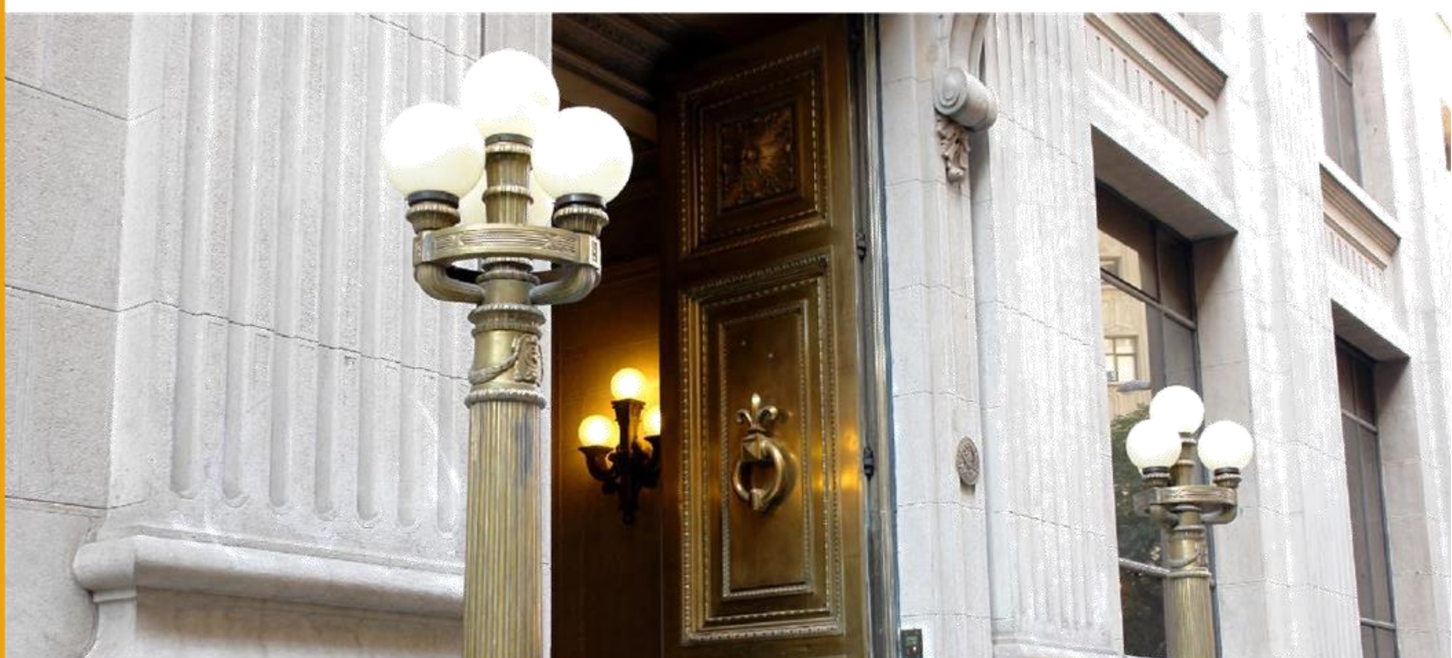
DOCUMENTOS DE TRABAJO

Trade Policy and Reallocation: Multinational vs. Single-Country Linkages in the Tire Industry

Brian Pustilnik

N° 1009 Marzo 2024

BANCO CENTRAL DE CHILE



banco central Chile

Documentos de Trabajo del Banco Central de Chile
Working Papers of the Central Bank of Chile
Agustinas 1180, Santiago, Chile
Teléfono: (56-2) 3882475; Fax: (56-2) 38822311

Documento de Trabajo N° 1009

Working Paper N° 1009

Trade Policy and Reallocation: Multinational vs. Single-Country Linkages in the Tire Industry*

Brian Pustilnik†
Central Bank of Chile

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 suppliers. I study an antidumping duty imposed by Colombia on the imports of Chinese truck tires. I observe the full network of Colombian importers and their foreign suppliers. More importantly, plant location data shows that a few suppliers engage in multinational production, while most suppliers produce in only one country. Due to the policy, approximately 75% of Chinese tire imports were replaced with those from other origins, predominantly involving multinational suppliers in a diverse array of interactions. I estimate a quantitative trade framework to match the reallocation and price changes in the data. The model isolates three distinct channels of reallocation, influenced by connections with multinational suppliers and other complex market dynamics. This nuanced approach reveals that traditional reduced-form strategies to quantify reallocation may overlook these channels, potentially skewing welfare effect predictions of tariff -and similar- shocks.

Resumen

Los efectos de las barreras comerciales en el bienestar están determinados por el impacto que tienen en las cantidades comerciadas y en los precios. Al nivel de las empresas importadoras, estos resultados dependen de su red de proveedores, diferenciando entre proveedores multinacionales y proveedores de un solo país. En este artículo, estudio el caso de un derecho antidumping impuesto por Colombia a las importaciones de neumáticos de camión chinos. Utilizando microdatos de aduanas, observo las redes de importadores colombianos con sus proveedores en todo el mundo. Algunos proveedores se dedican a la producción multinacional, mientras que la mayoría de los proveedores producen en un solo país; mayoritariamente China. Ante la barrera impuesta por Colombia, aproximadamente el 75% de las importaciones de neumáticos chinos fueron sustituidos por neumáticos de otros orígenes. La sustitución fue liderada por redes que involucraban a proveedores multinacionales. Estimando un modelo cuantitativo de comercio, identifico tres canales de sustitución, diferenciados por la flexibilidad que caracteriza a la red. Finalmente, discuto que las estrategias tradicionales para cuantificar la sustitución de orígenes suelen ignorar algunos de estos canales, sesgando el análisis sobre los efectos de las barreras comerciales en el bienestar.

*Previously circulated as Trade Policy on a Buyer-Seller Network.

†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, Kirill Ponomarev, Diego Zuñiga 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. The views expressed are those of the author and do not necessarily represent the views of the Central Bank of Chile or its board members. Email: bpustilnik@bcentral.cl

1 Introduction

The effect of trade policy on international supply chains has received 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 the alternatives are to undo or ease the effects of the disruption. This is especially true for the use of unilateral trade remedies. Imposing tariffs on individual countries always allows for the possibility of changing the origin of imports to undo the effects of the tariff. Moreover, this type of unilateral policy is 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 of measuring the impact of the US-China trade war, is to account for how imports from other countries could ease the effects of tariffs on 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 intensity of substitution. 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 the connection between importing firms with multinational suppliers is for the impact of trade policy.

In this paper I show that the structure of connections between importing firms and their foreign suppliers determine the price and allocation effects of trade barriers. When a tariff is imposed on products of a specific origin, strategies adopted by importers to source from alternative origins are diverse. This diversity relies on the possibilities that each importer faces, given their current network of supplier connections. For instance, a network that is dense with multinational suppliers might allow for a more flexible substitution strategy, compared to a network with few multinational suppliers.

A particular policy event allows me to study the effects of trade barriers conditional on the structure of connections. In October of 2012, the Colombian government introduced minimum price restrictions on Chinese truck tires imports[1]. 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.

