Supply Chain Disruptions and Diversification

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Abstract

Supply chain disruptions are becoming increasingly frequent, generating uncertainty for firms that need to source inputs to produce. We aim to understand whether firms, faced with supply chain disruption risk, would choose to diversify their sourcing from foreign countries, engage in re-shoring, or select suppliers based on cost or risk considerations. To answer this, and drawing inspiration from Antràs, Fort, and Tintelnot (2017), we write a multi-country sourcing model considering firms' self-selection into importing based on productivity, cost minimization, and trade disruptions that can alter the cost of importing. Our findings reveal that, even in the presence of aggregate or idiosyncratic uncertainty, a clear pecking order emerges, with larger firms self-selecting into importing from a more extensive set of suppliers. Despite the quantitative significance of marginal cost reduction as the primary driver of firms' sourcing decisions, risk introduces a nuanced dimension. Specifically, firm-specific import risk introduces a positive option value associated with diversifying the set of suppliers. Meanwhile, country-specific aggregate uncertainty has an ambiguous impact since it affects the market demand, leading to a reduction in firms' profits, as well as giving a positive option value. To empirically validate our model, we estimate supply chain disruption uncertainty and fixed costs of sourcing using firm-level data from Chile. Our analysis includes counterfactual scenarios to assess the impact of external shocks, such as the Covid-19 pandemic, on firms' sourcing strategies. Through this research, we contribute to understanding how firms navigate supply chain uncertainties and make strategic sourcing decisions in the face of disruptions.

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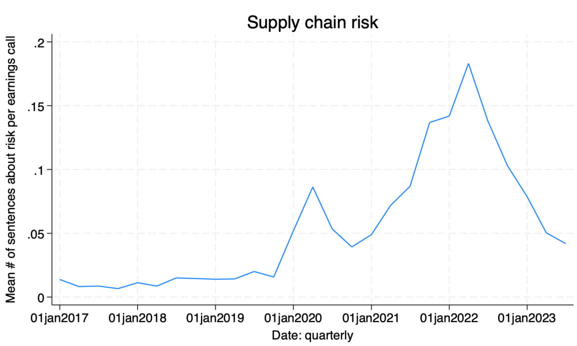
1 Introduction

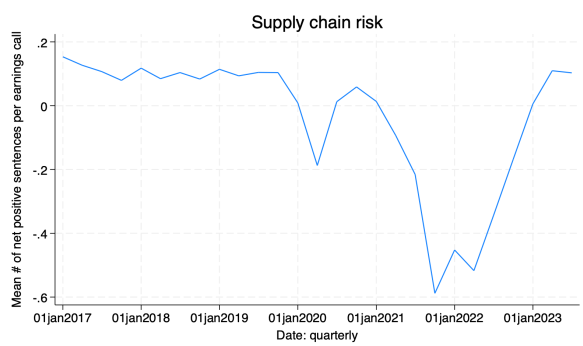
We live in a highly globalized and interconnected world. Trade to world GDP ratio increased from 25 percent in 1970 to 57 percent in 2021[1]. Because trade disruptions were infrequent until recently, supply chains were assumed to work smoothly, allowing companies to use just-in-time strategies, and only consider the cost reduction when deciding where to import from. This implies that firms did not need to consider the necessity of maintaining large inventories or diversifying their supplier portfolio for risk mitigation. However, recent events like Covid-19, the Russia-Ukraine war, as well as rapidly deteriorating climate change, have brought higher uncertainty to supply chains. As stated in Baldwin and Freeman (2021), the Business Continuity Institute (BCI) Supply Chain Resilience Report 2021, found that over a 25% of the surveyed firms experienced ten or more disruptions in 2020, while the number in 2019 was under 5%.

These supply chain disruptions seem to have increased delivery times as well as shipping costs. For example, Alessandria et al. (2023) show that, from the start of the pandemic through February 2022, the costs of shipping goods from Asia to the United States by air nearly doubled. They also show that cost increases were accompanied by delays in transactions. In line with this, LaBelle and Santacreu (2022) find that exposure to supply chain disruptions through global value chains greatly influenced the transmission of supply chain shocks to U.S. prices.

Figure 1: Quarterly average of supply chain risk and supply chain disruption sentiment



(a) Quarterly average of risk



(b) Quarterly average of sentiment

Notes: Own creation using Hassan et al. (2023)'s data. Sentiment and risk are supply chain disruption's overall perceived impact on the mean and variance of the firm's economic outlook, respectively.

As illustrated in Figure 1, firms are evidently concerned about supply chain uncertainty, impacting their expected economic outlook negatively. This uncertainty has led to a reduction in the expected average economic outlook and an increase in the expected variance of their profits. However, there is an ongoing debate regarding the appropriate response of firms to this heightened uncertainty affecting their economic outlook. Some argue for reshoring operations, while others advocate for diversifying the set of

[1]Trade to GDP ratio data from IMF. Available at `https://data.worldbank.org/indicator/NE.TRD.GNFS.ZS`

suppliers. This diversification includes both domestic and foreign suppliers, aiming to reduce exposure to the uncertainties of specific countries (Javorcik (2020), Bonadio et al. (2021), IMF (2022)). Consistent with this perspective, research by Dhyne et al. (2021) and Caselli et al. (2020) suggests that diversifying suppliers can decrease aggregate volatility and enhance resilience against sector shocks. The relevance of this theoretical discussion is reflected in actual sourcing decisions, where companies are actively considering the best strategies to manage supply chain risks, as depicted in Figure 1. For instance, a news article from the Financial Times on December 26, 2022, emphasizes this ongoing consideration of supply chain uncertainty by companies.

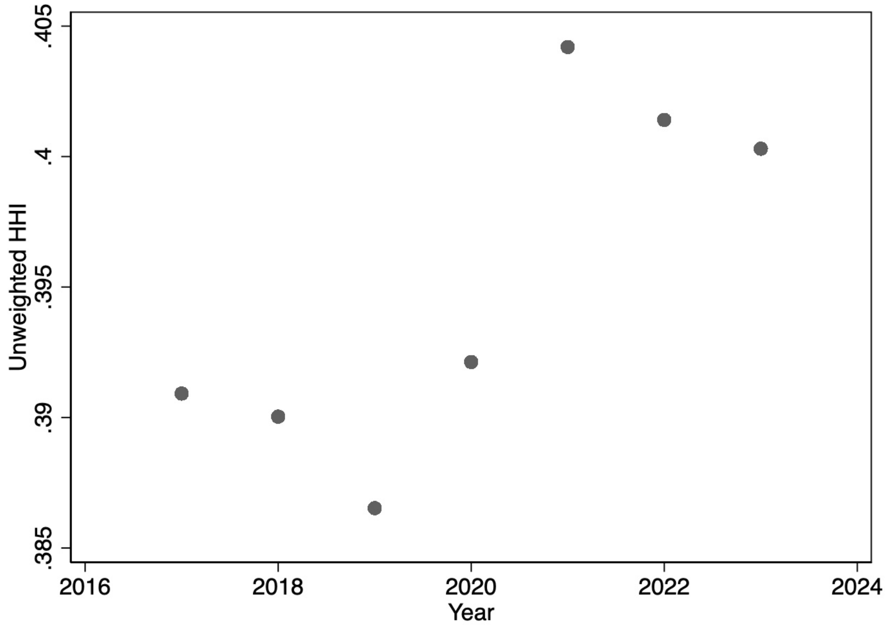
However, carmakers are also aiming to be more rigorous over their choice of suppliers as they ***focus on the resilience of the supply chain as well as costs****, to make sure it does not break down. "It is no longer an era where cost is the major driving factor," said Masahiro Moro, senior managing executive officer at Mazda. "Right now,* ***robustness*** *of our supply chain* ***also needs to be considered*** *to ensure the stable procurement of parts."*

