition, such as increases in exporting and quality upgrading of the product mix. The next section goes a step further and aims to build a model that is able to account for these empirical findings.

## 5 The Model

This section develops a general equilibrium model, where heterogeneous firms decide the bundle of goods to produce, where to sell those goods and at what prices. The main goal of the model is to shed light on the mechanism by which an exogenous increase in import competition in low-quality goods sold domestically encourages domestic firms to upgrade quality and increase exports.[27] The model builds on new models of trade that highlight the heterogeneity of firms, such as Melitz (2003), but with two important differences. Unlike those

[27] Appendix A presents the model in a closed economy. The main predictions on quality upgrading hold. Despite being called closed, this scenario can be used to study the impact of import competition a country where firms do not have the necessary connections or comparative advantage to be able to export their products.

models, it allows for non-homothetic preferences between countries and, given the existence of shared and less mobile inputs to the production structure, markets for each product are no longer segmented.

Consider a small open economy, the domestic market ($d$), with $L$ identical agents. In this economy, consumers buy domestically or import two vertically differentiated goods: high- ($h$) and low-quality ($l$) goods. For each good, there is a continuum of varieties, such that domestic and imported varieties are indexed by $\nu_k$ and $\nu_{km}$, respectively, where $k \in \{h, l\}$. In addition, in this economy, firms can sell domestically or export to a larger country, the foreign market ($x$).

### 5.1 Firms

A monopolistically competitive firm $j$ potentially produces variety $\nu_h$ and/or $\nu_l$ in period $t$. These varieties can be sold domestically or in the foreign market. Firms dynamically chose the product mix at every period and, conditional upon it, they optimize prices.

**Timing and Costs** To enter the market, firms need to pay an entry cost $w_t f_e$, where $w_t$ refers to the wage in the economy at time $t$. After paying this cost, they are able to get a productivity draw $\psi_{jt} \sim G(\psi)$ where $G(\psi)$ is common knowledge. Once they enter, firms make productive decisions. First, they determine their product mix, which consists of a combination of the product quality types and the geographical market(s) where the firm sells. That is, the product mix choice includes the options: {sell the low-quality good domestically}, {sell the high-quality good domestically}, {export the low-quality good}, {export the high-quality good}, and all their combinations, plus the option not to produce. Firms that decide not to produce exit the market and disappear. Second, conditional on a specific product mix, firms choose optimal prices.

In addition, firms face additional costs. In order to add a new product-market line to their product mix, firms must incur one-time irrecoverable sunk costs: $\gamma_k^c$ if including product $k$ sold in country $c$. Moreover, if the firm exports, it must consider a standard "iceberg cost", $\tau_{kt} > 1$, which means that in order to sell $q_{jkt}^x$ units abroad, the firm has to ship $\tau_{kt} q_{jkt}^x$ units.[28]

**Production** Considering the stylized facts of the apparel industry described in Section 3, I model the production process as follows. At each period $t$, a producer uses labor ($L$), a composite factor ($F$) and materials ($M$) to produce $q_{jt}$ physical units of apparel. Thus, $q_{jt}$ represents the total count of garments produced by the firm and is defined as $q_{jt} = q_{jht} + q_{jlt}$.

[28]Based on the empirical regularity that most firms do not export, some authors have suggested large costs of exporting and, along with other ways, have modeled them as the standard "iceberg" costs (Bernard et. al. (2003)).

Firm level production at time $t$ is Leontieff in materials ($M$) and Cobb-Douglas in labor ($L$) and the composite factor ($F$) such that,

$$q_{jt} = min\{\psi_{jt} L_{jt}^{\alpha} {F_{jt}}^{1-\alpha}, M_{jt}\} \tag{3}$$

where $\psi_{jt}$ is a firm-specific productivity parameter, and $\alpha < 1$.

As it is shown, labor and the composite factor are fully interchangeable to produce both types of apparel. Regarding materials, I do not model directly the specific use of different materials for each good, but rather treat materials as pieces of cloth. In order to adjust for quality in the final product, given the use of different material qualities, firms pay additional marginal costs per unit of output, $m_{kt}$, where $m_{ht} > m_{lt}$.

All factors are perfectly mobile within and across firms except for the composite factor, $F$. $F$ can only be reallocated across products within the firm, and ultimately reflects reflects any factor that cannot be easily adjusted for, such as specific capital, long-term contracted inputs, or managerial ability that is used for the production of both goods. Specifically, in order to produce, firms need to engage in ex ante fixed investments of the composite factor. That is, all firms contract $F_{jt} = \bar{F}$, where $\bar{F}$ is a fixed value and for which firms needs to pay a fixed cost $\theta\bar{F}$ commonly known before entry.[29]

As mentioned, these assumptions are mainly aimed at meeting the main features of the apparel industry and simplifying the estimation of the empirical model. However, this technology could be easily relaxed to production functions, such as Cobb-Douglas functions in labor, composite factors and materials without significant changes on the main qualitative predictions of the model.[30]

## 5.2 Demand

Following Fieler (2011), preferences of agents in country $c$ are given by,

$$U_t^c = (\alpha_h)^{\frac{1}{\sigma_h}} (\frac{\sigma_h}{\sigma_h - 1}) \left[ \int\limits_{\nu_h \in \Omega_h^c} q_{ht}^c(\nu_h)^{(\frac{\sigma_h - 1}{\sigma_h})} d\nu_h \right] + (\alpha_l)^{\frac{1}{\sigma_l}} (\frac{\sigma_l}{\sigma_l - 1}) \left[ \int\limits_{\nu_l \in \Omega_l^c} q_{lt}^c(\nu_l)^{(\frac{\sigma_l - 1}{\sigma_l})} d\nu_l \right] \tag{4}$$

where $q_{kt}^c(\nu_k)$ denotes the quantities of varieties $\nu_k$ of good $k \in \{h, l\}$ sold in country $c$, $\Omega_k^c$ corresponds to the set of available domestic and imported varieties of good $k \in \{h, l\}$ in

[29] You can think of this as a common requirement for production in this industry, such as production plant rental, manager hiring, minimum labor and capital quantity to produce (a cutter, a sewer and a packer, along with their respective machines) or other specific required input for apparel production. Even though I abstract for the formation process of $\bar{F}$, in a more general setting, the model could incorporate a firm's decision to invest ex ante in $\bar{F}_j$ or allow $\bar{F}_j$ to increase over time with investment on this factor.

[30] As will be clearer in Section 5.5 that describes the implication of the model, rather than assume any particular production function, the key assumption of the model is the existence of one factor that is shared in the production of all the goods and that remains fixed in the period where firms choose product mixes and prices.

country $c$, $\alpha_k > 0$ are weights for each good, and $\sigma_k > 1$, $k \in \{h, l\}$ both measures the elasticity of substitution within goods and across varieties, as well as determines the income elasticity of demand. Similar to Fieler (2011), I normalize $\alpha_h^{\frac{1}{\sigma_h}} + \alpha_l^{\frac{1}{\sigma_l}} = 1$.

The only difference between the two countries is that foreign consumers are richer than the domestic ones. Given that the ratio of income elasticity of demand for good $h$ and $l$ is $\frac{\sigma_h}{\sigma_l}$, if we assume $\sigma_l < \sigma_h$ as in Fieler (2011), all else equal, richer countries will consume relatively more high-quality goods than their poor counterparts. That is, $\frac{X^d_{ht}}{X^d_{lt}} < \frac{X^x_{ht}}{X^x_{lt}}$ where $X^c_{\tau t}$ represents the aggregate expenditure of country $c$ in good $k$.[31] The model therefore includes non-homothetic preferences across countries.[32]

Every period, consumers in each country take prices as given and choose quantities of varieties $\nu_k$, $k \in \{h, l\}$, to maximize their utility, subject to their budget constraints. Demand in country $c$ for each variety $k$ is,

$$q^c_{kt}(\nu_k) = \frac{X^c_{kt}(p^c_{kt}(\nu_k))^{-\sigma_k}}{P^{c\ 1-\sigma_k}_{kt}} \tag{5}$$

where $p^c_{kt}(\nu_k)$ denote prices for available varieties $\nu_k$ in country $c$, and $P^c_{kt}$ represents the price index for good $k$ sold in country $c$. In turn, these price indices are defined such that,

$$P^c_{kt} = [\int_{\nu_k \in \Omega^c_h} p^c_{kt}(\nu_k)^{1-\sigma_k} d\nu_k]^{\frac{1}{1-\sigma_k}} \tag{6}$$

### 5.3 Dynamic Problem: Product Mix

Every period, firms choose the product mix, $a_{jt} \in \mathbf{A}$, with the highest expected discounted profit or leave the market. $\mathbf{A}$, the set of all potential product mixes, corresponds to the sixteen combinations of {selling high-quality good domestically}, {selling low-quality good domestically}, {exporting high-quality good}, {exporting low-quality good}, plus the option of not producing at all and exiting. Firms take into account both the existence of sunk costs for including a new product and also the expectation they have about future productivity, industry-level price indices and aggregate expenditure.

Let $s_{jt}$ be the vector of state variables including productivity ($\psi_{jt}$), price indices ($\mathbf{P} = \{P^d_{ht}, P^d_{lt}, P^x_{ht}, P^x_{lt}\}$), aggregate expenditures ($\mathbf{X} = \{X^d_{ht}, X^d_{lt}, X^x_{ht}, X^x_{lt}\}$), composite factor level

[31] As noted in Fieler (2011)'s online appendix, the assumption of $\sigma_l < \sigma_h$ does not necessarily mean that the low-income elasticity good has the lower substitution elasticity, given that it is only a normalization. The demand function in equation (4) is generalized by $\sum_{k=1}^{\kappa}\{\alpha_k \frac{\sigma_k}{\gamma_k(\sigma_k-1)}[\int_0^1 q(\nu_k)^{\frac{\sigma_k-1}{\sigma_k}} d\nu_k]^{\gamma_k}$ with $\lambda_k \neq \frac{\sigma_k}{\sigma_k-1}$, $\forall k$. Given this expression, $\frac{X_{ht}}{X_{lt}} = \lambda^{\psi_l-\psi_h}(\frac{\alpha_h^{\psi_h}}{\alpha_l^{\psi_l}}\frac{P_{ht}^{\phi_h}}{P_{lt}^{\phi_l}})$ where $\lambda$ is the marginal utility of income, $\psi_k = -\sigma_k + \frac{\sigma_k(1-\sigma_k)(\gamma_k-1)}{\sigma_k+\gamma_k-\sigma_k\gamma_k}$ and $\phi_k = \frac{(1-\sigma_k)\gamma_k}{\sigma_k+\gamma_k-\sigma_k\gamma_k}$. Notice, the parameters ($\sigma_k$, $\gamma_k$), $\forall k$ cannot be separately identified. Thus, the ratio of expenditures in this problem should be seen as if $\gamma_h$ and $\gamma_l$ were set to 1. Nevertheless, this is only one possible normalization.

[32] See Appendix B for complete details.

$(\bar{F})$, and a variable summarizing previously paid sunk costs up to $t-1$ $(h_{t-1})$.

Firm $j$'s value function is,

$$V(s_{jt}) = \underset{a\in\mathbf{A}}{max} \quad \pi_{jt}(a, s_{jt}) - \Gamma(a, h_{jt-1}) + \beta \int V(s_{jt+1}) dF(s_{jt+1}|h(a, h_{jt-1}), s_{jt}) \tag{7}$$

where $\pi_{jt}$ is the static profit net of sunk costs defined in equation (8), $\Gamma(.)$ represents the sunk cost function, $\beta$ is the discount factor, $F(S_{jt+1}|S_{jt})$ is the transition probability of the state space, and $\mathbf{A}$ corresponds to the set of all potential product mixes.

### 5.4 Static Problem: Prices

Conditional on a product mix choice $a_{jt} = \{\mathbb{1}^d_{ht}, \mathbb{1}^d_{lt}, \mathbb{1}^x_{ht}, \mathbb{1}^x_{lt}\}$, where $\mathbb{1}^c_{kt}$ are indicator functions taking value 1 if product $k$ sold in country $c$ is included in the product mix at time $t$, a firm $j$ chooses prices maximizing static profits net of sunk costs, $\pi_{jt}$, as in,

$$\begin{aligned} \max_{\{p^d_{jht}, p^x_{jht}, p^d_{jlt}, p^x_{jlt}\}} \pi_{jt} = {} & \mathbb{1}^d_{ht} p^d_{jht} q^d_{jht} + \mathbb{1}^x_{ht} p^x_{jht} q^x_{jht} + \mathbb{1}^d_{lt} p^d_{jlt} q^d_{jlt} + \mathbb{1}^x_{lt} p^x_{jlt} q^x_{jlt} \\ & - w \left( \frac{q_{jt}}{\psi_{jt} \bar{F}^{1-\alpha}} \right)^{\frac{1}{\alpha}} - m_{ht}(\mathbb{1}^d_{ht} q^d_{jht} + \mathbb{1}^x_{ht} \tau_{ht} q^x_{jht}) - m_{lt}(\mathbb{1}^d_{lt} q^d_{jlt} + \mathbb{1}^x_{lt} \tau_{lt} q^x_{jlt}) \\ & - \theta \bar{F} \end{aligned} \tag{8}$$

subject to $q_{jt} = \mathbb{1}^d_{ht} q^d_{jht} + \mathbb{1}^x_{ht} \tau_{ht} q^x_{jht} + \mathbb{1}^d_{lt} q^d_{jlt} + \mathbb{1}^x_{lt} \tau_{lt} q^x_{jlt}$ and demands as specified in (5).

If a product is on $a_{jt}$, first-order conditions for firm-level prices of good $k$ sold domestically $(p^d_{jkt})$ and in the export market $(p^x_{jkt})$ are,

$$p^d_{jkt} = \left( \frac{\sigma_k}{\sigma_k - 1} \right) \left[ m_{kt} + \frac{w}{\alpha} \left( \frac{1}{\psi_{jt} \bar{F}^{1-\alpha}} \right)^{\frac{1}{\alpha}} (q_{jt})^{\frac{1}{\alpha}-1} \right] \tag{9}$$

$$p^x_{jkt} = \left( \frac{\sigma_k \tau_{kt}}{\sigma_k - 1} \right) \left[ m_{kt} + \frac{w}{\alpha} \left( \frac{1}{\psi_{jt} \bar{F}^{1-\alpha}} \right)^{\frac{1}{\alpha}} (q_{jt})^{\frac{1}{\alpha}-1} \right] \tag{10}$$

Unlike trade models of monopolistic competition and constant returns to scale, firm-level prices in this model depend on total quantity produced $(q_{jt})$. Thus, they react not only to changes in aggregate consumer expenditures and aggregate prices indices happening in the same market, but also to changes in these variables for all the other products or destination markets included in the firm's product mix. Production lines and markets are no longer segmented. However, given this non-segmentation, firm-level prices are now the result of a non-linear system of equations and will not have closed-form solutions.

Revenues take the form,

$$r^c_{jkt} = \frac{X^c_{kt}(p^c_{jkt})^{1-\sigma_k}}{P^{c\ 1-\sigma_k}_{kt}} \tag{11}$$

Similar to prices, profits do not have a closed-form solution and need to be calculated numerically following equation (8). However, more productive firms will charge lower prices, sell more output, and earn more revenues and profits from their sales.[33]

### 5.5 Implications in Partial Equilibrium

This section aims to analyze the effects of an increase of import competition through the lens of the model. For this purpose, I consider a partial equilibrium setting, where price indices and aggregate expenditures do not adjust immediately to domestic firms' reactions.

I begin by describing how we can analyze the effects of the intensification of import competition in the model. If we consider increases in competition coming from the exogenous rise of imported varieties at lower prices, the direct consequence of import competition will be a decrease in market price indices of the affected products. Specifically, I use the following definition.

**Definition 5.1.** An increase in import competition in good $k$ sold in country $c$ is defined as a decrease of its price index, such that $\Delta P^c_{kt} < 0$.

Thus, import competition derived from Chinese export growth, which mainly impacted low-quality segments, will be modeled as $\Delta P^d_{lt} < 0$ and $\Delta P^x_{lt} < 0$. In this setting, the model gives three main sets of results regarding the effect of an increase in import competition on within-firm responses. First, firms react to import competition by decreasing the prices of all their products. Second, quantities and revenues for low-quality products decrease, while sales increase for high-quality product lines, which is larger if these products are destined for the foreign market. Third, over time, it is more likely that firms start exporting and switch to high-quality products.

Formally,

**Theorem 5.1.** *Taking price indices and aggregate expenditures as a given, an increase in import competition in the low-quality segments of the domestic and export market, and their consequent decreases in $P^d_{lt}$ and $P^x_{lt}$, results in the following implications:*

*i (Prices) Decreases firm-level prices of all goods sold by firms that have low-quality goods in their product mixes.*

[33] See Appendix C for proofs.

ii *(Quantities and Revenues) Increases quantities and revenues of the high-quality goods in all markets for multi-product firms that are already selling high- and low-quality. However, it has an ambiguous effect on quantities and revenues of the low-quality goods in both markets. Final effects on the low-quality segments will ultimately depend on the relative increase in competition between the two economies and differences in their aggregate expenditures.*

iii *(Profits) Decreases profits for firms selling low-quality goods.*

iv *(Product Mix) Induces a shift towards product mixes that include high-quality goods. However, it has an ambiguous effect on the probability of including low-quality goods in both markets. As in quantities and revenues, the final effect on the low-quality segment will ultimately depend on the relative increase in competition between the two economies and the differences in their aggregate demand.*

*Proof.* See Appendix D. □

The intuition for the mechanism is as follows. To produce, multi-product firms use some amount of labor and materials, jointly with the fixed composite shared factor. The total quantity produced is determined by the profitability of the markets the firm sells to. Given an unanticipated increase in competition in the low-quality good segment for all markets (e.g., China starts exporting to the world), the profitability of these segments decreases. For firms, it is optimal to reduce the production of low-quality goods, freeing up resources. Labor and materials can be effectively reduced, but the composite shared factor is fixed –they cannot get rid of it. Given that firms need to pay a fixed cost for the usage of the composite factor, it is efficient to reallocate these idle resources to other lines of their product mix. Since profitability has been reduced in the low-quality segments, firms will effectively reallocate the shared factor to the production of high-quality goods. Because the export market places more value on higher quality goods, it would be more profitable to reallocate resources to these types of exports. Thus, the model predicts an upgrade in quality, and, given differences for tastes in quality, an export boom for the high-quality good.

Moreover, even though mark-ups are not variable, the model allows for changes in firm-level prices as a response to exogenous changes in environmental parameters of all the markets. This occurs because firms exhibit increasing marginal costs, given the fixed factor of production. Marginal costs will decrease, like prices, as the total amount produced decays due to the increase in import competition.

In addition, firms not affected by import competition do not show this reaction, as shown in the following corollary from theorem 5.1. That is, firms that were not selling these goods when the exogenous increase in import competition occurred will not need to re-optimize, and thus will not be affected at all by the import competition shock.

**Corollary 5.2.** *A decrease in $P^d_{lt}$ and $P^x_{lt}$ does not change firm-level prices, quantities, revenues or profits for firms that do not have low quality goods in their product mix.*

Finally, if the increase in import competition only happens domestically, the model produces even more stark predictions, as summarized in Theorem 5.3.[34]

**Theorem 5.3.** *Taking price indices and aggregate expenditures as given, an increase in import competition in the low-quality segments for the domestic economy alone has the following implications:*

i *(Prices) Decreases firm-level prices of all goods sold by firms that have low-quality goods in their product mixes.*

ii *(Quantities and Revenues) Increases sales of the high-quality goods in all markets and low-quality goods in the export market, for multi-product firms producing both high- and low-quality goods. However, decreases sales of low-quality good in the domestic market.*

iii *(Profits) Decreases profits for the firms that include the production of low-quality goods for the domestic market in their product mix.*

*Proof.* See Appendix E. □

In sum, theorem 5.1 predicts quality upgrading at the intensive and extensive margin and is the result of two key elements of the model: a fixed shared factor of production that cannot be sold and non-homotheticity on preferences. By including these, the model significantly departs from previous theoretical frameworks, such as in Melitz, and allows firms to respond to firm import competition through a previously unexplored channel.

### 5.6 General Equilibrium

The fundamentals of the model ($\mathbf{\Sigma}$) correspond to the demand elasticities ($\sigma_h, \sigma_l$), production parameters ($\alpha, \rho_0, \rho_1, \sigma^2_\xi$), iceberg costs ($\tau_{ht}, \tau_{lt}$), aggregate expenditures ($X^d_{ht}, X^d_{lt}, X^x_{ht}, X^x_{lt}$), shared factor ($\bar{F}$), and sunk costs ($\gamma^d_h, \gamma^x_h, \gamma^d_l, \gamma^x_l$). Besides the optimal choice of product mix and prices, there are additional conditions that should be balanced.