I focus on the difference between connections with multinational production suppliers and connections with single-origin suppliers. Reallocation for multinational-linked imports cannot be straightforwardly attributed solely to the 'multinational' nature of the

[1] For a complete description of the case -in spanish- visit file D-215/20-58/59 of the Antidumping Investigations at the International Trade division of the Colombian Ministry of Trade, Industry and Tourism. The documentation used in this study was retrieved from the web portal https://www.mincit.gov.co/mincomercioexterior/defensa-comercial/dumping/investigaciones-antidumping-concluidas/llantas-radiales-y-convencionales-para-autobuses-o

suppliers. Several forces influence this process: the increased attractiveness of non-Chinese products due to higher Chinese prices, and the additional push for non-Chinese products already procured by importers of now pricier Chinese goods. The variation in types of supplier allows me to disentangle these intertwined effects. As a benchmark, Flaaen, Hortaçsu and Tintelnot (2020) study the imposition of antidumping duties for washing machines, and find that "country-hopping" was a successful strategy to undo the effect of the tariff. This strategy presumably occurs due to all suppliers being multinational producers (GE, SAMSUNG, etc.). However there is no point of comparison to determine the role of their multinational nature. Instead, in this paper the network composition allows me to identify different substitution intensities.

Often, this source of variation occurs within the same importer. One instance of this is depicted in Figure 1, where "Company X" (on the left), an importer, procures tires from multiple countries (in the center), thereby forming business relationships with a variety of suppliers (on the right). For instance, Khumo Tire Co (in pink/on the right) produces tires in both China and Korea, and sells these products to Company X. Other suppliers (in green/on the right) produce tires in just one location and, although they may sell smaller quantities, their combined sales constitute a significant proportion of Company X's total purchases. This research examines a policy that drastically inflates the cost of Chinese tires. The results highlight the crucial role of these buyer-seller connections in replacing Chinese tires with those from Korea and Mexico, among other places.

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

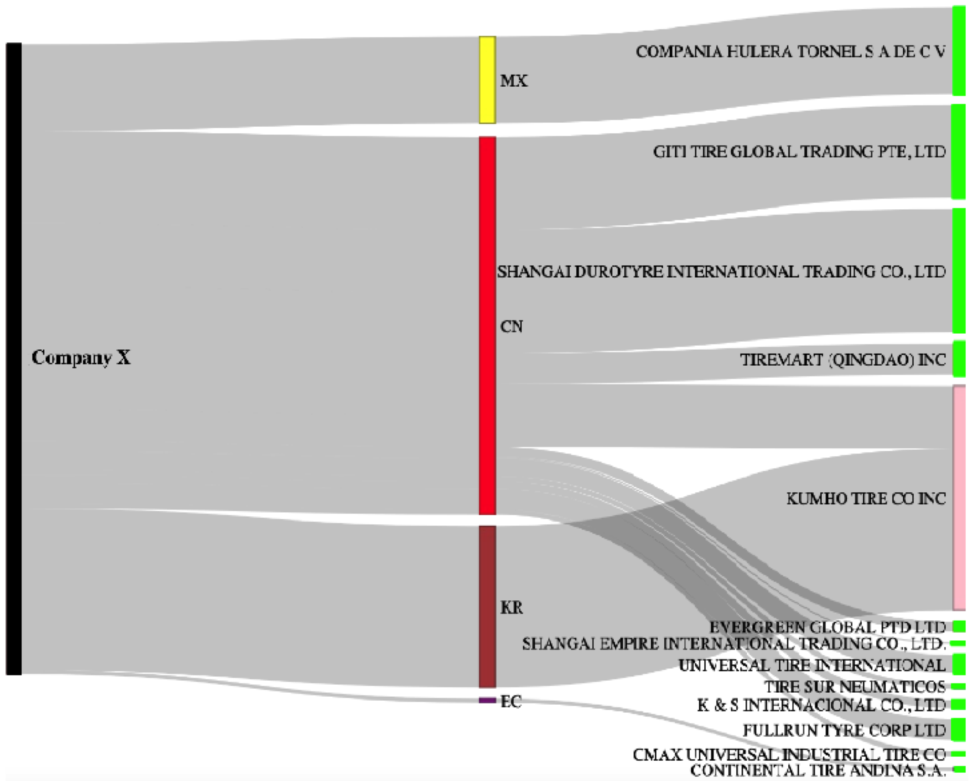


Figure 1: Company X's sourcing network structure

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 the two sides of importer-supplier relationships to understand the forces behind the observed patterns of substitution. On the importer side, the vast majority of reallocation is due to importers that prior to the policy procured simultaneously from multiple countries (regardless of the supplier identity). On the supplier side I find that, conditional on importers procuring from multiple countries, reallocation away from china is larger for firms connected to multinational production suppliers. In light of my empirical findings, I proceed to quantify different channels of reallocation.

I estimate a quantitative trade framework to perform the quantification accurately, given the high complexity of the network. Importers often have many connections, potentially with both types of suppliers. There is also substantial variation in pre-policy prices for Chinese tires, which condition the exposure of non-Chinese tires to the shock depending on the network connections. Finally, there is substantial exit of Chinese varieties in response to the policy. A reduced form approach would require controlling these nuances, which a model is better suited to capture simply through 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 country the importer is. 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 in the predictions of policy impacts relies 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[2]. 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 with the nests they belong to. This structure is designed to allow for

[2]The substitution I am interested in is related to 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.

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 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. The quantification suggests that simpler models could easily mask the heterogeneity and lead to biased predictions when they face a different network. The predictions in the absence of 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) and 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 focuses on the effects for global demands. A strand of research provides 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), shows that the production relocation of washing machines was effective in undoing the effects of tariffs. Along this line, several papers address the effect that the trade war had on bystander countries. These include Moeller (2018) for India, Pangestu (2019) for Indonesia, Tham et al. (2019) for Malasya and Hsieh (2020) for Taiwan. Finally, with a more general framework, Fajgelbaum et al. (2023) addresses the global reallocations effect of the war, identifying whether countries are substitutes or complements to the US and China.

Earlier literature on global production, multinationals and foreign direct investment, already addressed similar effects to global reallocations. Horstmann and Markusen (1992) and Blonigen (2002) show evidence of a tariff-jumping behavior in response to policy. Yeaple (2003), Helpman et al. (2004), Ekholm et al. (2007), Tintelnot (2017) and Conteduca et. al. (2018) provide frameworks where firms choose their production locations considering the structure of trade costs. More recently, a group of papers focused 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) focuses on the role of import intermediaries in linking small exporters and small customers. Monarch (2013) estimates the costs of switching 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") established 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.

At the same time, import competition from China began to take over the Colombian market. In response, both local manufacturers called for an antidumping investigation under file D-215/20-58/59 at the Colombian Ministry of Trade, Industry and Tourism. A price floor of $5.37 per kilo was imposed in October of 2012 for imports of truck tires manufactured in china. The unusual 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. All firm-level trade transactions are from Colombian Customs data[3]. 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 goods. This variables allow me to analyze a

[3]The data is available at the registry of import and export declarations of the Colombian customs authority Direccion de Impuestos y Aduanas Nacionales (DIAN). The publicly available data consists of digitized raw custom forms which are compiled in a spreadsheet prior to official validation. The registry is accessible through the "Dian - Cifras" menu from the web portal https://www.dian.gov.co/dian/. The data in this paper was retrieved from the url https://www.dian.gov.co/dian/cifras/Paginas/registrodeclaracionesimpoexponew.aspx

firm-to-firm trade framework using values and quantities traded at a very dissagregated level.

The second dataset, which is the novelty in the analysis, contains information on whether a supplier engages in multinational production or not. This information comes from several sources. First, the US Department of Transport establishes a series of codes for safety purposes, which all manufacturers that intend to sell in the US market must print on the tire's sidewall near the rim. The code is composed of the letters "DOT" followed by eight to thirteen characters that identify where the tire was manufactured and manufacturer's code, along with the week and year the tire was manufactured. Given the relative importance of the US market in the tire industry, all tire suppliers comply with this labeling rule for their export products. This is complemented by additional information to verify that truck tires are manufactured in a given facility as well as potential ownership changes, as reported either by the company (websites and -if available- annual reports) or from specialized industry magazines (Tire Business and Modern Tire Dealer).