This implies that managers are not solely focused on cost reduction when making sourcing decisions; they are also prioritizing resilience and robustness. Ensuring the ability to maintain production and minimize price increases during disruptions underscores the consideration of uncertainty in their decision-making process. With that in mind, we are interested in understanding the effect of supply chain uncertainty in the sourcing decision of firms.

Various types of firms are likely to make diverse sourcing decisions in response to uncertainty, potentially impacting the aggregate number of countries from which the home economy sources and not in a clear direction. To assess this impact on the concentration of sourcing at the country level, we calculate the aggregate unweighted Herfindahl–Hirschman index (HHI) for Chile using publicly available customs data from 2017 to 2023[2]. The HHI is calculated by summing the amount spent on imports from each country i in year t, dividing it by the total amount spent on imports from all countries in year t, and squaring the resulting market share for each country. The sum across all countries provides the concentration of importing countries. A higher HHI indicates less diversification, while a lower HHI implies more suppliers and greater diversification. So, for example, an HHI of 1 implies that Chile is buying everything from one country, while an HHI close to 0 means that Chile is buying from all countries.

[2]Data obtained from Chilean customs public database available at www.aduana.cl. Data available up to May 2023.

Figure 2: Aggregate Unweighted Herfindhal-Hirschman Index for Chile



Notes: Own creation using publicly available data from Chilean customs. HHI is calculated by summing the amount spent on imports from each country i in year t, dividing it by the total amount spent on imports from all countries in year t, and squaring the resulting market share for each country.

From Figure 2, we observe fluctuations in the HHI, with a notable change during the Covid-19 period. There is a slight increase in 2020 when the pandemic initially hit, followed by a more substantial increase in 2021. Subsequently, the HHI starts a gradual decline. This suggests that the uncertainty stemming from Covid-19 could have influenced the concentration of foreign suppliers at the aggregate level for the average products. Linking this to our model, the observed HHI trends may result from ex-ante decisions regarding the choice of sourcing partners or ex-post decisions on the allocation of sourcing volume among the countries with which firms have established relationships. We aim to investigate if our model can replicate this pattern and offer insights into its underlying drivers.

In this context, the objective of this paper is to develop a framework to understand the effect of supply chain uncertainty in the sourcing decision of firms when the characteristics of countries are also an important driving factor of this decision, not just the uncertainty. We will focus on intermediate goods trade because they constitute a substantial portion of global trade flows, accounting for approximately two-thirds of it (Feenstra (1998), Hummels et al. (2001), Johnson and Noguera (2017)). Given the contemporary relevance of vertical specialization across countries (Hummels et al. (2001), Hanson et al. (2005)), understanding how firms navigate sourcing decisions amid supply chain uncertainty becomes crucial. For the case of the US, Antràs et al. (2017), and Bernard et al. (2007) find that importers are larger and more productive than non-importers, which implies heterogeneity on the firm's productivity. Antràs et al. (2017) take this further and find that firm size increases in the number of countries they import from, giving rise to country level fixed costs. Nevertheless, the countries from which most firms source from do not necessarily match the amount spent on them, so these fixed costs must be heterogeneous across countries. Alessandria et al. (2023) and LaBelle and Santacreu (2022) find that supply chain disruptions increased the price index, which implies that this uncertainty affects the cost payed by final-good firms. Our goal is to explore these dynamics for Chile, aligning our model with empirical observations. Additionally, as demonstrated earlier, the aggregate Herfindahl–Hirschman index (HHI) has increased in recent years for Chile, especially during periods of heightened supply chain uncertainty. This suggests that, in the face of significant supply chain uncertainty, Chile has diversified its sourcing countries, a phenomenon we aim to capture in our model.

We build a multi-country sourcing model with heterogeneous firms that matches facts observed in the literature and in our data, and we add an extra layer in which there is supply chain uncertainty that affects iceberg costs, so it affects the price that final-good firms end up paying for the inputs they source. Firms have to decide if they want to enter the market or not before their productivity is known, and can decide to exit once their productivity is learned. Firms' that decide to produce form expectations on the shocks and choose where to source from by maximizing their expected profits before knowing the realization of the aggregate and idiosyncratic supply chain shocks. After they decide their set of suppliers considering the uncertainty, and payed the respective fixed costs of initiating the relationship with their set of suppliers, the shocks are realized and firms have to decide how much input to buy from their available set of suppliers, i.e., those they previously started a relationship with.

With our model, we can dissect the impacts of the decrease in marginal cost, supply chain shocks, market demand, and fixed costs on the expected profit of final good firms. Theoretical analysis reveals that uncertainty influences firms' profits and sourcing decisions through three margins: (i) sourcing potential, (ii) sourcing capability, and (iii) market demand. The decomposition of firms' expected profits includes: (i) the sourcing capability for expected shock, which is the term that increases by adding countries to the sourcing strategy through adding an extra cost draw which increases competition and lowers the overall cost, (ii) risk effect on capability, which is an option value since firms gain from adding riskier countries by being able to sell very cheap if they are hit with a positive shock, (iii) the covariance between sourcing capability and market demand, which is the effect of hedging by adding countries that negatively covaries with the countries that most firms add to their sourcing strategies, and (iv) the fixed cost of sourcing, which negatively affects expected profits. Utilizing a numerical example to elucidate how these terms influence expected profits, we find that the predominant driver is the sourcing capability for expected shocks term, with the risk effect on capability and the covariance term counteracting each other. This suggests that the impact of uncertainty on firms' sourcing decision is marginal compared to the effect of expected decrease in marginal cost.

Finally, we will estimate this model using quarterly data at the firm-level from the Chilean customs and IRS obtained through the Central Bank of Chile. We have data from 2012q1 to 2023q3, which we will leverage to obtain the distribution of the shocks. For the rest of the estimation, we use the average from 2012q1 to 2019q4. We do this to retrieve the firm-level fixed cost of sourcing avoiding the period

2020q1-2023q3, since there is high supply chain uncertainty due to Covid-19 and wars. Because sourcing decisions interact between countries, the dimensionality of our problem is very high, but assuming complementarity of these decisions we can leverage Jia (2008)'s algorithm to reduce the dimensionality of our problem. Finally, we will perform different counterfactual analyses to study the effect of changes in uncertainty on extensive and intensive margin. We will take a look at the effects of both reducing and increasing the uncertainty in supply chain disruptions.