[34] It should be noted that this was the case for the Peruvian economy during the 2001-2005 period, when China was still subject to textile and apparel quotas in the American market due to the Multi-Fiber Agreement, and thus import competition was particularly felt domestically.

**Free Entry Condition** Ex-ante, expected profits must be equal to entry costs,

$$w_t f_e = \int_\psi V_{\{s_{jt}\}}(\psi) dG(\psi) \tag{12}$$

**Factor Market Clearing Condition** Denote the mass of entrants for domestic firms in period $t$ by $M_t$. In every period, total revenue of domestic producers should account for factor payments in the domestic country such that,

$$\sum_k \sum_c \int_{\psi \in \mathbb{1}^c_{kt}} p^c_{kt} q^c_{kt} M_t \mu(\psi) d\psi = w_t L + \theta \bar{F} + m_{ht} Q_{ht} + m_{lt} Q_{jt} \tag{13}$$

where $Q_{ht} = \int_{\psi \in \mathbb{1}^d_{ht}} q^d_{ht} M_t \mu(\psi) d\psi + \tau_{ht} \int_{\psi \in \mathbb{1}^d_{lt}} q^x_{ht} M_t \mu(\psi) d\psi$ and $Q_{lt} = \int_{\psi \in \mathbb{1}^x_{ht}} q^d_{lt} M_t \mu(\psi) d\psi + \tau_{lt} \int_{\psi \in \mathbb{1}^x_{lt}} q^x_{lt} M_t \mu(\psi) d\psi$.

**Trade Balance Condition** Total export revenues should cover the foreign international value of imports such that,

$$\int_{\psi \in \mathbb{1}^x_{ht}} p^x_{ht} q^x_{ht} M_t \mu(\psi) d\psi + \int_{\psi \in \mathbb{1}^x_{lt}} p^x_{lt} q^x_{lt} M_t \mu(\psi) d\psi = \int_{\psi \in \mathbb{1}_{hmt}} p_{hmt} q_{hmt} M_{mt} \hat{\mu}(\psi) d\psi + \int_{\psi \in \mathbb{1}_{lmt}} p_{lmt} q_{lmt} M_{mt} \hat{\mu}(\psi) d\psi \tag{14}$$

where $p_{kmt}$ and $q_{kmt}$ represent import prices and import quantities of good $k \in \{h, l\}$.

With these conditions, the equilibrium in the model is defined as,

**Definition 5.2.** (*Equilibrium*) Given the fundamentals ($\mathbf{\Sigma}$), a sequential competitive equilibrium of the model is a sequence of price indices $\{P^d_{ht}, P^d_{lt}, P^x_{ht}, P^x_{lt}\}^T_{t=1}$ as defined in equation (6) and wages $\{w_t\}^T_{t=1}$ such that:

(i) Consumers in the domestic and foreign economy maximize their utilities specified in (4),

(ii) Firms maximize their expected profits specified by (8) and (7) and,

(iii) Equilibrium conditions (12), (13) and (14) are met.[35]

[35] Additionally, in equilibrium, there are zero profit conditions for foreign exporters, where firms export only if their profits are greater or equal to fixed costs of exporting. For those, I assume they do not solve a dynamic model, but rather a static period-by-period model.

$$\begin{aligned} \pi_{hm}(\hat{\bar{\psi}}_{ht}) &= F^h_{exp} \\ \pi_{lm}(\hat{\bar{\psi}}_{lt}) &= F^l_{exp} \end{aligned} \tag{15}$$

# 6 Empirical Strategy

This section builds an empirical model consistent with the theoretical model of Section 5 that will be applied to the Peruvian apparel industry. It first describes the estimation and identification strategies and then discusses the results for each of the structural parameters and the fit of the model.

## 6.1 Empirical Specification

I present the estimation procedure that provides the structural parameters of the model described in section 5. The model is estimated using the merged firm-level data spanning the 2007-2012 period, which contains both custom data and firms' characteristics.[36]

The full set of parameters to estimate includes demand elasticities ($\sigma_1$, $\sigma_2$), technological parameter ($\alpha$), productivity process parameters ($\rho_0$, $\rho_1$, $\sigma_\xi^2$), price index processes parameters ($\mathbf{\Theta_P}$), aggregate expenditure processes parameters ($\mathbf{\Theta_X}$), sunk costs ($\gamma_d$, $\gamma_{1x}$, $\gamma_{2x}$) and entry cost $f_e$.

In order to concretely bring the model to the data, three main comments are in order. First, the empirical model should account for some of the limitations in my dataset. In particular, given that I do not observe information on sales or prices by product in the domestic market, the options to produce low- or high- quality goods in the domestic market will be collapsed into one choice –selling domestically. Moreover, I will assume that when producing for the domestic market, firms are constrained to only selling low-quality goods.[37] Thus, for empirical purposes, I restrict the set of possible product mixes ($\mathbf{A}$) to eight choices resulting from the combinations of {selling in domestic market}, {exporting high-quality goods}, {exporting low-quality goods}, plus the possibility of not producing at all and exiting the market.

Second, in the dynamic problem specified in equation (7), I allow profits ($\pi(a, s_{jt})$) to be appended by an action-specific iid error term ($\eta_{jt}(a)$) aiming to reflect unobserved reasons why a firm will choose a particular product mix. Moreover, $\eta_{jt}$ is assumed to be independently drawn from a Type 1 extreme value distribution. Thus, the problem in equation (7) is equivalent to a multinomial choice model, where the value function can be expressed by the integrated value function (Rust (1997)) as in,

[36] See Appendix I for a detailed description of the construction of each variable for each stage of the estimation.

[37] Future work would consider two ways that these data limitations could be accounted for. First, I could use information on the firms that self-reported main products and main inputs in the EEA to determine choices at the domestic level. Second, the model could potentially be extended by assuming all firms produce domestically, according to the predictions of the model, and then the decisions could be aggregated into a single choice of selling domestically.

$$\bar{V}_{jt}(s_{jt}) = log(\sum_{a=0}^{J} exp\{\pi(a, s_{jt}) - \Gamma(a, h_{t-1}) + \beta \sum_{s_{jt+1}} \bar{V}(s_{jt+1}) dF(s_{jt+1}|a, s_{jt})\}) \quad (16)$$

Third, a full estimation of the model would require solving the full dynamic general equilibrium model for each potential value of the parameters and grids of state-space, which is extremely time consuming. To circumvent that problem, for estimation purposes, I will consider observed price indices ($\mathbf{P}$), aggregate expenditures ($\mathbf{X}$) and wages ($w$) as equilibrium outcomes and, conditional on their observed values, estimate the structural parameters of the model.[38] Moreover, I estimate the dynamic problem in two stages. Noticing that the estimation of elasticities, technological parameters and processes for price indices and aggregate expenditures only rely on data that does not need to be solved for the full model, I estimate these parameters separately in a first stage. In a second stage, sunk costs are estimated using a conditional choice probability approach (CCP) in a multinomial choice probability model.

### 6.2 First-Stage Estimation

This stage estimates elasticities ($\sigma_h, \sigma_l$), productivity and productivity parameters ($\psi_{jt}$, $\alpha$, $\rho_0$, $\rho_1$, $\sigma_\psi$), price indices and aggregate expenditure processes ($\mathbf{\Theta_P}, \mathbf{\Theta_X}$).

**Elasticities** In order to recover demand elasticities, I use information from the maximization problem of the firms. Combining the first-order conditions corresponding to firm-level prices in the export market for high- and low-quality goods, as specified in equation (10), we arrive at the following expression,

$$\left(\frac{\sigma_h - 1}{\sigma_h}\right)\left(\frac{1}{t_{ht}}\right) p^x_{jht} - \left(\frac{\sigma_l - 1}{\sigma_l}\right)\left(\frac{1}{t_{lt}}\right) p^x_{jlt} = m_{ht} - m_{lt} \quad (17)$$

Rearranging it, equation (17) can be formulated as,

$$\hat{p}^x_{jht} = \beta_1 \hat{p}^x_{jlt} + \beta_2(m_{ht} - m_{lt}) \quad (18)$$

where $\beta_1 = (\frac{\sigma_l - 1}{\sigma_l})(\frac{\sigma_h}{\sigma_h - 1})$, $\beta_2 = (\frac{\sigma_h}{\sigma_h - 1})$, and $\hat{p}^x_{jkt} = (\frac{1}{\tau_{kt}})p^x_{jkt}$, $k = \{h, l\}$. Noticeably, in equation (18) all variables are known except for the elasticities.

Based on equation (18), I use the following empirical specification to identify the elasticities,

$$\hat{p}^x_{jht} = \beta_1 \hat{p}^x_{jlt} + \beta_2(m_{ht} - m_{lt}) + \epsilon_{jt} \quad (19)$$

[38] Future work will focus on estimating the full general equilibrium model.

where $\epsilon_{jt}$ corresponds to an iid shock, which aims to reflect any firm-level differences in the production of cotton relative to synthetic clothes. For example, some firms might have some unobserved "ability" for producing only one type of product for a particular market, given their network of consumers or their technology, which can be observed by the firm but is unobserved by the econometrician.

Importantly, equation (19) identifies the elasticities without using data on firm-level prices by product in the domestic market or the need for a full estimation of domestic demand for high and low quality apparel. Therefore, this identification strategy allows me to overcome the limitations of my data in the domestic market, while taking full advantage of the richness of the customs data.

However, there might some threats to identification. First, firm-level prices could have a measurement error. If this is the case, $\beta_1$ would be biased downwards and $\beta_2$ would be biased in the direction of covariance between the measurement error and $(m_{ht} - m_{lt})$. If this covariance is negative, this measurement error would, in turn, bias $\sigma_h$ downwards while the effect on $\sigma_l$ would be ambiguous. A potential solution is to instrument $\hat{p}^x_{jlt}$ with firm-level prices of domestic firms to other destinations, under the assumption that the measurement error is the same type for both. Second, there could be sample selection, even within exporters. Hence, as a robustness check, I perform the same regression, using all observations in the customs data without significant changes in the estimated values.

**Production Function** Firm-level productivity ($\psi_{jt}$) is defined in equation (3) and, in principle, should be directly estimated from this expression. However, as is common in these types of data, there are some restrictions that must be accommodated for the estimation.

First, in my data, I only observe a measure of total revenues ($r_{jt}$) rather than physical output at the firm-level ($q_{jt}$). Thus, recovering a measure of productivity implies being able to relate the observed firm's revenues to firm productivity and input usage. In order to do that, I follow De Loecker (2011) and make use of demand structure to be able to express firm-level revenues in terms of physical production and, thus, in factors of production.

Second, even though firms in the model are assumed to produce only high- and low-quality apparel, in reality, these firms produce different types of these products, including items such as pants, t-shirts and shirts. Thus, empirically, I assume that firms are not only multi-product but also multi-line, where lines are defined at the 10-digit HTS code and products are defined as cotton and synthetic apparel.[39] Given that I do not observe data on the factor usage at this disaggregated level, I need to aggregate production from the product line to the firm

[39] In my dataset, 97% of the firms sell more than one type of apparel and 55% sell both products.

level, where I observe input usage. Similar to what has been done in the literature (see De Loecker (2011) and Foster et al. (2008)), I aggregate the production function by considering identical production functions for all lines and products. Additionally, I assume inputs are spread across products in exact proportion to the total number of product lines produced by the firm, $N_{jt}$. Importantly, this aggregation is consistent with the modeling of the production function for the apparel industry, given that the only difference in the productive process of these goods is the price of high- and low-quality materials.

Thus, production function for firm $j$ for product line $i$ at time $t$ can be written as,

$$\begin{aligned} q_{jt}^{i} =& (n_{jt}^{i} L_{jt})^{\alpha_L} (n_{jt}^{i} K_{jt})^{\alpha_K} (n_{jt}^{i} \bar{F})^{\alpha_F} \psi_{jt} \exp(u_{jt}) \\ =& N_{jt}^{-1} q_{jt} \end{aligned} \tag{20}$$

where $n_{jt}^{i}$ is the share of product $i$ in firm's $j$ input usage, $n_{jt}^{i} = N_{jt}^{-1}$ and $u_{jt}$ refers to unanticipated productivity component unobserved to the firm and the econometrician.

Given the CES structure of preferences, from equation (5), the demand system for line $i$ of product $k$ is given by $q_{jt}^{i} = \frac{Q_{kt}(p_{jt}^{i})^{-\sigma_k}}{P_{st}^{-\sigma_k}} \exp(\eta_{jt})$, where $\eta_{jt}$ accounts for an unobserved demand shock for firm $j$. Using this demand specification, revenues per product line ($r_{jt}^{i} = p_{jt}^{i} q_{jt}^{i}$) can be restated as,

$$r_{jt}^{i} = (q_{jt}^{i})^{1-\frac{1}{\sigma_k}} Q_{kt}^{\frac{1}{\sigma_k}} P_{kt} \exp(\eta_{jt})^{\frac{1}{\sigma_k}} \tag{21}$$

Including input proportionality and the production function definition stated in equation (20), revenues at the firm level can be related to input usage such that,

$$r_{jt} = \sum_{i} r_{jt}^{i} = (n_{jt}^{i})^{\frac{1}{\sigma_k}} (L_{jt}^{\alpha_L} K_{jt}^{\alpha_K} \bar{F}^{\alpha_F} \psi_{jt} \exp(u_{jt}))^{1-\frac{1}{\sigma_k}} Q_{kt}^{\frac{1}{\sigma_k}} P_{kt} \exp(\eta_{jt})^{\frac{1}{\sigma_k}} \tag{22}$$

or in logs,

$$\tilde{r}_{jt} = \beta_{np} np_{jt} + \beta_L l_{jt} + \beta_K k_{jt} + \beta_{\bar{F}} + \sum_{k} \beta_k s_{jkt} q_{kt} + \psi_{jt}^{*} + \eta_{jt}^{*} + u_{jt} \tag{23}$$

where $\tilde{r}_{jt}$ are logs of deflated revenues, $np_{jt} = ln(N_{jt})$, and the demand shifter $q_{kt}$ is weighted by the importance of the product in the firm's total output and aims to serve as a proxy for different demand conditions firms might face in the high and low quality segments.

Given the absence of data on output per product to control for demand shifters, I follow De Loecker (2011) and Klette and Griliches (1996) to construct total demand for product $k$ as a market share weighted average of deflated revenue, such that $q_{kt} = \sum_{i=1}^{M_{kt}} ms_{jkt} \tilde{r}_{jst}$ where $M_{kt}$ is the number of firms selling product $k$ at time $t$, $ms_{jkt}$ is the market share of firm $j$ in product $k$ at time $t$, and $\tilde{r}_{jkt}$ is log deflated revenue of firm $j$ in product $k$ at time $t$.[40]

Even with this construction, there are still several issues with equation (23). In order to get consistent estimates, both demand and productivity unobserved shocks should be accounted for. First, input coefficients might be biased if unobserved demand factors are driving firm-level prices. In this case, differences in exposure to Chinese import competition across firms and over time directly impact a firm's residual demand, and thus firm-level prices. Therefore, I follow De Loecker (2011) and Goldberg (1995), and decompose the demand shock $\eta_{jt}$ in an unobservable and observable component such that,

$$\eta_{jt} = \delta Comp_{jt} + \tilde{\eta}_{jt} \tag{26}$$

where $Comp_{jt}$ is the exposure to Chinese import competition at the firm level, defined in Section 4, and $\tilde{\eta}_{jt}$ corresponds to a firm-specific iid shock. Hence, controlling for unobserved demand shocks, the estimation equation is,

$$\tilde{r}_{jt} = \beta_{\bar{F}} + \beta_{np} np_{jt} + \beta_L l_{jt} + \beta_K k_{jt} + \sum_k \beta_k s_{jkt} q_{kt} + \psi^*_{jt} + \delta Comp_{jt} + \epsilon_{jt} \tag{27}$$

Second, input coefficients might also be biased by simultaneity concerns. Simultaneity bias arises because the productivity innovation term is correlated with labor decisions, if firms are able to observe the productivity innovation term before they optimize labor. To correct for unobserved productivity shocks, I follow De Loecker (2011) and Olley and Pakes (1996). Similar to Olley and Pakes, I assume investment in machinery ($i_{jt}$) is a strictly increasing function of productivity. Additionally, I follow De Loecker (2011), and assume that it takes time for Chinese import competition to impact productivity due to investment reactions. Therefore, $i_{jt} = i_t(k_{jt}, \psi_{jt}, Comp_{jt})$. Considering $Comp_{jt}$ is an exogenous variable with support from 0 to 1, the invertibility of $i_t(.)$ is preserved, and thus $\psi_{jt} = h_t(k_{jt}, i_{jt}, Comp_{jt})$.[41]

Thus, equation (27) can be rearranged such as,

$$\tilde{r}_{jt} = \beta_{np} np_{jt} + \beta_L l_{jt} + \sum_k \beta_k s_{jkt} q_{kt} + \phi_t(i_{jt}, k_{jt}, Comp_{jt}) + \epsilon_{jt} \tag{28}$$

where $\phi_t(i_{jt}, k_{jt}, Comp_{jt}) = \beta_F + \beta_K k_{jt} + \delta Comp_{jt} + h_t(k_{jt}, i_{jt}, Comp_{jt})$.

This first stage identifies the coefficients for number of products, labor and demand

[40] These two terms are also typically not observed and are constructed as,

$$r_{jkt} = ln(R_{jt} \frac{n_{jkt}}{N_{jt}}) \tag{24}$$

$$ms_{jkt} = \frac{R_{jkt}}{\sum_j R_{jst}} \tag{25}$$

See De Loecker (2011) for more discussion.

[41] See De Loecker (2011) for an extensive proof.

per product, which are now consistent since $\phi_t(.)$ is controlling for unobserved productivity shocks. Then, with the estimated coefficients in the first stage and the fact that $\psi_{jt} = g(\psi_{jt-1}) + \xi_{jt}$, coefficients of capital and import competition are identified, non-parametrically estimating the following expression,

$$\tilde{r}_{jt} - \hat{\beta}_{np} np_{jt} - \hat{\beta}_L l_{jt} - \sum_k \hat{\beta}_k s_{jkt} q_{kt} = \beta_{\bar{F}} + \beta_K k_{jt} + \delta Comp_{jt} + g(\hat{\phi}_{t-1}, i_{jt-1}, k_{jt-1}, Comp_{jt-1}) + \epsilon_{jt} \quad (29)$$

where g(.) is a non-parametric function of $\hat{\phi}_{t-1}$, $i_{jt-1}$, $k_{jt-1}$, and $Comp_{jt-1}$.

**Price Indices Processes** The process for price indices ($P^c_{kt}$) is assumed to follow a non-stationary process as in,

$$P^c_{kt} = \rho_0^{P_i} + \rho_1^{P_i} P^c_{kt-1} + \delta^{P_i} \mathbf{D}_t + \upsilon_{it} \quad (30)$$

where $k \in \{h, l\}$, $c \in \{d, x\}$, $\upsilon_{it}$ is a normally distributed iid shock with mean zero and variance $\sigma^2_{P_i}$ and, $\mathbf{D}_t$ refers to a vector of time dummies. Therefore, $\mathbf{\Theta_P} = \{\rho_0^{P_{dt}}$, $\rho_1^{P_{dt}}$, $\delta^{P_{dt}}$, $\sigma_{P_{dt}}$, $\rho_0^{P_{ht}}$, $\rho_1^{P_{ht}}$, $\delta^{P_{ht}}$, $\sigma_{P_{ht}}$, $\rho_0^{P_{lt}}$, $\rho_1^{P_{lt}}$, $\delta^{P_{lt}}$, $\sigma_{P_{lt}}\}$ .

Given the short time span of price data, I estimate equation (30) as a dynamic panel on product-year observations at the HS6-digit level, where the working assumption is that all average import prices by product share the same underlying process.