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 and averages and standard deviations (in brackets) for unit values and quantities of these varieties.

3 Stylized Facts

This section introduces empirical evidence to support the importance of network connections on understanding policy outcomes. The evidence is presented with four stylized facts about the price and allocation effects of the policy. Throughout these facts, the policy is analyzed at different levels of aggregation including country-level, importer-level and

Table 1: Summary 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 (0.54)	0.395 (0.419)	16	4.81 (0.37)	0.994 (1.013)
Single-Country Supplier	79	3.76 (0.36)	0.211 (0.297)	40	4.53 (0.77)	0.602 (1.171)
Importer sources from a single country	Freq.	Price	Quantity (MM)	Freq.	Price	Quantity (MM)
Single-Country Supplier	42	3.75 (0.53)	0.108 (0.174)	-	-	-

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 (i.e. at the most disaggregated level).

In what follows, I will present my analysis of all companies in the study. Additional results for robustness, which involve figures for both large and small companies, will be found in the appendix. The appendix will also include figures displaying the total volume of Colombia's truck tire imports, combining all origins. The current analysis aims to illustrate the total imports by the origin of the product, highlighting how the policy has prompted a shift away from Chinese imports in favor of those from other countries.

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).

Fact 1: ***The policy materializes as a binding price floor on truck tires manufactured in China.***

Figure 2 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 for both goods sourced from China and those sourced 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. 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.

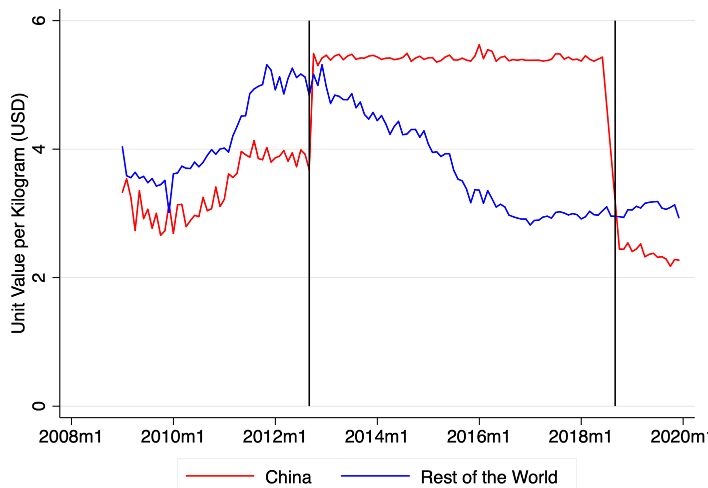


Figure 2: Average price of Colombian imports of truck tires, by origin

Evidence that prices for origins other than China follow a general trend comes from a control within the same industry. I show average import prices for passenger-car tire. Unlike truck tires, the latter were not subject to a policy. Figure 3 shows that passenger-car tire prices followed their natural trend regardless of the origin they were sourced from.

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

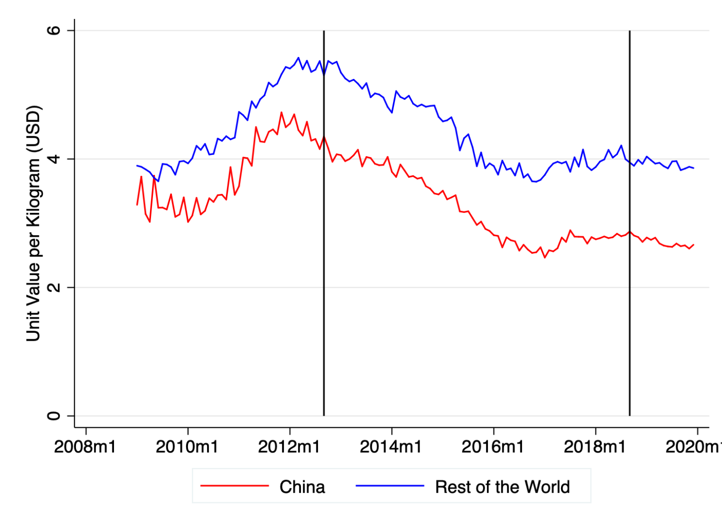


Figure 3: Average price of Colombian imports of passenger-car tires, by origin

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

***Fact 2:* 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 4. 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.

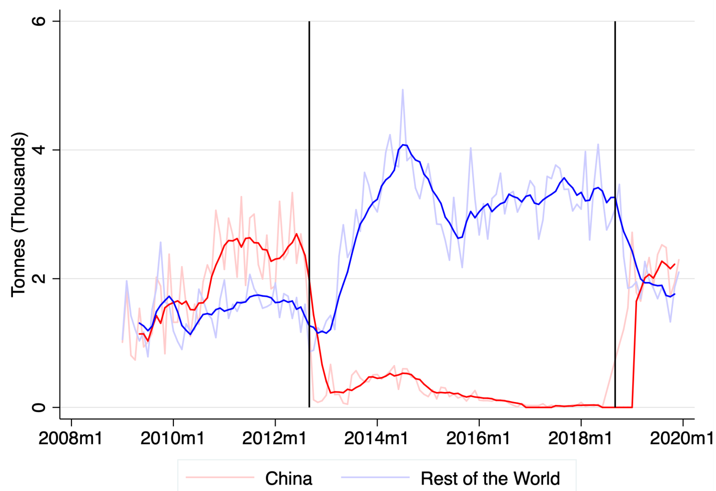


Figure 4: Total volume of Colombian imports of truck tires, by origin

At this stage, we would like to think about the extent to which the substitution pattern observed in Figure 4 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

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

I first look at the allocation effects for importers who were only sourcing their imports from China when the trade policy was enacted. In the left panel in Figure 5, 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.

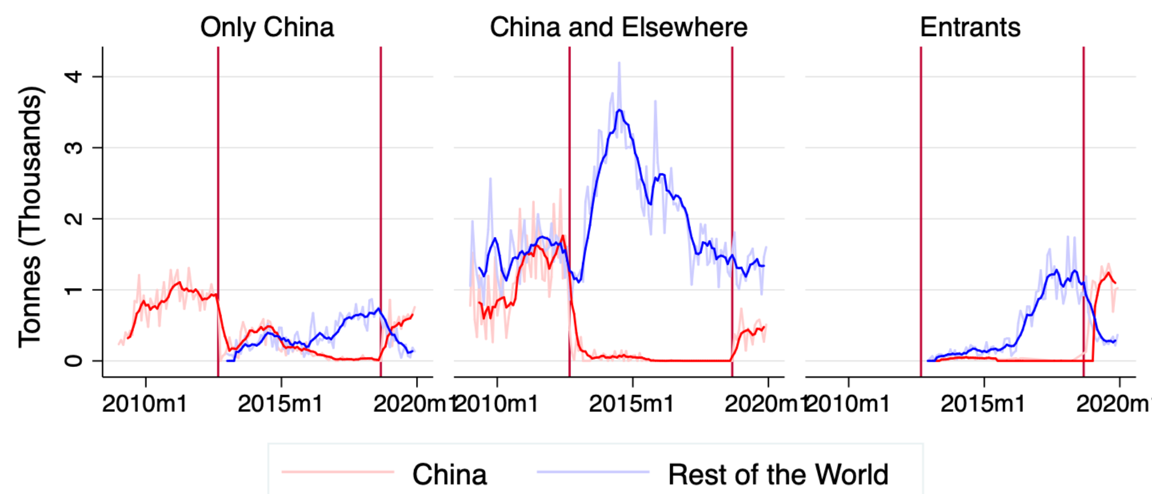


Figure 5: Total volume of Colombian imports of truck tires, by origin. Panels are defined by importer's pre-policy sourcing status

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 5 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. Moreover, their entry is delayed, which is consistent with the substitution across origins being conditioned by an importer's network of 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 *and* 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.

