Trade Policy on a Buyer-Seller Network

Brian Pustilnik *

Central Bank of Chile

February 6, 2023

Abstract

The welfare effects of trade policy are shaped by the outcomes of imports reallocation and price changes. In this paper, I show that these outcomes crucially depend on whether importing firms are matched with multinational suppliers or with single-country producers. I study an antidumping duty imposed by Colombia on the imports of Chinese truck tires. In the data I observe the full network of Colombian importers and their foreign suppliers. For the latter, I use data on tire plant's location to distinguish between multinational (manufacturing in many countries) and single-country manufacturers. Due to the policy, approximately 75% of imports of Chinese tires where replaced with imports from other origins, and the bulk of this geographical substitution involved multinational suppliers. I estimate a quantitative trade framework to match the reallocation and price changes in the data. I analyse the policy under a counterfactual network without multinational suppliers, and find that pass-through increases. The analysis suggests that ignoring this type of network structure could lead to biases for the prediction of the welfare effects of tariff -and similar- shocks.

*bgpustilnik@gmail.com. This paper was a chapter of my dissertation at UCLA. I am grateful to Ariel Burstein, Pablo Fajgelbaum and Jonathan Vogel for their guidance and superb advice. I also thank Alvaro Boitier, Oleg Itskhoki, Augusto Ospital, and participants of the Trade and Industrial Organization Proseminars at UCLA for helpful comments. This work benefited greatly from interactions with Gustavo Lima, Orlando Murra and Javier Madanes Quintanilla who provided excellent insights and resources from the tire industry.

1 Introduction

The effect of trade policy on international supply chains has received a renewed interest due to the US-China trade war. Together with Covid-19, these events raised awareness about the importance that supply chain disruption has for prices and allocations. Amiti et al. (2019) and Fajgelbaum et al. (2020) find evidence that most of the costs of the 2018 US tariffs have been passed through to US consumers as higher prices. To predict the magnitude of these effects, it is important to understand what are the alternatives to undo or ease the effects of the disruption. This is especially true for the use of unilateral trade remedies. Imposing tariffs to individual countries always allows for the possibility to change the origin of imports to undo the effects of the tariff. Moreover, this type of unilateral policies are not something new. Barriers such as antidumping and countervailing duties are the most widely used trade remedies and they predate the trade war as far back as the 1980's (Blonigen 2002, Bown et al. 2020).

An important aspect to measure the impact of the US-China trade war, was to account how imports from other countries could ease the effects of tariffs for US consumers. For goods targeted by the first two rounds of tariffs imposed by the US in 2018, the value of imports from China decreased from US$ 130 billion in in the first half of 2018, to US$ 95 billion in the first half of 2019. However, out of the US$ 35 billion loss, US$ 21 billion have been replaced by imports originating from other countries (Nicita 2019). Moreover, these patterns show heterogeneity across sectors, with motor vehicles, machinery, transport equipment and electrical equipment experiencing the largest substitution (Bekkers and Schroeter 2020).

However, not every product necessarily experiences the same substitution intensity. I focus on how multinational production affects such intensity. From the demand side, switching consumption to products from a different country might involve considering if the manufacturer or brand is the same or not. The preference for product attributes such as the brand is a common feature in the literature that uses discrete choice models for demand estimation (Goldberg 1995, Coşar et al. 2018, Head and Mayer 2019). On the supply side, multinational production might ease the effects of a tariff by shifting production between existing foreign based operations, or through production relocation (Flaeen, Hortaçsu and Tintelnot 2020, Blanchard et al. 2021). Therefore, I ask the question of how important is the connection between importing firms with multinational suppliers for the impact of trade policy.

In this paper I study how the network of connections between importing firms and their foreign suppliers conditions the price and allocation effects of trade barriers. The strategies adopted by importers to source their imports can be very diverse in how they are connected with different types of suppliers. This diversity can be characterized in the form of a network. A tariff imposed to a single country can have different price implications for networks with different compositions. For instance, a network that is dense with multinational suppliers might experience a smaller price jump by allocating imports to non-tariffed countries more, compared to a network with few multinational suppliers.

I focus on the difference between connections with multinational production suppliers and connections with single-origin suppliers. This variation is key to identify quantitatively how the network conditions price effects. In the absence of such variation, it is not possible to quantify counterfactual scenarios. For instance, Flaaen, Hortaçsu and Tintelnot (2020) study the imposition of antidumping duties for washing machines. They find that product relocation was a successful strategy to undo the effect of the tariff. However, all the manufacturers considered in their study are multinationals that relocated production. Instead, I study a case where the network composition allows me to identify different substitution intensities and perform counterfactuals.

A particular policy event allows me to study this kind of variation. In October of 2012, the Colombian government introduced minimum price restrictions on Chinese truck tires imports. This specific policy event is interesting due the composition of firms involved in this industry. The tire industry is very globalized with many heterogeneous players. On one hand, there are suppliers with many plants in different countries, which simultaneously serve the Colombian market. On the other hand, there are suppliers that have their plant in a single country that export to Colombia only from that origin.

With this case study, I contribute to the understanding of the impacts of trade policy by remarking that its effects are conditioned by the importer-supplier network. I document a series of stylized facts to show that the network should not be ignored. First, I show that when Colombia imposed the price floor, it became binding for the entire duration of the policy. Second, the aggregate imports from China rapidly decreased and quickly reallocated to alternative origins. Then I assess whether this pattern of reallocation does vary depending on the network connections. In the case that it continues to hold, a simple model that ignores the network connections would predict the same price effects, regardless of the composition of suppliers. However, I show that substitution crucially depends on the importer-supplier network.

I explore two margins in which the importer-supplier network conditions the substitution patterns. First, The vast majority of substitution is due to firms that were connected to multiple countries prior to the policy. This suggests that the connection between importing firms and exporting countries matters for shaping the patterns of substitution. Then, I take a step further to understand how the network connections of importers to suppliers matter for substitution patterns. I find that conditional on the importers purchasing from multiple countries, substitution across source countries is larger for firms that were initially connected to multinational production suppliers.

In light of my empirical findings, I proceed to quantify the differential effect in allocations due to connection with multinational production suppliers. There are two goals to the quantification. First, to understand the importance of different channels of reallocation. For instance, how much reallocation is due to the importer sourcing simultaneously from various origins and how much is due to the multinational activity of the supplier. Second, I perform a counterfactual analysis where I consider alternative networks. Equipped with a quantification of the differential effect, I can simulate the policy for a network that does not count with multinational suppliers, and evaluate how would the overall price increase relative to the observed network.

I use a structural model of trade to perform the quantification accurately. I need a model because the structure of the network is highly complex. The goal is to compare the response to policy for two types of network connections; multinational versus single-country suppliers. However, the difference is not captured with a simple comparison of outcomes for two subgroups. For instance, importers differ in the number of connections they have. Some importers have many connections, with both types of suppliers and of very different magnitudes. On top of that, there is substantial variation in the initial prices for Chinese tires, which conditions the exposure of non-Chinese alternatives to the shock depending on the network connections. Without a model, one can resort to a reduced form quantification, but it is far from ideal. This would require adding several controls on top of the multinational versus single-country distinction, in order to account for the additional complex heterogeneity. Instead, using a model captures all the relevant economic forces driving the heterogeneity using simple objects such as price indexes and observable market shares.

By conditioning on the importer-supplier network connections, the model improves the prediction of policy impacts. Existing trade models have proved to be flexible and successful in reproducing substitution patterns and hence a suitable tool for the understanding of the effects trade policy. The simplest version, Armington (1969), considers a single elasticity of substitution between products from different sources. This elasticity is typically estimated using bilateral trade flows for many countries. However, the elasticity might vary for different network structures, for instance, depending on which is the importing country. The estimate of a single elasticity would pool them together, and using it for predictions of policy impacts would miss the network effect.

The improvement for the predictions of policy impacts rely on two margins of differential substitution. First, for firms that were initially connected with different countries. Second, for connections of importers to suppliers that produce in different countries. To achieve these I use a model of product differentiation across importers, suppliers and origins. Products are not only considered different when they come from different sources, but also when they are traded through different importer-supplier connections. Hence, I define a variety as a combination of importer-supplier-origin[1]. To account for the differential substitution patterns, I use a nested structure of aggregation. With this structure, the price increase of Chinese varieties affect varieties from other sources through the price indexes associated to the nests they belong to. This structure is designed to allow for larger substitution as the network connection are stronger between products in different countries.

To estimate the model I use the binding price floor imposed by the policy together with the observed network structure. Chinese varieties with prices that were initially below the price floor are forced to increase their price. The rest of the varieties do not necessarily experience price changes. Following Card and Kureger (1994) I use the gap between pre-policy prices and the minimum price to identify the effect of the price increase on allocations. They use the gap to a new minimum wage in New Jersey, while Pennsylvania's minimum wage did not change. The variation on the gap level reflects both the New Jersey-Pennsylvania contrast and differences within New Jersey initial wages. In my setup, the gap to the price floor reflects the Chinese versus non-Chinese contrast, but also accounts for the additional variation due to the network structure. This is reflected through the price indexes of the model, where the gap is aggregated using their structure.

I find that the heterogeneity characterized by the network is sizeable and important

[1]The substitution I am interested in is over origins. Having the importer and supplier defining the varieties will allow for different types of importer-supplier connection to determine the strength of origin substitution. In what follows I refer to varieties that have "connections with multinational suppliers" to denote that for a given variety, the supplier is a multinational producer and that there is another variety which has the same importer-supplier component, and only differs in the origin.

for allocation effects. Once the parameters of the model are estimated, I can compute the model-implied elasticity for each variety. This captures the responsiveness of a variety's quantity given its particular network connections. The average elasticity for varieties imported from multinational suppliers is 5.35, while for varieties imported from single-country suppliers it is 2.93. The aggregate elasticity is estimated to be 4.04, which is in the ballpark of the "micro" elasticity estimates described in Feenstra et al (2018) by models that ignore this network. I simulate the policy under a counterfactual network without multinational suppliers. The results show that the policy induces expenditure to increase by 17%, compared to the 9% increase observed with the original network. The quantification suggest that simpler models could easily mask the heterogeneity and lead to biased predictions when they face a different network. The predictions in the absence multinationals would underestimate the impacts on prices, as the more rigid network cannot easily undo the effects of the tariff.