**Aggregate Expenditure Processes** Similarly, I estimate the process of aggregate expenditures ($X^c_{kt}$), assuming it follows a non-stationary process as in,

$$X^c_{kt} = \rho_0^{X_i} + \rho_1^{X_i} X^c_{kt-1} + \delta^{X_i} \mathbf{D}_t + \epsilon_{it} \quad (31)$$

where $k \in \{h, l\}$, $c \in \{d, x\}$, $\epsilon_{it}$ is a normally distributed iid shock with mean zero and variance $\sigma^2_{X_i}$ and, $\mathbf{D}_t$ refers to a vector of time dummies. Therefore, $\mathbf{\Theta_X} = \{\rho_0^{X_{dt}}$, $\rho_1^{X_{dt}}$, $\delta^{X_{dt}}$, $\sigma_{X_{dt}}$, $\rho_0^{X_{ht}}$, $\rho_1^{X_{ht}}$, $\delta^{X_{ht}}$, $\sigma_{X_{ht}}$, $\rho_0^{X_{lt}}$, $\rho_1^{X_{lt}}$, $\delta^{X_{lt}}$, $\sigma_{X_{lt}}\}$ .

### 6.3 Second Stage: Sunk Costs

In the second stage, I estimate sunk costs ($\gamma_d$, $\gamma_h$, $\gamma_l$) using a conditional choice probability (CCP) approach. To do this, I rely on the fact that firms can choose to exit during all time periods. Since *exit* is a terminal choice for firms, the expectation term on the conditional choice value functions, $v(a|s_{jt})$, can be expressed only as a function of the probability of *exit* ($p_0$) and the Euler constant ($C$) such that,

$$v(a|s_{jt}) = \pi(s_{jt}) - \Gamma(a_{jt}, a_{jt-1}) - \beta \sum_{s_{jt+1}} ln(p_0(s_{jt+1}) f(s_{jt+1}|s_{jt}) + \beta C \quad (32)$$

Given the parameters estimated on the first stage, variables such as prices, profits net of sunk costs, and transition probabilities, $f(s_{jt+1}|s_{jt})$, can be calculated outside the optimization procedure for each possible state space value of the data. Moreover, the exit probabilities, $p_0(s_{jt+1})$, can also be non-parametrically estimated outside the optimization process. Therefore, conditional choice probabilities can be constructed only depending on the value of sunk costs and take the following form,

$$p(a|s_{jt}) = \frac{\exp(v(a|s_{jt})}{\sum_{a'} \exp(v(a'|s_{jt}))} \tag{33}$$

Thus, the likelihood function can be expressed as,

$$\mathcal{L}(\gamma) = \Pi_j \Pi_t \Pi_a [p(a|s_{jt}) f(s_{jt+1}|s_{jt})]^{(d_{jt}=a)} \tag{34}$$

where $d_{jt}$ are the choices observed in the data, or in logs,

$$L(\gamma) = \sum_j \sum_t \sum_a (d_{jt} = a)[ln(p(a|s_{jt})) + ln(f(s_{jt+1}|s_{jt}))] \tag{35}$$

This, in turn, is equivalent to maximize,

$$L(\gamma) = \sum_j \sum_t \sum_a (d_{jt} = a)[ln(p(a|s_{jt}))] \tag{36}$$

### 6.4 Identification

Regarding the elasticities, the intuition behind their identification is that differences in product specific firm-level prices respond only to changes in differences in material unit costs and elasticities (mark-ups). Given that elasticities are not moving across time, and this relationship remains constant for every period for all multi-product exporters, this will provide the necessary equations to estimate both elasticities. Note that the combination first order conditions in the domestic market provide us with the same expression as equation (18). That is, one combination is redundant. Therefore, prices per product on the export market provide the same information as domestic prices in identifying elasticities, and thus elasticities can be identified even though prices by product are not observed in the domestic market. Noticeably, this identification strategy is possible given the specific production process of the apparel industry, where final quality is effectively determined by material quality, and the only cost difference is due to material unit price.

On the technology side, $\alpha_L$ and $\alpha_K$ are identified by variation on value added related to changes in relative intensity of labor with respect to capital, controlling for unobserved productivity and demand shocks. For the productivity process, changes in estimated productivity over time will identify $\rho_0$, $\rho_1$, and $\sigma^2_\xi$.

Additionally, parameters in $\mathbf{\Theta_P}$ related to the three price indices are identified with the information on the time series of average import prices of apparel of Peru and the United States. Similarly, parameters on $\mathbf{\Theta_X}$ are identified with time series of aggregate import values of apparel of Peru and the United States. The identification for both assumes values represent equilibrium objects and are exogenous from the domestic firms' point of view.

Finally, sunk costs ($\gamma_d$, $\gamma_h$, $\gamma_l$) are identified by the variation on product mix switching, and the entry cost $f_e$ is determined from the average value of a firm in the market.

### 6.5 Results

This section presents the main results of the empirical model in both estimation stages. Table 5 summarizes the estimated structural parameters of the model.[42]

I start by estimating demand elasticities using equation (19). Results are shown in the first row of 5. For this specification, I use information on existing multi-product exporters in my dataset. Consistent with the non-homotheticity assumption that $\sigma_h > \sigma_l$, the coefficient $\beta_1$ is positive and less than one (0.82). Moreover, the coefficient on the difference in material costs, $\beta_2$ is positive and larger than one (1.65), a fact also consistent with $\sigma_h > 1$. Both of these are encouraging results, as no constrains were imposed of the estimation. With these coefficients, the implied elasticities are $\sigma_h = 2.51$ and $\sigma_l = 1.98$, which, in turn, represent mark-ups of 67% and 100% for the high- and low-quality goods, respectively. Although these mark-ups might seem high for a manufacturing industry, there is ample evidence of mark-ups of up to 200% in the wholesale segment of apparel. Moreover, estimates considering the entire universe of multi-product exporters produce similar results.[43]

The production function coefficients are shown in Row 2 of Table 5. Output elasticities in labor (0.72) and capital (0.13) imply reasonable estimates, which are compatible with a labor intensive industry. Moreover, they are consistent with similar findings in the literature for apparel and textile industries in the developing world, such as Pavcnik (2002).

Taking into account labor and capital expenditures and the estimated coefficients in Row 2, a value of productivity for each firm-year observation is predicted. I rely on those estimates to provide the necessary time series information to obtain parameters on the AR1 process of productivity. As observed in Row 3 of Table 5, the coefficients on the AR1 process show moderate persistence of productivity over time, but considerable heterogeneity between firms.

[42] The complete list of parameters is detailed in Appendix J.

[43] When considering the full sample of exporters in the Peruvian apparel industry, $\sigma_h = 2.77$ and $\sigma_l = 2.18$. In turn, these coefficients imply mark-ups of 56% and 84% for high- and low-quality goods, respectively.

Finally, estimates for sunk costs ($\gamma_d$, $\gamma_h$, $\gamma_l$) are presented in Row 6 of Table 5. The estimates are expressed in millions of US dollars and are in line with the common empirical fact of substantial sunk costs related to exporting and starting a business. However, they are relatively large compared to other estimates for developing countries such as Das et al. (2007). Considering these firms have, on average, total sales of approximately US$ 10 million, the sunk costs estimates seem reasonable. At first, it might seem surprising that sunk costs for the domestic market are considerably higher than the sunk costs for the low-quality goods in the export market. However, given the assumption that collapses all sales in the domestic market to low-quality sales, this estimate might be driven upwards because it actually captures a combined effect of firms that are selling both cotton and synthetic apparel to the domestic market.

| Stage | Estimation | Parameters | Coefficient | Std. Dev | No. Obs. |
|---|---|---|---|---|---|
| First | Elasticities | $\sigma_h$ | 2.53 | (1.53) | 685 |
| | | $\sigma_l$ | 1.98 | (0.82) | |
| First | Production Function | $\alpha_l$ | 0.72 | (0.02) | 511 |
| | | $\alpha_k$ | 0.13 | (0.03) | |
| First | Production Process | $\rho_0$ | 0.25 | (0.03) | 404 |
| | | $\rho_1$ | 0.22 | (0.08) | |
| | | $\sigma^2_\psi$ | 0.42 | | |
| Second | Sunk Costs | $\gamma_d$ | 6.08 | (2.30) | 222 |
| | | $\gamma_1$ | 7.10 | (1.27) | |
| | | $\gamma_2$ | 3.85 | (3.87) | |

Table 5: Structural Estimation Parameters

### 6.6 Model Fit

To assess the fit of the model, I use the estimated parameters and fully solve the model to simulate industry dynamics for 400 firms during the 2001-2012 period. With the simulated industry, I calculate several relevant criteria that the model should be able to explain and compare them to what is observed in the data. The model fits well with both the main qualitative features of the data and also accurately matches the levels of sales in the industry.

#### 6.6.1 Computing the New Equilibrium

The estimation of the model in Section 6 assumed that the observed price indices were already equilibrium objects. However, given that a change of the fundamentals in the model would necessarily imply changes in those aggregate price indices due to firm-level reactions, the model must be fully solved to perform any simulation.

Table 6 presents an outline for the method used to fully solve for the new equilibrium. The implemented algorithm takes all the fundamental parameters ($\mathbf{\Sigma}$) as inputs and the state of the industry at time zero, and returns the equilibrium states for each period $t$ where $t = \{1, ..., T\}$. This equilibrium outcomes correspond to the sequence of actions of each firm ($\{a_{jt}\}_{t=1}^{T}$) as well as the industry price indices for every period ($\{\mathbf{P}\}_{t=1}^{T}$).

The algorithm starts with an assumption of parameters of the price indices processes, where the value function can be computed at every grid of the state-space. Then, it proceeds to simulate the vector of actions and consistent price indices that clear the market of goods at each period. At period $T$, it computes the price indices processes resulting from the simulated sequence of price indices. The algorithm ends when all actions, price indices' sequences, and price indices' processes parameters are self-fulfilling and consistent with the equilibrium conditions. Given that the algorithm is based on a simulation of firm decisions, given a set of errors for productivity, price indices process, and choice specific value functions, this process is repeated $S$ times.

Two important comments are in order. First, departing from the estimation procedure, I do not consider non-stationary processes for price indices or aggregate expenditures when fully solving the model. To keep the simulations tractable, I instead assume AR1 stationary processes. This allows me to compute the value functions for each value of the state-space outside the iterative processes that look for a convergence of price indices and firm-level choices for each period, generating substantial gains in computing time. The main caveat is that the model will potentially predict effects which are not as sharp as the ones observed in the data. Second, because of the assumption of a stationary environment, I do not include data for the year 2004 in my simulations. Because the Peruvian government imposed temporary tariffs that largely affecting industry performance that year, the observed values for price indices as well as for aggregate expenditures will not be consistent with firms forming expectations under a stationary environment.

| | **Algorithm:** |
|---|---|
| 1. | Set parameters $\Sigma = \{\sigma_h, \sigma_l, m_h, m_l, \theta, \bar{F}, \rho_x\}$. |
| 2. | Set errors for productivity process, price indices processes and value functions. |
| 2. | Set counter $iterar1 = 0$. |
| 3. | Guess price indices processes: $\Theta^0$. |
| 4. | Compute $V(S_{jt})$ given $\Theta^0$ for each value of grid of $s_{jt}$. |
| 5. | For $t = 1$ to $T$: |
| 6. | Get $X_{dt}$, $X_{ht}$, $X_{lt}$, $\psi_{jt}$: |
| 7. | Set counter $itera = 0$. |
| 8. | Guess actions $a^0_{jt}$: |
| 9. | Set counter $iterp = 0$. |
| 10. | Guess price indices $P^0_{dt}$, $P^0_{ht}$, $P^0_{lt}$: |
| 11. | Compute firm level prices $p_{jt}$. |
| 12. | Compute $P^1_{dt}$, $P^1_{ht}$, $P^1_{lt}$. |
| 13. | Stop if $\lvert P^1_{\kappa t} - P^0_{\kappa t}\rvert < \epsilon \ \forall \kappa$; otherwise update $P^0_{\kappa t}$, $iterp = iterp + 1$ and repeat (10)-(13). |
| 14. | Solve the dynamic decision of firms and compute $a^1_{jt}$. |
| 15. | Stop if $\lvert a^1_{jt} - a^0_{jt}\rvert < \epsilon$; otherwise update $a^0_{jt}$, $itera = itera + 1$ and repeat (8)-(15). |
| 16. | End and move to $t = t + 1$. |
| 17. | Using all sequence $\{P^0_t, P^0_{ht}, P^0_{lt}\}^T_t$, compute price indices processes $\Theta^1 = \{\rho_d\}$. |
| 18. | Iterate until $\lvert\Theta^1 - \Theta^0\rvert < \epsilon$. |

Table 6: Solution Algorithm

### 6.6.2 Model Fit Criteria

Even though the estimates are sensible and consistent with key facts in the apparel industry, the model is useful because it allows us to perform and quantify the effect of policy experiments. In that sense, the first step is to review how well the model fits some of the major features of the data. The main criteria for model fit is summarized in Table 7 and Figure 4.

In Table 7, I calculate the correlation between the observed price indices and the price indices resulting from aggregation of the firm -level prices in the simulation of the model. As shown in Row 2 of Table 7, for each market, the correlations are considerably high, as the model is able to precisely capture the dynamics of the price indices. The same is true for the correlation among the logs of aggregate expenditures, as shown in Row 3. In addition, the model does a good job of predicting the patterns of the ratio of export sales of cotton relative to synthetic fiber, a key feature given that, as seen in Section 3, most of the export growth was associated with the growth of cotton clothes rather other types of apparel.

| Criteria | Variable | Data-Model |
|---|---|---|
| Correlation Price Indices | $P_t^d$ | 0.9879 |
| | $P_t^h$ | 0.9995 |
| | $P_t^l$ | 0.9680 |
| Correlation Log Aggregate Expenditures | $X_t^d$ | 0.8653 |
| | $X_t^h$ | 0.8228 |
| | $X_t^l$ | 0.9994 |
| Correlation Ratio Synthetic-Cotton | $\frac{X_t^h}{X_t^l}$ | 0.9571 |

Table 7: Model Fit

Finally, Figure 4 shows how the model accounts for the total size of the apparel exports of the Peruvian industry. On average, the model is able to explain 86% of Peruvian total exports.

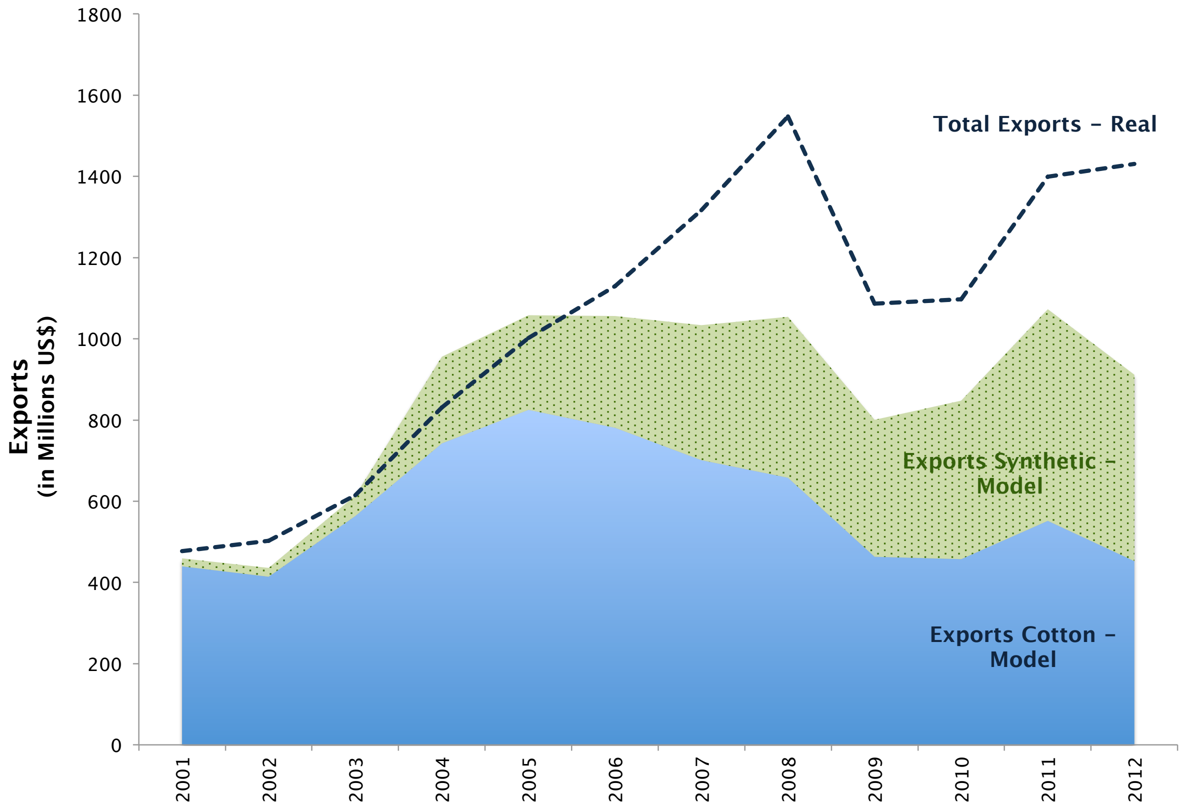



**Figure 4: Exports - Fit of the Model**

To sum up, the model is able to capture the critical patterns shown in Section 3. Thus, the next section proceeds to evaluate specific policies through the lens of the model.

# 7 Policy Experiments

In this section, I use the general equilibrium model in Section 5, as well as the estimated parameters of the model from Section 6 to predict welfare and productivity changes associated with several counter-factual scenarios.

## 7.1 The Role of Quality Upgrading

The key mechanism for quality upgrading and exporting responses in the model consists of the redeployment of shared less mobile factors across product lines. However, this mechanism ultimately relies on the fact that firms are able to retain profitability while switching to other products and destinations. The question thus arises: what would have happened if firms found it difficult to diversify to high-quality products or to start exporting.

Empirically, this question may shed light on the heterogeneous responses to Chinese import competition observed across various Latin American countries. In principle, Peruvian cotton fabric could have been imported by other Latin American countries following the expansion of Chinese apparel exports in the early 2000s. The fact that firms in other countries did not follow this path could have been due to either existing trade barriers that directly increased the cost of using these high-quality inputs, or to other differences in their ability to enter a market captured by higher sunk costs.

In that regard, I follow two approaches to understand what role the comparative Peruvian advantage played on industry performance. On one hand, supposing that Peruvian firms would have had to import the high-quality productive factor, I increase the additional marginal price firms pay to produce cotton apparel, $m_{ht}$ from 4 to 16 US$. Considering I am using the same aggregate demand for Peruvian goods, I look at this scenario as a lower bound on the effect of the industry in preventing firms from switching to high-quality products. On the other hand, to simulate the situation that firms in other countries would have been subject to additional factors that could have prevented them from entering new markets, I increase the sunk cost, so that firms would have a harder time switching to high quality segments and foreign markets. In reality, this experiment speaks to the difficulty for firms to start exporting and selling a particular product, which relates to the acquisition of a network of customers, the uncertainty of a new market and, the one-time irrecoverable costs of becoming an exporter. In an extreme scenario, I effectively prevent firms from exporting and selling high-quality apparel as a response to import competition. Analytically, I increase different combinations of firms' sunk costs by 10 times, so that only exceptionally productive firms would find it profitable to include high-quality products or to export.

For the first experiment, Column 1 of Table 8 shows the percent changes in industry sales, given an increase in unit prices of cotton fabric. During the sample period, exports are reduced by 7.9 percent on average, while domestic sales increase by an average of 2.3 percent. Overall, the combined effect results in a reduction of total industry sales by approximately 4 percent. In monetary terms, these results imply a cumulative increase in sales for the domestic market of US$ 146 million, as well as a reduction of cumulative exports of US$ 682 million during the sample period. From the firms point of view, average annual profits decrease by 4.2 percent and employment diminishes by 8 percent. However, in terms of total consumer welfare, utility per capita in the domestic and export markets remains unchanged.