1.1 Related literature

Our paper contributes to five literatures. We contribute to the literature on firms' sourcing decisions. Antràs et al. (2017) write a multi-country sourcing model with firm and fixed cost heterogeneity that accounts for the fact that more productive firms are heavier importers than less productive firms. They follow both Melitz (2003) and Eaton and Kortum (2002) and find that, under certain conditions, the interdependencies in the decision of firms on who to source from are very relevant. Blaum et al. (2018) also write a multi-country sourcing model to understand the aggregate effect of input trade when firms are heterogeneous. Using French data, they find that trade of inputs decreased manufacturing prices by around 27%. Antràs and Helpman (2004) write a model in which firms have to decide weather to produce intermediate goods or to import them, and from where. They then add contractual frictions in Antràs and Helpman (2006). Finally, Bernard and Moxnes (2018) reviews the literature on networks in trade. The closest work to ours is Antràs et al. (2017), however, we contribute by adding both aggregate and idiosyncratic supply chain uncertainty to an international sourcing model. We are able to understand how this new channel affects both the decisions of who to source from (extensive margin) as well as how much to source from each of the importers they initiated a relationship with (intensive margin). To the best of our knowledge we are the first ones to add supply chain uncertainty to a sourcing model and calibrate it. We also contribute by calibrating our model for a small open economy, like Chile, which might provide a new insight as well as by recovering the moments of the supply chain uncertainty during the period 2012-2023.

Our work is also related to the theoretical literature on supply chain uncertainty and sourcing decisions. Grossman et al. (2023) study's the effect of supply chain disruption uncertainty in the sourcing decision of firms. The authors focus on the efficiency of sourcing decisions for different utility functions when there are variable markups. They find that for the CES case, the government should subsidize diversification. Grossman et al. (2023) writes a model for supply chain uncertainty resilience with vertical production tiers and study the first- and second-best policies. Gervais (2018) writes a theoretical model in which there is supply chain uncertainty and managers are risk-averse use diversification of suppliers to make their profits less variable. He finds that, in this case, firms tend to import from suppliers with less variance. Gervais (2021) writes a theoretical model to study if risk diversification can be motive enough by itself to produce multi-country sourcing when firms are risk averse. Our work expands on the previous papers by having a multi-country model that allows for a non-linear production function, sourcing interdependencies, and to separate effect of cost and aggregate and idiosyncratic uncertainty. We also have a model that can speak to features of the data, like the fact that most productive firms are the ones that import and they import from more countries, which is relevant to understand how different types of firms would react to uncertainty and how that would affect the aggregate economy. This will allow us to understand how much of the sourcing decision is being driven by the effect of uncertainty and how much comes from cost reduction and degree of complementarity between sourcing decisions as well as evaluate counterfactual scenarios.

Another literature we relate to is the literature on tariff policy uncertainty. Handley et al. (2020) write a sourcing model in which there is policy uncertainty. Firms have to decide who to buy from considering the expected marginal cost and the sunk cost they have to pay. They are able to separate between a substitution and complementarity effect between inputs and find that the accession of China to the WTO, which reduces tariff uncertainty, increased firms' imports. Handley and Limão (2017) also study the effects of reduced policy uncertainty from the accession of China to the WTO on trade, prices, and real income. Charoenwong et al. (2023) study the relationship between trade and foreign economic policy uncertainty and the supply chain networks of American firms, and find that firms that require more specific inputs, produce more differentiated products, have higher market shares, or those located in a more central position in the production network are more sensitive to policy uncertainty. Our model is very similar in spirit to Handley et al. (2020), since they add uncertainty to a multi-country sourcing model, but our shocks are supply chain shocks and we have a static model, whereas they have a dynamic one. We contribute to this literature by having a general framework for policy, supply-chain risk, and trade shocks.

Another literature that relates to ours is the empirical literature on propagation of supply chain shocks through trade networks. Carvalho et al. (2021) and Boehm et al. (2019), both study the transmission of shocks using the specific case of the Great East Japan Earthquake of 2011 as an exogenous shock and the later finds that the elasticity of substitution between inputs is around zero (close to Leontief). Bonadio et al. (2021) study how Covid-19 impacted GDP through global supply chains and find that global value chains explain one quarter of the model-implied real GDP decline but re-shoring does not eliminate the effect of the pandemic since domestic inputs were also shocked. They also find that trade helped countries with high degrees of lockdown. Di Giovanni et al. (2020) use data on French firms to study how business cycle shocks transmit both at the micro and macro level. They find that larger firms are significantly more sensitive to foreign shocks because they are the most likely to trade internationally, and they transmit these shocks to the domestic economy through input-output linkages. Our paper contributes to this literature by studying the effect of supply chain disruption uncertainty on firms' sourcing decisions, which affects the transmission of these shocks, so we study firms' joint sourcing and diversification decision.

We also contribute to the literature on trade disruption shocks. A way firms can deal with the uncertainty in supply chains is by holding inventories, as stated by Alessandria et al. (2023), Carreras-Valle (2021), firms have a trade-off between importing from the cheapest foreign supplier and uncertainty in the delivery time in a world with an idiosyncratic demand risk. Carreras-Valle (2021) finds that the decrease in delivery times explains more than half of the decline in inventory holding in the US. Novy and Taylor (2020) write a trade model with uncertainty in the supply chain and inventories which they take to the data and find that when there are uncertainty on supply chains, firms usually stop supplying from foreign countries because of the high fixed cost. Our work contributes to this literature by adding supply chain risk to a sourcing model that explains importing patterns and understand how uncertainty affects this. Another way to deal with uncertainty in supply and demand is by having a diversified set of suppliers. In this paper we focus on this counterpart of risk management, i.e., supply chain restructuring and we contribute by analyzing uncertainty and firm's sourcing choice using a structural model. In reality, we expect both options to be working along side, but we abstract from the inventory holding decision to focus on the specific effect of uncertainty in sourcing decisions.