This study is related to a growing body of literature that analyzes the effects of trade policy. In recent years a group of studies focused on the US-China trade war. Amiti et al. (2019), Fajgelbaum et al. (2020) show the effects that US tariffs had on US import prices. They find evidence that the costs of US tariffs have mostly been borne by US consumers, as there was complete pass-through of tariffs to import prices. A survey by Fajgelbaum and Khandelwal (2021) explores the broad list of topics that the analysis of tariffs embraces. Their main focus is on the possible explanations for tariff pass-through. Additionally, they show how the literature extends on other margins. These include distributional consequences of tariffs, labor market effects and political motivations, among others.

Within the literature on the impacts of trade policy, this paper is mostly related to the group of studies that focus on the effects for global demands. A strand of research provide evidence for the diversion effect of trade conflicts. Nicita (2019) and Bekkers and Schroeter (2020) document that for early rounds of tariffs in 2018, approximately two thirds of the import value that the US stopped sourcing from China was replaced with imports from other countries. Flaaen, Hortaçsu and Tintelnot (2019), show that the production relocation of washing machines was effective to undo the effects of tariffs. Along this line, several papers address the effect that the trade war had for bystander countries. These include Moeller (2018) for India, Pangestu (2019) for Indonesia, Tham et al. (2019) for Malasya and Hsieh (2020) for Taiwan.

An early literature on global production, multinationals, foreign direct investment has prepared the grounds to discuss this effect. Horstmann and Markusen (1992) and Blonigen (2002) show evidence of a tariff jumping behavior that induces a reallocation across origins. On the theoretical side, Yeaple (2003), Helpman et al. (2004), Ekholm et al. (2007) and Tintelnot (2017) provide frameworks to understand how firms choose to locate their production considering the structure of trade costs. A more recent group of papers focus on the effect of trade conflict on global value chains and foreign direct investment (Head and Mayer 2019, Gereffi et al 2021, Blanchard et al 2021).

Finally, this paper is also related to the literature that studies firm-to-firm relationships. Blum et al. (2010, 2012) focus on the role of import intermediaries in linking small exporters and small customers. Monarch(2013) estimates switching costs using a panel of U.S. importers and Chinese exporters, and Dragusanu (2014) explores how the matching process varies across the supply chain using U.S.-Indian data. Eaton, Jinkins, Tybout, and Xu (2018) study the formation of international relationships using Colombian data. Sugita, Teshima, and Siera (2014) study matching patterns in U.S.-Mexico trade, while Benguria (2014) estimates a trade model with search costs using matched French-Colombian data. Huneeus (2018) and Lim (2018) study the implication of firm-to-firm relationships for the amplification of shocks through supplier networks.

The rest of the paper is organized as follows. Section 2 introduces the institutional framework and the data. Section 3 shows the empirical evidence on the heterogeneity in responses to the policy. Section 4 introduces the model. Section 5 contains the estimation strategy and Section 6 shows results and implications for trade.

2 Institutional Framework and Data

2.1 Colombian Tire Industry and the imposition of Antidumping

National tire production in Colombia has historically been carried out by two of the largest global tire manufacturers. In 1942, The Goodyear Tire and Rubber Company ("Goodyear") opened its own local manufacturing plant in the city of Cali. In the same decade, the local company Icollantas S.A. ("Icollantas") mounted two manufacturing plants in Cali and Bogota using technology supplied by American manufacturer BF Goodrich.

In 1992, French tire maker Michelin established a dominant commercial presence. By the time they arrived in the country,local production accounted for almost half of the local consumption market. Michelin's import based strategy rapidly modified this figure. National production's market share dropped to one third of the total sales in 1992.

With Michelin's dominance, national production kept falling steadily until 1998, when the company acquired the local manufacturer Icollantas. During this period, market share of local manufactures reached levels as low as 11%. The acquisition of Icollantas reverted this trend, but not for long.

By the second half of the 2000s Goodyear and Michelin began to import tires from their Brazilian facilities. The natural rubber prices were peaking and both local manufacturers had a better input cost structure in their operations in Brazil.

In parallel, import competition from China began to take over the Colombian market. In response, both local manufacturers claimed for an antidumping investigation. A price floor of $5.37 per kilo was imposed in October of 2012 for imports of truck tires manufactured in china. The curious fact about it is that the price used as a reference to set the value of the price floor was not the price of local manufactures, but rather the average unit value of Brazilian imports during the investigation period. Moreover, Michelin decided to stop its Colombian operation in 2013, with the antidumping duties still in place, a price floor that would last five years.

2.2 Data

To study the episode of antidumping I use two datasets. First, I get all firm-level trade transactions from Colombian Customs Data. This dataset identifies several key variables for my analysis. The main three are: i) The importing firm in Colombia, ii) the foreign supplier and iii) the country of manufacture of the good. This variables allow me to analyze a firm-to-firm trade framework using values and quantities traded at a very dissagregated level. Colombian customs data does not report ownership, and for most of suppliers it is not obvious how to match them across source countries. For this I resort to an alternative dataset. The second data set is a series of tire industry reports created by the magazine Tirebusiness from Crain Comunications. These reports identify all the tire manufacturing plants in the world for every year since 2008, and report their ownership.

Combining these datasets I can identify Colombian importers that source from single-plant producers, as well as from multi-plant producers with plants in different countries. I track the transactions of 193 varieties of truck tires imported to Colombia from 2009 to 2019, as defined by their origin and type of importer-supplier connection. Table 1 reports summary statistics for the frequency, unit values and quantities of these varieties.

3 Stylized Facts

This section introduces empirical evidence to support the importance of network connections for the understanding of policy outcomes. The evidence is presented with four stylized facts about the price and allocation effects of the policy. In each of them, the policy is analyzed at different levels of aggregation including country-level, importer-level and importer-supplier-level. The purpose of this comparison is to establish whether the allocation effects of the policy vary depending on the network connections between importers and suppliers.

3.1 Price Effects and Country-Level Reallocation

The first level of aggregation studied is the country-level imports of truck tires by Colombia. The price and quantity of imports are categorized by the origin they are sourced from, distinguishing between China and the rest of the world (RoW).

<u>Fact 1:</u> The policy materializes as a binding price floor to truck tires manufactured in China.

Figure 1 shows the effect of the policy on prices. Prior to the enactment of the policy, the prices that Colombia paid for the import of truck tires were following a common trend both if the good was sourced from China or from the rest of the world. Such trend is guided by the price of natural rubber, which is the main raw material in the manufacturing process for tires.[2] The antidumping policy imposed by Colombia was of a discriminatory character; it only affected truck tires manufactured in China. The policy materialized as a price floor of 5.37 dollars per kilogram of tires. The most salient feature about the policy is that the price floor is binding for the entire duration of the duty. The price floor is at a level that Chinese tires had never reached before. Moreover, it is slightly higher than the rest of the world's average. This occurs as the Brazilian price of tires was used as a reference to set the floor level; a price that is typically on the higher end of the price distribution. The binding character of the policy becomes even more salient as the price trend for non-targeted sources becomes negative. Chinese varieties are precluded from following the overall price trend that other countries follow. However, when the policy ends,

[2] As evidence that prices for non-targeted origins are following a general trend, I show average import prices for passenger-car tire. Unlike truck tires, the latter were not subject to a policy. Figure 2 shows that passenger-car tire prices followed their natural trend regardless of the origin they were sourced from.

Chinese prices return to their naturally cheaper value, in line with the general price trend.

<u>Fact 2:</u> While the policy is in place, there is reallocation of imports across sourcing origins, away from China towards competing countries

The effect of the policy on quantities at the country-level is shown in Figure 3. The quantity imported from China reduces abruptly immediately after the policy begins. Moreover, with the same immediacy, the quantity imported from alternative origins increases. As time goes by and Chinese prices are still constrained, the quantity imported from China becomes close to zero. However, once the constraint is removed, imports from China surge to recover more than half of the market, as they used to be before the policy. The pattern of substitution observed at the country-level is not unexpected. A standard model of trade in which several countries compete as source origins would predict this response when the price of one of such countries experiences a large increase.

At this stage, we would like to think about the extent to which the substitution pattern observed in Figure 3 does vary depending on the network connections. Consider the case that the pattern of substitution holds at a more disaggregated level. In that case, the standard model can be used to infer the impact in one location versus the others, without taking into account the network connections. On the other hand we have the case where the pattern does vary with the network of importers and suppliers. Then, there is no general lesson to be learned on the impact of trade policy, because that lesson will be conditional on a network that the standard model ignores. The following stylized facts show that substitution crucially depends on the importer-supplier network.

3.1.1 Heterogeneous import reallocation patterns at more desegregated levels of observation

<u>Fact 3:</u> The vast majority of substitution is due to firms that were connected to multiple countries prior to the policy

I first look at the allocation effects for importer who, when the trade policy is enacted were initially only sourcing their imports from China. In the left panel in Figure 4, we can see that there is some substitution across origins, but it is not very large. On one hand, while purchases from China drop significantly, they do not stop immediately. On the other hand, sourcing from alternative origins shows a slowly increasing trend. The conclusion that substitution is little steams from the comparison to a second group.

The second group is comprised of importers who, before the policy was enacted were buying both from China and other origins. The middle panel in Figure **??** show that substitution is much larger for this group. They get rid entirely of the imports sourced from China and their switching to source from alternative origins is large.

A third group includes the firms that began importing only after the policy was enacted. Not surprisingly, they source their imports from origins other than China. Their activity is not crucial for the understanding of the heterogeneous response to policy. However, their delayed entry is consistent with the fact that the substitution of origins vary when we condition on the network connections.

The comparison in the response for the groups defined above reveals that substitution is larger is larger for firms who, before the policy were buying from China an other countries. This is a first step in understanding how network connections condition the effects of trade policy. The type of connection between importing firms and exporting countries matters for shaping the patterns of substitution.

<u>Fact 4:</u> Conditional on the importers purchasing from multiple countries,

substitution across source countries is larger for firms that were initially connected to suppliers with production in multiple countries

Now I take a step further to understand how the network connections of importers to suppliers matter for substitution patterns. The goal is to assess whether the connection to a supplier that had presence producing in multiple countries induces a different response to the policy. I analyze the response to policy for the imports of importer-supplier connections, conditioning on importers that initially purchased from multiple countries. For these importers I distinguish between connections with multinational suppliers and connections with single-country suppliers. The comparison will reflect whether it matters for reallocation that a supplier sells from China and other origins, or it would have been the same as having separate suppliers in each origin.