In the second experiment, the predictions are more striking, as Column 2 - 3 of Table 8 shows. In all of these cases, the Peruvian apparel industry is severely affected. Even when firms only face higher cost to export high-quality apparel, average annual industry sales are decreased by 13.2%. If, in addition, firms are also prevented from exporting any type of apparel, the negative impact rises to 17.5%. Most of these effects come from a dramatic fall in exports–28% and 38.3%, respectively–that cannot be offset by the increase in domestic market sales. In monetary terms, the effects are substantial. Considering the case where firms face higher costs to export and include high-quality apparel in their product mix, cumulative domestic sales over the sample period increase by US$ 4.9 million while cumulative cotton apparel exports decrease by US$ 2.59 billion and, cumulative synthetic apparel exports are reduced by US$ 1.02 billion. Overall, the industry loses US$ 3.12 billion over the 2001-2012period. Moreover, in terms of firm surplus, the inability to quality upgrade and export costs firms approximately 16.4 percent of their annual profits. Unemployment also rises by approximately 18 percent. In particular, this effect is troubling, given the importance of the apparel industry for the dynamics of the manufacturing industry in Peru. In reality, this would imply significant job cuts to the Peruvian formal employment sector. Finally, given that firms are prevented from exporting and since they are only selling low-quality goods in the domestic market, domestic consumer welfare increases by 0.10 percent.

| Criteria | Increase in | | |
|---|---|---|---|
| | (1) | (2) | (3) |
| | $\mathbf{m_h}$ | $\gamma_\mathbf{h}$ | $\gamma_\mathbf{h}, \gamma_\mathbf{l}$ |
| Annual % Change of Sales: | | | |
| Exports | -7.9% | -28.0% | -38.3% |
| Domestic | 2.3% | 5.9% | 6.4% |
| Industry | -3.7% | -13.2% | -17.5% |
| Cumulative change 2001-2012 (in millions of US$) | -536 | -2,160 | -3,124 |
| Annual Profits | -4.2% | -11.8% | -16.4% |
| Men Hours | -8% | -14.8% | -17.7% |
| Total Consumer welfare | 0.02% | 0.14% | 0.29% |
| Domestic Consumer welfare | 0.02% | 0.06% | 0.10% |

Table 8: Higher Switching Costs

In sum, both results point to significant industry losses, if due to up-front costs or high-cost inputs, firms are not capable of changing their product mix in response to import competition. Broadly, these effects help to explain the contrast between the Peruvian apparel industry and what has happened in other Latin American countries. In addition, these experiments highlight the need to think deeply about the existing frictions that could be preventing firms in other developing countries from importing the necessary inputs that would allow them to switch production lines or export. In particular, if the only barrier for other economies was a higher price for high-quality inputs, due to market frictions such as tariffs, the government could help their industry by reducing tariffs, so that domestic firms would find it profitable to switch. Alternatively, if the key barriers for firms to switch to higher quality products were the up-front costs of exporting or the costs associated with building reputation and customer network, then policies such as export promotion agencies or expedited export declarations could have a considerable effect on industry survival when confronted with import competition.

### 7.2 Tariffs

With the rapid expansion of China in the early 2000s, several countries in Latin America feared the worst and rushed to impose additional tariffs on imported Chinese apparel to protect their domestic industry. In fact, as a consequence of numerous petitions by domestic firms, in 2004, Peru raised tariffs for 200 calendar days to examine whether they represented a threat to the domestic industry. Ultimately, as explained in Section 3, these tariffs were repealed and, even without protection, the industry managed to survive and grow. This section examines what would have happened, if, in the early 2000s, the Peruvian government had imposed these additional tariffs permanently.

Empirically, the counterfactual is implemented as a raise in $\tau$ equal to 30 percent of the price index of Chinese imports to the domestic market, $P_t^{dm}$. This change effectively corresponds to the average increase in tariffs established by the Peruvian government in December 2003, but is imposed here from 2001 to 2012. I perform this change for an economy with the baseline switching costs estimated in Section 6 and assuming firm had higher switching costs, as defined in Section 7.1.

The percent change in industry sales under this policy experiment are shown in Table 9. In Column 1, I analyze the effect on tariffs in the Peruvian economy. As expected, annual domestic sales increase, on average, by 26.3 percent, while total exports decrease by 3.3 percent. This contraction occurs for both high- and low-quality exports, which shrink by 3.8 and 2.5 percent, respectively. Combining these effects, the overall Peruvian industry increases, on average, by 10.4 percent. In monetary values, this effect implies a cumulative increment in total sales of the industry of US$ 2.31 billion. Moreover, annual profits increase by 11 percent and employment performs similarly. However, this result contrasts sharply with the effect of tariffs on domestic consumer welfare, which is annually cut back by 12 percent over the sample period. In terms of compensating variation, annual welfare losses amount to US$ 276 million.

In Column 2, I examine the effects of those tariffs in the case that the Peruvian apparel industry faced higher switching costs. Comparing these effects with the ones shown in Table 8, it is important to highlight that even though tariffs would help alleviate the impact of Chinese import competition, in an industry where firms experience substantial difficulties in exporting or switching to high-quality goods, this policy would not do a sufficient job fostering industry growth. Not only that, but it would also still impose substantial welfare costs on consumers.

Therefore, while in the short run, industry performance is effectively increased by protective measures such as tariffs, overall welfare is highly compromised. In contrast, policies such as the ones described in Section 7.1 both promote industry growth, and also avoid these detrimental effects on welfare.

Moreover, this scenario could also help explain what the Peruvian apparel industry would have looked like, had China not had the tremendous export growth it experienced in the

| Criteria | Increase of Chinese Import Tariffs | | |
|---|---|---|---|
| | (1) | (2) | |
| | Baseline Switching Costs | High-Switching Costs $m_h$ | $\gamma_h, \gamma_l$ |
| Annual % Change of Sales: | | | |
| Exports | -3.3% | -10.9% | -40.3% |
| Domestic | 26.4% | 28.7% | 32.8% |
| Industry | 10.4% | 6.9% | -6.5% |
| Cumulative change 2001-2012 (in millions of US$) | 2,313 | 1,804 | -676 |
| Annual Profits | 10.9% | 7.1% | -4.7% |
| Men Hours | 10.8% | 3.3% | -6.2% |
| Total Consumer welfare | -12.0% | -11.98% | -11.72% |
| Domestic Consumer welfare | -12.0% | -11.97% | -11.90% |

Table 9: Higher Import Tariffs

in the 2000s. Given that the 2000 temporary tariff increase effectively eliminated most of Chinese import competition, these counterfactuals can also be viewed as a reflection of the situation of the industry had Chinese apparel exports not grown as much. Importantly, these results are consistent the reduced form-evidence in Section 4 given that the cumulative change in exports in the period 2001-2012 is approximately 30% larger in the event of import competition from China.

### 7.3 Cost-Benefit of Alternative Policies

Considering the policy experiments presented in Sections 7.1 and 7.2, a follow-up question is what effective policies could be put into place by governments that would like to boost the domestic industry and increase employment following some target numbers.

To do so, I calculate the implied tariff for import competition, and the subsidy needed in switching costs to achieve an average 5 percent growth in both employment and industry sales, along with associated costs and benefits in terms of firm and consumer surplus. I found that either an additional import tariff of 15% or a decrease in up-front costs of exporting high-quality goods by approximately 50% could achieve these objectives. However, tariffs would entail a domestic consumer welfare cost of 6.6%, while alternative policies would be exerted at no cost. In terms of compensating variation, this increase in tariffs leads to domestic consumer welfare annual loses of approximately US$ 133 million.

From a cost-benefit point of view, it is more costly for governments to enact additional tariffs than decrease the up-front costs of exporting high-quality goods. Even though tariffs might be considered a revenue source, as opposed to measures aimed at decreasing switching costs, import taxes do not represent an important source of government funding.[44] Moreover, despite the fact that tariffs might not be seen as having a direct cost, they certainly entail several indirect costs of implementation in addition to welfare connotations. Most notably, additional tariffs must be approved by the WTO and be consistent with any bilateral trade agreements that the country is party to. In contrast, in Latin America, measures that diminish the up-front costs of switching to higher quality goods and exporting, such as decreases in transportation costs, strengthening of high-quality input supply chain or export promotion, could be achieved by policies such as road construction, fostering cluster activity, and international trade fairs. These policies would be both beneficial for consumers, as well as consistent with several other existing government objectives.

## 8 Conclusion

Import competition can lead to quality-upgrading of the product mix and exporting activity, which is key to understanding the survival of some industries in the developing world in the face of recent export growth by low-wage countries. This paper develops and structurally estimates an industry dynamic equilibrium model to study the response of Peruvian apparel manufacturers to the increase in Chinese import competition during the 2000s. The model builds on standard general equilibrium trade models of heterogeneous multi-product firms with the addition of two important empirical regularities: firms optimize over non-segmented markets, and preferences are non-homothetic between countries. The estimation is done in two-stages, where parameters related to static profits are estimated first and parameters in the dynamic problem are then estimated using a conditional choice probability approach.

With the estimated parameters of the model, I fully solve the industry general equilibrium to perform several policy experiments. In particular, I analyze: (1) the extent of the impact of Chinese import competition on the Peruvian apparel industry and the role of firms' ability to escape competition by moving across products and destinations, and (2) the effect that commonly used trade policies, such as tariffs, have on welfare and industry growth. These experiments highlight the importance for governments to rethink the set of trade policies aimed at protecting their industries, and to consider initiatives promoting firm mobility in

[44] All import taxes represent only 10 percent of all income associated with trade duties and 2 percent of total tax collection in the country. Even more, tax collection in Peru corresponds to 15 percent of the GDP.

the product and industry space. For example, revising import tariffs on high-quality inputs, strengthening supply chain relationships and creating export promotion agencies.

Finally, even though the model is constructed assuming that shared less mobile factors are used in the production of two goods in the same industry, the takeaway of the model goes beyond that point. In general, the model emphasizes the ability of firms to quickly switch to other lines of production, but also to other industries and sectors. Moreover, while in this case, the factors are used in the production of goods, it does not rule out a circumstance in which they are used to produce different outcomes, such as in Bloom et al. (2013), where labor could be used for the production of goods or the "production" of innovation. In more general terms, the model highlights the importance of firms being able to diversify their business in a timely manner following an increase in import competition, and points to the adoption of policies aimed at eliminating any frictions that prevent firms from switching.

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# Appendix

## A Closed Economy

Consider a small economy with $L$ identical agents. In this economy, there are two differentiated goods: high- ($h$) and low-quality ($l$) goods. For each good, there is a continuum of varieties indexed by $\nu_k$ where $k \in \{h, l\}$.

### A.1 Demand

Following Fieler (2011a), all consumers in the country have the same utility function of the form,

$$U_t = (\alpha_h)^{\frac{1}{\sigma_h}}(\frac{\sigma_h}{\sigma_h - 1}) \int\limits_{\nu_h \in \Omega_h} q_{ht}(\nu_h)^{(\frac{\sigma_h - 1}{\sigma_h})} d\nu_h + (\alpha_l)^{\frac{1}{\sigma_l}}(\frac{\sigma_l}{\sigma_l - 1}) \int\limits_{\nu_l \in \Omega_l} q_{lt}(\nu_l)^{(\frac{\sigma_l - 1}{\sigma_l})} d\nu_l \tag{A-1}$$

where $q_{kt}(\nu_k)$ represents quantity consumed of variety $\nu_K$ from good $k$, $\Omega_h$ and $\Omega_l$ represent the available varieties of both goods, $\alpha_\tau > 0$ are weights for each good and $\sigma_\tau > 1$, $\forall \tau$ represents the elasticities of substitution within goods and across varieties, and also determines the income elasticity of demand. Similar to Fieler (2011a), I normalize $\alpha_h^{\frac{1}{\sigma_h}} + \alpha_l^{\frac{1}{\sigma_l}} = 1$.

Consumers maximize their utility given by equation (A-1) choosing the quantity of variety $\nu_h$ and $\nu_l$ at time $t$ subject to their budget constraints.

$$\max_{\{\{q_{ht}\},\{q_{lt}\}\}} U_t$$

subject to:

$$\int\limits_{\nu_h \in \Omega_h} p_{ht}(\nu_h) q_{ht}(\nu_h) d\nu_h + \int\limits_{\nu_l \in \Omega_l} p_{lt}(\nu_l) q_{lt}(\nu_l) d\nu_l = I_t \tag{A-2}$$

First-order conditions imply,

$$\frac{X_{ht}}{X_{lt}} = \lambda^{\sigma_l - \sigma_h}(\frac{\alpha_h}{\alpha_l}\frac{P_{ht}^{1-\sigma_h}}{P_{lt}^{1-\sigma_l}}) \tag{A-3}$$

with

$$P_{ht} = [\int\limits_{\nu_h \in \Omega_h} p_{ht}^{1-\sigma_h} d\nu_h]^{\frac{1}{1-\sigma_h}} \tag{A-4}$$

$$P_{lt} = [\int_{\nu_l \in \Omega_l} p_{lt}^{1-\sigma_l} d\nu_l]^{\frac{1}{1-\sigma_l}} \quad \text{(A-5)}$$

where $P_{ht}$ and $P_{lt}$ are CES aggregate price indices, $X_{ht}$ and $X_{lt}$ represent total expenditures in good $h$ and $l$, and $\lambda$ is the marginal utility of income.

The main difference with a standard homothetic preferences specification is given by equation (A-3). Assuming that $\sigma_h > \sigma_l$ as in Fieler (2011a), the ratio of expenditures described in (5) is decreasing in $\lambda$, and thus increasing in income. Therefore, everything else given, richer countries will consume relatively more high-quality goods than their poor counterparts.

Thus, solving for demanded quantities by variety, it is straightforward to show that,

$$q_{ht}(\nu_h) = \frac{X_{ht} p_{ht}(\nu_h)^{-\sigma_h}}{P_{ht}^{1-\sigma_h}} \quad \text{(A-6)}$$

$$q_{lt}(\nu_l) = \frac{X_{lt} p_{lt}(\nu_l)^{-\sigma_l}}{P_{lt}^{1-\sigma_l}} \quad \text{(A-7)}$$

## A.2 Production

The competitive environment is monopolistic competition. Firms are potentially single- or multi-product, (i.e., they can produce one or both goods), and are heterogeneous only in their productivity, $\psi_{jt}$.

Firms maximize discounted profits. Every period, after observing their productivity and characteristics of the market, they choose their product mix (sell only the low-quality good, only the high-quality good, or both), as well as the corresponding optimal prices and quantities, or to not produce at all. Firms that decide not to produce at all exit the market and disappear.

### A.2.1 Technology and Costs

I assume that both goods can be produced using the same technology, i.e., inputs can be used interchangeably under the same production technology to get one unit of either good.

The production technology uses labor ($L_{jt}$) and a bundle of composite productive inputs ($F_{jt}$) complemented by a fixed amount of materials, $M$. The production function has the form $q_{jt} = min\{\psi_{jt} L_{jt}^{\alpha} {F_{jt}}^{1-\alpha}, M\}$, where $\alpha < 1$ and $q_{jt} = q_{jht} + q_{jlt}$. In order to account for the differences in materials, there is an additional constant marginal cost $m_{kt}$ associated with the production of each good, where $m_{ht} > m_{lt}$.

Firms need to pay the following costs. First, in order to enter the market, firms must pay an entry cost $wf_e$ after which they are able to get a productivity draw $\psi_{jt} \sim G(\psi)$. Second, in order to produce, firms need to engage ex ante in a fixed investment of the composite productive input. This is captured, assuming that firms need to contract $F_{jt} = \bar{F}$, where $\bar{F}$ is a fixed value and for which firms need to pay a fixed cost $\theta\bar{F}$, commonly known before entry. Finally, to include a product in the mix for the first time, the firm must pay a non-recoverable sunk cost, $\gamma_k$, $k = \{h, l\}$.

### A.2.2 Static Profit Maximization

Conditional on a product mix choice, $a = \{\mathbb{1}_{ht}, \mathbb{1}_{lt}\}$, a productivity draw $\psi_{jt}$, price indices, $\mathbf{P} = \{P_{ht}, P_{lt}\}$, and aggregate expenditures, $\mathbf{X} = \{X_{ht}, X_{lt}\}$; the general static maximization problem of every firm is the following,[45]

$$\max_{\{p_{jht}, p_{jht}\}} \pi_{jt} = \mathbb{1}_h(p_{jht}q_{jht}) + \mathbb{1}_l(p_{jht}q_{jht}) - w(\frac{q_{jt}}{\psi_{jt}\bar{F}^{1-\alpha}})^{\frac{1}{\alpha}} - m_{ht}(\mathbb{1}_h q_{jht}) - m_{lt}(\mathbb{1}_l q_{jlt}) - \theta\bar{F} \tag{A-8}$$

where $q_{jt} = \mathbb{1}_h q_{jht} + \mathbb{1}_l q_{jlt}$, $w$ refers to average wages in the sector, and $\theta$ is the cost associated with factor $\bar{F}$.

The corresponding first-order conditions are,

$$p_{jht} = \left[\frac{\sigma_h}{\sigma_h - 1}\right]\left[m_{ht} + \frac{w}{\alpha}\left(\frac{1}{\psi_{jt}\bar{F}^{1-\alpha}}\right)^{\frac{1}{\alpha}}(q_{jt})^{\frac{1}{\alpha}-1}\right] \tag{A-9}$$

$$p_{jlt} = \left[\frac{\sigma_l}{\sigma_l - 1}\right]\left[m_{2t} + \frac{w}{\alpha}\left(\frac{1}{\psi_{jt}\bar{F}^{1-\alpha}}\right)^{\frac{1}{\alpha}}(q_{jt})^{\frac{1}{\alpha}-1}\right] \tag{A-10}$$

Notice that prices react both to changes in consumer expenditures and competition environment in the same market, as well as to changes in these variables for the other goods produced by the firm. Thus, even though mark-ups are not variable, the model does allow for changes in firm-level prices.

Moreover, given prices and the condition of producing that good, firm revenues are,

$$r_{jht} = \frac{X_{ht}p_{jht}^{1-\sigma_h}}{P_{ht}^{1-\sigma_h}} \tag{A-11}$$

[45] The cost minimization problem for every firm is,

$$\min_{\{l_{jt}\}} TC_{jt} = w(L_{jt}) + m_h q_{jht} + m_l q_{jlt} + \theta\bar{F}$$

subject to:

$$q_{jt} \leq \psi_{jt}L_{jt}^{\alpha}F^{1-\alpha}$$

Therefore,

$$L_{jt} = (\frac{q_{jt}}{\psi_{jt}\bar{F}^{1-\alpha}})^{\frac{1}{\alpha}}$$

Thus, the maximization problem of every firm is as stated in equation (A-8).

$$r_{jlt} = \frac{X_{ht} p_{jlt}^{1-\sigma_l}}{P_{lt}^{1-\sigma_l}} \tag{A-12}$$

Given the assumption of a shared input, a closed-form solution cannot be achieved. Thus, static profits given values for the competition environment, productivity and a specific product mix are:

$$\pi_{jt} = \mathbb{1}_h r_{jht} + \mathbb{1}_l r_{jlt} - w(\frac{q_{jt}}{\psi_{jt}\bar{F}^{1-\alpha}})^{\frac{1}{\alpha}} - m_{ht}\mathbb{1}_h q_{jht} - m_{lt}\mathbb{1}_l q_{jlt} - \theta\bar{F} \tag{A-13}$$

#### A.2.3 Dynamic Problem

Firms decide dynamically over their product mix, $a_{jt}$, considering as state variables $s_{jt} = \{\psi_{jt}, P_{ht}, P_{lt}, X_{ht}, X_{lt}, \bar{F}, h_{jt-1}\}$, where $h_{jt-1}$ is a variable summarizing if which sunk costs the firm has paid up to $t-1$.

Productivity evolves over time as a first-order Markov process, $\psi_{jt} = g(\psi_{jt-1}) + \xi_{jt}$, so it depends on previous levels. Particularly, I will assume an AR1 process for the variable such that,

$$\psi_{jt} = \rho_0 + \rho_1 \psi_{jt-1} + \xi_{jt} \tag{A-14}$$

where $\xi_{jt}$ captures the stochastic nature of productivity and is assumed to be an iid shock with zero mean and variance $\sigma^2_\xi$. That is, it represents the innovation in the productivity process that cannot be anticipated by the firm and therefore, it is not correlated with $\psi_{jt-1}$.

Similarly, price indices, $P$, and aggregate expenditures $X$ follow Markov processes such that,

$$\begin{aligned} P_{kt} &= p(P_{kt-1}) + \mu_t \\ X_{kt} &= x(X_{kt-1}) + e_t \end{aligned} \tag{A-15}$$

where $\mu_t$ and $e_t$ are iid shocks at the industry level with mean zero and variance $\sigma^2_\mu$ and $\sigma^2_e$, respectively.

Firm $j$'s value function is,

$$V(s_{jt}) = \max_{a \in A} \quad \pi_{jt}(a, s_{jt}) - \Gamma(a, h_{jt-1}, \gamma) + \beta \int_{s_{jt+1}} V(s_{jt+1}) dF(s_{jt+1}|a, s_{jt}) \tag{A-16}$$

where $A = \{1, 2, 3, 4\}$ refers to the complete set of potential product mixes being 1 = {sell only low-quality good}, 2 = {sell only high-quality good}, 3 = {sell both goods} and, 4 = {do not produce}, $\Gamma(.)$ is the sunk cost function, and $F(s_{jt+1}|s_{jt})$ represents the transition probabilities of the state space.