***Fact 4:* 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 whether it would have been the same as having separate suppliers in each origin.

I start by 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 6 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.

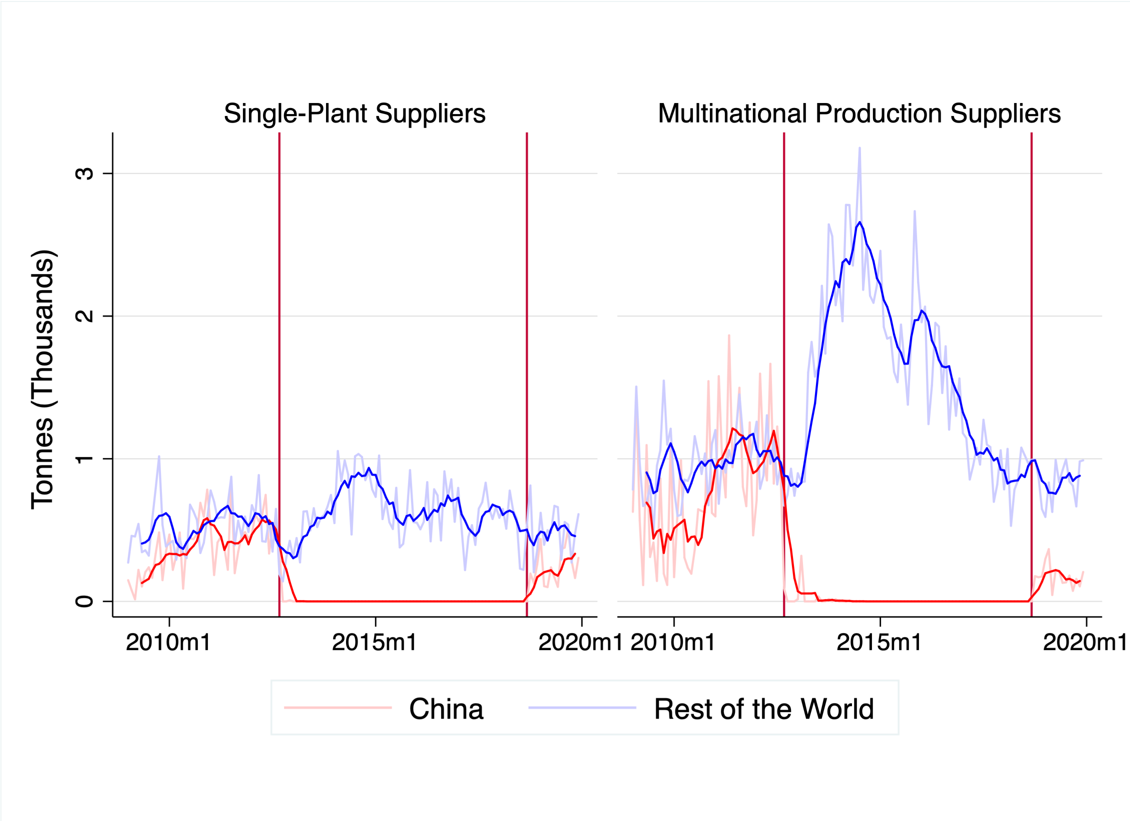


Figure 6: Total volume of Colombian imports of truck tires, by origin for importers with a simultaneous origins sourcing strategy. Panel A: Different suppliers, Panel B: Same supplier

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 networks to their structure.

Standard models of trade, the simplest being Armington (1969), consider a single elasticity of substitution between origins. Products from different origins are viewed as imperfect substitutes, and the quantity imported depends on the relative price compared to products from other origins. Using bilateral trade flows for many countries, such elasticity is estimated for different industries.

Simple models that can accurately reproduce country-level patterns, however, could mislead the analysis if such patterns are determined by substantial underlying heterogeneity. This is the case for the policy studied in this paper. When an importer's network of connections is crucial in granting access to alternative origins, there is loss of generality in the simple model's prediction for the country-level response.

4.2 A trade model with network connections

By conditioning the model on the network of importer-supplier connections, I improve the prediction on 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 things being equal, the nature of the connection makes these varieties less suitable substitutes, compared to the multinational 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 the price indexes 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 which 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.[4] 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

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

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 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 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.[5] Here the gap is also

[5] 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 2, 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.

a strong predictor of the actual changes in prices and price indexes.[6] 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.

The main caveat for the estimation of the linear specification is the exit of Chinese varieties. This can be seen in figures 5 and 6. With the importer-supplier connections 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 varieties that exit 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,

[6] 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 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.[7] In appendix 2 I show the details of two margins of the problem. First, I explain 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.[8]

[7] 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 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.

[8] 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.

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 2.

Consider the price index p_{ij} associated with the *bottom* nest, which aggregates the prices for varieties defined by importer i and multinational supplier j and origins China and Korea. The equation for this price index is

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

where the nest contains varieties from two origins, such that $O_{ij} = \{China, Korea\}$. Consider a case where initially, the Chinese variety has 25% of the market share within the nest of importer-supplier connection ij. The policy increases the price for the Chinese variety, but the price of the Korean variety does not change. As a result the Chinese variety exits. We can define $C(O_{ij})$ as the set of origins for continuing varieties within the set O_{ij}. In our example, as the only continuing variety is Korean, we have $C(O_{ij}) = \{Korea\}$. Additionally, define $S(C(O_{ij}))$ as the market share of continuing varieties within the bottom nest. The equation for this market share is

$$S(C(O_{ij})) = \frac{\sum_{o \in C(O_{ij})} p_{ijo} y_{ijo}}{\sum_{o \in O_{ij}} p_{ijo} y_{ijo}} \tag{5.7}$$

In this case, since the Korean variety is the only one that continues, and the Chinese variety had 25% of the market, this share is $S(C(O_{ij})) = 0.75$. With these objects defined, we can rewrite the price index using only varieties that continue in the market once the policy is in place

$$p_{ij} = \left[\sum_{o \in C(O_{ij})} a_{ijo} p_{ijo}^{1-\kappa} \frac{1}{S(C(O_{ij}))} \right]^{\frac{1}{1-\kappa}} \tag{5.8}$$

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 has 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 $\hat{x} \equiv \frac{dx}{x}$

$$\hat{y}_{ijo} = (\sigma - 1)\hat{P} - (\sigma - \rho)\hat{P}_i - (\rho - \kappa)\hat{p}_{ij} - \kappa \hat{p}_{ijo} + \hat{E} + \hat{a}_{ijo} \tag{5.9}$$

with

$$\hat{P} = \sum_{i \in I} \mathbb{S}_i^* \hat{P}_i - \frac{1}{1-\sigma} \hat{S}(C(I)) \tag{5.10}$$

$$\hat{P}_i = \sum_{j \in J_i} S_{ij}^* \hat{p}_{ij} - \frac{1}{1-\rho} \hat{S}(C(J_i)) \tag{5.11}$$

$$\hat{p}_{ij} = \sum_{o \in O_{ij}} s_{ijo}^* \hat{p}_{ijo} + \frac{1}{1-\kappa} \sum_{o \in O_{ij}} s_{ijo}^* \hat{a}_{ijo} - \frac{1}{1-\kappa} \hat{S}(C(O_{ij})) \tag{5.12}$$

$$\hat{p}_{ijo} = \hat{z}_{ijo} \tag{5.13}$$

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.[9]