I start analyzing the set of connections in which the importer purchases from single-country suppliers in each country. The plot in the left panel of Figure 5 shows the substitution patterns for this group. Imports sourced from China plummet when the policy begins. However the quantity of imports sourced from other countries does not increase dramatically. In particular, the amount of substitution seems to be small when compared to a second group of importer-supplier connections. The substitution pattern for connections in which suppliers incur in multinational production is much more striking. The imports sourced from China are also quickly set to zero, but now the increase in sourcing from other origins is much larger.

4 Model

4.1 Simple models ignore importer-supplier networks

The purpose of the model is to reproduce the patterns of sourcing substitution across different origins. Existing trade models have proved to be flexible and successful in reproducing substitution patterns and hence a suitable tool for the understanding of the effects trade policy. Strangely, these models do not tend to incorporate importer-supplier connections as a determinant of substitution. In light of the heterogeneity in substitution patterns observed in this study, I leverage their tractability and ease to take to the data and incorporate such network to their structure.

Standard models of trade, the simplest being Armington (1969), consider a single elasticity of substitution between source country products. Products from alternative source countries are viewed as imperfect substitutes. The quantity traded for any pair of countries depends on income and the relative price of the competing products. Using bilateral trade flows for many countries, such elasticity is estimated for different industries.

The predictions for the effect of trade policy depend crucially on how seriously the model takes the observed substitution patterns. In occasions, the country level responses to policy are fully consistent with a simple theory. This is the case for the policy imposed to Chinese truck tires in Colombia. A significantly large price jump might seem a reasonable explanation for such substitution. Hence, the policy can seemingly be analyzed with a simple model that reproduces the country-level substitution patterns. However, when network is relevant, the general predictions of the simple model are not suitable to analyze the policy. This is because under a different network, the policy can result in different outcomes, which the simple model cannot account for. Before developing my model, I illustrate this point by explaining the setup for a simple model.

4.2 A trade model with network connections

By conditioning the model on the network of importer-supplier connections, I improve the prediction of the impacts of trade policy.

4.2.1 Nested Constant Elasticity of Substitution Demand

Consumers choose among differentiated varieties of truck tires. Each variety is indexed by retailer (i), foreign supplier (j) and origin (o). The aggregate demand for these varieties is structured according to a three-layers CES demand system. Demand is aggregated the industry level and yields utility Y. There is a set I of retailers in this industry, which corresponds to the importers that commercialize the imported goods in the domestic market. In the upper nest of the system there is differentiation among these retailers

$$Y = \left[\sum_{i \in I} y_i^{\frac{\sigma-1}{\sigma}} \right]^{\frac{\sigma}{\sigma-1}} \tag{4.1}$$

where y_i is an aggregate of varieties imported by retailer i. Within each retailer there is a set J_i of foreign suppliers (or brands). The middle nest of the system aggregates varieties differentiating suppliers within a retailer

$$y_i = \left[\sum_{j \in J_i} y_{ij}^{\frac{\rho-1}{\rho}} \right]^{\frac{\rho}{\rho-1}} \tag{4.2}$$

where y_{ij} is an aggregate of varieties imported by retailer i from supplier j. Finally, within the nest of importer-supplier connections, varieties are differentiated by sourcing origin. For every importer-supplier connection ij there is a set O_{ij} of origin countries from where the imports transacted by that pair are sourced. The bottom nest aggregation is given by

$$y_{ij} = \left[\sum_{o \in O_{ij}} a_{ijo}^{\frac{1}{\kappa}} y_{ijo}^{\frac{\kappa-1}{\kappa}} \right]^{\frac{\kappa}{\kappa-1}} \tag{4.3}$$

where y_{ijo} is a single variety of truck tires and a_{ijo} is a demand shock.

The purpose for this structure is to capture a complex network of connections between importers and suppliers. In the model, the network is characterized by the sets I, J_i and O_{ij}. I illustrate this with an example. Consider first the case of an importer indexed by $i = 1$ who is connected only with a Multinational Production supplier indexed by $j = 1$, and with origins China and Korea. In that case, the set O_{11} contains both origins involved in that importer-supplier connection. In turn, the set J_1 for this importer contains only supplier $j = 1$. On the other hand, consider the importer indexed $i = 2$, connected to two Single-Country suppliers, $j = 2$ in China and $j' = 3$ in Korea, each in a different country. This time, the sets O_{22} and O_{23} contain only one country each. Moreover the set J_2 now contains both suppliers.

Given a certain network, the substitution across varieties can be determined using the nested structure. For any pair of varieties, their substitution intensity can be determined the following way: Starting from the bottom nest in equation (4.3), we can determine if they share the nest or not. If not, we climb to the nest in equation (4.2) and we re-assess. Finally if they do not share the middle nest, we can determine that they share the nest in equation (4.1). Following these steps, the more we climb up the nests, we consider these varieties less substitutable.

I now illustrate the substitution intensity across origins. As it was discussed in the stylized facts of Section 3, connections with Multinational Production suppliers experienced higher substitution in response to the policy. For connections with MP suppliers, varieties with different source origins belong to the same nests of aggregation including the bottom nest of equation (4.3). Now consider the connections where importers simultaneously source from two origins, but from different suppliers. In this case, we have two varieties from different origins, that do not share the bottom nest. However, given the importer's simultaneous sourcing, these varieties share the middle nest of aggregation, represented by equation (4.2). All else equal, the nature of the connection makes these varieties less substitutes, compared to the MP supplier case.

The mechanism by which the policy induces reallocation across origins is captured by how demand changes with prices. I begin by defining the price indexes associated to every layer of aggregation. These price indexes measure the overall price level for varieties within the same nest. The relative price of each individual variety to the within-nest overall price is a key determinant for allocations. Moreover, the effect of relative prices on allocations is larger at lower level nests. The price indexes are defined as follows. The industry level price index associated with equation (4.1) is

$$P = \left[\sum_{i \in I} P_i^{1-\sigma} \right]^{\frac{1}{1-\sigma}} \tag{4.4}$$

where P_i is the price index for all varieties imported by importer i, associated with equation (4.2)

$$P_i = \left[\sum_{j \in J_i} p_{ij}^{1-\rho} \right]^{\frac{1}{1-\rho}} \tag{4.5}$$

where p_{ij} is the price index for all varieties that belong to the connection of importer i with supplier j, which is associated with equation (4.3) and given by

$$p_{ij} = \left[\sum_{o \in O_{ij}} a_{ijo} p_{ijo}^{1-\kappa} \right]^{\frac{1}{1-\kappa}} \tag{4.6}$$

and p_{ijo} is the retail price for a single variety.

This structure yields an optimal demand for each variety y_{ijo} as a function of the aggregate expenditure, the taste shock a_{ijo} and prices. The value of sales by importer i in the domestic market is given by

$$P_i y_i = E \left(\frac{P_i}{P} \right)^{1-\sigma} \tag{4.7}$$

where E is the aggregate expenditure for this industry in the domestic market.

Within the sales of an importer i, the value of sales for varieties imported from supplier j is

$$p_{ij} y_{ij} = P_i y_i \left(\frac{p_{ij}}{P_i} \right)^{1-\rho} \tag{4.8}$$

Finally, the quantity of a single variety indexed by importer i, supplier j and source origin o is given by

$$y_{ijo} = y_{ij} a_{ijo} \left(\frac{p_{ijo}}{p_{ij}} \right)^{-\kappa} \tag{4.9}$$

From these expressions we can interpret the differences in the substitution intensity across origins. For connections with MP suppliers, the price change for Chinese varieties affects the relative price in equation (4.9). For a Korean variety not affected by the policy, its relative price decreases as p_{ij} increases. Substitution between the Korean and Chinese variety be determined in part by parameter κ. For connections with single-country suppliers, the relative price in equation (4.9) does not play a role in allocations. This is because there is only one price p_{ijo} nested into p_{ij} according to equation (4.6). Hence, the only parameters guiding the allocation effects are σ and ρ.

4.2.2 Model implications for reallocation elasticity

Combining equations (4.7) to (4.9) we get the following expression for the quantity of an individual variety:

$$y_{ijo} = a_{ijo}\, p_{ijo}^{-\kappa}\, p_{ij}^{\kappa-\rho}\; P_i^{\rho-\sigma}\; P^{\sigma-1}\; E \tag{4.10}$$

We can see that, as long as $\kappa > \rho > \sigma > 1$, the demand for a particular variety increases as prices of other varieties increase. Differential substitution effects are determined by which of those price indexes are actually affected by the price change. This is determined entirely by the network of connections between importers and suppliers.

The price indexes in equation (4.10) capture the complex economic structure that guides reallocation due to the policy. They capture not only whether suppliers are multinational or not, but also characteristics such as the number of total suppliers and origins as well as the prices that each importer faces. Eventually, in a reduced form analysis, one could add more controls to account for the heterogeneity. Instead, using the model provides a more detailed yet tractable way of controlling for such complexity.

A linear approximation of the cross-price elasticity derived from equation (4.10) can depict how the network determines substitution intensity across origins. Let ω index an individual variety (i.e. $\omega = i \times j \times o$). The elasticity of variety ω from Korea with respect to a price change by ω' from China is

$$\begin{aligned} \mathcal{N}_{\omega\omega'} = \; & (\sigma - 1)\ \mathbb{S}_{\omega'} S_{\omega'} s_{\omega'} \\ & + (\rho - \sigma)\ S_{\omega'} s_{\omega'}\ \mathbb{I}(i = i') \\ & + (\kappa - \rho)\ \ s_{\omega'}\ \mathbb{I}(i = i', j = j') \end{aligned} \tag{4.11}$$

where $\mathbb{S} = \frac{P_i y_i}{PY}$, $S = \frac{p_{ij} y_{ij}}{P_i y_i}$ and $s = \frac{p_{ijo} y_{ijo}}{p_{ij} y_{ij}}$ are market shares within each nest and the indicators $\mathbb{I}(i = i')$ and $\mathbb{I}(i = i', j = j')$ determine whether the pair of varieties belong to common middle and bottom nest respectively.