## A.3 Implications in Partial Equilibrium

The model gives a set of predictions on the impact of an openness to imports that leads to an increase in import competition. As in the open economy model, define import competition by the average CES price index of every product (i.e., $P_{ht}$ and $P_{lt}$). Thus, an increase in import competition in the low-quality market is defined as the exogenous increase of import varieties at a lower price such that $\Delta P_{lt} < 0$.

The analysis of the impact in partial equilibrium, where price indices and aggregate expenditures do not react to changes in firm-level decisions. The predictions are described as follows.

**Proposition A.1.** *Prices*

*A decrease in $P_{lt}$ unambiguously decreases prices for all goods of multi-product firms and firms producing only the low-quality good.*

*Proof.* Using equations (A-9) and (A-10), the impact of a change in $P_{lt}$ in the prices set by the firms can be described as follows.

For the firm-level unit price of the high-quality good, $p_{jht}$,

$$\{\frac{\sigma_h - 1}{\sigma_h} + \frac{w}{\alpha}\frac{1}{(\psi_{jt}\bar{F}^{1-\alpha})^{\frac{1}{\alpha}}}(\frac{1-\alpha}{\alpha})q_{jt}^{\frac{1}{\alpha}-2}[\frac{\sigma_h X_{ht} p_{jht}^{-\sigma_h - 1}}{P_{ht}^{1-\sigma_h}} + (\frac{\sigma_h - 1}{\sigma_h})(\frac{\sigma_l}{\sigma_l - 1})\frac{\sigma_l X_{lt} p_{jlt}^{-\sigma_l - 1}}{P_{lt}^{1-\sigma_l}}]\}dp_{jht} =$$

$$\frac{w}{\alpha}\frac{1}{(\psi_{jt}\bar{F}^{1-\alpha})^{\frac{1}{\alpha}}}(\frac{1-\alpha}{\alpha})q_{jt}^{\frac{1}{\alpha}-2}\frac{(\sigma_l - 1)X_{lt} p_{jlt}^{-\sigma_l}}{P_{lt}^{2-\sigma_l}} dP_{lt} \tag{A-17}$$

where $\frac{dp_{jht}}{dP_{lt}} = A > 0$, where $A = \frac{\frac{w}{\alpha}\frac{1}{(\psi_{jt}\bar{F}^{1-\alpha})^{\frac{1}{\alpha}}}(\frac{1-\alpha}{\alpha})q_{jt}^{\frac{1}{\alpha}-2}\frac{(\sigma_l - 1)X_{lt} p_{jlt}^{-\sigma_l}}{P_{lt}^{2-\sigma_l}}}{\{\frac{\sigma_h - 1}{\sigma_h} + \frac{w}{\alpha}\frac{1}{(\psi_{jt}\bar{F}^{1-\alpha})^{\frac{1}{\alpha}}}(\frac{1-\alpha}{\alpha})q_{jt}^{\frac{1}{\alpha}-2}[\frac{\sigma_h X_{ht} p_{jht}^{-\sigma_h - 1}}{P_{ht}^{1-\sigma_h}} + (\frac{\sigma_h - 1}{\sigma_h})(\frac{\sigma_l}{\sigma_l - 1})\frac{\sigma_l X_{lt} p_{jlt}^{-\sigma_l - 1}}{P_{lt}^{1-\sigma_l}}]\}}$.

For the firm-level unit price of the low-quality good $p_{jlt}$,

$$\{\frac{\sigma_l - 1}{\sigma_l} + \frac{w}{\alpha}\frac{1}{(\psi_{jt}\bar{F}^{1-\alpha})^{\frac{1}{\alpha}}}(\frac{1-\alpha}{\alpha})q_{jt}^{\frac{1}{\alpha}-2}[(\frac{\sigma_h}{\sigma_h - 1})(\frac{\sigma_l - 1}{\sigma_l})\frac{\sigma_h X_{ht} p_{jht}^{-\sigma_h - 1}}{P_{ht}^{1-\sigma_h}} + \frac{\sigma_l X_{lt} p_{jlt}^{-\sigma_l - 1}}{P_{lt}^{1-\sigma_l}}]\}dp_{jht} =$$

$$\frac{w}{\alpha}\frac{1}{(\psi_j \bar{F}^{1-\alpha})^{\frac{1}{\alpha}}}(\frac{1-\alpha}{\alpha})q_{jt}^{\frac{1}{\alpha}-2}\frac{(\sigma_l - 1)X_{lt}p_{jlt}^{-\sigma_l}}{P_{lt}^{2-\sigma_l}}dP_{lt} \tag{A-18}$$

where $\frac{dp_{jlt}}{dP_{lt}} = B > 0$, where $B = \frac{\frac{w}{\alpha}\frac{1}{(\psi_{jt}\bar{F}^{1-\alpha})^{\frac{1}{\alpha}}}(\frac{1-\alpha}{\alpha})q_{jt}^{\frac{1}{\alpha}-2}\frac{(\sigma_l-1)X_{lt}p_{jlt}^{-\sigma_l}}{P_{lt}^{2-\sigma_l}}}{\{\frac{\sigma_l-1}{\sigma_l}+\frac{w}{\alpha}\frac{1}{(\psi_{jt}\bar{F}^{1-\alpha})^{\frac{1}{\alpha}}}(\frac{1-\alpha}{\alpha})q_{jt}^{\frac{1}{\alpha}-2}[(\frac{\sigma_h}{\sigma_h-1})(\frac{\sigma_l-1}{\sigma_l})\frac{\sigma_h X_{ht}p_{jht}^{-\sigma_h-1}}{P_{ht}^{1-\sigma_h}}+\frac{\sigma_l X_{lt}p_{jlt}^{-\sigma_l-1}}{P_{lt}^{1-\sigma_l}}]\}}$.

□

**Proposition A.2.** *Quantities and Sales:*

*A decrease in $P_{lt}$:*

*(i) Unambiguously decreases quantities and sales in low-quality goods.*

*(ii) For multi-product firms, unambiguously increases quantities and sales of the high-quality good.*

*(iii) Quantities and sales of firms only producing high-quality goods are not affected.*

*Proof.* The proof is as follows,

(i) For a multi-product firm, the impact on revenues of the low-quality good, $r_{jlt}$, is,

$$dr_{jlt} = \frac{X_{lt}(1-\sigma_l)p_{jlt}^{-\sigma_l}}{P_{lt}^{1-\sigma_l}}dp_{jlt} + \frac{(\sigma_l - 1)X_{lt}p_{jlt}^{1-\sigma_l}}{P_{lt}^{2-\sigma_l}}dP_{lt}$$

$$dr_{jlt} = \frac{(\sigma_l - 1)X_{lt}p_{jlt}^{-\sigma_l}}{P_{lt}^{1-\sigma_l}}\{\frac{p_{jlt}}{P_{lt}} - B\}dP_{lt}$$

and given that $B = \frac{p_{jlt}}{P_{lt}} * (\text{expression} < 1)$, $\frac{dr_{jlt}}{dP_{lt}} > 0$.

(ii) Revenues of the firm from the high-quality good, $r_{jht}$, are negatively affected by its own price.

$$dr_{jht} = \frac{X_{ht}(1-\sigma_h)p_{jht}^{-\sigma_h}}{P_{ht}^{1-\sigma_h}} dp_{jht}$$

Thus, they are positively affected by changes in average prices of the low-quality good,

$$dr_{jht} = \frac{X_{ht}(1-\sigma_h)p_{jht}^{-\sigma_h}}{P_{ht}^{1-\sigma_h}} AdP_{lt} \tag{A-19}$$

which means $\frac{dr_{jht}}{P_{lt}} < 0$, i.e., a negative shock in the average price of the low-quality product reduces the price of the high quality product and raises its sales.

(iii) If a firm is only producing the high-quality good, its first-order condition is,

$$p_{jht} = [\frac{\sigma_h}{\sigma_h - 1}][m_{ht} + \frac{w}{\alpha}(\frac{1}{\psi_{jt}\bar{F}^{1-\alpha}})^{\frac{1}{\alpha}}(\frac{X_{ht}p_{jht}^{-\sigma_h}}{P_{ht}^{1-\sigma_h}})^{\frac{1}{\alpha}-1}] \tag{A-20}$$

Thus, there is no effect for those firms when $P_{lt}$ changes.

□

**Proposition A.3.** *Dynamics and Product Mix Change:*

*If $P_{2t}$ decreases, the frequency of the mixes observed will be more likely to include high-quality goods.*

*Proof.* Follows from the fact that the low-quality good market is now relatively less profitable, everything else being equal. □

The basic mechanism is straightforward. To produce, multi-product firms allocate labor and the composite factor to production of high- and low-quality goods. A negative shock in the low-quality market makes it less profitable, and it is optimal for firms to adjust their use of factors. Given that the composite factor is fixed, reallocation of this idle factor must take place. High quality is now the most profitable market. Therefore, idle factors will be reallocated to produce high-quality goods. Thus, for multi-product firms, there will be an upgrade in quality.

### A.4 General Equilibrium

The fundamentals of the model ($\mathbf{\Sigma}$) correspond to the demand elasticities ($\sigma_h, \sigma_l$), production parameters ($\alpha, \rho_0, \rho_1, \sigma_\xi^2$), aggregate expenditures ($X_{ht}, X_{lt}$), shared factor ($\bar{F}$), and sunk costs ($\gamma_h, \gamma_l$). Moreover, let $M_t$ be the mass of entrants for domestic firms at period $t$.

Equilibrium conditions are the following. First, there are indifferent conditions. Let $v(s_{jt}, a)$ be choice specific value functions. Then, discounted profits of all options at each cut-off level of productivity should be equal when evaluated at the minimum cutoff.

$$v(s_{jt}, a) = v(s_{jt}, a') = v(\psi_{jt}^{\{a,a'\}}, \mathbf{P}, \mathbf{X}, \bar{F}, h_{jt-1}, a') \tag{A-21}$$

for $a \neq a'$ where $\psi_{jt}^{\{a,a'\}}$ represents the productivity cutoffs where firms are indifferent between choosing product mix $a$ and $a'$, given the state variables.

Second, there is a free-entry condition. That is, ex ante, expected profits must be equal to entry costs,

$$w_t f_e = \int_{\psi} V_{\{s_{jt}\}}(\psi) dG(\psi) \tag{A-22}$$

Third, at every period $t$, total revenue of domestic producers should account for factor payments in the country such that,

$$\int_{\psi \in \mathbb{1}_{ht}} p_{ht} q_{ht} M_t \mu(\psi) d\psi + \int_{\psi \in \mathbb{1}_{lt}} p_{lt} q_{lt} M_t \mu(\psi) d\psi = wL + \theta \bar{F} + m_{ht} \int_{\psi \in \mathbb{1}_{ht}} q_{ht} M_t \mu(\psi) d\psi + m_{lt} \int_{\psi \in \mathbb{1}_{lt}} q_{lt} M_t \mu(\psi) d\psi \tag{A-23}$$

**Definition A.1.** (*Equilibrium*) Given the fundamentals ($\mathbf{\Sigma}$), a sequential competitive equilibrium of the model is a sequence of price indices $\{P_{ht}, P_{lt}\}_{t=1}^{T}$ as defined in (A-4) - (A-5), and wages $\{w_t\}_{t=1}^{T}$ such that:

(i) Consumers in the domestic economy maximize their utilities specified in (A-2),

(ii) Firms maximize their expected profits specified by (A-8) and (A-16) and,

(iii) They solve equilibrium conditions (A-21), (A-22), and (A-23).[46]

[46] Additionally, in equilibrium, there are zero profit conditions for foreign exporters. For those, I assume they do not solve a dynamic model, but rather a static period-by-period model.

$$\begin{aligned} \pi_{hm}(\hat{\bar{\psi}}_{ht}) &= F_{exp}^{h} \\ \pi_{lm}(\hat{\bar{\psi}}_{lt}) &= F_{exp}^{l} \end{aligned} \tag{A-24}$$

## B Non-homotheticity across countries

First order conditions for the domestic consumer are such that,

$$\alpha_h^{\frac{1}{\sigma_h}} {q_{ht}^d}^{-\frac{1}{\sigma_h}} - \lambda p_{ht}^d = 0 \tag{A-25}$$

$$\alpha_h^{\frac{1}{\sigma_h}} {q_{hmt}^d}^{-\frac{1}{\sigma_h}} - \lambda p_{hmt}^d = 0 \tag{A-26}$$

$$\alpha_l^{\frac{1}{\sigma_l}} {q_{lt}^d}^{-\frac{1}{\sigma_l}} - \lambda p_{lt}^d = 0 \tag{A-27}$$

$$\alpha_l^{\frac{1}{\sigma_l}} {q_{lmt}^d}^{-\frac{1}{\sigma_l}} - \lambda p_{lmt}^d = 0 \tag{A-28}$$

Therefore, equation (A-25) can be expressed as,

$$\begin{aligned}
{q_{ht}^d}^{-\frac{1}{\sigma_h}} &= \lambda^{-\sigma_h} {p_{ht}^d}^{\sigma_h} \alpha_h \\
p_{ht}^d {q_{ht}^d}^{-\frac{1}{\sigma_h}} &= \lambda^{-\sigma_h} {p_{ht}^d}^{1-\sigma_h} \alpha_h \\
\int\limits_{\nu\in\Omega_h} p_{ht}^d {q_{ht}^d}^{-\frac{1}{\sigma_h}} d\nu_h &= \lambda^{-\sigma_h} \alpha_h \int\limits_{\nu\in\Omega_h} {p_{ht}^d}^{1-\sigma_h} d\nu_h \\
X_{ht}^{dd} &= \lambda^{-\sigma_h} \alpha_h {P_{ht}^{dd}}^{1-\sigma_h}
\end{aligned} \tag{A-29}$$

where $P_{ht}^{dd}$ refers to the CES price aggregator of firm-level prices of high-quality goods of domestic firms selling to the domestic market, and $X_{ht}^{dd}$ corresponds to the aggregate expenditure on high-quality goods by domestic consumers in domestic firms.

Similarly, equations (A-26) - (A-28) can be expressed as,

$$\begin{aligned}
X_{ht}^{dm} &= \lambda^{-\sigma_h} \alpha_h {P_{ht}^{dm}}^{1-\sigma_h} \\
X_{lt}^{dd} &= \lambda^{-\sigma_l} \alpha_h {P_{lt}^{dd}}^{1-\sigma_l} \\
X_{lt}^{dm} &= \lambda^{-\sigma_l} \alpha_h {P_{lt}^{dm}}^{1-\sigma_l}
\end{aligned} \tag{A-30}$$

where $P_{lt}^{dd}$ refers to the CES price aggregator of firm-level prices of high-quality goods of domestic firms selling to the domestic market, $X_{lt}^{dd}$ corresponds to the aggregate expenditure on high-quality goods by domestic consumers in domestic firms, $P_{kt}^{dm}$ refers to the CES price aggregator of firm-level prices of good $k$ of foreign firms selling to the domestic market, and $X_{kt}^{dm}$ corresponds to the aggregate expenditure on good $k$ by domestic consumers in foreign firms.

Define, $X_{ht}^d$ as total domestic expenditure in the high-quality good and $X_{lt}^d$ as total domestic expenditure in the low-quality good. Then,

$$
\begin{aligned}
X^d_{ht} =& X^{dd}_{ht} + X^{dm}_{ht} = \lambda^{-\sigma_h}\alpha_h {P^d_{ht}}^{1-\sigma_h} \\
X^d_{lt} =& X^{dd}_{lt} + X^{dm}_{lt} = \lambda^{-\sigma_l}\alpha_l {P^d_{lt}}^{1-\sigma_l}
\end{aligned}
\tag{A-31}
$$

Taking the ratio of those,

$$
\frac{X^d_{ht}}{X^d_{lt}} = \lambda^{\sigma_l-\sigma_h}\frac{\alpha_h}{\alpha_l}\frac{{P^d_{ht}}^{1-\sigma_h}}{{P^d_{lt}}^{1-\sigma_l}}
\tag{A-32}
$$

where $\lambda$ represents the marginal utility of income. Given that the only difference between the domestic and foreign economy is the fact the foreign economy is richer, this implies that $\lambda^d > \lambda^x$ and thus, conditional on $\frac{(P^d_{ht})^{1-\sigma_h}}{(P^d_{lt})^{1-\sigma_l}} \leq \frac{(P^x_{ht})^{1-\sigma_h}}{(P^x_{lt})^{1-\sigma_l}}$, $\frac{X^d_{ht}}{X^d_{lt}} < \frac{X^x_{ht}}{X^x_{lt}}$.

# C Productivity Relations

1. More productive firms sell at lower prices.

   Differentiating equation (9), we get,

$$
\begin{aligned}
(\frac{\sigma_h-1}{\sigma_h})dp^d_{jht} = & \left(-\frac{w}{\alpha^2}(\frac{1}{\bar{F}^{1-\alpha}})^{\frac{1}{\alpha}}\psi_{jt}^{-\frac{1}{\alpha}-1}q_{jt}^{\frac{1-\alpha}{\alpha}}\right)d\psi_{jt} + \frac{w}{\alpha}(\frac{1}{\bar{F}^{1-\alpha}})^{\frac{1}{\alpha}}(\frac{1-\alpha}{\alpha})q_{jt}^{\frac{1-\alpha}{\alpha}-1} * \\
& * \left[-\sigma_h X^d_{ht}(P^d_{ht})^{\sigma_h-1}(p^d_{jht})^{-\sigma_h-1}dp^d_{jht} - \sigma_h t_{ht} X^x_{ht}(P^x_{ht})^{\sigma_h-1}(p^x_{jht})^{-\sigma_h-1}dp^x_{jht}\right. \\
& \left. - \sigma_l X^d_{lt}(P^d_{lt})^{\sigma_l-1}(p^d_{jlt})^{-\sigma_l-1}dp^d_{jlt} - \sigma_l t_{lt} X^x_{lt}(P^x_{lt})^{\sigma_l-1}(p^x_{jlt})^{-\sigma_l-1}dp^x_{jlt}\right]
\end{aligned}
\tag{A-33}
$$

   Given $(\frac{\sigma_h-1}{\sigma_h})dp^d_{jht} = (\frac{\sigma_l-1}{\sigma_l})dp^d_{jlt}$, and $(\frac{\sigma_h-1}{\sigma_h})\frac{1}{t_{ht}}dp^x_{jht} = (\frac{\sigma_l-1}{\sigma_l})\frac{1}{t_{lt}}dp^x_{jlt}$, then,

$$
\begin{aligned}
(\frac{\sigma_h-1}{\sigma_h})dp^d_{jht} = & \left(-\frac{w}{\alpha^2}(\frac{1}{\bar{F}^{1-\alpha}})^{\frac{1}{\alpha}}\psi_{jt}^{-\frac{1}{\alpha}-1}q_{jt}^{\frac{1-\alpha}{\alpha}}\right)d\psi_{jt} + \frac{w}{\alpha}(\frac{1}{\bar{F}^{1-\alpha}})^{\frac{1}{\alpha}}(\frac{1-\alpha}{\alpha})q_{jt}^{\frac{1-\alpha}{\alpha}-1} * \\
& * \left[-\sigma_h X^d_{ht}(P^d_{ht})^{\sigma_h-1}(p^d_{jht})^{-\sigma_h-1} - \sigma_h t^2_{ht} X^x_{ht}(P^x_{ht})^{\sigma_h-1}(p^x_{jht})^{-\sigma_h-1}\right. \\
& - \sigma_l X^d_{lt}(P^d_{lt})^{\sigma_l-1}(p^d_{j2t})^{-\sigma_l-1}(\frac{\sigma_l}{\sigma_l-1})(\frac{\sigma_h-1}{\sigma_h}) \\
& \left. - \sigma_l t^2_{lt} X^x_{lt}(P^x_{lt})^{\sigma_l-1}(p^x_{jlt})^{-\sigma_l-1}(\frac{\sigma_l}{\sigma_l-1})(\frac{\sigma_h-1}{\sigma_h})\right] dp^d_{jht}
\end{aligned}
\tag{A-34}
$$

   Therefore, $\frac{dp^d_{jht}}{d\psi_{jt}} < 0$.

   Similarly, using equations (10) - (**??**), $\frac{dp^d_{jlt}}{d\psi_{jt}} < 0$, $\frac{dp^x_{jht}}{d\psi_{jt}} < 0$, and $\frac{dp^x_{jlt}}{d\psi_{jt}} < 0$.