Empirically, there seems to be contradictory evidence on the relationship between sourcing and uncertainty. Lafrogne-Joussier et al. (2022), study how firms in GVC react to input shortages and find that diversification doesn't help mitigate the effect of shocks since it seems like firms were willing to pay the sunk cost to import from other countries. LaBelle et al. (2021) investigate the role of global value chains in the declines of manufacturing employment and output in the U.S. during COVID-19 and find a modest impact of diversifying or re-nationalizing GVCs in mitigating the economy's exposure to foreign shocks, and Khanna et al. (2022) characterize what features make supply chains more resilient. D'Aguanno et al. (2021) find that re-shoring increases aggregate volatility, while diversifying can lower it by decreasing the exposure to a single country. Chung (2017) finds multi-sourcing seems to be more likely when the biggest supplier is more risky. Finally, Ersahin et al. (2023) use textual analysis of earnings conference calls to proxy for supply chain risk and find that firms that experience an increase in supply chain risk increase investment and establish relationships with closer and domestic suppliers and with suppliers that are industry leaders. Our paper contributes to this strand of the literature by providing a multi-country allows us to quantify how much of the sourcing decision comes from uncertainty because of supply chain disruptions.

The remainder of our paper is organized as follows. In Section 2 we present our trade model with exogenous supply chain disruptions and the main mechanisms for the competitive equilibrium. Then, in Section 3 we solve for the equilibrium. In section 4 we introduce our data and provide descriptive evidence. In Section 5 we estimate our structural model. In Section 6 we perform our counterfactual analysis. Finally, in Section 7 we conclude.

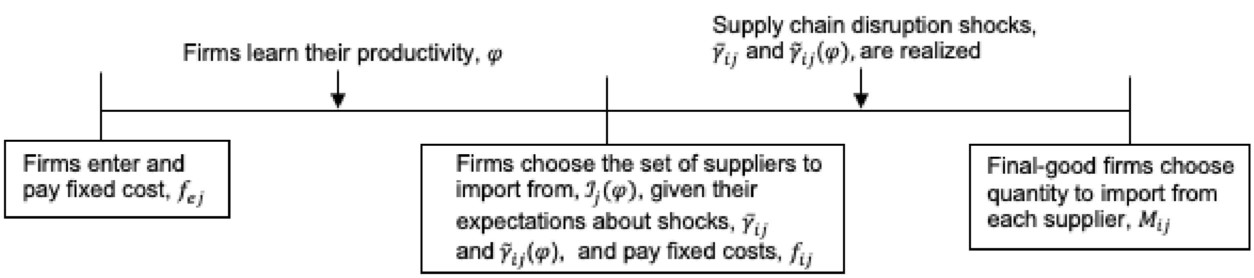
2 Model

In this segment, we construct a quantifiable multi-country sourcing model rooted in the framework proposed by Antràs et al. (2017). The model incorporates supply chain uncertainty, which directly impacts the pricing dynamics for intermediate inputs acquired by final-good firms. The decision-making process for firms involves a decision to enter and paying the fixed cost of entry, without prior knowledge of their productivity levels. Once their productivity is realized, they have to choose the set of suppliers to source from by drawing expectations about the supply chain shocks and pay the relationship-specific fixed costs. Following the revelation of supply chain shock realizations, firms make informed decisions regarding the quantity of imports from each available supplier they previously started a relationship with.

2.1 Setup

The world consists of I countries, with $i = 1, \ldots, I$ denoting the origin country and $j = 1, \ldots, I$ representing the destination country. Our proposed static model delineates a three-stage decision-making process for final-good firms. As illustrated in Figure 3, firms in country j commit to paying the fixed entry cost, f_{ej} and enter the market prior to knowledge of their productivity, denoted by φ. Following entry, firms learn their productivity, draw expectations for both aggregate ($\bar{\gamma}_{ij}$) and idiosyncratic ($\tilde{\gamma}_{ij}(\varphi)$) supply chain shocks. Incorporating these expectations, firms select a set of suppliers, $\mathcal{I}j(\varphi)$, and incur relationship-specific fixed costs, f_{ij}. Subsequently, the realized shocks, $\bar{\gamma}_{ij}$ and $\tilde{\gamma}_{ij}(\varphi)$, dictate that firms cannot source from countries with which they lack established relationships. However, firms retain the flexibility to determine the quantity of imports from each previously established supplier.

Figure 3: Timeline



2.2 Preferences

In each country j, there are L_j homogeneous individuals who value consumption of our designated sector of interest. This sector, as explored in our empirical analysis, encompasses a synthesis of mining, manufacturing, and business activities. Additionally, individuals also derive utility from goods originating in an external sector given by

$$U_j(C_{oj}, C_{sj}) = C_{oj}^{1-\alpha} C_{sj}^{\alpha} \tag{1}$$

with C_{oj} denoting the consumption of the outside sector and C_{sj} the consumption of the sector of interest. This expenditure allocation is characterized by a parameter α, signifying the proportion of income dedicated to the consumption of goods from the sector of interest, while $1 - \alpha$ corresponds to spending on goods from the outside sector. Notably, within the sector of interest, individuals place value on the consumption of differentiated varieties, denoted as ω. The elasticity of substitution for these varieties is characterized by $\alpha > 1$.

$$C_{sj} = \left(\int_{\omega \in \Omega_j} y_j(\omega)^{\frac{\sigma-1}{\sigma}} d\omega \right)^{\frac{\sigma}{\sigma-1}} \tag{2}$$

with Ω_j representing the set encompassing all available varieties accessible to individuals within country $j \in I$ under the prevailing state of the world. From these preferences, which we assume the same for all individuals around the world, the resulting demand function for the variety ω in country j is as follows:

$$y_j(\omega, \bar{\gamma}, \tilde{\gamma}(\varphi)) = C_{sj} \left(\frac{p_j(\omega, \bar{\gamma}, \tilde{\gamma}(\varphi))}{P_j(\bar{\gamma})} \right)^{-\sigma} = E_j P_j(\bar{\gamma})^{\sigma-1} p_j(\omega, \bar{\gamma}, \tilde{\gamma}(\varphi))^{-\sigma} \tag{3}$$

where $p_j(\omega, \bar{\gamma}, \tilde{\gamma}(\varphi))$ is the price of variety ω in country j, for given aggregate and idiosyncratic shocks, $\bar{\gamma}$, $\tilde{\gamma}(\varphi)$, respectively, E_j is the total expenditure in our sector of interest in country j, which we will take as fixed, and $P_j(\bar{\gamma})$ is the ideal price index, given by

$$P_j(\bar{\gamma}) = \left(\int_{\omega \in \Omega_j} \int_{\tilde{\gamma}(\varphi)} p_j(\omega, \bar{\gamma}, \tilde{\gamma}(\varphi))^{1-\sigma} d\tilde{\Psi}_j^{\varphi}(\tilde{\gamma}) d\omega \right)^{\frac{1}{1-\sigma}} \tag{4}$$

To simplify the notation from now on, we will define a market size term for country j as

$$B_j(\bar{\gamma}) \equiv \frac{1}{\sigma} \left(\frac{\sigma}{\sigma - 1} \right)^{1-\sigma} E_j P_j(\bar{\gamma})^{\sigma-1} \tag{5}$$

The outside sector in this economy, denoted C_{oj}, which serves as a numeraire in our model, is homogeneous and freely tradable and big enough to pin down wages, w_j, in the economy in terms of the outside sector's output. This establishes the price of labor, the exclusive factor of production in our capital-free economy. Aggregate income in country j is expressed as $Y_j = w_j L_j$. Finally, equilibrium only necessitates the determination of the aggregate price index, $P_j(\bar{\gamma})$.