The term in the first row of equation (4.11) does not depend of how the pair of varieties are connected. This term is the cross price elasticity to which any model that does not account for network connections boils down to. Every variety is affected by the price of other varieties, given the competition in the domestic market. The term in the second row represents the increase in the elasticity for variety pairs ω and ω' that are retailed by the same importer. Hence, every importer that simultaneously sources from China and somewhere else counts with this additional force in the substitution across origins. Finally, term in the third row materializes only if the pair of varieties share the same importer-supplier connection. For connections with Multinational Production suppliers, the substitution across origins is represented all three terms. The importance of the network connections in conditioning reallocation is given by the quantification of the terms $(\rho - \sigma)$ and $(\kappa - \rho)$.

4.2.3 Importer's problem

Importers are monopolistic competitors. They have a product mix that is exogenously determined by the sets J_i and O_{ij} that corresponds to their importer-supplier connections. For profit maximization, importers internalize the sales cannibalization between varieties that are belong to their product mix. Their maximization problem is

$$\max_{\{y_{ijo}\}} \sum_{j \in J_i} \sum_{o \in O_{ij}} (p_{ijo} - z_{ijo})\, y_{ijo} \tag{4.12}$$

subject to

$$p_{ijo} = PY^{\frac{1}{\sigma}} y_i^{\left(1-\frac{1}{\sigma}\right)} y_{ij}^{\left(\frac{1}{\kappa}-\frac{1}{\rho}\right)} y_{ijo}^{-\frac{1}{\kappa}} a_{ijo}^{\frac{1}{\kappa}} \tag{4.13}$$

where z_{ijo} is the import price for a variety and it represents the importer's marginal cost. Equation (4.13) is the inverse demand facing an importer, obtained from equations (4.7)-(4.9).

The first order condition is given by equation (4.14). The right hand side of the equation is the expression for the marginal revenue. Given that the importer internalizes the cannibalization effect of varieties within its product mix, there are three components of the marginal revenue. The first term represents the direct effect of increasing the quantity of a variety on the revenue. This term can be either positive or negative, depending on the magnitudes of the parameters. The second term represents the indirect effect on revenue through varieties are obtained from the same supplier. Finally, the third term is the indirect effect through varieties obtained from other suppliers. Note that both indirect effect terms are negative, indicating that there is cannibalization of revenues, with its magnitudes determined by the elasticity parameters.

$$\begin{aligned} z_{ijo} = {} & p_{ijo}\left[\left(1-\tfrac{1}{k}\right)+\left(\tfrac{1}{\kappa}-\tfrac{1}{\rho}\right)s_{ijo}+\left(\tfrac{1}{\rho}-\tfrac{1}{\sigma}\right)s_{ijo}S_{ij}\right] \\ & + \textstyle\sum_{o' \neq o} p_{ijo}\left[\left(\tfrac{1}{\kappa}-\tfrac{1}{\rho}\right)s_{ijo'}+\left(\tfrac{1}{\rho}-\tfrac{1}{\sigma}\right)s_{ijo'}S_{ij}\right] \\ & + \textstyle\sum_{j' \neq j} \sum_{l \in O_{ij}} p_{ijo}\left[\left(\tfrac{1}{\rho}-\tfrac{1}{\sigma}\right)s_{ij'l}S_{ij'}\right] \end{aligned} \tag{4.14}$$

The first order condition yields a constant markup pricing rule. The relevant elasticity for the markup is σ, which governs the substitution across importers in the CES system.

$$p_{ijo} = \frac{\sigma}{\sigma - 1} z_{ijo} \tag{4.15}$$

Under this pricing rule, changes in import prices like the ones imposed by the policy are passed-though to consumer prices. This way, the binding price floor imposed by policy can be used to identify the elasticity parameters in the nested system.

5 Estimation

5.1 Linear specification and identification

I use the binding price floor and the structure of network connections to estimate the elasticity parameters of the model. There are two sources of variation that make identification possible. First, given that the minimum price is binding, there is variation in price changes within Chinese varieties that are necessary to reach the price floor. The second source of variation comes from the network structure. The network structure conditions the contrast between China and rest of the world's responses to the policy.

Both of these margins of variation are captured in a linear specification derived from equations (4.10) and (4.15). Applying the logarithm and taking differences over time yields the following linear specification

$$\Delta \ln y_{ijo} = (\sigma - 1)\Delta \ln P + (\rho - \sigma)\Delta \ln P_i + (\kappa - \rho)\Delta \ln p_{ij} - \kappa \, \Delta \ln p_{ijo} + \Delta \ln E + \Delta \ln a_{ijo} \tag{5.1}$$

$$\Delta \ln p_{ijo} = \Delta \ln z_{ijo} \tag{5.2}$$

where the change in the observed import prices z_{ijo} is passed-through to retail prices. Then, the structure of price indexes determines the elasticity with which those price changes affect quantities.

The statutory minimum price imposed by the policy induces a price jump. Chinese varieties with prices that were initially below the price floor are forced to increase their price. The rest of the varieties do not necessarily experience price changes. However, there are economic forces not captured by my model that could result in price changes for these varieties.[3] For this reason, I instrument the price changes using the exogeneity in the gap between pre-policy prices and the price floor. This gap is a lower bound for each affected variety. On the other hand, the gap is non existent for varieties that are not forced to increase their price. Formally, the instrument is constructed as

$$\hat{p}_{ijo}^{IV} = \begin{cases} ln(5.37) - ln(z_{ijo}^{pre}) & \text{for Chinese varieties with } z_{ijo}^{pre} < 5.37. \\ 0 & \text{for other Chinese varieties} \\ 0 & \text{for non-Chinese varieties} \end{cases} \tag{5.3}$$

where \$5.37 is the value of the price floor for Chinese varieties and z_{ijo}^{pre} is the pre policy import price.

This instrument has the same structure as the one used by Card and Krueger (1994) to study the effect of minimum wages on employment for New Jersey and Pennsylvania. They use the gap between pre-policy wages and a new minimum wage in New Jersey, while Pennsylvania's minimum wage did not change. The variation on the gap level reflects both the New Jersey-Pennsylvania contrast and differences within New Jersey initial wages. In their setup, the gap is a strong predictor of the actual wage change. Moreover, conditional on the the instrument, there is no difference in wage behavior between stores in New Jersey and Pennsylvania.

In my setup, the gap works in a very similar way, with a difference stemming from the additional variation due to the network structure. All the regressors in equation (5.1) are

[3] For instance, the prices of varieties that are not reached by the price floor could increase as a consequence of oligopolistic competition.

functions of the changes in import prices. Hence, the instrument is used to exploit the exogenous variation along the entire network, using the price indexes. Equations (5.4) and (5.5) use the gap to construct instruments for the price indexes.[4] Here the gap is also a strong predictor of the actual changes in prices and price indexes.[5] Additionally, in my setup, one has to condition on the entire set of instruments - prices and price indexes - to account for the differences in price changes across varieties. This is because conditioning only on the variety level gap would still leave substantial variation due to the network connections.

$$\hat{p}_{ij}^{IV} = \sum_{o \in O_{ij}} s_{ijo} \hat{p}_{ijo}^{IV} \tag{5.4}$$

$$\hat{P}_{i}^{IV} = \sum_{j \in J_i} S_{ij} \hat{p}_{ij}^{IV} \tag{5.5}$$

5.2 Caveats for linear specification

My main specification is a Generalized Method of Moments estimation, in which the estimating equation is non-linear on the elasticity parameters. The GMM estimation will be addressed in section 5.3. In this section I the caveat that precludes a linear estimation using least squares with my data. In addition, I discuss a workaround that allows for an ad-hoc estimation using least squares.

[4]The indexes in equations 5.4 and 5.5 are linear approximations of the price indexes implied by the model. In log-differences, the exact price indexes are given by $\Delta \ln p_{ij} = \frac{1}{1-\kappa} \ln(\sum_{o \in O_{ij}} s_{ijo} e^{(1-\kappa)\Delta \ln p_{ijo} + (1-\kappa)\Delta \ln a_{ijo}})$ and $\Delta \ln P_i = \frac{1}{1-\rho} \ln(\sum_{j \in J_i} S_{ij} e^{(1-\rho)\Delta \ln p_{ij}})$. There are two reasons to use the linear approximation. The linear approximation allows to build the index instruments as weighted averages of observable price changes, without involving the parameters in the calculation. On the other hand, as I show in appendix 1, I cannot estimate each elasticity parameter individually using fixed effects. This precludes me from constructing the exact price indexes as regressors for least squares estimation. Finally, if I wanted to use the exact indexes and estimate all parameters simultaneously, the estimating equation would be non-linear in the unobservables a_{ijo}. In my estimation streategy of section 5.3 I use the linear approximation of the model to estimate all parameters simultaneously using GMM.

[5]Given the exit of Chinese varieties, addressed in appendix 5.3, the actual price change is non-existent for a large number of them. Empirically, the price indexes are constructed using the adjustment proposed by Feenstra(1994). In such cases, the instrument is a strong predictor for the "Feenstra correction terms" associated with the exiting varieties.

The main caveat for the estimation of the linear specification is the exit of Chinese varieties. This can be seen in figures 4 and 5. The importer-suppliers connections with driving the substitution across origins, the imports of Chinese varieties stops when the policy is enacted. Computationally, Chinese varieties that exit are missing observations for the specification in (5.1).

The problem manifests as the impossibility to construct the price indexes for non-Chinese varieties. Note that exiting varieties will have missing values for both quantity and price changes. Missing the quantity changes is not the main problem. In the setup of this paper, the relevant quantity change is that of non-Chinese imports. In other words, the change in Korean imports due to a shock to Chinese prices can identify the elasticities as long as we have observations for the changes in Korean quantities. However, even when we have the quantity changes and price changes for non-Chinese varieties, we want to use the price changes for Chinese varieties to identify the elasticities.

The solution to this problem is to use the adjustment proposed by Feenstra (1994) to construct the price indexes. The *Feenstra correction* allows to compute the price indexes using price and market share changes for varieties that do not exit. In section 5.3 I show how to use this adjustment in the estimation procedure. There is also an alternative solution that allows for an ad-hoc least squares estimation. Instead of using the correction, I can proxy for the missing price changes of exiting varieties using the gap between their pre policy prices and the price floor. I explore this option in the appendix and report the results together with the GMM estimates in section 6.