2. More productive firms produce more.

$$
dq^d_{jht} = -\sigma_h X^d_{ht}(P^d_{ht})^{\sigma_h-1}(p^d_{jht})^{\sigma_h-1}dp^d_{jht}
\tag{A-35}
$$

   Thus, $\frac{dq^d_{jht}}{dp^d_{jht}} < 0$. Then, $\frac{dq^d_{jht}}{d\psi_{jt}} = \frac{dq^d_{jht}}{dp^d_{jht}}\frac{dp^d_{jht}}{d\psi_{jt}} > 0$.

Similarly, $\frac{dq^d_{jlt}}{d\psi_{jt}} > 0$, $\frac{dq^x_{jht}}{d\psi_{jt}} > 0$, and $\frac{dq^x_{jlt}}{d\psi_{jt}} > 0$.

3. More productive firms sell more.

$$dr^d_{jht} = (-\sigma_h + 1)X^d_{ht}(P^d_{ht})^{\sigma_h - 1}(p^d_{jht})^{\sigma_h} dp^d_{jht} \tag{A-36}$$

Thus, $\frac{dr^d_{jht}}{dp^d_{jht}} < 0$. Then, $\frac{dr^d_{jht}}{d\psi_{jt}} = \frac{dr^d_{jht}}{dp^d_{jht}}\frac{dp^d_{jht}}{d\psi_{jt}} > 0$.

Similarly, $\frac{dr^d_{jlt}}{d\psi_{jt}} > 0$, $\frac{dr^x_{jht}}{d\psi_{jt}} > 0$, and $\frac{dr^x_{jlt}}{d\psi_{jt}} > 0$.

4. More productive firms have higher profits.

$$\begin{aligned} d\pi_{jt} =& \frac{X^d_{ht}(P^d_{ht})^{\sigma_h-1}}{(p^d_{jht})^{\sigma_h}}\left[(1-\sigma_h) + \frac{w}{\alpha}(\frac{1}{\psi_{jt}\bar{F}^{1-\alpha}})^{\frac{1}{\alpha}} q_{jt}^{\frac{1-\alpha}{\alpha}}\frac{\sigma_1}{p^d_{jht}} + m_{ht}\frac{\sigma_h}{p^d_{jht}}\right] dp^d_{jht} \\ &+ \frac{X^d_{lt}(P^d_{lt})^{\sigma_l-1}}{(p^d_{jlt})^{\sigma_l}}\left[(1-\sigma_l) + \frac{w}{\alpha}(\frac{1}{\psi_{jt}\bar{F}^{1-\alpha}})^{\frac{1}{\alpha}} q_{jt}^{\frac{1-\alpha}{\alpha}}\frac{\sigma_l}{p^d_{jlt}} + m_{lt}\frac{\sigma_l}{p^d_{jlt}}\right] dp^d_{jlt} \\ &+ \frac{t_{ht}X^x_{ht}(P^x_{ht})^{\sigma_h-1}}{(p^x_{jht})^{\sigma_h}}\left[\frac{(1-\sigma_h)}{t_{ht}} + \frac{w}{\alpha}(\frac{1}{\psi_{jt}\bar{F}^{1-\alpha}})^{\frac{1}{\alpha}} q_{jt}^{\frac{1-\alpha}{\alpha}}\frac{\sigma_h}{p^x_{jht}} + m_{ht}\frac{\sigma_h}{p^x_{jht}}\right] dp^x_{jht} \\ &+ \frac{t_{lt}X^x_{lt}(P^d_{lt}x^{\sigma_l-1}}{(p^x_{jlt})^{\sigma_l}}\left[\frac{(1-\sigma_l)}{t_{lt}} + \frac{w}{\alpha}(\frac{1}{\psi_{jt}\bar{F}^{1-\alpha}})^{\frac{1}{\alpha}} q_{jt}^{\frac{1-\alpha}{\alpha}}\frac{\sigma_l}{p^x_{jlt}} + m_{lt}\frac{\sigma_l}{p^x_{jlt}}\right] dp^x_{jlt} \\ &+ \frac{w}{\alpha^2}(\frac{1}{\bar{F}^{1-\alpha}})^{\frac{1}{\alpha}}\psi_{jt}^{-\frac{1}{\alpha}-1} d\psi_{jt} \end{aligned} \tag{A-37}$$

Given all terms in brackets are 0 by FOCs, $d\pi_{jt} = \frac{w}{\alpha^2}(\frac{1}{\bar{F}^{1-\alpha}})^{\frac{1}{\alpha}}\psi_{jt}^{-\frac{1}{\alpha}-1} d\psi_{jt}$. Thus, $\frac{d\pi_{jt}}{d\psi_{jt}} > 0$.

# D Theorem 5.1

*Proof.* The proof is as follows.

i Prices:

Using first order conditions (9) - (10), the impact of a decrease in $P^d_{lt}$ and $P^x_{lt}$ in the prices set by the firms can be described as follows.

For the firm-level price of the high-quality good in the domestic market, $p^d_{jht}$, total differentiation of equation (9) yields,

$$\begin{aligned} &\{\frac{\sigma_h - 1}{\sigma_h} + \frac{w}{\alpha}\frac{1}{(\psi_{jt}\bar{F}^{1-\alpha})^{\frac{1}{\alpha}}}(\frac{1-\alpha}{\alpha})q_{jt}^{\frac{1}{\alpha}-2}[\sigma_h[\frac{q^d_{jht}}{p^d_{jht}} + t^2_{ht}\frac{q^x_{jht}}{p^x_{jht}}] + \sigma_l(\frac{\sigma_h - 1}{\sigma_1})(\frac{\sigma_l}{\sigma_l - 1})[\frac{q^d_{jlt}}{p^d_{jlt}} + t^2_{lt}\frac{q^x_{jlt}}{p^x_{jlt}}]\}dp^d_{jht} = \\ &\frac{w}{\alpha}\frac{1}{(\psi_{jt}\bar{F}^{1-\alpha})^{\frac{1}{\alpha}}}(\frac{1-\alpha}{\alpha})q_{jt}^{\frac{1}{\alpha}-l}(\sigma_l - 1)(\frac{q^d_{jlt}}{P^d_{lt}}dP^d_{lt} + \frac{q^x_{jlt}}{P^x_{lt}}t_{lt}dP^x_{lt}) \end{aligned} \tag{A-38}$$

where $\frac{dp^d_{jht}}{\Delta} > 0$ given $dP^d_{lt} < 0$ and $dP^x_{lt} < 0$.

Similarly, for the firm-level price of the high-quality good in the export market, $p^x_{jht}$, total differentiation of equation (10) yields,

$$\{\frac{\sigma_h - 1}{\sigma_h}\frac{1}{t_{ht}} + \frac{w}{\alpha}\frac{1}{(\psi_{jt}\bar{F}^{1-\alpha})^{\frac{1}{\alpha}}}(\frac{1-\alpha}{\alpha})q_{jt}^{\frac{1}{\alpha}-2}[\sigma_h[\frac{q^d_{jht}}{p^d_{jht}}\frac{1}{t_{ht}} + t_{ht}\frac{q^x_{jht}}{p^x_{jht}}] + \sigma_l\frac{1}{t_{ht}}(\frac{\sigma_h - 1}{\sigma_h})(\frac{\sigma_l}{\sigma_l - 1})[\frac{q^d_{jlt}}{p^d_{jlt}} + t^2_{lt}\frac{q^x_{jlt}}{p^x_{jlt}}]\}dp^x_{jht} =$$

$$\frac{w}{\alpha}\frac{1}{(\psi_j\bar{F}^{1-\alpha})^{\frac{1}{\alpha}}}(\frac{1-\alpha}{\alpha})q_{jt}^{\frac{1}{\alpha}-2}(\sigma_l - 1)(\frac{q^d_{jlt}}{P^d_{lt}}dP^d_{lt} + \frac{q^x_{jlt}}{P^x_{lt}}t_{lt}dP^x_{lt}) \tag{A-39}$$

where $\frac{dp^x_{jht}}{\Delta} > 0$ given $dP^d_{lt} < 0$ and $dP^x_{lt} < 0$.

Likewise, for the firm-level price of the low-quality good in the domestic market, $p^d_{jlt}$, total differentiation of equation (9) yields,

$$\{\frac{\sigma_l - 1}{\sigma_l} + \frac{w}{\alpha}\frac{1}{(\psi_{jt}\bar{F}^{1-\alpha})^{\frac{1}{\alpha}}}(\frac{1-\alpha}{\alpha})q_{jt}^{\frac{1}{\alpha}-2}[\sigma_h(\frac{\sigma_h}{\sigma_h - 1})(\frac{\sigma_l - 1}{\sigma_l})[\frac{q^d_{jht}}{p^d_{jht}} + t^2_{ht}\frac{q^x_{jht}}{p^x_{jht}}] + \sigma_l[\frac{q^d_{jlt}}{p^d_{jlt}} + t^2_{lt}\frac{q^x_{jlt}}{p^x_{jlt}}]\}dp^d_{jlt}$$

$$= \frac{w}{\alpha}\frac{1}{(\psi_j\bar{F}^{1-\alpha})^{\frac{1}{\alpha}}}(\frac{1-\alpha}{\alpha})q_{jt}^{\frac{1}{\alpha}-2}(\sigma_l - 1)(\frac{q^d_{jlt}}{P^d_{lt}}dP^d_{lt} + \frac{q^x_{jlt}}{P^x_{lt}}t_{lt}dP^x_{lt}) \tag{A-40}$$

where $\frac{dp^d_{jlt}}{\Delta} > 0$ given $dP^d_{lt} < 0$ and $dP^x_{lt} < 0$.

Finally, for the firm-level price of the low-quality good in the export market, $p^x_{jlt}$, total differentiation of equation (10) yields,

$$\{\frac{\sigma_l - 1}{\sigma_l}\frac{1}{t_{lt}} + \frac{w}{\alpha}\frac{1}{(\psi_{jt}\bar{F}^{1-\alpha})^{\frac{1}{\alpha}}}(\frac{1-\alpha}{\alpha})q_{jt}^{\frac{1}{\alpha}-2}[\sigma_h(\frac{\sigma_1}{\sigma_h - 1})(\frac{\sigma_l - 1}{\sigma_l})\frac{1}{t_{lt}}[\frac{q^d_{jht}}{p^d_{jht}} + t^2_{ht}\frac{q^x_{jht}}{p^x_{jht}}] + \sigma_l[\frac{q^d_{jlt}}{p^d_{jlt}}\frac{1}{t_{lt}} + t_{lt}\frac{q^x_{jlt}}{p^x_{jlt}}]\}dp^x_{jlt}$$

$$= \frac{w}{\alpha}\frac{1}{(\psi_{jt}\bar{F}^{1-\alpha})^{\frac{1}{\alpha}}}(\frac{1-\alpha}{\alpha})q_{jt}^{\frac{1}{\alpha}-2}(\sigma_l - 1)(\frac{q^d_{jlt}}{P^d_{lt}}dP^d_{lt} + \frac{q^x_{jlt}}{P^x_{lt}}t_{lt}dP^x_{lt}) \tag{A-41}$$

where $\frac{dp^x_{jlt}}{\Delta} > 0$ given $dP^d_{lt} < 0$ and $dP^x_{lt} < 0$.

ii Quantities and Revenues:

Using the demand systems given by equations (5), and the reaction of prices to changes in $P^d_{lt}$ and $P^x_{lt}$ established before, the following can be shown.

(a) If a firm is producing low- and high-quality goods, for quantities produced of the high-quality good in the domestic market,

$$dq^d_{jht} = -\sigma_1 \frac{q^d_{jht}}{p^d_{jht}} dp^d_{jht} \tag{A-42}$$

and since $\frac{dp^d_{jht}}{\Delta} > 0$, $\frac{dq^d_{jht}}{\Delta} < 0$, i.e., when both $P^d_{lt}$ and $P^x_{lt}$ decrease, the firm increases the quantity produced of the high-quality good for the domestic market.

For quantities produced of the high-quality good for the export market,

$$dq^x_{jht} = -\sigma_1 \frac{q^x_{jht}}{p^x_{jht}} dp^x_{jht} \tag{A-43}$$

and since $\frac{dp^x_{jht}}{\Delta} > 0$, $\frac{dq^x_{jht}}{\Delta} < 0$, i.e., when both $P^d_{lt}$ and $P^x_{lt}$ decrease, the firm increases the quantity produced of the high-quality good for the export market.

For the revenues of firm from the high-quality good in the domestic market, $r^d_{jht}$,

$$dr^d_{jht} = (1 - \sigma_h) q^d_{jht} dp^d_{jht} \tag{A-44}$$

and since by point (i) it is shown that $\frac{dp^d_{jht}}{\Delta} > 0$; therefore, $\frac{dr^d_{jht}}{\Delta} < 0$. That is, a joint decrease in $P^d_{lt}$ and $P^x_{lt}$ increases revenues of the high-quality good in the domestic market.

Moreover, for export revenues of the firm from the high-quality good, $r^x_{jht}$,

$$dr^x_{jht} = (1 - \sigma_h) q^x_{jht} dp^x_{jht} \tag{A-45}$$

and since point (i) it is shown that $\frac{dp^x_{jht}}{\Delta} > 0$; therefore, $\frac{dr^x_{jht}}{\Delta} < 0$. That is, a joint decrease in $P^d_{lt}$ and $P^x_{lt}$ increases revenues of the high-quality good in the export market.

(b) For quantities produced of the low-quality good in the domestic market,

$$\begin{aligned} dq^d_{jlt} &= q^d_{jlt} \{ \frac{-\sigma_l}{p^d_{jlt}} dp^d_{jlt} + \frac{(\sigma_l - 1)}{P^d_{lt}} dP^d_{lt} \} \\ &= q^d_{jlt} \frac{(\sigma_l - 1)}{P^d_{lt}} \{ A dP^d_{lt} - B dP^x_{lt} \} \end{aligned} \tag{A-46}$$

where

$$A = 1 - \frac{\frac{w}{\alpha}\frac{1}{(\psi_j \bar{F}^{1-\alpha})^{\frac{1}{\alpha}}}(\frac{1-\alpha}{\alpha})q_{jt}^{\frac{1}{\alpha}-2}(\sigma_l)\frac{q_{jlt}^d}{p_{jlt}^d}}{\{\frac{\sigma_l-1}{\sigma_l} + \frac{w}{\alpha}\frac{1}{(\psi_{jt}\bar{F}^{1-\alpha})^{\frac{1}{\alpha}}}(\frac{1-\alpha}{\alpha})q_{jt}^{\frac{1}{\alpha}-2}[\sigma_1(\frac{\sigma_h}{\sigma_h-1})(\frac{\sigma_l-1}{\sigma_l})[\frac{q_{jht}^d}{p_{jht}^d} + t_{ht}^2\frac{q_{jht}^x}{p_{jht}^x}] + \sigma_l[\frac{q_{jlt}^d}{p_{jlt}^d} + t_{lt}^2\frac{q_{jlt}^x}{p_{jlt}^x}]\}} \tag{A-47}$$

$$B = \frac{\frac{w}{\alpha}\frac{1}{(\psi_j \bar{F}^{1-\alpha})^{\frac{1}{\alpha}}}(\frac{1-\alpha}{\alpha})q_{jt}^{\frac{1}{\alpha}-2}(\sigma_l)t_{lt}\frac{q_{jlt}^x}{p_{jlt}^x}\frac{P_{lt}^d}{P_{lt}^x}}{\{\frac{\sigma_l-1}{\sigma_l} + \frac{w}{\alpha}\frac{1}{(\psi_{jt}\bar{F}^{1-\alpha})^{\frac{1}{\alpha}}}(\frac{1-\alpha}{\alpha})q_{jt}^{\frac{1}{\alpha}-2}[\sigma_h(\frac{\sigma_h}{\sigma_h-1})(\frac{\sigma_l-1}{\sigma_l})[\frac{q_{jht}^d}{p_{jht}^d} + t_{ht}^2\frac{q_{jht}^x}{p_{jht}^x}] + \sigma_l[\frac{q_{jlt}^d}{p_{jlt}^d} + t_{lt}^2\frac{q_{jlt}^x}{p_{jlt}^x}]\}} \tag{A-48}$$

with $0 < A < 1$ and $0 < B\frac{P_{lt}^x}{P_{lt}^d} < 1$. Therefore, $\frac{dp_{jlt}^d}{\Delta}$ depends.

However, if $\frac{dP_{lt}^d}{P_{lt}^d} > \frac{dP_{lt}^x}{P_{lt}^x}$ (i.e., import competition is fiercer in the domestic market in percentage terms), it is a sufficient condition for $\frac{dq_{jlt}^d}{\Delta} > 0$, i.e., the decrease in $P_{lt}^d$ and $P_{lt}^x$ induces firms to decrease quantity of the low-quality good in the domestic market.

Moreover, for quantities produced of the low-quality good in the export market,

$$\begin{aligned} dq_{jlt}^x &= q_{jlt}^x\{\frac{-\sigma_l}{p_{jlt}^x}dp_{jlt}^x + \frac{(\sigma_l - 1)}{P_{lt}^x}dP_{lt}^x\} \\ &= q_{jlt}^x\frac{(\sigma_l - 1)}{P_{lt}^x}\{A'dP_{lt}^x - B'dP_{lt}^d\} \end{aligned} \tag{A-49}$$

where

$$A' = 1 - \frac{\frac{w}{\alpha}\frac{1}{(\psi_j \bar{F}^{1-\alpha})^{\frac{1}{\alpha}}}(\frac{1-\alpha}{\alpha})q_{jt}^{\frac{1}{\alpha}-l}(\sigma_l)\frac{q_{jlt}^x}{p_{jlt}^x}t_{lt}}{\{\frac{\sigma_l-1}{\sigma_l}\frac{1}{t_{lt}} + \frac{w}{\alpha}\frac{1}{(\psi_{jt}\bar{F}^{1-\alpha})^{\frac{1}{\alpha}}}(\frac{1-\alpha}{\alpha})q_{jt}^{\frac{1}{\alpha}-2}[\sigma_h(\frac{\sigma_h}{\sigma_h-1})(\frac{\sigma_l-1}{\sigma_l})\frac{1}{t_{lt}}[\frac{q_{jht}^d}{p_{jht}^d} + t_{ht}^2\frac{q_{jht}^x}{p_{jht}^x}] + \sigma_l[\frac{q_{jlt}^d}{p_{jlt}^d}\frac{1}{t_{lt}} + t_{lt}\frac{q_{jlt}^x}{p_{jlt}^x}]\}} \tag{A-50}$$

$$B' = \frac{\frac{w}{\alpha}\frac{1}{(\psi_j \bar{F}^{1-\alpha})^{\frac{1}{\alpha}}}(\frac{1-\alpha}{\alpha})q_{jt}^{\frac{1}{\alpha}-2}(\sigma_2)\frac{q_{jlt}^d}{p_{jlt}^d}\frac{1}{t_{lt}}\frac{P_{lt}^x}{P_{lt}^d}}{\{\frac{\sigma_l-1}{\sigma_l}\frac{1}{t_{lt}} + \frac{w}{\alpha}\frac{1}{(\psi_{jt}\bar{F}^{1-\alpha})^{\frac{1}{\alpha}}}(\frac{1-\alpha}{\alpha})q_{jt}^{\frac{1}{\alpha}-2}[\sigma_1(\frac{\sigma_1}{\sigma_1-1})(\frac{\sigma_l-1}{\sigma_l})\frac{1}{t_{lt}}[\frac{q_{jht}^d}{p_{jht}^d} + t_{ht}^2\frac{q_{jht}^x}{p_{jht}^x}] + \sigma_l[\frac{q_{jlt}^d}{p_{jlt}^d}\frac{1}{t_{lt}} + t_{lt}\frac{q_{jlt}^x}{p_{jlt}^x}]\}} \tag{A-51}$$

with $0 < A' < 1$ and $0 < B'\frac{P_{lt}^d}{P_{lt}^x} < 1$. Therefore, $\frac{dp_{jlt}^x}{\Delta}$ depends.

However, if $\frac{dP_{lt}^d}{P_{lt}^d} < \frac{dP_{lt}^x}{P_{lt}^x}$ (import competition is fiercer in the export market in percentage terms), it is a sufficient condition for $\frac{dq_{jlt}^x}{\Delta} > 0$, i.e., the decrease in $P_{lt}^d$ and $P_{lt}^x$ induces firms to decrease the quantity of the low-quality good in the export market. Otherwise, it depends on the relative size of the shocks and the parameters of the market.