2.3 Technology and Market Structure

There exists a measure N_j of final-good firms in each country $j \in I$, owned by risk-neutral managers. Ex-post profits are entirely redistributed to these global managers that are outside our economy. Each of these firms specializes in producing a uniquely differentiated variety, since they each own a blueprint. There is free entry in the market and, to produce their specific variety, final-good firms use a unit measure of intermediate goods and operate in a monopolistically competitive environment.

Drawing from the framework established by Melitz (2003), final-good firms face a sequential decision-making process. Initially, they have to decide to enter, and pay the fixed cost of entry, f_{ej}, in units of labor specific to country j, before knowing their productivity, φ. Subsequently, after paying the fixed cost of entry and having learned their productivity, firms assess their expected profits to determine whether to engage in production or exit the market.

Firms, indexed by their productivity level φ, anticipate the realization of supply chain shocks, shaping their decisions regarding importing relationships. The set of countries firms choose to start relationships with is denoted as $\mathcal{I}_j(\varphi)$. Firms select this set of countries by maximizing their expected profits, and paying the fixed cost for each established sourcing relationship, f_{ij}, also in units of labor specific to country j.

Upon the realization of shocks, both aggregate ($\bar{\gamma}_{ij}$) and idiosyncratic ($\tilde{\gamma}_{ij}(\varphi)$), final-good firms must determine the quantity to procure from each supplier with whom a relationship has been initiated, denoted as $M_{ij}(\varphi, \gamma)$. The productivity parameter φ associates a final-good with a specific bundle of inputs, drawn from a country-specific distribution $g_j(\varphi)$ characterized by support in $[\underline{\varphi}_j, \infty)$, and an associated continuous cumulative distribution $G_j(\varphi)$. The supply chain disruptions are captured by $\gamma_{ij}(\varphi) = \bar{\gamma}_{ij} \times \tilde{\gamma}_{ij}(\varphi)$, where $\bar{\gamma}_{ij}$ represents common relationship-specific aggregate shocks, and $\tilde{\gamma}_{ij}(\varphi)$ accounts for firm-relationship-specific idiosyncratic shocks. We have that $\bar{\gamma}_{ij} \sim_{\text{iid}} \Psi_{ij}(\bar{\gamma})$, and $\tilde{\gamma}_{ij}(\varphi) \sim_{\text{iid}} \Psi^{\varphi}_{ij}(\tilde{\gamma})$, and idiosyncratic and aggregate shock are uncorrelated. These disruptions can be interpreted as a country-specific aggregate shock, like a national level quarantine, or war, or an idiosyncratic shock, like a factory problem, the Evergreen boat stuck in the Suez canal, a problem with the specific outputs, or weather problems. We interpret this as a shock to the iceberg cost because these events will make it more expensive for a country to import from the country that was affected. We will take this shock to be mean-preserving and change the variance as to evaluate the effect of the uncertainty.

Our model posits that final-good firms procure a unit measure of firm-specific intermediate inputs, characterized by imperfect substitutability within a firm and perfect substitutability across different firms, irrespective of their country of origin. The degree of substitution is captured by a constant elasticity parameter denoted as ρ. Notably, the specific value of the elasticity of substitution between intermediate inputs does not drive the results in our model, as it leverages a within-firm framework inspired by Eaton and Kortum (2002), similar to the approach taken by Antràs et al. (2017).

Intermediate-good firms in our model operate under a constant-returns-to-scale technology for the production of their varieties, utilizing labor as the primary input. The unit labor requirement associated with the production of firm φ's intermediate input $\nu \in [0, 1]$ in country $i \in I$ is denoted as $a_i(\nu, \varphi)$, where the specificity of the firm is accounted for to avoid including innocuous fixed costs. There is perfect competition on the intermediate-good market, so firms sell at marginal cost. Then, in our world, the price at which final-good firms procure intermediate goods from country i encompasses the iceberg trade cost of shipping from country i to country j, τ_{ij}, as well as the potential extra cost in case of supply chain disruptions, $\gamma_{ij}(\varphi)$. Then, the cost of an input is $\tau_{ij}\gamma_{ij}(\varphi)a_i(\nu, \varphi)w_i$. This implies that the price paid by firm φ in country j for its input ν is given by:

$$s_i(\nu, \varphi, \gamma(\varphi); \mathcal{I}_j(\varphi)) = \arg \min_{i \in \mathcal{I}_j(\varphi)} \left\{ w_i a_i(\nu, \varphi) \tau_{ij} \gamma_{ij}(\varphi) \right\} \tag{6}$$

As the production of a final-good variety by final-good firms entails utilizing a unit measure of inputs, the marginal cost for firm φ situated in country j can be expressed as:

$$c_j(\varphi, \gamma(\varphi)) = \frac{1}{\varphi} \left(\int_0^1 s_i(\nu, \varphi, \gamma(\varphi); \mathcal{I}_j(\varphi))^{1-\rho} d\nu \right)^{1/(1-\rho)} \tag{7}$$

Following Antràs et al. (2017) and Eaton and Kortum (2002), we will allow the productivity parameter, $1/a_i(\nu, \varphi)$ to follow a Fréchet distribution, such that:

$$\mathbb{P}(a_i(\nu, \varphi) \geq a) = e^{-T_i a^{\theta}}, \text{ with } T_i > 0 \tag{8}$$

where T_i is the state of technology in country i, so better technology implies more productivity, while θ determines the variability of productivity draws across inputs. A low θ implies more comparative advantage within intermediates across countries.

2.4 Discussion of assumptions

Before closing down the model and finding the equilibrium, we will discuss the assumptions we have made, why we make them, and how relevant they are for our results. First, in defining the timing of our model, we specify that firms determine their sourcing decisions before the occurrence of supply chain disruptions. Subsequently, once the shocks materialize, firms possess the flexibility to adjust through their intensive margin, dictating the quantity sourced from each pre-established supplier. We justify this timing assumption for several reasons. The first reason is our reliance on ex-post data; we typically observe the actual purchase made by firms after the realization of the state of the world, rather than having access to data on potential sourcing decisions for every conceivable state. The second reason is that this assumption serves as a simplifying heuristic, streamlining the analysis and enabling a focused examination of the distinct impacts of uncertainty on the sourcing decision, or extensive margin, apart from its influence on the intensive margin. This separation facilitates a more nuanced understanding of the specific dynamics at play and contributes to the clarity of our analytical framework.