Using the *Feenstra correction* comes at a cost in my particular setup. The computation of the price indexes under this method implies that the estimating equation becomes non-linear in the elasticity parameters σ, ρ and κ. This issue is similar to the one faced by Costinot, Donaldson and Smith (2016), where aggregation breaks the log-linearity of their model.[6] In appendix 1 I show the details of two margins of the problem. First, I explain

[6]If the data allowed for the estimation of each parameter individually, then the non-linearity of the price indexes in the parameter would not be a problem. Fajgelbaum et al (2020) estimate the elasticities

how data limitations preclude the estimation of each elasticity parameter individually. Then I discuss that under the exit of varieties, GMM is most suitable for the simultaneous estimation of all parameters.[7]

5.3 Corrections for exit and GMM estimation

5.3.1 Corrections for exit

A salient feature of the data is that a large amount of varieties respond to the policy through the extensive margin. In particular there is abundant exit of Chinese varieties. This feature represents a problem for the analysis as the change in quantity for continuing varieties (e.g. Korean tires) is driven, in principle, by the price shock that Chinese varieties experience.

To deal with this problem, I follow Feenstra (1994) and apply a correction for entry and exit of varieties the calculation of the price indexes. I illustrate how the correction works using the price index p_{ij}, and leave the calculations to appendix 1.

Consider the price index p_{ij} associated to the bottom nest that aggregates varieties traded by an importer connected wit a Multinational Production supplier

$$p_{ij} = \left[\sum_{o \in O_{ij}} a_{ijo} p_{ijo}^{1-\kappa} \right]^{\frac{1}{1-\kappa}} \tag{5.6}$$

where the set O_{ij} contains two origins; China and Korea. Consider a case where initially, the Chinese variety has 25% of the market share within the nest of importer-supplier

of a U.S. import nested demand system, where each parameter is estimated individually. Using the estimated parameter and residuals from lower nests, they construct a price index that is non-linear in the parameter aggregate up to the upper tier nest to individually estimate its elasticity parameter.

[7] Technically, the model becomes nonlinear in the individual parameter, but it is still linear in non-linear combinations of the parameters. In this case the *Feenstra correction* terms for each nest become the additional regressors for which the coefficients are non-linear combinations of the parameters. The issue is that to recover the parameters from these coefficients there are now more equations than unknowns. The GMM estimation deals with this overidentification issue.

connection ij. The policy increases the price for the Chinese variety, but the price of the Korean variety does not change and the Chinese variety exits. Define $C(O_{ij})$ as the set of origins for continuing varieties within the set O_{ij}; in this case just Korea. Additionally, define $S(C(O_{ij}))$ as the within-nest market share of continuing varieties. In this case, since the Korean variety is the only one that continues, this share is 75%. With these objects defined, we can rewrite the price index using only varieties that continue in the market once the policy is in place

$$p_{ij} = \left[\sum_{o \in C(O_{ij})} a_{ijo} p_{ijo}^{1-\kappa} \frac{1}{S(C(O_{ij}))} \right]^{\frac{1}{1-\kappa}} \tag{5.7}$$

Under this formulation, even when the continuing variety does not change its price, the price index picks up the overall change in prices. The change in the share $S(C(O_{ij}))$ can be interpreted as a measure of price variation once it is interacted with the elasticity parameter corresponding to the nest. Hence, the relative prices in the demand expression (4.9) yields the increase in quantity associated with a price increase for the Chinese variety.

5.3.2 Generalized Method of Moments

To estimate the model, I use a first order approximation of (5.1) where I define $\hat{x} \equiv \frac{dx}{x}$

$$\hat{y}_{ijo} = (\sigma - 1)\hat{P} - (\sigma - \rho)\hat{P}_i - (\rho - \kappa)\hat{p}_{ij} - \kappa\hat{p}_{ijo} + \hat{E} + \hat{a}_{ijo} \tag{5.8}$$

with

$$\hat{P} = \sum_{i \in I} \mathbb{S}_i^* \hat{P}_i - \frac{1}{1-\sigma} \hat{S}(C(I)) \tag{5.9}$$

$$\hat{P}_i = \sum_{j \in J_i} S_{ij}^* \hat{p}_{ij} - \frac{1}{1-\rho} \hat{S}(C(J_i)) \tag{5.10}$$

$$\hat{p}_{ij} = \sum_{o \in O_{ij}} s_{ijo}^* \hat{p}_{ijo} + \frac{1}{1-\kappa} \sum_{o \in O_{ij}} s_{ijo}^* \hat{a}_{ijo} - \frac{1}{1-\kappa} \hat{S}(C(O_{ij})) \tag{5.11}$$

$$\hat{p}_{ijo} = \hat{z}_{ijo} \tag{5.12}$$

where $\hat{z}_{ijo}$ are changes in import prices which, under the assumption that retailers charge a constant markup are passed-through to consumer prices. $\mathbb{S}^*$, S^* and s^* are market shares of each variety in total sales of continuing varieties within its corresponding nest.[8]

In appendix 2, I show the relevant moment condition for GMM estimation and the assumptions for the identification of the elasticity parameters. In what follows, I explain how the instruments are constructed under the new structure imposed by the first order approximation and the use of the *Feenstra correction* terms.

The first thing to notice is that with this new structure, the price indexes in equations (5.9) to (5.11) have the additional components that correspond to the exit correction terms. Hence, instruments are now required for the first term in each of those equations -i.e. the actual price changes- and for the correction terms. The former are instrumented in the same way the instrument it initially constructed. Consider the gap between the pre policy price and the price floor:

[8] A linear approximation is performed to ensure that the conditions for GMM estimation are met. As the parameters cannot be estimated individually, the specification incorporates the structure for the price indexes which introduces non-linearities. If exact price indexes where used instead of their approximated counterparts, the specification would also become nonlinear in the unobservables a_{ijo}, precluding the moment condition required for GMM estimation to hold.

$$
\hat{p}_{ijo}^{IV} = \begin{cases} ln(5.37) - ln(z_{ijo}^{pre}) & \text{for Chinese varieties with } z_{ijo}^{pre} < 5.37. \\ 0 & \text{for other Chinese varieties} \\ 0 & \text{for non-Chinese varieties} \end{cases} \tag{5.13}
$$

Then the instrument for the expressions containing the averages of actual price changes, $\sum_{o \in O_{ij}} s_{ijo}^{*} \hat{p}_{ijo}$ and $\sum_{j \in J_i} S_{ij}^{*} \hat{p}_{ij}$ are constructed by taking the same weighted averages to the gap variable instead

$$
\sum_{o \in C(O_{ij})} s_{ijo}^{*} \hat{p}_{ijo}^{IV} \tag{5.14}
$$

$$
\sum_{j \in C(J_i)} S_{ij}^{*} \hat{p}_{ij}^{IV} \tag{5.15}
$$

On the other hand, for the correction terms, the instruments are constructed using the gap to the price floor for Chinese varieties, weighted by their pre-policy market shares:

$$
\hat{S}(C(O_{ij}))^{IV} = s_{ij,china} \; \hat{p}_{ij,china}^{IV} \tag{5.16}
$$

$$
\hat{S}(C(J_i))^{IV} = \sum_{\{j/china \in O_{ij}\}} S_{ij} \; s_{ij,china} \; \hat{p}_{ij,china}^{IV} \tag{5.17}
$$

The intuition behind the instruments for the correction terms is that the size of the gap is a good predictor of the changes the correction terms. Larger distances to the minimum price are are most common among varieties that were taking a larger share of the market due to their initial low prices. Hence, after their exit, the remaining varieties experience a larger increase in market share, which implies a larger correction term.

6 Findings and Trade Implications

The estimated values for the elasticity parameters are presented in table 2. These values reflect a large difference between parameters κ and ρ, which determines the importance of multinational production for substitution across origins as depicted by (4.11). This difference reflects that to switch origins, not having to switch suppliers provides much more flexibility. With this estimates, together with the market shares and the network structure I use (4.11) to compute the model-implied elasticity for each variety. On average, varieties imported from multinational suppliers have an elasticity of 5.35. On the other hand, varieties imported from single country suppliers have an average elasticity of 2.93. The aggregate elasticity is estimated to be 4.04.

The quantification suggests that the heterogeneity in the responses could be masked under a single elasticity that is in the ballpark of the ”micro” elasticities described in Feenstra et al. (2018). The model allows us to understand how does the heterogeneity in the network shape the aggregate outcomes. Table 3 shows a variance decomposition of the quantity changes into different channels of substitution for non-Chinese varieties. The first column indicates the amount of substitution that occurred due to the average price increase triggered by the policy. The second column shows the percentage of the price increase that occurs due to the simultaneous sourcing of the importer from many countries. The third column represents the amount of substitution explained due to sourcing from a multinational supplier. In the aggregate, each channel explained about one third of total substitution.

For different types of connections, the channels played very different roles. The first row shows that for connections with multinational suppliers, the vast majority of their increase in quantity is due to the multinational connection. This means that the quantity they ”stole” from other connections is not more important than the shift within the connection. In particular, becoming a relatively cheaper option than other suppliers within the same importer is not much more relevant than becoming cheaper than other importers. Taking a look at the initial prices in the summary stats of Table 1 might explain why this happens. The products sourced from multinational suppliers were initially more expensive in every origin. The consumption of tires from single-country producers, which is initially cheaper, does not switch to the more expensive option in large magnitudes. The most likely explanation for this pattern it that consumers consider the varieties with same brand as closer substitutes, regardless of the origin. This is exactly what the model picks up with its nesting structure, and reflected in the switching quantification. In turn, for varieties sourced from single-country suppliers, the second row shows that the effect is similar for both of its available channels. Overall, the substitution explained by the simultaneous presence of an importer in multiple countries does not seem to play a major role on its own right. Rather, it is the multinational presence of suppliers that larger substitution.

Using the model we can also calculate counterfactual scenarios, where the networks do not feature multinational producers or importers simultaneously sourcing from different countries. To do this, I consider the same set of importers and suppliers observed in the data, but if a supplier is multinational, I regard it as two different suppliers, one in each origin. The same treatment applies for importers when I consider the network without multi-origin sourcing by importers. For these alternative network structures the overall elasticity is substantially lower, given that the additional channels in (4.11) no longer play a role for substitution. Therefore, the more rigid structure results in larger price increases, compared to the relatively flexible observed network. Findings for this exercise are in Table 4.

With the observed network, 75% of the quantity that was initially imported from China is replaced with imports from the rest of the world. The average price increase associated with this level of substitution is of 9%. The second and third rows of Table 4 show the results of the simulation for the alternative networks. The largest impact comes from splitting the multinational suppliers. Under this scenario, 58.7% of the quantity imported form China is replaced and as a consequence the average price increases 17% which is almost double the price increase with the original network. If we additionally split multi-origin importers, the quantity replaced drops to 47.4% and prices increase 21%. This is a relatively smaller drop than for the first comparison, and the price increase is not dramatically higher.