In appendix 3, 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 structure, the price indexes in equations (5.10) to (5.12) have the additional components that correspond to the exit correction terms. Hence, instruments are required for both the weighted average of price changes and the correction terms in each price index. Consider once again the gap between the pre policy price and the price floor:

[9] 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.

$$\hat{p}^{IV}_{ijo} = \begin{cases} ln(5.37) - ln(z^{pre}_{ijo}) & \text{for Chinese varieties with } z^{pre}_{ijo} < 5.37. \\ 0 & \text{for other Chinese varieties} \\ 0 & \text{for non-Chinese varieties} \end{cases} \tag{5.14}$$

The instruments for the weighted averages of actual price changes, $\sum_{o\in O_{ij}} s^*_{ijo}\hat{p}_{ijo}$ and $\sum_{j\in J_i} S^*_{ij}\hat{p}_{ij}$ consist on replacing the price changes with the gap variable for each of the terms.

$$\sum_{o\in C(O_{ij})} s^*_{ijo}\hat{p}^{IV}_{ijo} \tag{5.15}$$

$$\sum_{j\in C(J_i)} S^*_{ij}\hat{p}^{IV}_{ij} \tag{5.16}$$

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:

$$\hat{S}(C(O_{ij}))^{IV} = s_{ij,china}\ \hat{p}^{IV}_{ij,china} \tag{5.17}$$

$$\hat{S}(C(J_i))^{IV} = \sum_{\{j/china\in O_{ij}\}} S_{ij}\ s_{ij,china}\ \hat{p}^{IV}_{ij,china} \tag{5.18}$$

The idea behind using 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 switching origins while keeping the same supplier, rather than switching 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.

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)				

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. Figure 7 shows a decomposition of the

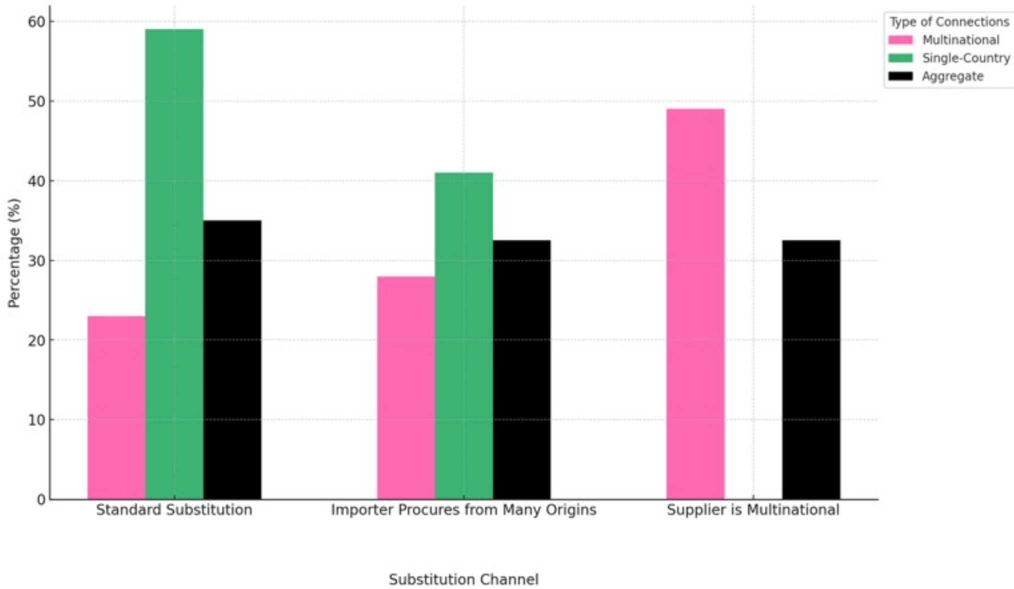


Figure 7: Decomposition of substitution into channels governed by different elasticity parameters, grouped by type of connection

quantity changes into channels of substitution that are defined by the nesting structure. Each of these channels is governed by the elasticity parameter used in the corresponding nest. The bars on the left indicate the amount of substitution that occurred due to the average price increase triggered by the policy. The middle set of bars correspond to the effect of simultaneously sourcing from many countries. Finally, bars on the right represent the share of the effect explained due to sourcing from a multinational supplier.

In the aggregate, each channel explained about one third of total substitution. However, for different types of connections, the channels played very different roles:

For multinational suppliers (in pink), the right bar indicates that almost half of their quantity increase in the rest of the world was due to the substitution of their own Chinese product, rather than stealing market share from other suppliers. This is particularly relevant given the massive exit of Chinese suppliers from the Colombian market once the policy was enacted. The other half is due to the substitution of other suppliers' products. The comparable sizes of the left and middle bars suggests that capturing market share is common both within the own network and from competitors outside that network. The slight prominence of the middle bar, however, hints at a residual network dependence after accounting for the multinational channel. In contrast, for single-country suppliers outside China (in green), the largest portion of effect is due to the substitution of varieties outside their network.

A glance at the initial prices in the summary stats of Table 1 might explain why this happens. Products sourced from multinational suppliers were initially more expensive in every origin. Despite being less expensive, single-country suppliers outside China are not a significant substitute for "already expensive" Chinese tires. It is likely then, that the brand plays a role in determining close substitutes, regardless of the origin. This is captured by the model with its nesting structure, and reflected in the consistent results for substitution channels' relevance.

There is an important lesson to learn from these results about the consequences of ignoring the network structure for policy predictions. The elasticity estimates, together with the decomposition into channels of substitution, show that the aggregate elasticity masks substantial heterogeneity in the responses to policy. Therefore, when the underlying network changes, there will be a large bias if we make predictions using just the aggregate elasticity.

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. 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 global value chains in the context of trade remedies such as the US-China trade war, or disrupting episodes like Covid-19. The tire industry offers a good environment to analyze their role. In this industry, several countries apart from Colombia have resorted to 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 of 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] Conteduca, F.P., Kazakova, E. (2018). The Structure of Multinational Sales under Demand Risk.

[12] 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.

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

[14] 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

[15] 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.

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

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

[18] 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

[19] Pablo Fajgelbaum, Pinelopi K. Goldberg, Patrick J. Kennedy, Amit Khandelwal, Daria Taglioni, 2023. ”The US-China Trade War and Global Reallocations”, NBER WP 29562

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

[21] 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

[22] 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

[23] 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.

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

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

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

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

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

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

[30] 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).

[31] 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

[32] Nicita, A., 2019. “Trade and trade diversion effects of United States tariffs on China”. United Nations.

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

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

[35] 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.

[36] Tintelnot, Felix. 2017. “Global Production with Export Platforms.” Quarterly Journal of Economics

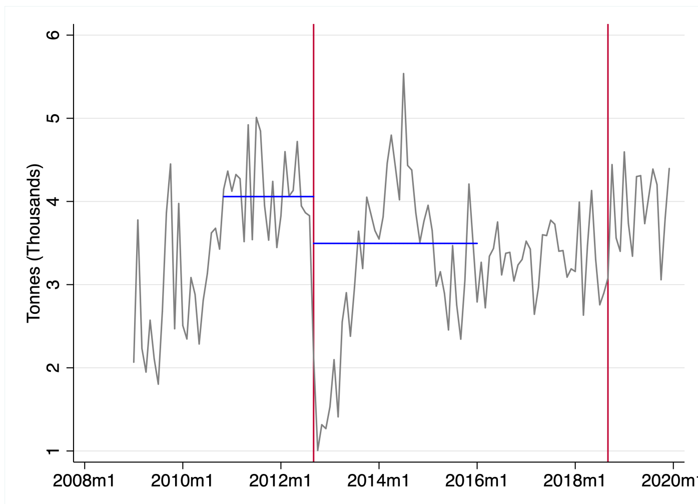
[37] Yeaple, Stephen R. 2003. “The Complex Integration Strategies of Multinationals and Cross Country Dependencies in the Structure of Foreign Direct Investment.” Journal of International Economics