The second assumption pertains to the ownership structure of final-good firms, positing that risk-neutral managers own these firms, and ex-post profits are entirely redistributed to these global managers situated outside our small open economy. To assess the sensitivity of our results to this assumption, as a robustness check, we introduce an alternative scenario where firms take households' preferences into account through the inclusion of a stochastic discount factor (SDF) in the profit function. Relying on finance and option pricing theory, changing the SDF is analogous to a change in the probability distribution of the shock, implying a larger weight on high-marginal utility events. Alternatively, the firm could be owned by risk-averse managers, like in Gervais (2021) and Gervais (2018). In this context, firms owned by risk-averse managers trade only due to uncertainty in intermediate-good prices, with the author introducing portfolio theory concepts, including a variance term in the final-good firm's problem and considering correlations between shocks. While these alternative approaches in ownership and decision-making frameworks offer valuable insights, our focus remains on the trade literature's prevailing models concerning sourcing decisions. Our choice to maintain risk-neutral firms aligns with the majority of literature in this domain. By adhering to this standard, we aim to isolate and comprehend the distinct impact of uncertainty on firms' sourcing decisions within well-established frameworks. Comparisons with other motives for trade, such as comparative advantage, could be explored in future extensions to enrich the understanding of risk-neutral firms' import decisions in the presence of uncertainty.

The third assumption in our modeling framework pertains to the specification of final-good firms' production functions as constant-elasticity-of-substitution (CES) across input varieties. Moreover, following Eaton and Kortum (2002), we use a Fréchet distribution for each intermediate-variety firms' productivities. Because of extreme values, there always exists a set of variety for which each country serves as the most cost-effective producer, exporting to the rest of the world. Notably, our assumption implies that the elasticity of substitution between inputs, ρ, does not influence the sourcing strategy decision across countries. As we previously discussed, this could potentially be an important assumption because Boehm et al. (2019) find that elasticity of substitution between domestic factors and imported intermediates is close to zero, which means that the production function could be model closer to a Leontief. Despite this potential sensitivity, we adhere to the standard assumption in the trade literature, allowing for tractability in our analytical approach. Although it would be an interesting avenue to explore the impact of relaxing this assumption and setting the elasticity close to Leontief, such an investigation lies beyond the scope of our current study. Our modeling framework remains aligned with Eaton and Kortum (2002) and Antràs et al. (2017) to facilitate a more direct comparison and integration into the existing literature.

The fourth assumption in our model involves the allocation of risk, designating final-good firms as the entities bearing all the risk. This decision arises from the consideration that intermediate-good firms operate in a perfectly competitive environment, selling their products at marginal cost. Consequently, any increase in prices is absorbed by final-good firms. This simplifying assumption is adopted to streamline the focus on the decision-making processes of final-good firms. This assumption is inherited from Antràs et al. (2017), where final-good firms operate in a monopolistically competitive setting while intermediate-good firms function within perfect competition. We follow this assumption for the sake of analytical tractability and practical considerations, since this would introduce extra complexities into our structural estimation process.

The fifth assumption in our model involves the separation of supply chain shocks from iceberg costs. This decision is made primarily for exposition purposes, allowing for a more targeted examination of the specific effects of uncertainty. Alternatively, it could be conceivable to model iceberg costs as stochastic, which would be equivalent from a modeling perspective. Nonetheless, we wanted to be able to separate the effects to understand the specific effect of uncertainty on top of the usual iceberg cost motive. This assumption does not affect our results.

Finally, we carry some of the same assumptions from Antràs et al. (2017): (i) Labor requirements are specific to the final-good firm, introducing a motive for the existence of non-trivial fixed costs. However, the model remains unchanged if labor requirements are not firm-specific. (ii) Final goods are deemed too costly to be traded internationally. Consequently, individuals exclusively procure final goods from their own country, denoted as j. We assume this because it underscores the localized nature of the final goods market and allows us to focus on the intermediate-goods' imports, which accounts for 2/3 of international trade. (iii) Different market structures are used between intermediate and final good firms. We do this so that firms can cover the fixed cost of entry and of starting a relationship and to focus on the final-good firms. (iv) All final good producers combine a measure one of inputs in production, simplifying the structural estimation process. Finally, (v) wages are pinned down by this big outside sector, which provides tractability.

3 Equilibrium

The equilibrium of the competitive model is derived through a sequential backward induction process. First, we will assume that firms in country j already payed all the fixed costs, f_{ej} and f_{ij}, associated with a predetermined sourcing strategy, $\mathcal{I}_j(\varphi)$. With knowledge of the realization of φ, $\bar{\gamma}_{ij}$, and $\tilde{\gamma}_{ij}(\varphi)$, firms have to choose the optimal share of intermediate inputs to buy from their available sources. Second, we assume that firms have not yet payed the country-specific fixed cost of sourcing, f_{ij}, do not know the realization of the supply chain shocks, $\bar{\gamma}_{ij}$ and $\tilde{\gamma}_{ij}(\varphi)$, yet and have to form expectations about these shocks to choose their sourcing strategy, $\mathcal{I}_j(\varphi)$. Finally, after firms have solved for both the share of intermediate input purchase and their sourcing strategy, we aggregate and use the free-entry condition and our outside sector that pins down wages to solve for the number of firms that enter in equilibrium. From now on, we will denote firms in country j by their distinct productivity level φ.

3.1 Final-good Firm Behavior Conditional on Sourcing Strategy, $\mathcal{I}_j(\varphi)$

Consider a firm φ, in country j that has already incurred the fixed cost of entry, f_{ej}, and all the country-specific fixed cost of sourcing, f_{ij}, associated with a given sourcing strategy, $\mathcal{I}_j(\varphi)$. Each firm wants to minimize the cost at which they get their intermediate goods for each specific variety, ν. As previously stated, final-good firms make decisions regarding the country from which to source each variety, guided by the minimization of $w_i a_i(\nu,\varphi)\tau_{ij}\bar{\gamma}_{ij}\tilde{\gamma}_{ij}(\varphi)$ for each $i \in \mathcal{I}_j(\varphi)$. Now, leveraging the properties of the Fréchet distribution, we proceed to derive the expression for the share of intermediate input purchases by firm φ in country j from country i. We get

$$\mathcal{X}_{ij}(\varphi,\gamma) = \frac{T_i(\tau_{ij}\bar{\gamma}_{ij}\tilde{\gamma}_{ij}(\varphi)w_i)^{-\theta}}{\Theta_j(\varphi,\gamma)} \text{ if } i \in \mathcal{I}_j(\varphi) \tag{9}$$

and $\mathcal{X}_{ij}(\varphi,\gamma)=0$ otherwise, where

$$\Theta_j(\varphi,\gamma) \equiv \sum_{k\in\mathcal{I}_j(\varphi)} T_k(\tau_{kj}\bar{\gamma}_{ij}\tilde{\gamma}_{kj}(\varphi)w_k)^{-\theta} \tag{10}$$

From the use of the Fréchet distribution, we get that firms always buy a positive amount of input from each country in their sourcing strategy set. We will denote $\Theta_j(\varphi,\gamma) \equiv \sum_{k\in\mathcal{I}_j(\varphi)} T_k(\tau_{kj}\bar{\gamma}_{ij}\tilde{\gamma}_{kj}(\varphi)w_k)^{-\theta}$ as the *sourcing capability* of firm φ in country j and to $T_i(\tau_{ij}\bar{\gamma}_{ij}\tilde{\gamma}_{ij}(\varphi)w_i)^{-\theta}$ as the *sourcing potential* of country i from the point of view of firm φ in country j. The sourcing potential of country i from the point of view of firms in country j is increasing in the technology parameter and decreasing in iceberg costs, supply chain shocks and wages. The sourcing capability of firm φ in country j also depends on these parameters, extending beyond a single country i to encompass all countries within firm φ's sourcing strategy. We will call this an *ex-post* Eaton and Kortum, within the firm.