There is an important lesson to learn from these results about the consequences of ignoring the network structure for policy predictions. The elasticity estimates show that the aggregate elasticity masks substantial heterogeneity in the responses to policy. Therefore, when the underlying network is changes, there will be a large bias if we make predictions using just the aggregate elasticity. From the simulations, we learn that these predictions would largely underestimate the impacts on prices in the absence of multinationals. For the exercise performed in this study, we would predict a price increase of just half of the actual increase.

7 Conclusion

Using the case of an antidumping duty for the tire industry in Colombia, I study the effects of trade policy on import reallocation and aggregate prices. In doing so, this paper addresses two challenges facing the recent literature on trade policy. First, it shows direct evidence that there are different supply-chain structures within a narrowly defined industry, and that this heterogeneity shapes the response to trade policy. In particular, the range of distinct supply-chains is determined by whether a foreign supplier exhibits multinational presence or not. Second, it develops a framework that structurally links multinational activity with trade elasticities.

The antidumping adopted by Colombia triggered a reallocation of imports, where Chinese tires where almost fully replaced by tires from other origins. I argue that multinational production is a key driver of this substitution across origins. To do so, I exploit the full network of Colombian buyer with global sellers in the tire industry. Sellers that manufacture and send their tires from multiple origins capture the bulk of the reallocation. From the buyers' side, there is variation in the state of their connections (i.e. portfolio of suppliers) when policy materializes, which is used to identify the structural elasticity parameters.

Reallocation across origins has become important to properly study the role of global value chains in events such as the US-China trade war and similar trade remedies, or disrupting episodes like Covid-19. The tire industry offers a good environment to portray their role. In this industry, several countries apart from Colombia have incurred in the use of trade remedies. In particular, the US imposed antidumping measures against China in 2015, and after a sunset review not only the measure was renewed in 2020 but also new antidumping duties were imposed to South Korea, Taiwan, Thailand and Vietnam. Further, the US antidumping in this industry involves one of the largest amounts of foreign suppliers receiving a 'separate rate' treatment, hinting on the importance of within-industry heterogeneity for the policy outcomes.

The heterogeneous effects of trade policy I identify also point to questions for future research. In this paper I have focused on the state of buyer-seller connections across origins. This focus allows for a short-run analysis as the network structure provides different reallocation channels with varying intensities. However, important questions remain regarding the network formation implications of trade policy. As much of the reallocation is guided by multinationals, such research will need to take into account the effects of trade policy on foreign investments by Chinese firms and the changes these will trigger on global value chains.

References

[1] Amiti, M., S. J. Redding, and D. E. Weinstein 2019, "The impact of the 2018 tariffs on prices and welfare," Journal of Economic Perspectives, 33, 187–210.

[2] Armington, P. S. 1969. "A Theory of Demand for Products Distinguished by Place of Production". Staff Papers (International Monetary Fund), 16(1), 159–178.

[3] Bekkers, Eddy and Sofia Schroeter. 2020. "An economic analysis of the US-China trade conflict". WTO staff working paper ERSD-2020-04, march 19

[4] Benguria, Felipe, 2014 "Production and Distribution of International Trade: Evidence from Matched Exporter-Importer Data,"

[5] Blanchard, Emily J. and Santos-Paulino, Amelia U. and Trentini, Claudia and Milet, Emanuel, 2021, "Implications of Rising Trade Tensions for FDI Projects". Transnational Corporations Journal, Vol. 28, No. 2, 2021

[6] Blonigen, Bruce A. 2002. "Tariff-Jumping Antidumping Duties." Journal of International Economics

[7] Blum, Bernardo S., Sebastian Claro, and Ignatius Horstmann, 2010. "Facts and Figures on Intermediated Trade," American Economic Review

[8] Blum, Bernardo S., Sebastian Claro, and Ignatius Horstmann, 2012. "Import Intermediaries and Trade Costs: Theory and Evidence", mimeo

[9] Bown, C. P., P. Conconi, A. Erbahar, and L. Trimarchi 2021, "Trade protection along supply chains," Tech. rep., CEPR Discussion Paper No. DP15648.

[10] Card, David and Krueger, Alan B. 1994 "Minimum Wages and Employment: A Case Study of the Fast-Food Industry in New Jersey and Pennsylvania." American Economic Review, 84(4), pp. 772–93.

[11] Coşar, A.K., Grieco, P.L., Li, S. and Tintelnot, F., 2018. “What drives home market advantage?”. Journal of international economics, 110, pp.135-150.

[12] Dragusanu, Raluca, 2014. “Firm-to-Firm Matching along the Global Supply Chain,” Harvard University working paper

[13] Eaton, Jonathan, Marcela Eslava, David Jinkins, C. J. Krizan, and James Tybout, 2014. “A Search and Learning Model of Export Dynamics,” Society for Economic Dynamics 2015 meeting paper

[14] Eaton, Jonathan, James Tybout, David Jinkins and Daniel Yi Xu, 2016. ”Two-sided Search in International Markets,” 2016 Meeting Papers 973, Society for Economic Dynamics.

[15] Ekholm, Karolina, Rikard Forslid, and James R. Markusen. 2007. “Export-Platform Foreign Direct Investment.” Journal of the European Economic Association

[16] Fajgelbaum PD, Khandelwal AK. 2021. The Economic Impacts of the Trade War. Annu. Rev. Econ. 3: Submitted. DOI: 10.1146/annurev-economics-051420-110410.

[17] Fajgelbaum, P. D., Goldberg, P. K., Kennedy, P. J., Khandelwal, A. K., 2020. “The return to protectionism”. The Quarterly Journal of Economics, 135(1), 1-55

[18] Feenstra, Robert C. Philip Luck Maurice Obstfeld Katheryn N. Russ, 2018. ”In Search of the Armington Elasticity,” The Review of Economics and Statistics, MIT Press, vol. 100(1), pages 135-150

[19] Flaaen, A., Hortaçsu, A. and Tintelnot, F., 2020. The production relocation and price effects of US trade policy: the case of washing machines. American Economic Review

[20] Gereffi, Gary, Hyun-Chin Lim and JoonKoo Lee (2021). "Trade policies, firm strategies, and adaptive reconfigurations of global value chains", Journal of International Business Policy

[21] Goldberg, P.K., 1995. "Product differentiation and oligopoly in international markets: The case of the US automobile industry". Econometrica: Journal of the Econometric Society, pp.891-951.

[22] Head, K. and Mayer, T., 2019. "Brands in motion: How frictions shape multinational production". American Economic Review, 109(9), pp.3073-3124.

[23] Helpman, Elhanan, Marc J. Melitz, and Stephen R. Yeaple. 2004. "Export versus FDI with Heterogeneous Firms." American Economic Review

[24] Horstmann, Ignatius J., and James R. Markusen. 1992. "Endogenous Market Structures in International Trade." Journal of International Economics

[25] Huneeus, F., 2018. Production network dynamics and the propagation of shocks. Graduate thesis, Princeton University, Princeton, NJ.

[26] Wen-jen Hsieh, 2020, "Implications of the U.S.–China Trade War for Taiwan". Asian Economic Papers; 19 (1): 61–81

[27] Lim, K., 2017. Firm-to-firm trade in sticky production networks. In 2017 Meeting Papers (Vol. 280). Society for Economic Dynamics.

[28] Moeller, Joergen O. 2018. "US-China trade war: opportunities and risks for Southeast Asia", ISEAS Perspective, 2018 (64), 16 October (Singapore: ISEAS Yusof Ishak Institute).

[29] Monarch, Ryan, 2013 "It's Not You, It's Me: Breakups in U.S.-China Trade Relationships," Center for Economic Studies working paper CESWP-14-08

[30] Nicita, A., 2019. "Trade and trade diversion effects of United States tariffs on China". United Nations.

[31] Pangestu, Mari 2019. China–US trade War: an Indonesian perspective. China Economic Journal, 12 (2), pp.208–230.

[32] Sugita, Yoichi, Kensuke Teshima, and Enrique Siera, 2014. "Assortative Matching of Exporters and Importers," Research Institute of Economy, Trade and Industry discussion paper 17016

[33] Tham, Siew Y., Andrew K.J. Yi and Tee B. Ann 2019. "US-China trade war: potential trade and investment spillovers into Malaysia", Asian Economic Papers, 18 (3), pp. 117–135.

[34] Tintelnot, Felix. 2017. "Global Production with Export Platforms." Quarterly Journal of Economics

[35] Yeaple, Stephen R. 2003. "The Complex Integration Strategies of Multinationals and Cross Country Dependencies in the Structure of Foreign Direct Investment." Journal of International Economics

Tables

Table 1: Summaty Statistics

Type of connection	China			Rest of the World		
Importer sources from many countries	Freq.	Price	Quantity (MM)	Freq.	Price	Quantity (MM)
Multinational Production Supplier	16	4.12	0.395	16	4.81	0.994
		(0.54)	(0.419)		(0.37)	(1.013)
Single-Country Supplier	79	3.76	0.211	40	4.53	0.602
		(0.36)	(0.297)		(0.77)	(1.171)
Importer sources from a single country	Freq.	Price	Quantity (MM)	Freq.	Price	Quantity (MM)
Single-Country Supplier	42	3.75	0.108	-	-	-
		(0.53)	(0.174)			

Table 2: Estimated parameter values

	OLS	IV		IV	GMM	Elasticity governs substitution
$-\kappa$	-6.139***	-6.799***	κ	6.7	8	Varieties with same importer and supplier
	(1.534)	(1.139)				
$\kappa - \rho$	3.513***	4.521***	ρ	2.2	3.3	Varieties with the same importer
	(1.48)	(1.51)				
$\rho - \sigma$	1.587***	1.392	σ	0.88	1.9	All varieties
	(0.743)	(0.773)				

Table 3: Decomposition

	$(\sigma-1)\hat{P}$	$(\rho-\sigma)\hat{p}_i$	$(\kappa-\rho)\hat{p}_{ij}$	Varieties
Multinational	23%	28%	49%	16
Not Multinational	59%	41%	-	40
Aggregate	35%	32.5%	32.5%	56