Appendix

1 Additional figures from empirical facts

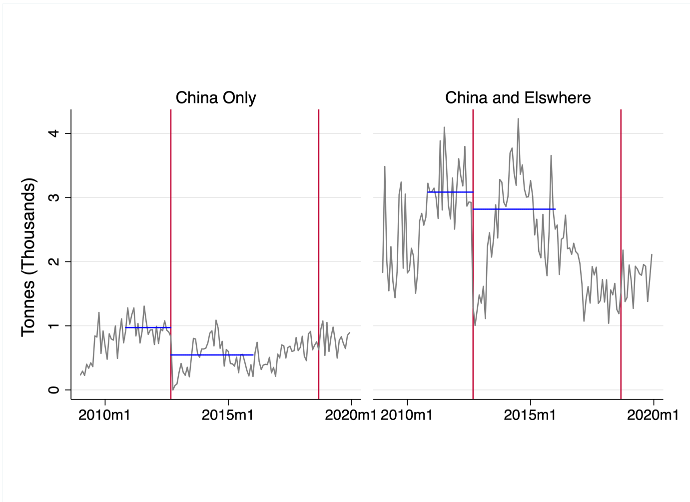
<u>Fact 2:</u> While the policy is in place, there is reallocation of imports across sourcing origins, away from China towards competing countries

Total import of truck tires, all origins pooled

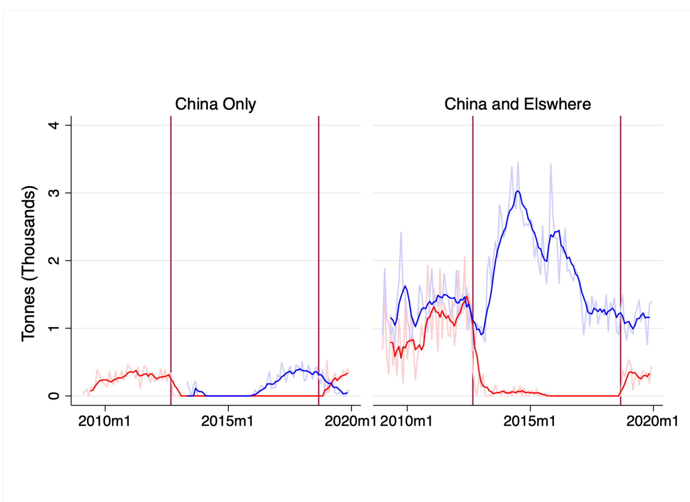


<u>Fact 3:</u> The vast majority of substitution is due to firms that were connected to multiple countries prior to the policy

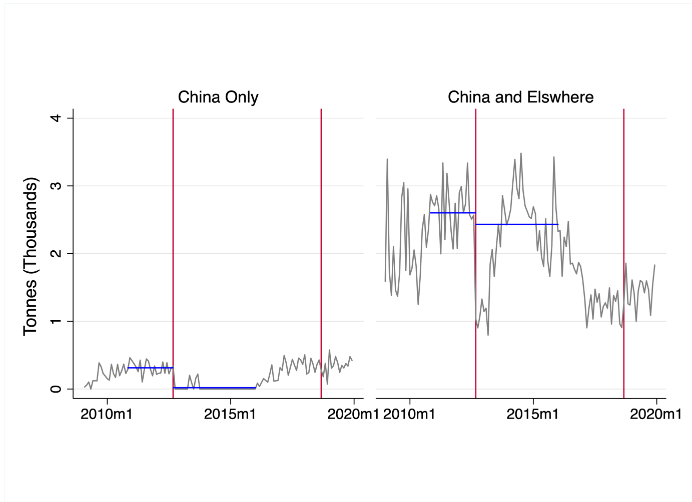
Total import of truck tires, all origins pooled. Panels are defined by importer's pre-policy sourcing status



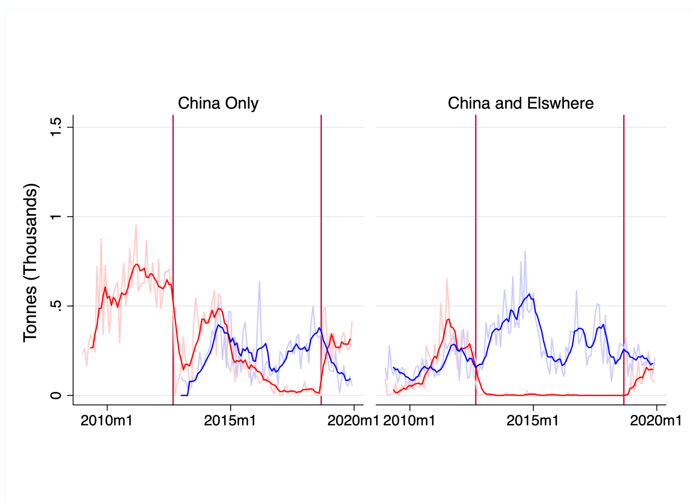
Large firms. Import of truck tires, by origin. Panels are defined by importer's pre-policy sourcing status



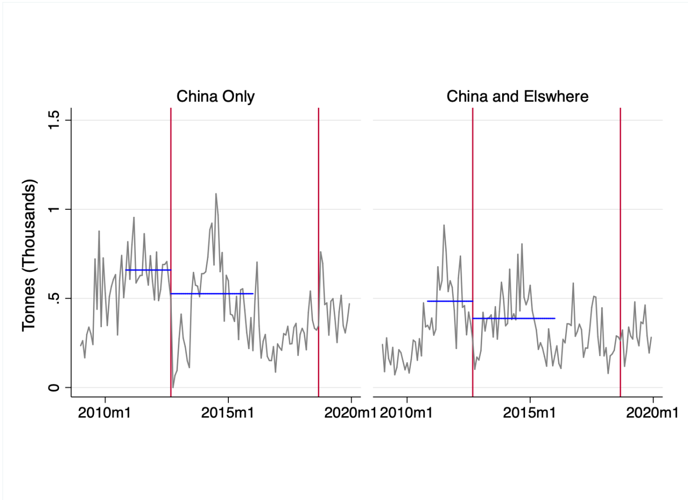
Large firms. Import of truck tires, all origins pooled. Panels are defined by importer's pre-policy sourcing status



Small firms. Import of truck tires, by origin. Panels are defined by importer's pre-policy sourcing status

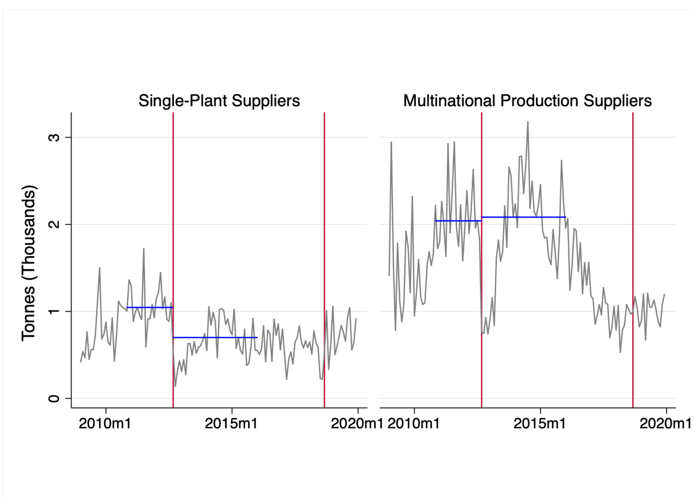


Small firms. Import of truck tires, all origins pooled. Panels are defined by importer's pre-policy sourcing status