Once firm φ in country j chooses their least costly supplier for each variety ν, as obtained in Eaton and Kortum (2002), the overall marginal cost faced by firm φ from j can be written as

$$c_j(\varphi,\bar{\gamma},\tilde{\gamma}) = \frac{1}{\varphi}\left(\eta\Theta_j(\varphi,\bar{\gamma},\tilde{\gamma})\right)^{-1/\theta} \tag{11}$$

with $\eta = \left[\Gamma\left(\frac{\theta+1-\rho}{\theta}\right)\right]^{\frac{\theta}{1-\rho}}$ and Γ the Gamma function. To ensure that this is well defined, as in Eaton and Kortum (2002), we need that $\theta > \rho - 1$. Since final-good firms are monopolistically competitive they charge a homogeneous markup over marginal cost, so the price charged by the final-good firm φ in country j is given by

$$p_j(\varphi,\bar{\gamma},\tilde{\gamma}) = \frac{\sigma}{\sigma-1}c_j(\varphi,\bar{\gamma},\tilde{\gamma}) \tag{12}$$

Analyzing the overall marginal cost for firm φ in country j, we observe that incorporating an additional country into a firm's sourcing strategy, given specific shocks, consistently reduces the overall marginal cost and, consequently, lowers their prices. This outcome arises because adding a country gives the firm an extra chance to draw on a lower marginal cost, which increases competition and lowers the expected minimum price per intermediate good for all varieties ν and countries in the sourcing strategy. In the context of disruptions, it also gives the firm a chance to draw on an extra marginal cost of a country that was positively affected by supply chain disruptions. Examining a fixed sourcing strategy reveals that negative (positive) supply chain disruptions will increase (decrease) the overall marginal cost, and hence increase (decrease) final-good prices if the shocked countries are part of the firm's sourcing strategy.

Then, the ex-post profits of firm φ in country j given the sourcing strategy $\mathcal{I}_j(\varphi)$ can be written as

$$\pi(\varphi,\bar{\gamma},\tilde{\gamma}) = \varphi^{\sigma-1}\left(\eta\Theta_j(\varphi,\bar{\gamma},\tilde{\gamma})\right)^{\frac{\sigma-1}{\theta}} B_j(\bar{\gamma}) - w_j \sum_{i\in\mathcal{I}_j(\varphi)} f_{ij} \tag{13}$$

For a fixed market demand, $B_j(\bar{\gamma})$, there is a trade-off between including a country in the sourcing set, thus increasing the sourcing capability, and paying for the fixed cost of starting the relationship with that country. For the ex-post profits, we see that, the bigger the sourcing set, the less the profits are affected by specific shocks through the sourcing capability term. So, there is also a trade-off between adding more countries to be less influenced by particular shocks and paying for the fixed cost of sourcing. Since these are ex-post profits, this will only affect the intermediate share of input purchases, not the sourcing decision. For a non-fixed market demand term, there is also an equilibrium effect of aggregate shocks on the price index, which directly impacts the market demand term.

3.2 Choice of Optimal Sourcing Strategy, $\mathcal{I}_j(\varphi)$

Firm φ in country j forms expectations of the supply chain shocks and chooses the optimal sourcing strategy, $\mathcal{I}_j(\varphi) \subseteq I$, that maximizes ex-ante profits. With $\mathbb{1}_{ij}$ an indicator function that takes the value 1 when country i is included in the sourcing strategy of firm φ in country j and 0 if not. We can write the ex-ante problem of the firm as

$$\max_{\mathbb{1}_{ij}\in\{0,1\}_{i=1}^{I}} \mathbb{E}(\pi_j(\varphi,\gamma)) = \mathbb{E}\left(\varphi^{\sigma-1}\Big(\underbrace{\eta\sum_{i=1}^{I}\mathbb{1}_{ij}T_i\big(\tau_{ij}\bar{\gamma}_{ij}\tilde{\gamma}_{ij}(\varphi)w_i\big)^{-\theta}}_{\equiv\Theta_j(\varphi,\bar{\gamma},\tilde{\gamma})}\Big)^{\frac{\sigma-1}{\theta}}B_j(\bar{\gamma})\right) - w_j\sum_{i=1}^{I}\mathbb{1}_{ij}f_{ij} \tag{14}$$

From this, we can see that, given the market demand term $B_j(\bar{\gamma})$, for $(\sigma-1)/\theta > 1$, the firm faces a trade-off between the expected increase in revenues from adding a country to their sourcing strategy and the increase in costs because of the country-specific fixed cost of starting a relationship, $w_j f_{ij}$. The effect of shocks on profits is twofold; supply chain disruption uncertainty affects the sourcing capability of firms as well as the market demand in country j. To see the effect of aggregate supply chain disruption uncertainty on the market demand term for country j, remember that it is defined as

$$B_j(\bar{\gamma}) \equiv \frac{1}{\sigma}\left(\frac{\sigma}{\sigma-1}\right)^{1-\sigma}E_jP_j(\bar{\gamma})^{\sigma-1}$$

where aggregate shocks affect the term through its effect on the price index, since

$$P_j(\bar{\gamma}) = \left(\int_{\tilde{\varphi}}\int_{\tilde{\gamma}(\varphi)} p_j(\varphi,\bar{\gamma},\tilde{\gamma}(\varphi))^{1-\sigma}d\tilde{\Psi}_j^{\varphi}(\tilde{\gamma})dG_j(\varphi)\right)^{\frac{1}{1-\sigma}}$$

This can be thought of as an externality to the firm, since the decision of all other firms of where to source from affects firm φ's expected profits. In the last subsections of section 3 we will dive into the effect of the shock on $P_j(\bar{\gamma})$ and hence on $B_j(\bar{\gamma})$, and how that affects firm's decisions on where to source from.

Examining equation (14), we observe that it is a combinatorial optimization problem in expectation, introducing complexity due to the interdependence inherent in sourcing decisions and the uncertainty.