Table 4: Counterfactuals

	Relocation Percentage	Change in Average Price
Baseline	75%	9%
Network without Multinational Suppliers (MS)	58.7%	17%
Network w/neither MS nor simultaneous sourcing	47.4%	21%

Figures

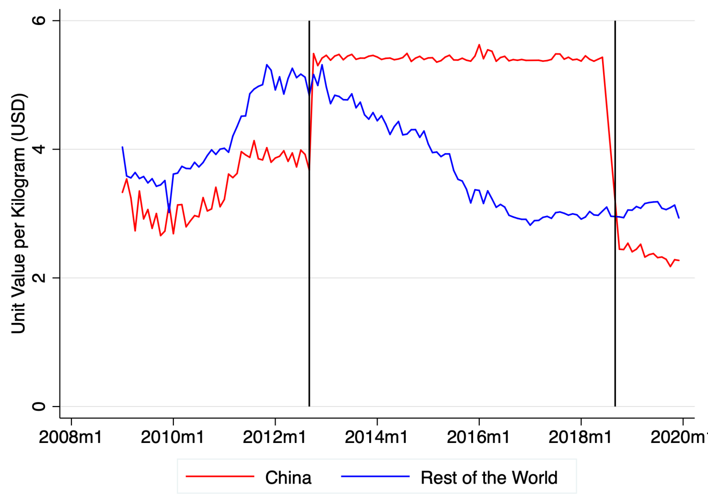

Figure 1: Average price of Colombian imports of truck tires, by origin

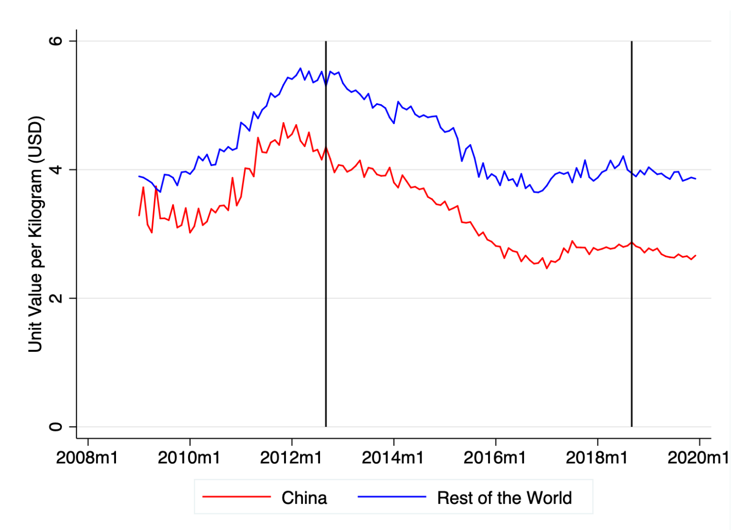

Figure 2: Average price of Colombian imports of passenger-car tires, by origin

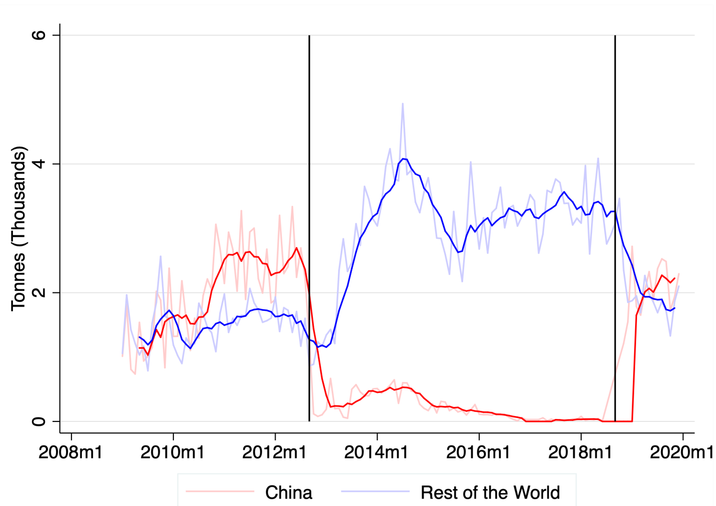

Figure 3: Total volume of Colombian imports of truck tires, by origin

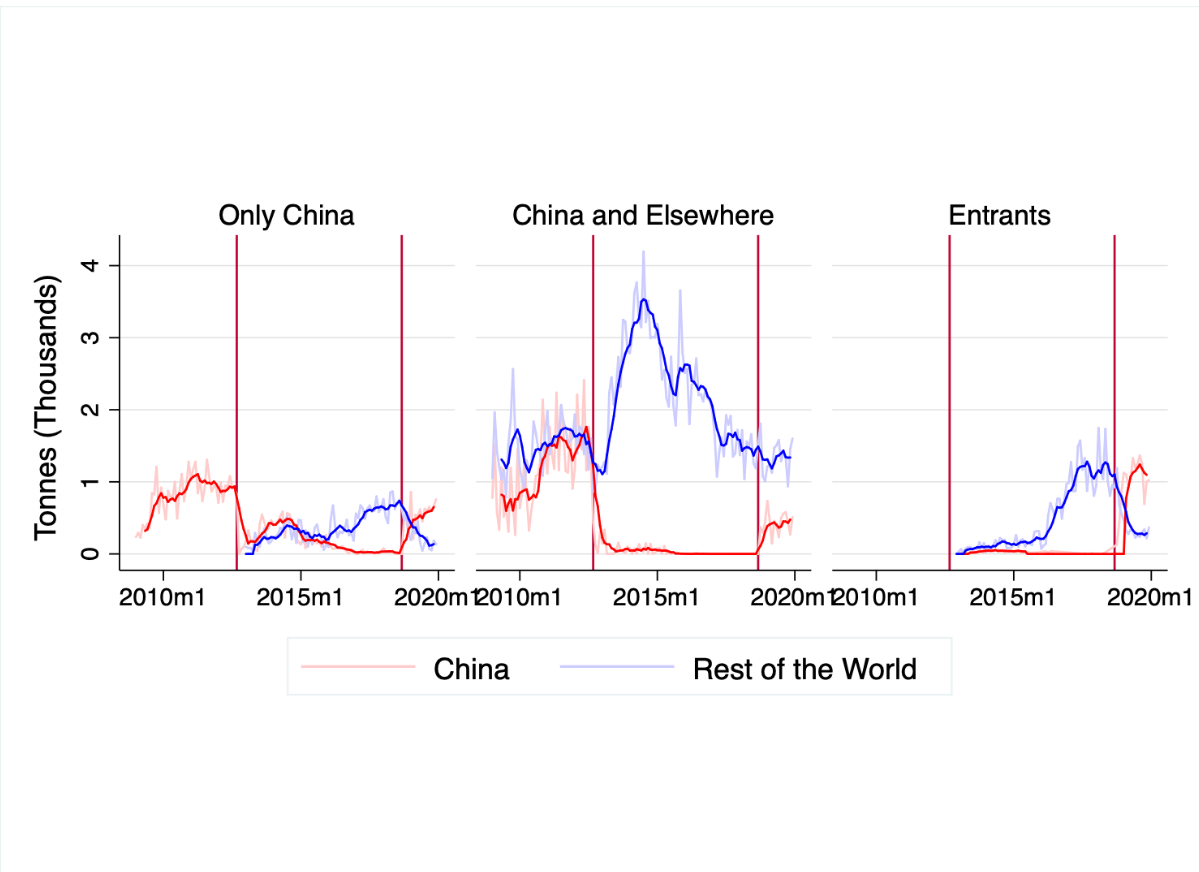

Figure 4: Total volume of Colombian imports of truck tires, by origin. Panels are defined by importer's pre-policy sourcing status

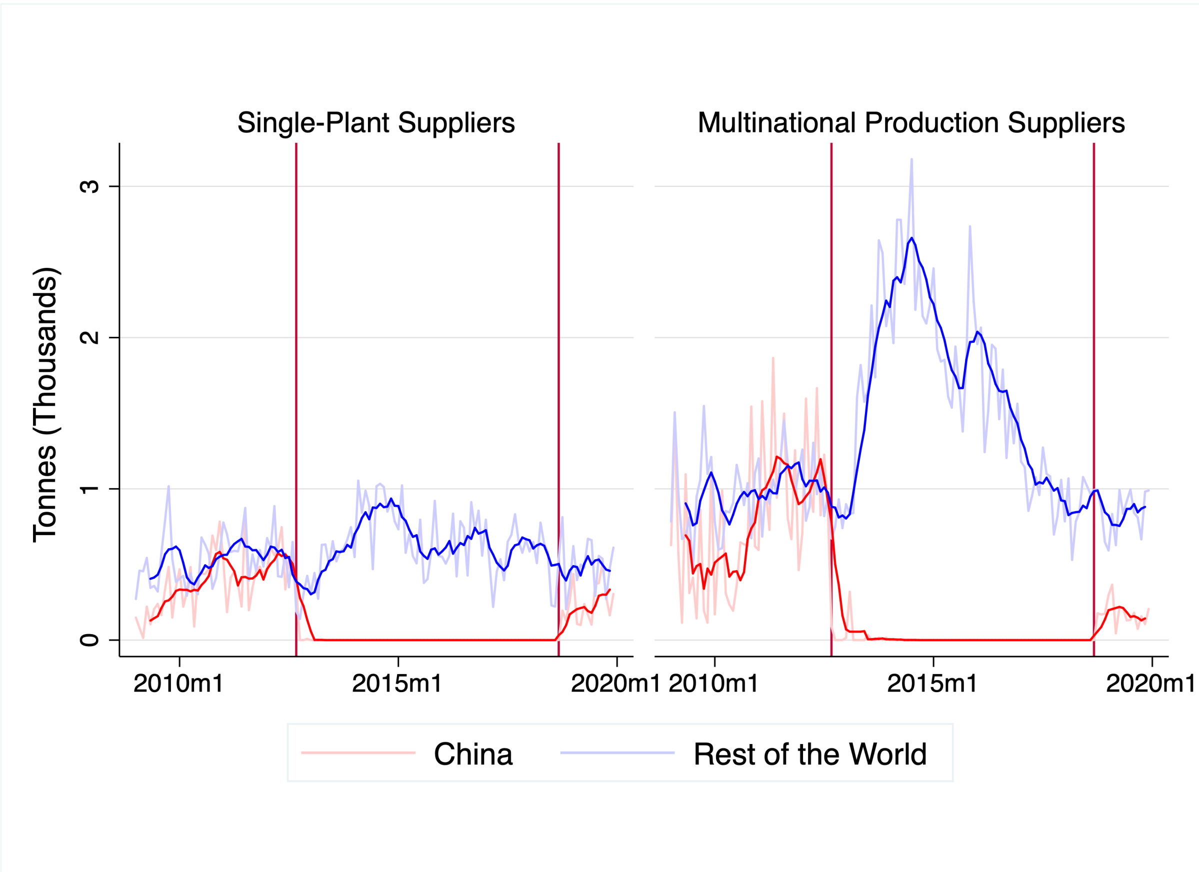

Figure 5: Total volume of Colombian imports of truck tires, by origin for importers with a simultaneous origins sourcing strategy. Panel A: Different suppliers, Panel B: Same supplier