In addition, the change in the revenues of the low-quality good in the domestic country,

$r^d_{jlt}$, is,

$$dr^d_{jlt} = q^d_{jlt}\{(-\sigma_l + 1)dp^d_{jlt} + (\sigma_l - 1)\frac{p^d_{jlt}}{P^d_{lt}}dP^d_{lt}\}$$
$$dr^d_{jlt} = q^d_{jlt}(\sigma_l - 1)\frac{p^d_{jlt}}{P^d_{lt}}\{A''dP^d_{lt} - B''dP^x_{lt}\}$$

where

$$A'' = 1 - \frac{\frac{w}{\alpha}\frac{1}{(\psi_j\bar{F}^{1-\alpha})^{\frac{1}{\alpha}}}(\frac{1-\alpha}{\alpha})q_{jt}^{\frac{1}{\alpha}-2}(\sigma_2 - 1)\frac{q^d_{jlt}}{p^d_{jlt}}}{\{\frac{\sigma_l-1}{\sigma_l} + \frac{w}{\alpha}\frac{1}{(\psi_{jt}\bar{F}^{1-\alpha})^{\frac{1}{\alpha}}}(\frac{1-\alpha}{\alpha})q_{jt}^{\frac{1}{\alpha}-2}[\sigma_h(\frac{\sigma_h}{\sigma_h-1})(\frac{\sigma_l-1}{\sigma_l})[\frac{q^d_{jht}}{p^d_{jht}} + t^2_{ht}\frac{q^x_{jht}}{p^x_{jht}}] + \sigma_l[\frac{q^d_{jlt}}{p^d_{jlt}} + t^2_{lt}\frac{q^x_{jlt}}{p^x_{jlt}}]\}} \tag{A-52}$$

$$B'' = \frac{\frac{w}{\alpha}\frac{1}{(\psi_j\bar{F}^{1-\alpha})^{\frac{1}{\alpha}}}(\frac{1-\alpha}{\alpha})q_{jt}^{\frac{1}{\alpha}-2}(\sigma_l - 1)t^2_{lt}\frac{q^x_{jlt}}{p^x_{jlt}}\frac{P^d_{lt}}{P^x_{lt}}}{\{\frac{\sigma_l-1}{\sigma_l} + \frac{w}{\alpha}\frac{1}{(\psi_{jt}\bar{F}^{1-\alpha})^{\frac{1}{\alpha}}}(\frac{1-\alpha}{\alpha})q_{jt}^{\frac{1}{\alpha}-2}[\sigma_h(\frac{\sigma_h}{\sigma_h-1})(\frac{\sigma_l-1}{\sigma_l})[\frac{q^d_{jht}}{p^d_{jht}} + t^2_{ht}\frac{q^x_{jht}}{p^x_{jht}}] + \sigma_l[\frac{q^d_{jlt}}{p^d_{jlt}} + t^2_{lt}\frac{q^x_{jlt}}{p^x_{jlt}}]\}} \tag{A-53}$$

with $0 < A'' < 1$ and $0 < B''\frac{P^x_{lt}}{P^d_{lt}} < 1$. Therefore, $\frac{dr^d_{jlt}}{\Delta}$ is ambiguous.
However, if $\frac{dP^d_{lt}}{P^d_{lt}} > \frac{dP^x_{lt}}{P^x_{lt}}$ (i.e., import competition is fiercer in the domestic market in percentage terms), it is a sufficient condition for $\frac{dr^d_{jlt}}{\Delta} > 0$, i.e., the decrease in $P^d_{lt}$ and $P^x_{lt}$ induces firms to decrease sales of the low-quality good in the domestic market.
Moreover, the effect on the export revenues of the firm from the low-quality good, $r^x_{jlt}$, is the following,

$$dr^x_{jlt} = q^x_{jlt}\{(-\sigma_l + 1)dp^x_{jlt} + (\sigma_l - 1)\frac{p^x_{jlt}}{P^x_{lt}}dP^x_{lt}\}$$
$$dr^x_{jlt} = q^x_{jlt}(\sigma_l - 1)\frac{p^x_{jlt}}{P^x_{lt}}\{A'''dP^x_{lt} - B'''dP^d_{lt}\} \tag{A-54}$$

where

$$A''' = 1 - \frac{\frac{w}{\alpha}\frac{1}{(\psi_j\bar{F}^{1-\alpha})^{\frac{1}{\alpha}}}(\frac{1-\alpha}{\alpha})q_{jt}^{\frac{1}{\alpha}-2}(\sigma_l - 1)\frac{q^x_{jlt}}{p^x_{jlt}}t_{lt}}{\{\frac{\sigma_l-1}{\sigma_l}\frac{1}{t_{lt}} + \frac{w}{\alpha}\frac{1}{(\psi_{jt}\bar{F}^{1-\alpha})^{\frac{1}{\alpha}}}(\frac{1-\alpha}{\alpha})q_{jt}^{\frac{1}{\alpha}-2}[\sigma_h(\frac{\sigma_h}{\sigma_h-1})(\frac{\sigma_l-1}{\sigma_l})\frac{1}{t_{lt}}[\frac{q^d_{jht}}{p^d_{jht}} + t^2_{ht}\frac{q^x_{jht}}{p^x_{jht}}] + \sigma_l[\frac{q^d_{jlt}}{p^d_{jlt}}\frac{1}{t_{lt}} + t_{lt}\frac{q^x_{jlt}}{p^x_{jlt}}]\}} \tag{A-55}$$

$$B''' = \frac{\frac{w}{\alpha}\frac{1}{(\psi_j\bar{F}^{1-\alpha})^{\frac{1}{\alpha}}}(\frac{1-\alpha}{\alpha})q_{jt}^{\frac{1}{\alpha}-2}(\sigma_l - 1)\frac{q^d_{jlt}}{p^d_{jlt}}\frac{1}{t_{lt}}\frac{P^x_{lt}}{P^d_{lt}}}{\{\frac{\sigma_l-1}{\sigma_l}\frac{1}{t_{lt}} + \frac{w}{\alpha}\frac{1}{(\psi_{jt}\bar{F}^{1-\alpha})^{\frac{1}{\alpha}}}(\frac{1-\alpha}{\alpha})q_{jt}^{\frac{1}{\alpha}-2}[\sigma_h(\frac{\sigma_h}{\sigma_h-1})(\frac{\sigma_l-1}{\sigma_l})\frac{1}{t_{lt}}[\frac{q^d_{jht}}{p^d_{j1t}} + t^2_{ht}\frac{q^x_{jht}}{p^x_{jht}}] + \sigma_l[\frac{q^d_{jlt}}{p^d_{jlt}}\frac{1}{t_{lt}} + t_{lt}\frac{q^x_{jlt}}{p^x_{jlt}}]\}} \tag{A-56}$$

with $0 < A''' < 1$ and $0 < B'''\frac{P^d_{2t}}{P^x_{2t}} < 1$. Therefore, $\frac{dr^x_{j2t}}{\Delta}$ is ambiguous.
However, if $\frac{dP^d_{lt}}{P^d_{lt}} < \frac{dP^x_{lt}}{P^x_{lt}}$ (i.e., import competition is fiercer in the export market in

percentage terms), it is a sufficient condition for $\frac{dr^x_{jlt}}{\Delta} > 0$, i.e., the decrease in $P^d_{lt}$ and $P^x_{lt}$ induces firms to decrease sales of the low-quality good in the export market.

iii Profits:

Differentiating equation (8) and using the first-order conditions, it can be shown that,

$$d\pi_{jt} = \frac{(\sigma_l - 1)}{\sigma_l}\{\frac{r^d_{jlt}}{P^d_{lt}}dP^d_{lt} + \frac{r^x_{jlt}}{P^x_{lt}}dP^x_{lt}\} \tag{A-57}$$

Therefore, if the changes in $dP^d_{lt}$ and $dP^x_{lt}$ are in the same direction, $\frac{d\pi^x_{jt}}{\Delta} > 0$, i.e., a decrease in both price indices decreases the firm-level profits of firms.

iv Product Mix:

The proof comes straight from the fact that relative to high-quality products, low-quality ones are less profitable when their price indices decrease, everything else constant.

□

# E Corollary 5.3

*Proof.* The proof is as follows,

(i) First note that by totally differentiating equations (9) - (10), the impact of a change in $P^d_{lt}$ in the prices set by the firms can be described as follows.
For the firm-level price of the high-quality good, $p^d_{jht}$,

$$\{\frac{\sigma_h - 1}{\sigma_h} + \frac{w}{\alpha}\frac{1}{(\psi_{jt}\bar{F}^{1-\alpha})^{\frac{1}{\alpha}}}(\frac{1-\alpha}{\alpha})q_{jt}^{\frac{1}{\alpha}-2}[\sigma_h[\frac{q^d_{jht}}{p^d_{jht}} + t^2_{ht}\frac{q^x_{jht}}{p^x_{jht}}] + \sigma_l(\frac{\sigma_h - 1}{\sigma_h})(\frac{\sigma_l}{\sigma_l - 1})[\frac{q^d_{jlt}}{p^d_{jlt}} + t^2_{lt}\frac{q^x_{jlt}}{p^x_{jlt}}]\}dp^d_{jht} =$$

$$\frac{w}{\alpha}\frac{1}{(\psi_{jt}\bar{F}^{1-\alpha})^{\frac{1}{\alpha}}}(\frac{1-\alpha}{\alpha})q_{jt}^{\frac{1}{\alpha}-2}(\sigma_l - 1)\frac{q^d_{jlt}}{P^d_{lt}}dP^d_{lt} \tag{A-58}$$

thus, $\frac{dp^d_{jht}}{dP^d_{lt}} > 0$.

For the firm-level price of the high-quality good in the export market, $p^x_{jht}$,

$$\{\frac{\sigma_h-1}{\sigma_h}\frac{1}{t_{ht}}+\frac{w}{\alpha}\frac{1}{(\psi_{jt}\bar{F}^{1-\alpha})^{\frac{1}{\alpha}}}(\frac{1-\alpha}{\alpha})q_{jt}^{\frac{1}{\alpha}-2}[\sigma_h[\frac{q^d_{jht}}{p^d_{jht}}\frac{1}{t_{ht}}+t_{ht}\frac{q^x_{jht}}{p^x_{jht}}]+\frac{\sigma_l}{t_{ht}}(\frac{\sigma_h-1}{\sigma_h})(\frac{\sigma_l}{\sigma_l-1})[\frac{q^d_{jlt}}{p^d_{jlt}}+t^2_{lt}\frac{q^x_{jlt}}{p^x_{jlt}}]]\}dp^x_{jht}=$$

$$\frac{w}{\alpha}\frac{1}{(\psi_{jt}\bar{F}^{1-\alpha})^{\frac{1}{\alpha}}}(\frac{1-\alpha}{\alpha})q_{jt}^{\frac{1}{\alpha}-2}(\sigma_l-1)\frac{q^d_{jlt}}{P^d_{lt}}dP^d_{lt} \tag{A-59}$$

thus, $\frac{dp^x_{jht}}{dP^d_{lt}}>0$.

For the price of the low-quality good in the domestic market, $p^d_{jlt}$,

$$\{\frac{\sigma_l-1}{\sigma_l}+\frac{w}{\alpha}\frac{1}{(\psi_{jt}\bar{F}^{1-\alpha})^{\frac{1}{\alpha}}}(\frac{1-\alpha}{\alpha})q_{jt}^{\frac{1}{\alpha}-2}[\sigma_h(\frac{\sigma_h}{\sigma_h-1})(\frac{\sigma_l-1}{\sigma_l})[\frac{q^d_{jht}}{p^d_{jht}}+t^2_{ht}\frac{q^x_{jht}}{p^x_{jht}}]+\sigma_l[\frac{q^d_{jlt}}{p^d_{jlt}}+t^2_{lt}\frac{q^x_{jlt}}{p^x_{jlt}}]]\}dp^d_{jlt}=$$

$$\frac{w}{\alpha}\frac{1}{(\psi_{jt}\bar{F}^{1-\alpha})^{\frac{1}{\alpha}}}(\frac{1-\alpha}{\alpha})q_{jt}^{\frac{1}{\alpha}-2}(\sigma_l-1)\frac{q^d_{jlt}}{P^d_{lt}}dP^d_{lt} \tag{A-60}$$

where $\frac{dp^d_{jlt}}{dP^d_{lt}}>0$.

For the price of the low-quality good in the export market, $p^x_{jlt}$,

$$\{\frac{\sigma_l-1}{\sigma_l}\frac{1}{t_{lt}}+\frac{w}{\alpha}\frac{1}{(\psi_{jt}\bar{F}^{1-\alpha})^{\frac{1}{\alpha}}}(\frac{1-\alpha}{\alpha})q_{jt}^{\frac{1}{\alpha}-2}[\frac{\sigma_h}{t_{lt}}(\frac{\sigma_h}{\sigma_h-1})(\frac{\sigma_l-1}{\sigma_l})[\frac{q^d_{jht}}{p^d_{jht}}+t^2_{ht}\frac{q^x_{jht}}{p^x_{jht}}]+\sigma_l[\frac{q^d_{jlt}}{p^d_{jlt}}\frac{1}{t_{lt}}+t_{lt}\frac{q^x_{jlt}}{p^x_{jlt}}]]\}dp^x_{jlt}=$$

$$\frac{w}{\alpha}\frac{1}{(\psi_{jt}\bar{F}^{1-\alpha})^{\frac{1}{\alpha}}}(\frac{1-\alpha}{\alpha})q_{jt}^{\frac{1}{\alpha}-2}(\sigma_l-1)\frac{q^x_{jlt}}{P^d_{lt}}dP^d_{lt} \tag{A-61}$$

where $\frac{dp^x_{jlt}}{dP^d_{lt}}>0$.

(ii) If the firm is multi-product, quantities of the high-quality good in both markets change as follow,

For the high-quality good in the domestic market,

$$dq^x_{jht}=-\sigma_h\frac{q^d_{jht}}{p^d_{jht}}dp^d_{jht} \tag{A-62}$$

and given results in the previous item where $\frac{dp^d_{jht}}{dP^d_{lt}}>0$, then $\frac{dq^d_{jht}}{dP^d_{lt}}<0$.

For the high-quality good in the export market,

$$dq^x_{jht} = -\sigma_h \frac{q^x_{jht}}{p^x_{jht}} dp^x_{jht} \tag{A-63}$$

and given results in the previous item where $\frac{dp^x_{jht}}{dP^d_{lt}} > 0$, then $\frac{dq^x_{jht}}{dP^d_{lt}} < 0$.

For the low-quality good in the domestic market,

$$\begin{aligned} dq^d_{jlt} =& q^d_{jlt} \frac{(\sigma_l - 1)}{P^d_{lt}} \{dP^d_{lt} - \frac{\sigma_l}{(\sigma_l - 1)} \frac{P^d_{lt}}{p^d_{jlt}} dp^d_{jlt}\} \\ =& q^d_{jlt} \frac{(\sigma_l - 1)}{P^d_{lt}} (C) dP^d_{lt} \end{aligned} \tag{A-64}$$

with

$$C = 1 - \frac{\frac{w}{\alpha} \frac{1}{(\psi_{jt} \bar{F}^{1-\alpha})^{\frac{1}{\alpha}}} (\frac{1-\alpha}{\alpha}) q_{jt}^{\frac{1}{\alpha}-2} \sigma_l \frac{q^d_{jlt}}{p^d_{jlt}}}{\{\frac{\sigma_l - 1}{\sigma_l} + \frac{w}{\alpha} \frac{1}{(\psi_{jt} \bar{F}^{1-\alpha})^{\frac{1}{\alpha}}} (\frac{1-\alpha}{\alpha}) q_{jt}^{\frac{1}{\alpha}-2} [\sigma_h (\frac{\sigma_h}{\sigma_h - 1}) (\frac{\sigma_l - 1}{\sigma_l}) [\frac{q^d_{jht}}{p^d_{jht}} + t^2_{ht} \frac{q^x_{jht}}{p^x_{jht}}] + \sigma_l [\frac{q^d_{jlt}}{p^d_{jlt}} + t^2_{lt} \frac{q^x_{jlt}}{p^x_{jlt}}]\}} > 0 \tag{A-65}$$

then $\frac{dq^d_{jlt}}{dP^d_{lt}} > 0$.

For the low-quality good in the export market,

$$dq^x_{jlt} = -\sigma_l \frac{q^x_{jlt}}{p^x_{jlt}} dp^x_{jlt} \tag{A-66}$$

and given results in the previous item, where $\frac{dp^x_{jlt}}{dP^d_{lt}} > 0$, then $\frac{dq^x_{jlt}}{dP^d_{lt}} < 0$.

(iii) If the firm is multi-product, revenues from the high-quality segment change as follows.

For revenues of the firm from the high-quality good in the domestic market, $r^d_{jht}$,

$$dr^{=}_{jht} (1 - \sigma_h) q^d_{jht} dp^d_{jht} \tag{A-67}$$

and given results in the previous item, where $\frac{dp^x_{jht}}{dP^d_{lt}} > 0$, then $\frac{dr^d_{jht}}{dP^d_{lt}} < 0$. Thus, $\frac{dr^d_{jht}}{P^d_{lt}} < 0$.

For revenues of the firm from the high-quality good in the export market, $r^x_{jht}$,

$$dr^x_{jht} = (1 - \sigma_h) q^x_{jht} dp^x_{jht} \tag{A-68}$$

and given results in the previous item, where $\frac{dp^x_{jht}}{dP^d_{lt}} > 0$, then $\frac{dr^x_{jht}}{dP^d_{lt}} < 0$.

(iv) The change in revenues of the low-quality good in the domestic country, $r^d_{jlt}$, is,

$$dr^d_{jlt} = q^d_{jlt}(\sigma_l - 1)\frac{p^d_{jlt}}{P^d_{lt}} D dP^d_{lt} \tag{A-69}$$

with

$$D = 1 - \frac{\frac{w}{\alpha}\frac{1}{(\psi_{jt}\bar{F}^{1-\alpha})^{\frac{1}{\alpha}}}(\frac{1-\alpha}{\alpha})q_{jt}^{\frac{1}{\alpha}-2}(\sigma_l - 1)\frac{q^d_{jlt}}{p^d_{jlt}}}{\{\frac{\sigma_l - 1}{\sigma_l} + \frac{w}{\alpha}\frac{1}{(\psi_{jt}\bar{F}^{1-\alpha})^{\frac{1}{\alpha}}}(\frac{1-\alpha}{\alpha})q_{jt}^{\frac{1}{\alpha}-2}[\sigma_h(\frac{\sigma_h}{\sigma_h - 1})(\frac{\sigma_l - 1}{\sigma_l})[\frac{q^d_{jht}}{p^d_{jht}} + t^2_{ht}\frac{q^x_{jht}}{p^x_{jht}}] + \sigma_l[\frac{q^d_{jlt}}{p^d_{jlt}} + t^2_{lt}\frac{q^x_{jlt}}{p^x_{jlt}}]\}} > 0 \tag{A-70}$$

then $\frac{dr^d_{jlt}}{dP^d_{lt}} > 0$.

(v) The change in revenues of the low-quality good in the export market, $r^d_{jlt}x$, is

$$dr^x_{jlt} = (1 - \sigma_l)q^x_{jlt}dp^x_{jlt} \tag{A-71}$$

and given results in the previous item, where $\frac{dp^x_{jlt}}{dP^d_{lt}} > 0$, then $\frac{dr^x_{jlt}}{dP^d_{lt}} < 0$.

(vi) The change in profits is equal to,

$$d\pi_{jt} = \frac{(\sigma_l - 1)}{\sigma_l}\frac{r^d_{jlt}}{P^d_{lt}}dP^d_{lt} \tag{A-72}$$

Therefore, $\frac{d\pi_{jt}}{dP^d_{lt}} > 0$, i.e., a decrease in price index of the low-quality good in the domestic market decreases the firm-level profits of firms.

□

# F Data Appendix

1. Firm-level customs data:

   Customs data comes from the Peruvian Tax Authority and consist in detailed information of all the trade transactions made by all firms in Peru. For the analysis, I consider all the firm-level annual exports of products in Chapters 61 and 62 of the HST code from the 2000-2012 period.

   These data contain, among other variables, information on the exporter name and tax ID, the FOB and CIF values of the transaction, the origin and destination country, as well as the duties paid and a detailed description of the products and exporters. Products are defined in the 10-digit HS code.

2. Firms' characteristics:

   The main source of firm-level information is the National Economic Survey (EEA). This consists in a representative survey of the manufacturing industry in Peru and, effectively, a census of medium and large firms.

   The survey spans from 2007 to present and includes firm-level variables such as revenues, value added, expenditures and composition of the firms. Most of these variables are reported in Nuevos Soles, the Peruvian currency. Therefore, I use the annual exchange rates given by the Peruvian Reserve Bank to convert these figures to US dollars.