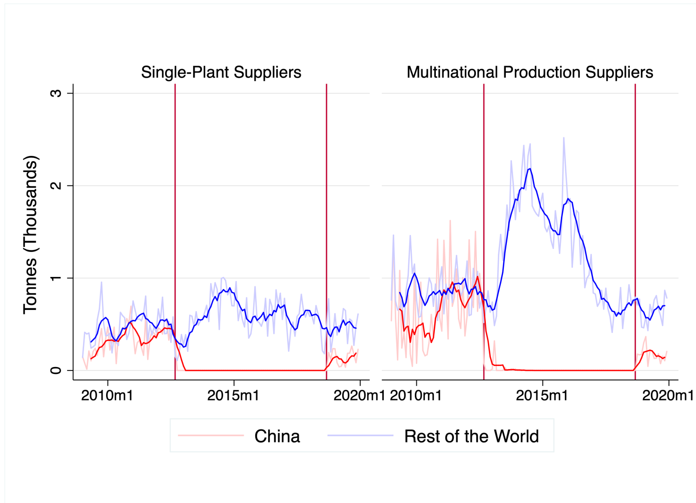


Fact 4: Conditional on the importers purchasing from multiple countries, substitution across source countries is larger for firms that were initially connected to suppliers with production in multiple countries

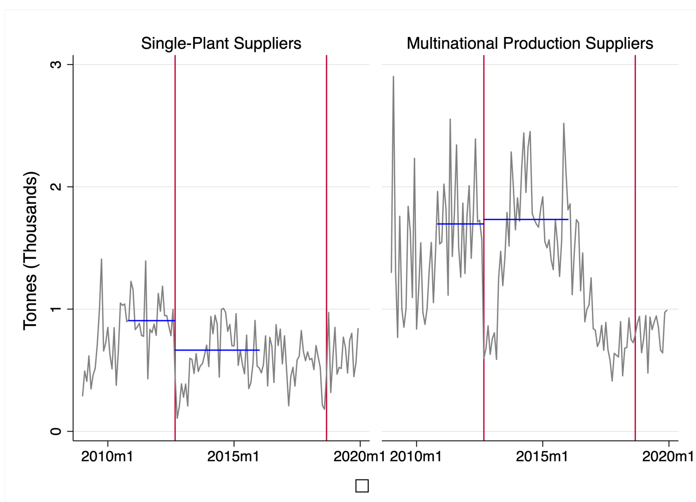
Total volume of Colombian imports of truck tires, all origins pooled, for importers with a simultaneous origins sourcing strategy. Panel A: Different suppliers, Panel B: Same supplier



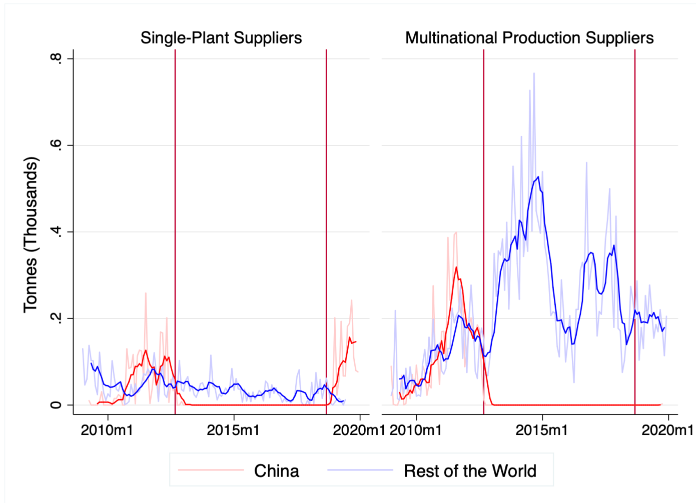
Large firms. Total volume of Colombian imports of truck tires, by origin, for importers with a simultaneous origins sourcing strategy. Panel A: Different suppliers, Panel B: Same supplier



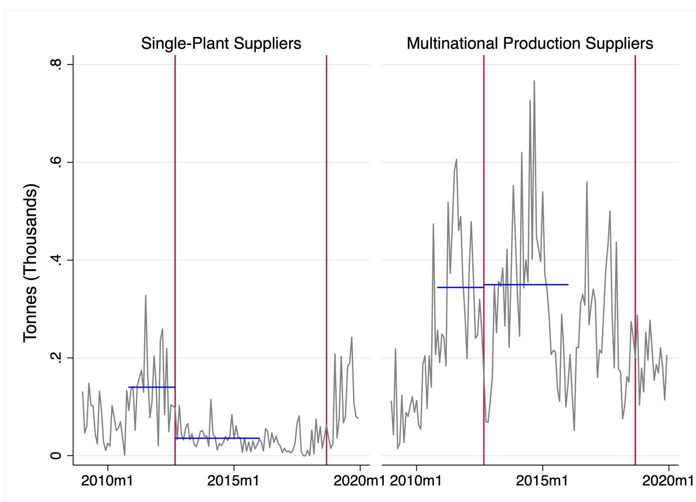
Large firms. Total volume of Colombian imports of truck tires, all origins pooled, for importers with a simultaneous origins sourcing strategy. Panel A: Different suppliers, Panel B: Same supplier



Small firms. 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



Small firms. Total volume of Colombian imports of truck tires, all origins pooled, for importers with a simultaneous origins sourcing strategy. Panel A: Different suppliers, Panel B: Same supplier



2 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

$$\Delta \ln p_{ij} = \frac{1}{1-\kappa} \ln \left(\sum_{o \in O_{ij}} s_{ijo} e^{(1-\kappa)\Delta \ln p_{ijo} + (1-\kappa)\Delta \ln a_{ijo}} \right) \tag{2.1}$$

$$\Delta \ln P_i = \frac{1}{1-\rho} \ln \left(\sum_{j \in J_i} S_{ij} e^{(1-\rho)\Delta \ln p_{ij}} \right) \tag{2.2}$$

Plugging-in (2.1) and (2.2) 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

$$\Delta \ln y_{ijo} = \alpha + \delta_i + \delta_{ij} - \kappa \; \Delta \ln p_{ijo} + \Delta \ln a_{ijo} \tag{2.3}$$

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 (2.1). 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 (2.4) shows how to re-write the price index (4.6) to obtain (5.6)

$$
\begin{aligned}
p_{ij} &= \left[\sum_{o \in O_{ij}} a_{ijo} p_{ijo}^{1-\kappa} \right]^{\frac{1}{1-\kappa}} \\
&= \left[\sum_{o \in O_{ij}} \frac{p_{ijo} y_{ijo}}{y_{ij} p_{ij}^{\kappa}} \right]^{\frac{1}{1-\kappa}} \\
&= \left[\frac{\sum_{o \in O_{ij}} p_{ijo} y_{ijo}}{y_{ij} p_{ij}^{\kappa}} \frac{\sum_{o \in C(O)_{ij}} p_{ijo} y_{ijo}}{\sum_{o \in C(O)_{ij}} p_{ijo} y_{ijo}} \right]^{\frac{1}{1-\kappa}} \\
&= \left[\sum_{o \in C(O)_{ij}} \frac{p_{ijo} y_{ijo}}{y_{ij} p_{ij}^{\kappa}} \frac{\sum_{o \in O_{ij}} p_{ijo} y_{ijo}}{\sum_{o \in C(O)_{ij}} p_{ijo} y_{ijo}} \right]^{\frac{1}{1-\kappa}} \\
&= \left[\sum_{o \in C(O_{ij})} a_{ijo} p_{ijo}^{1-\kappa} \frac{1}{S(C(O_{ij}))} \right]^{\frac{1}{1-\kappa}}
\end{aligned} \tag{2.4}
$$

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.