Appendix

1 Price Indexes, Non-linearities and Exit

To construct the log changes of price indexes in (5.1) we have to use the elasticity parameters. The expressions for the exact price indexes are

$$\Delta \ln p_{ij} = \frac{1}{1-\kappa} \ln \left(\sum_{o \in O_{ij}} s_{ijo} e^{(1-\kappa)\Delta \ln p_{ijo} + (1-\kappa)\Delta \ln a_{ijo}} \right) \tag{1.1}$$

$$\Delta \ln P_i = \frac{1}{1-\rho} \ln \left(\sum_{j \in J_i} S_{ij} e^{(1-\rho)\Delta \ln p_{ij}} \right) \tag{1.2}$$

Plugging-in (1.1) and (1.2) in (5.1), would make the equation become non-linear both in the log-changes and parameters. This non-linearity can avoided for the estimation of the parameters. To do this, one would ideally estimate κ first without the need of computing any price indexes. The elasticity κ can be identified using the price changes induced by the policy at the variety level and the instrument (5.3). From (5.1) we can rewrite an estimating equation as follows

$$\Delta \ln y_{ijo} = \alpha + \delta_i + \delta_{ij} - \kappa \, \Delta \ln p_{ijo} + \Delta \ln a_{ijo} \tag{1.3}$$

where the parameters $\delta_i = (\rho - \sigma)\Delta \ln P_i$ and $\delta_{ij} = (\kappa - \rho)\Delta \ln p_{ij}$ are importer and importer-supplier fixed effects respectively and α is a constant that picks up the aggregate effects on imports. Once κ is estimated, $\Delta \ln p_{ij}$ can be constructed according to (1.1). Elasticity parameters ρ and σ can be recovered by aggregating and repeating the procedure for upper tier nests.

However, when a Chinese variety exits, the fixed effect δ_{ij} will not pick up the average price effect within an importer-supplier connection. Take the case of a Chinese and a Korean variety with the same importer i and supplier j. If the Chinese variety represents a missing value in the estimation, then the only observation corresponding to δ_{ij} is the Korean variety. Hence, the fixed effect coefficient does not reflect that overall ij varieties are more expensive, so that the Korean variety is now relatively cheaper. Hence, using the fixed effects specification is not possible when most (or all for some nests) Chinese varieties exit.

The consequence is that price indexes must be used each as a separate regressor to estimate all parameters simultaneously. To construct the price indexes, the exit of Chinese varieties is also a problem: There is no realization of the price change for the exiting varieties. This is illustrated in the following tables

Variety	origin	importer	supplier	Status	Pre Price	Post Price	price floor
1	Korea	A	B	Continuing	4.7	4.7	-
2	China	A	B	Dropped	4.1	MISSING	5.3

Variety	Δln y	Δln pijo	Δln pij	ln Pi
1	0.7	0	MISSING	MISSING
2	MISSING	MISSING	MISSING	MISSING

The solution is to use the Feenstra correction method. Equation (1.4) shows how to re-write the price index (4.6) to obtain (5.6)

$$
\begin{aligned}
p_{ij} &= \left[\sum_{o\in O_{ij}} a_{ijo} p_{ijo}^{1-\kappa}\right]^{\frac{1}{1-\kappa}} \\
&= \left[\sum_{o\in O_{ij}} \frac{p_{ijo} y_{ijo}}{y_{ij} p_{ij}^{\kappa}}\right]^{\frac{1}{1-\kappa}} \\
&= \left[\frac{\sum_{o\in O_{ij}} p_{ijo} y_{ijo}}{y_{ij} p_{ij}^{\kappa}} \frac{\sum_{o\in C(O)_{ij}} p_{ijo} y_{ijo}}{\sum_{o\in C(O)_{ij}} p_{ijo} y_{ijo}}\right]^{\frac{1}{1-\kappa}} \\
&= \left[\sum_{o\in C(O)_{ij}} \frac{p_{ijo} y_{ijo}}{y_{ij} p_{ij}^{\kappa}} \frac{\sum_{o\in O_{ij}} p_{ijo} y_{ijo}}{\sum_{o\in C(O)_{ij}} p_{ijo} y_{ijo}}\right]^{\frac{1}{1-\kappa}} \\
&= \left[\sum_{o\in C(O_{ij})} a_{ijo} p_{ijo}^{1-\kappa} \frac{1}{S(C(O_{ij}))}\right]^{\frac{1}{1-\kappa}}
\end{aligned}
\tag{1.4}
$$

where the second and last lines use (4.9).

An alternative to using the Feenstra correction method is to construct the price indexes with a proxy for the change in price of Chinese varieties. I construct the ad-hoc proxies for the price indexes and estimate the elasticity parameters using least squares. The results are reported in table 2, together with the main -GMM- specification.

2 GMM

The specification in (5.8) has the unobserved component $\hat{a}_{ijo}$, which not only shows up directly, but also indirectly through the price indexes. In equation (2.1) the vector of quantity changes in the left-hand-side is written as a linear function of all price changes, all exit correction terms and all unobserved demand components.

$$\overrightarrow{\hat{y}} = \mathcal{N}\,\overrightarrow{\hat{z}} + \Theta^I\,\overrightarrow{\hat{S}}(C(I)) + \Theta^J\,\overrightarrow{\hat{S}}(C(J)) + \Theta^O\,\overrightarrow{\hat{S}}(C(O)) + \xi\,\overrightarrow{\hat{a}} \tag{2.1}$$

Note that the change in the unobserved component is, by construction, part of every price index. Hence, in the matrix representation of the estimating equation, the error inherits the network structure imposed by the nesting layers that characterize demand. The matrices on the right-hand-side only depend on the pre-policy market shares and parameters. Their structure is shown in equations (2.2) to (2.6)

$$\begin{aligned} \mathcal{N}_{\omega\omega'} = \; & (\sigma-1)\;\mathbb{S}_{\omega'}S_{\omega'}s_{\omega'} \\ & + (\rho-\sigma)\;S_{\omega'}s_{\omega'}\;\mathbb{I}(i=i') \\ & + (\kappa-\rho)\;\;s_{\omega'}\;\mathbb{I}(i=i',j=j') \\ & - \kappa\;\;\mathbb{I}(\omega=\omega') \end{aligned} \tag{2.2}$$

$$\begin{aligned} \Theta^O_{\omega\omega'} = \; & -\frac{\sigma-1}{1-\kappa}\;\mathbb{S}_{\omega'}S_{\omega'}s_{\omega'} \\ & + \frac{\sigma-\rho}{1-\kappa}\;S_{\omega'}s_{\omega'}\;\mathbb{I}(i=i') \\ & + \frac{\rho-\kappa}{1-\kappa}\;s_{\omega'}\;\mathbb{I}(i=i',j=j') \end{aligned} \tag{2.3}$$

$$\begin{aligned} \Theta^J_{\omega\omega'} = \; & -\frac{\sigma-1}{1-\rho}\;\mathbb{S}_{\omega'}S_{\omega'}s_{\omega'} \\ & + \frac{\sigma-\rho}{1-\rho}\;S_{\omega'}s_{\omega'}\;\mathbb{I}(i=i') \end{aligned} \tag{2.4}$$

$$\Theta^I_{\omega\omega'} = \mathbb{S}_{\omega'} S_{\omega'} s_{\omega'} \tag{2.5}$$

$$\begin{aligned}
\xi_{\omega\omega'} = \ & \frac{\sigma-1}{1-\kappa}\,\mathbb{S}_{\omega'} S_{\omega'} s_{\omega'} \\
& + \frac{\rho-\sigma}{1-\kappa}\, S_{\omega'} s_{\omega'}\ \mathbb{I}(i=i') \\
& + \frac{\kappa-\rho}{1-\kappa}\, s_{\omega'}\ \mathbb{I}(i=i', j=j') \\
& + \mathbb{I}(\omega=\omega')
\end{aligned} \tag{2.6}$$

From these structure, we get that every observation in (5.8) has an error

$$\hat{\epsilon_{ijo}} = \hat{a_{ijo}} + \frac{\kappa-\rho}{1-\kappa}\sum s_{ijo}\hat{a_{ijo}} + \frac{\rho-\sigma}{1-\kappa}\sum\sum s_{ij}s_{ijo}\hat{a_{ijo}} + \frac{\sigma-1}{1-\kappa}\sum\sum\sum S_i s_{ij} s_{ijo}\hat{a_{ijo}} \tag{2.7}$$

The relevant moment conditions for GMM estimation is

$$E\left[Z'\epsilon_{ijo}\right] = 0 \tag{2.8}$$

where Z is the set of instruments. Under the assumption that the changes in $\hat{a}_{ijo}$ are uncorrelated with the gap between pre policy prices and the price floor, we have

$$\begin{aligned}
E\left[\hat{\epsilon_{ijo}}|Z\right] &= E\left[\hat{a_{ijo}}|Z\right] \\
&+ \frac{\kappa-\rho}{1-\kappa}\sum s_{ijo}E\left[\hat{a_{ijo}}|Z\right] \\
&+ \frac{\rho-\sigma}{1-\kappa}\sum\sum s_{ij}s_{ijo}E\left[\hat{a_{ijo}}|Z\right] \\
&+ \frac{\sigma-1}{1-\kappa}\sum\sum\sum S_i s_{ij}s_{ijo}E\left[\hat{a_{ijo}}|Z\right] \\
&= E\left[\hat{a_{ijo}}|Z\right]\left(1 - \frac{1}{1-\kappa} + \frac{\kappa}{1-\kappa}\right) \\
&= 0
\end{aligned} \tag{2.9}$$