## G Quality definition

The high-quality good ($h$) is defined by apparel made of Peruvian cotton. The low-quality good ($l$) is defined as apparel made of synthetic or man-made fibers.

At the 10-digit HS code, cotton clothes are defined by the products belonging to the following HS codes: "6101200000", "6102200000", "6103220000", "6103320000", "6103420000", "6104192000", "6104220000", "6104320000", "6104420000", "6104520000", "6104620000", "6105100041", "6105100042", "6105100049", "6105100051", "6105100052", "6105100059", "6105100080", "6105100091", "6105100092", "6105100099", "6106100021", "6106100022", "6106100029", "6106100031", "6106100032", "6106100039", "6106100090", "6107110000", "6107210000", "6107910000", "6108210000", "6108310000", "6108910000", "6109100031", "6109100032", "6109100039", "6109100041", "6109100042", "6109100049", "6109100050", "6110201010", "6110201090", "6110202000", "6110203000", "6110209010", "6110209090", "6111200000", "6112110000", "6114200000", "6115950000", "6116920000", "6201120000", "6201920000", "6202120000", "6202920000", "6203220000", "6203320000", "6203421010", "6203421020", "6203422010", "6203422020", "6203429010", "6203429020", "6204120000", "6204220000", "6204320000", "6204420000", "6204520000", "6204620000", "6205200000", "6206300000", "6207110000", "6207210000", "6207910000", "6208210000", "6208910000", "6209200000", "6211320000", "6111420000", "6213200000".

Moreover, at the 10-digit HS code, synthetic and man-made clothes are defined by the products belonging to the following HS codes: "6101300000", "6102300000", "6103102000", "6103230000", "6103330000", "6103430000", "6104130000", "6104230000", "6104330000", "6104430000", "6104530000", "6104630000", "6105201000", "6105209000", "6106200000", "6107120000", "6107220000", "6107991000", "6108110000", "6108220000", "6108320000", "6108920000", "6109901000", "6110301000", "6110309000", "6111300000", "6112120000", "6112310000", "6112410000", "6114300000", "6115101000", "6115109000", "6115210000", "6115220000", "6115301000", "6115960000", "6116930000", "6117901000", "6201130000", "6201930000", "6202130000", "6202930000", "6203120000", "6203230000", "6203330000", "6203430000", "6204130000", "6204230000", "6204330000", "6204430000", "6204440000", "6204530000", "6204630000", "6205300000", "6206400000", "6207220000", "6207991000", "6208110000", "6208220000", "6208920000", "6209300000", "6211330000", "6211430000", "6214300000", "6214400000", "6215200000".

Two important qualifications are in order. First, I assume that all cotton apparel from Peru is high-quality. Given that custom data does not provide information about the type of cotton used in the analysis, at the firm level, I cannot differentiate whether they are using Peruvian cotton or not. However, evidence from the National Survey of Firms from the period 2007-2013 reveals that on average, when using cotton, 90% of Peruvian apparel manufacturers use varieties such as Pima or Tangüis. This information is also verified by the results of EFAPREVE, a representative survey of the Peruvian apparel sector, which shows that when producing clothes with cotton fabric, 80% of firms claim that their inputs were purchased domestically. Thus, I consider this assumption to be reasonable approximation of what happens in the firm production process.

Second, I exclude fibers such as leather, silk, fine animal hair, and wool apparel from the analysis, given that their quality comparison with cotton and synthetic fibers is not apparent. Moreover, the productive process of these clothes might, in some cases, be significantly different from cotton or synthetic materials. However, it is important to note that cotton and synthetic or man-made apparel are the two largest categories of apparel exported by Peruvian firms, and represent, on average, 90% of the total annual apparel exports of Peru during the sample period.

# H Robustness Checks

## H.1 Endogeneity on $t_0$ bundle - Sample Selection:

Table A-1 presents the reduced-form estimation using only firms that had begun to export by 2000. Given that import competition in China was not as noteworthy in 2000 as it became later in the sample period, the bundle of these firms at $t_0$, as well as the likelihood that these firms were exporters is unlikely to have been driven by the exposure to Chinese import competition.

As shown, the main effects still hold for this sample in both qualitative and quantitative terms. Importantly, for the intensive margin, the impact of Chinese import competition is much larger, consistent with the fact that having already incurred the fixed or sunk costs of exporting, these firms have an easier time selling to the foreign market, as well as shifting their product mix.

### H.2 ATDA, APTDEA, and FTA with the United States

An additional concern about the rapid growth of Peruvian apparel exports is that this growth could have been driven by special conditions in the foreign market, such as free-trade agreements.

In fact, in 1991, Peru, Colombia, Bolivia and Ecuador signed the Andean Trade Preference Act (ATPA) with the United States, a treaty that allowed the entry of approximately 5500 tariff-free products to the United States to create incentives for exporters to substitute for coca leaf production. According to the WTO database, 86 6-digit HS code apparel products were under the exceptions granted by this agreement. The agreement expired in December of 2001, but after three years of negotiations, the Andean Trade Promotion and Drug Eradication Act (ATPDEA) was signed in August 2002. The ATPDEA renews the benefits for the products previously included in ATPA, and added additional beneficiaries to the list of tariff-free apparel list, namely apparel made with regional fibers, up to an equivalent to 2% of total apparel imports by the United States to the world in 2002, and, in 2005, up the 5%. It also granted tariff-free status to apparel manufactured with American inputs, apparel manufactured with fine fiber of alpaca, llama or vicua, among other products. The aforementioned benefits expired on December of 2006. After that, the Peruvian government started the negotiations on a Free Trade Agreement with the United States that would capture the same benefits as the APTDEA and possibly include more products. This was effectively signed that same year came into force January 2009 and remains so today.

In order to alleviate those concerns, I present three pieces of evidence supporting the existence of within-firm effects of import competition explained in Section **??**. First, the ATPA was signed signed far before China entered the WTO and subsequent rapid growth. Therefore, by 2000, the Peruvian export bundle should have already taken into account any preferential treatment for a specific set of products. Moreover, according to the WTO tariff database, with the ATPDEA, there is only a decrease in tariffs for 5 of the 86 apparel products contemplated in the ATPA. Thus, this treaty cannot, by itself, explain the observed rapid increase in exports and, in particular, exports of cotton apparel. However, with the passage of the FTA with the United States in 2009, there was a substantial increase in the scope of apparel products with preferential tariffs going from 86 to 219 products at the 6-digit HTS level that receive preferential treatment. Even when this preferential treatment was given to both cotton and synthetic apparel, as may be the case in 2010, the effect of import competition and the FTA can be interrelated.

Thus, to further control for this issue, I run the same specification as Table **??** but consider only the United States as the export market. In this specification, any changes over the year in foreign or domestic conditions should be accounted for by the year fixed effects and therefore, conditional the special treatment was not specific for a particular set of products but rather general, the effects should be void of foreign conditions. Table A-2 presents the results. As shown, the main qualitative effects still hold. However, while firms exporting to the United States respond to import competition by increasing their exports, the quality upgrade of their product mix happens in the adjustment of the number of high-quality products they sell rather than in the total exports of high quality products.

Finally, in a third robustness check, I consider only exports to destinations other than the United States, where Peru had no special treatment in any apparel product and where it did not sign FTAs. Thus, for these destinations, the effect should not be contaminated by these external forces. Table A-3 presents the results. Similarly, the main qualitative effects stand at both the extensive and intensive margin and, firms adjust to import competition by increasing total exports, increasing the number of products in the high-quality product segment, and including new high-quality products in their product mix.

| | Intensive Margin | | | | | | | Extensive Margin | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) | (9) | (10) | (11) |
| **VARIABLES** | **Export Sales** | **Export Sales Cotton** | **Export Sales Synthetic** | **Number of Products** | **Number of Cotton Products** | **Number of Synthetic Products** | **Average Exports per Product** | **Exit Exporting** | **New Product** | **New Cotton Product** | **New Synthetic Product** |
| Comp $_{t-1}$ | 1.249*** | 1.167*** | 0.951* | 0.689*** | 0.601*** | 0.393** | 0.906*** | -0.217*** | 0.259*** | 0.095 | 0.161* |
| | (0.289) | (0.331) | (0.522) | (0.173) | (0.198) | (0.178) | (0.288) | (0.067) | (0.095) | (0.103) | (0.094) |
| Firm level FE | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |
| Year FE | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |
| Weak identification test | 285.59 | 228.58 | 150.807 | 285.594 | 228.58 | 150.81 | 285.59 | 243.96 | 285.59 | 285.59 | 285.59 |
| Overidentification test | 1.73 | 1.72 | 0.86 | 3.426 | 1.69 | 2.81 | 3.26 | 5.03 | 10.15 | 4.65 | 7.49 |
| Observations | 2,595 | 2,177 | 1,041 | 2,595 | 2,177 | 1,041 | 2,595 | 2,462 | 2,595 | 2,595 | 2,595 |
| R-squared | 0.019 | 0.026 | 0.097 | 0.000 | 0.011 | 0.017 | 0.021 | 0.084 | 0.078 | 0.100 | 0.010 |
| Number of Firms | 339 | 305 | 176 | 339 | 305 | 176 | 339 | 338 | 339 | 339 | 339 |

Clustered standard errors at the firm level in parentheses. Weak identification test refers to the Cragg-Donald Wald F statistic. Overidentification test of all instrument refers to Hansen J statistic.
*** $p<0.01$, ** $p<0.05$, * $p<0.1$

**Table A-1: Reduced-Form Evidence: Panel of Firms Exporting by 2000**

| | Intensive Margin | | | | | | | Extensive Margin | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) | (9) | (10) | (11) |
| **VARIABLES** | **Export Sales** | **Export Sales Cotton** | **Export Sales Synthetic** | **Number of Products** | **Number of Cotton Products** | **Number of Synthetic Products** | **Average Exports per Product** | **Exit Exporting** | **New Product** | **New Cotton Product** | **New Synthetic Product** |
| $Comp_{t-1}$ | 0.604** | 0.471 | 1.412** | 0.362** | 0.489*** | -0.020 | 0.533* | -0.293*** | -0.046 | 0.060 | -0.038 |
| | (0.236) | (0.301) | (0.649) | (0.162) | (0.167) | (0.208) | (0.291) | (0.069) | (0.080) | (0.086) | (0.089) |
| Firm level FE | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |
| Year FE | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |
| Weak identification test | 432.45 | 375.55 | 145.192 | 432.453 | 375.553 | 145.19 | 432.45 | 432.45 | 432.45 | 432.45 | 432.45 |
| Overidentification test | 1.13 | 1.48 | 3.53 | 1.189 | 1.25 | 3.58 | 0.44 | 0.62 | 1.57 | 1.39 | 0.71 |
| Observations | 2,990 | 2,552 | 993 | 2,990 | 2,552 | 993 | 2,990 | 2,990 | 2,990 | 2,990 | 2,990 |
| R-squared | 0.037 | 0.033 | 0.064 | 0.023 | 0.010 | 0.023 | 0.029 | 0.553 | 0.056 | 0.087 | 0.007 |
| Number of Firms | 576 | 497 | 232 | 576 | 497 | 232 | 576 | 576 | 576 | 576 | 576 |

Clustered standard errors at the firm level in parentheses. Weak identification test refers to the Cragg-Donald Wald F statistic. Overidentification test of all instrument refers to Hansen J statistic.
*** $p<0.01$, ** $p<0.05$, * $p<0.1$

**Table A-2: Reduced-Form Evidence: Exports to the United States**

| | Intensive Margin | | | | | | | Extensive Margin | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) | (9) | (10) | (11) |
| **VARIABLES** | **Export Sales** | **Export Sales Cotton** | **Export Sales Synthetic** | **Number of Products** | **Number of Cotton Products** | **Number of Synthetic Products** | **Average Exports per Product** | **Exit Exporting** | **New Product** | **New Cotton Product** | **New Synthetic Product** |
| Comp $_{t-1}$ | 0.479*** | 0.578*** | 0.277 | 0.504*** | 0.528*** | 0.319*** | 0.226 | -0.413*** | 0.141*** | 0.141** | 0.124** |
| | (0.150) | (0.185) | (0.267) | (0.098) | (0.099) | (0.123) | (0.151) | (0.054) | (0.052) | (0.068) | (0.062) |
| Firm level FE | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |
| Year FE | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |
| Weak identification test | 1227.04 | 1203.05 | 818.06 | 1227.04 | 1203.05 | 818.06 | 1227.04 | 1227.04 | 1227.04 | 1227.04 | 1227.04 |
| Overidentification test | 1.93 | 2.92 | 5.00 | 1.42 | 3.60 | 4.77 | 3.74 | 0.07 | 1.24 | 0.28 | 5.65 |
| Observations | 4,891 | 4,392 | 2,389 | 4,891 | 4,392 | 2,389 | 4,891 | 4,891 | 4,891 | 4,891 | 4,891 |
| R-squared | 0.063 | 0.039 | 0.083 | 0.014 | 0.015 | 0.022 | 0.050 | 0.114 | 0.062 | 0.085 | 0.005 |
| Number of Firms | 1,077 | 985 | 627 | 1,077 | 985 | 627 | 1,077 | 1,077 | 1,077 | 1,077 | 1,077 |

Clustered standard errors at the firm level in parentheses. Weak identification test refers to the Cragg-Donald Wald F statistic. Overidentification test of all instrument refers to Hansen J statistic.
*** $p<0.01$, ** $p<0.05$, * $p<0.1$

**Table A-3: Reduced-Form Evidence: Exports to other countries (Not United States)**

# I Definitions for Structural Estimation

1. Elasticities Estimation:

   (a) Firm-level prices ($p_{jht}$, $p_{jlt}$):

   Firm-level prices are defined as firm-level unit values of cotton and synthetic apparel. First, unit values for each transaction at the 10-digit HS code are calculated as the division of transaction value over quantity in unit of apparel. Second, these unit values are aggregated at the 10-digit HS code-firm-year level using a weighted average of the transaction unit values where the weights correspond to the export share of each transaction in the annual exports for each 10-digit HS category. Third, unit values at the 10-digit HS code are aggregated at the product-firm-year level, where product is defined as cotton and synthetic apparel following the procedure explained in Appendix G. Thus, unit prices for cotton products at the firm-level, $p_{jht}$, correspond to the weighted average of unit values at the 10-digit HS code-firm-year level, where the weights are given by the export shares of each HS category on annual exports of cotton apparel. Similarly, unit prices for synthetic products at the firm-level, $p_{jlt}$, correspond to the weighted average of unit values at the 10-digit HS code-firm-year level, where the weights are given by the export shares of each HS category in annual exports of synthetic apparel.

   (b) Materials' Prices ($m_{ht}$, $m_{lt}$):

   High- and low-quality materials correspond to cotton and synthetic fabrics, respectively. Cotton fabrics are defined by 4-digit HS codes 5208 to 5212. Synthetics fabrics are defined by 4-digit HS codes 5407, 5408, and 5512 to 5516. Material prices were constructed as the weighted average import price existing within these categories, where the weights refer to import shares of the product over the annual imports of materials.

   (c) Iceberg Costs ($\tau_{ht}$, $\tau_{lt}$):

   Iceberg costs are proxied by tariff data from the United States to apparel imports from Peru, defined at the 6-digit HS code. This publicly available data is collected by the WTO.

2. Productivity Estimation:

   (a) $\tilde{r}_{jt}$ is defined as log of deflated value added, where the deflator refers to the price index in apparel in the domestic economy.

(b) $l_{jt}$ is defined as log expenditure in labor at the firm level.

(c) $k_{jt}$ is defined as log capital stock of machinery at the end of the period.

(d) $i_{jt}$ is defined as the log of the change in capital stock the next period net of depreciation.

(e) $Comp_{jt}$ is defined as in Section 4. However, to construct a measure of import competition when the firm only sold to the domestic market, I assume that the most competitive environment for the firms took place during the sample period. Results are robust if I use the mean or the lowest competition level.

(f) $np_{jt}$ is defined as the log of the number of products a firm sells at the 6-digit HS code. For firms that sell only to the domestic market, I assume firms sell only synthetic products and that they sell the maximum number of products sold by the firm in the sample period.

3. Price Indices Processes:

   For the price index of the domestic market, $P_t^d$, I construct a weighted unit price of Peruvian apparel imports originating in China, where the weights correspond to the share of sales of that product on the total imported bundle for each year.

   For the price index of the foreign market on cotton apparel, $P_{ht}^x$, and synthetic apparel, $P_{lt}^x$, I rely on information given by OTEXA and construct a weighted unit price of U.S. apparel imports, where the weights correspond to the share of sales of that product on the total import bundle for each year.

4. Aggregate Expenditure Processes:

   For aggregate expenditures in the domestic market, $X_t^d$, I add up the total annual sales in the domestic market of Peruvian firms and the total annual Peruvian apparel imports, both collected by the Peruvian Tax Authority.

   For aggregate expenditure in the U.S. market for cotton clothes, $X_{ht}^x$, and synthetic clothes, $X_{lt}^x$, I use information provided by OTEXA and construct a measure of total annual imports of cotton and synthetic apparel to the US where the definitions of cotton and synthetic are as defined in Appendix G.

5. Sunk Costs Estimation:

   (a) Wage $w$ corresponds to the average hourly salary of a worker in the apparel industry and is expressed in U.S. dollars.

(b) Rental rate $r$ is assumed to be 10%, which is the average interest rate for corporate loans.

(c) Material Prices $m_h$ and $m_l$ are assumed fixed during the sample period and correspond to average prices of a square meter of cotton and synthetic fabric, respectively.

(d) Fixed shared factor $\bar{F}$ and its cost $\theta$ correspond to the average capital stock of buildings in the sample and the mortgage rate, respectively.

# J Full Set of Estimated Parameters

| Stage | Estimation | Parameters | Coefficient | Std. Dev | No. Obs. |
|---|---|---|---|---|---|
| First | Elasticities | $\sigma_h$ | 2.53 | (1.53) | 685 |
| | | $\sigma_l$ | 1.98 | (0.82) | |
| First | Production Function | $\alpha_l$ | 0.72 | (0.02) | 511 |
| | | $\alpha_k$ | 0.13 | (0.03) | |
| | | $\rho_0$ | 0.25 | (0.03) | |
| First | Production Process | $\rho_1$ | 0.22 | (0.08) | 404 |
| | | $\sigma^2_\psi$ | 0.41 | | |
| | | $\rho_0^{P_d}$ | 6.36 | (0.84) | |
| | | $\rho_1^{P_d}$ | 0.27 | (0.06) | 339 |
| | | $\sigma^2_{P_d}$ | 3.35 | | |
| | | $\rho_0^{P_1}$ | 4.89 | (0.47) | |
| First | Price Index Processes | $\rho_1^{P_1}$ | 0.54 | (0.03) | 1240 |
| | | $\sigma^2_{P_1}$ | 2.90 | | |
| | | $\rho_0^{P_2}$ | 5.58 | (0.55) | |
| | | $\rho_1^{P_2}$ | 0.46 | (0.02) | 1630 |
| | | $\sigma^2_{P_2}$ | 3.92 | | |
| | | $\rho_0^{X_d}$ | 16 | (8) | |
| | | $\rho_1^{X_d}$ | 0.39 | (0.19) | 48 |
| | | $\sigma^2_{X_d}$ | 16 | | |
| | | $\rho_0^{X_1}$ | 40.83 | (508.93) | |
| First | Aggregate Expenditure Processes | $\rho_1^{X_1}$ | 0.87 | (0.13 ) | 25 |
| | | $\sigma^2_{X_1}$ | 62.73 | ( 8.35) | |
| | | $\rho_0^{X_2}$ | $-17.13$ | (17.81) | |
| | | $\rho_1^{X_2}$ | 0.88 | (0.11) | 25 |
| | | $\sigma^2_{X_2}$ | 7.22 | (1.41) | |
| | | $\gamma_d$ | 6.08 | (2.30) | |
| Second | Sunk Costs | $\gamma_1$ | 7.10 | (1.27) | 222 |
| | | $\gamma_2$ | 3.85 | (3.87) | |

*Notes*: Alternative specifications have also been attempted for the estimation of prices indices processes in which the level of aggregation is changed such as using data of weighted average unit prices at the 10 and 6 digit HTS-code level and trimester, at the 10 HTS-code product level and year, without significantly different results. As in the case of the price indices, alternative specifications have also been attempted in which the level of aggregation is changed such as using data of weighted average unit prices at the 10 and 6 digit HTS-code level and trimester, at the 10 digit