3 GMM

The specification in (5.9) has the unobserved component $\hat{a}_{ijo}$, which not only shows up directly, but also indirectly through the price indexes. In equation (3.1) 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.

$$
\overrightarrow{\hat{y}} = \mathcal{N} \overrightarrow{\hat{z}} + \Theta^I \overrightarrow{\hat{S}}(C(I)) + \Theta^J \overrightarrow{\hat{S}}(C(J)) + \Theta^O \overrightarrow{\hat{S}}(C(O)) + \xi \overrightarrow{\hat{a}} \tag{3.1}
$$

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 (3.2) to (3.6)

$$\begin{aligned}\mathcal{N}_{\omega\omega'} = \; & (\sigma-1)\ \mathbb{S}_{\omega'}S_{\omega'}s_{\omega'} \\ & + (\rho-\sigma)\ S_{\omega'}s_{\omega'}\ \mathbb{I}(i=i') \\ & + (\kappa-\rho)\ \ s_{\omega'}\ \mathbb{I}(i=i', j=j') \\ & - \kappa\ \ \mathbb{I}(\omega=\omega')\end{aligned} \tag{3.2}$$

$$\begin{aligned}\Theta^{O}_{\omega\omega'} = \; & -\frac{\sigma-1}{1-\kappa}\ \mathbb{S}_{\omega'}S_{\omega'}s_{\omega'} \\ & + \frac{\sigma-\rho}{1-\kappa}\ S_{\omega'}s_{\omega'}\ \mathbb{I}(i=i') \\ & + \frac{\rho-\kappa}{1-\kappa}\ s_{\omega'}\ \mathbb{I}(i=i', j=j')\end{aligned} \tag{3.3}$$

$$\begin{aligned}\Theta^{J}_{\omega\omega'} = \; & -\frac{\sigma-1}{1-\rho}\ \mathbb{S}_{\omega'}S_{\omega'}s_{\omega'} \\ & + \frac{\sigma-\rho}{1-\rho}\ S_{\omega'}s_{\omega'}\ \mathbb{I}(i=i')\end{aligned} \tag{3.4}$$

$$\Theta^{I}_{\omega\omega'} = \; \mathbb{S}_{\omega'}S_{\omega'}s_{\omega'} \tag{3.5}$$

$$
\begin{aligned}
\xi_{\omega\omega'} = \; & \frac{\sigma-1}{1-\kappa}\; \mathbb{S}_{\omega'} S_{\omega'} s_{\omega'} \\
& + \frac{\rho-\sigma}{1-\kappa}\; S_{\omega'} s_{\omega'}\; \mathbb{I}(i=i') \\
& + \frac{\kappa-\rho}{1-\kappa}\; s_{\omega'}\; \mathbb{I}(i=i', j=j') \\
& + \mathbb{I}(\omega=\omega')
\end{aligned}
\tag{3.6}
$$

From these structure, we get that every observation in (5.9) has an error

$$
\hat{\epsilon_{ijo}} = \hat{a_{ijo}} + \frac{\kappa-\rho}{1-\kappa}\sum s_{ijo}\hat{a_{ijo}} + \frac{\rho-\sigma}{1-\kappa}\sum\sum s_{ij}s_{ijo}\hat{a_{ijo}} + \frac{\sigma-1}{1-\kappa}\sum\sum\sum S_i s_{ij} s_{ijo}\hat{a_{ijo}}
\tag{3.7}
$$

The relevant moment conditions for GMM estimation is

$$
E\left[Z'\epsilon_{ijo}\right] = 0 \tag{3.8}
$$

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

$$
\begin{aligned}
E\left[\hat{\epsilon_{ijo}}|Z\right] = \; & E\left[\hat{a_{ijo}}|Z\right] \\
& + \frac{\kappa-\rho}{1-\kappa}\sum s_{ijo} E\left[\hat{a_{ijo}}|Z\right] \\
& + \frac{\rho-\sigma}{1-\kappa}\sum\sum s_{ij}s_{ijo} E\left[\hat{a_{ijo}}|Z\right] \\
& + \frac{\sigma-1}{1-\kappa}\sum\sum\sum S_i s_{ij} s_{ijo} E\left[\hat{a_{ijo}}|Z\right] \\
& = E\left[\hat{a_{ijo}}|Z\right]\left(1 - \frac{1}{1-\kappa} + \frac{\kappa}{1-\kappa}\right) \\
& = 0
\end{aligned}
\tag{3.9}
$$

Documentos de Trabajo **Banco Central de Chile**	**Working Papers** **Central Bank of Chile**
NÚMEROS ANTERIORES	PAST ISSUES
La serie de Documentos de Trabajo en versión PDF puede obtenerse gratis en la dirección electrónica: www.bcentral.cl/esp/estpub/estudios/dtbc. Existe la posibilidad de solicitar una copia impresa con un costo de Ch$500 si es dentro de Chile y US$12 si es fuera de Chile. Las solicitudes se pueden hacer por fax: +56 2 26702231 o a través del correo electrónico: bcch@bcentral.cl.	Working Papers in PDF format can be downloaded free of charge from: www.bcentral.cl/eng/stdpub/studies/workingpaper. Printed versions can be ordered individually for US$12 per copy (for order inside Chile the charge is Ch$500.) Orders can be placed by fax: +56 2 26702231 or by email: bcch@bcentral.cl.

DTBC – 1009
Trade Policy and Reallocation: Multinational vs. Single-Country Linkages in the Tire Industry
Brian Pustilnik

DTBC – 1008
The finances of Chilean households during the pandemic: an assessment from the 2021 Household Financial Survey
Enzo Cerletti, Magdalena Cortina, Alejandra Inzunza, Felipe Martínez, Patricio Toro

DTBC – 1007
UIP Deviations: Insights from Event Studies
Elias Albagli, Luis Ceballos, Sebastian Claro, Damian Romero

DTBC – 1006
Input price dispersion across buyers and misallocation Ariel Burstein, Javier Cravino, Marco Rojas

DTBC – 1005
The Role of Parental Altruism in Parents Consumption, College Financial Support, and Outcomes in Higher Education
Agustín Díaz Casanueva

DTBC – 1004
Indebtedness and labor risk sorting across consumer lender types: evidence from Chile
Carlos Madeira

DTBC – 1003
Central Bank Independence at Low Interest Rates
Benjamín García, Arsenios Skaperda

DTBC – 1002
Altas temperaturas y escasez de lluvia: el impacto del cambio climático en la actividad económica de Chile
María Teresa Reszczynski Zúñiga

DTBC – 1001
The Effect of Cognitive Skills on Fertility Timing
Agustín Díaz

DTBC – 1000
Time-Varying Expenditure Shares and Macroeconomic Dynamics
Benjamín García, Mario Giarda, Carlos Lizama, Damián Romero

DTBC – 999
Relationship Lending: Characteristics and Real Effects Miguel Acosta-Henao, Sangeeta Pratap, Manuel Taboada

DTBC – 998
International Sourcing during COVID-19: How did Chilean firms fare?
Jennifer Peña, Elvira Prades

DTBC – 997
A Preliminary Assessment of the Economic Effects of Climate Change in Chile
Felipe Beltrán, Luigi Durand, Mario González-Frugone, Javier Moreno

DTBC – 996
Monetary Policy Tightening and Bank Lending Standards: Evidence from the Chilean Bank Loan Survey
Helmut Franken, Alejandro Jara

DOCUMENTOS DE TRABAJO Marzo 2024