The decision to incorporate a country in the sourcing strategy depends on the number and characteristics of the other countries in the set. If we just calculate the expected profits for different sourcing strategies and we choose the one that maximizes the equation above, we would have to compute 2^I expectations and choose the highest one. This is feasible for a small number of countries, around 12, but it becomes quickly unfeasible for a larger number of countries. To address this computational challenge, we establish that our problem adheres to a Pecking order in expectation. This distinctive property allows for the application of Jia (2008)'s algorithm, offering a more computationally tractable solution to the optimization problem, particularly in scenarios involving a substantial number of countries.

From the problem of the firm, we can see that there is a relationship between productivity, φ, and sourcing capability, $\Theta_j(\varphi, \bar{\gamma}, \tilde{\gamma}(\varphi))$. From Antràs et al. (2017) we know that, for the case under no uncertainty, the profit function is supermodular in φ and $\Theta_j(\varphi)$. In the case under uncertainty, we have that $\bar{\gamma}_{ij},\ \bar{\gamma}_{ij}(\varphi) > 0$ and the expectation is a weighted average, so we have a weighted average of supermodular functions, which is supermodular. We will prove that the profit function is also supermodular in expectation.

Proposition 1: For $\bar{\gamma}_{ij},\ \tilde{\gamma}_{ij}(\varphi) > 0$ and i.i.d, the solution $\mathbb{1}_{ij}(\varphi) \in \{0,1\}_{i=1}^{I}$ to the optimal sourcing problem is such that

(a) a firm's expected sourcing capability times its market demand term $\mathbb{E}\left(\Theta_j(\varphi, \bar{\gamma}, \tilde{\gamma}(\varphi))^{\frac{\sigma-1}{\theta}} B_j(\bar{\gamma})\right) = \mathbb{E}\left(\left(\sum_{i=1}^{I} \mathbb{1}_{ij}(\varphi) T_i (\tau_{ij} w_i \bar{\gamma}_{ij} \tilde{\gamma}_{ij}(\varphi))^{-\theta}\right)^{\frac{\sigma-1}{\theta}} B_j(\bar{\gamma})\right)$ is nondecreasing in φ;

(b) if $(\sigma-1)/\theta \geq 1$, then $\mathcal{I}_j(\varphi_L) \subseteq \mathcal{I}_j(\varphi_H)$ for $\varphi_H \geq \varphi_L$, where $\mathcal{I}_j(\varphi) = \{i : \mathbb{1}_{ij}(\varphi) = 1\}$

Proof: See Appendix.

Proposition 1, part (a), reveals that more productive firms exhibit a larger expected sourcing capability times market demand compared to less productive firms. This outcome may arise from multiple factors. Firstly, more productive firms may engage in sourcing from a greater number of countries than their less productive counterparts. Alternatively, it could stem from their strategic sourcing from countries characterized by high sourcing potential (i.e., high $T_{ij}(\tau_{ij}\bar{\gamma}_{ij}\tilde{\gamma}_{ij}(\varphi)w_i))$, attributed to factors such as (i) high technology, (ii) low wages, (iii) low iceberg costs, or (iv) small/positive shocks, or because (v) their shocks negatively correlate with the shocks that affect the market demand. For example, it could happen that high productivity firms can have a larger expected sourcing capability times market demand because they buy from one foreign country that is cheaper or has shocks that decrease the price in expectation or that covariate negatively with shocks from the countries that most firms source from. On the opposite side, low productivity firms could be buying from two countries that have lower fixed cost of sourcing than the other country from which the high productivity firm sources from, but have a higher marginal cost. It could be instead that high productivity firms are sourcing from more countries than low productivity firms thus reducing the overall marginal cost for the firm by giving an extra cost draw and increasing competition between countries.

Proposition 1, part (a), leaves the specific mechanism undisclosed, while part (b) provides insight that, under the condition $(\sigma - 1)/\theta \geq 1$, implying complementarity in sourcing decisions, more productive firms source from a greater number of countries compared to less productive firms. This is because the expected profit function has increasing differences in $(\mathbb{1}_{ij}, \mathbb{1}_{kj})$ for $i, k \in \{1, \ldots, I\}$ and $j \neq k$, implying that the marginal benefit of adding an extra country is not reduced by adding other countries to the set $\mathcal{I}_j(\varphi)$. We understand complementarity as the fact that the marginal benefit of adding an extra country increases with the number of countries, since there's an extra draw to lower the cost and that creates competition between countries that lowers the overall cost. This is the case when $(\sigma - 1)/\theta \geq 1$ because it means that either σ is high, and/or, θ is low. A high σ means that consumers are price elastic, so they are more sensitive to lower prices, and a low θ means that inputs are more heterogeneous. When either of this is true, lowering the price has higher benefits, so more productive firms will always want to add countries to their sourcing strategy to reduce the cost.

From Proposition 1 (b), there exists a "pecking" order, which means that there is a strict hierarchical order in the extensive margin of offshoring. This implies a distinct hierarchical arrangement wherein all firms importing from one country source from the same one (e.g., China), and correspondingly, firms importing from two countries do so from the same specific countries (e.g., China and Argentina). However, it is crucial to note that this hierarchical order, under uncertainty, is not necessarily identical to the case without uncertainty. The determination of the hierarchical order now encompasses not only countries' marginal and fixed costs but also their expectations of shocks and how these shocks correlate with market demand, so the pecking order is in expectation. This is the case if we have fixed costs that are relationship specific but not relationship-firm specific.

As we show in Proposition 1, because of increasing differences in the profit function, when $\sigma - 1 \geq \theta$, we can now write:

Proposition 2: For all $i \in \{1, \ldots, I\}$, define the mapping $V_{ij}(\varphi, \bar{\gamma}, \tilde{\gamma}(\varphi), \mathcal{I})$ to take the value of one whenever including country i in the sourcing strategy $\mathcal{I}$ raises firm-level expected profits $\mathbb{E}(\pi_j(\varphi, \bar{\gamma}, \tilde{\gamma}(\varphi), \mathcal{I}))$, and to take a value of zero otherwise. Then, whenever $(\sigma - 1)/\theta \geq 1$, $V_{ij}(\varphi, \bar{\gamma}, \tilde{\gamma}(\varphi), \mathcal{I}') \geq V_{ij}(\varphi, \bar{\gamma}, \tilde{\gamma}(\varphi), \mathcal{I})$ for $\mathcal{I} \subseteq \mathcal{I}'$.

Proof: See Appendix.

Building on Proposition 1, akin to Antràs et al. (2017), we exploit this proposition's insights to employ Jia (2008)'s algorithm. This allows us to reduce the dimensionality of our problem. Leveraging the hierarchical order, we initiate the process from the set comprising all countries, denoted as $\bar{\mathcal{I}}$. Subsequently, we iteratively eliminate countries until we identify the point where $V_{ij}(\varphi, \bar{\gamma}, \tilde{\gamma}(\varphi)) = 0$. This outcome provides the upper bound for the sourcing strategy. Conversely, starting with the set that encompasses no countries, denoted as $\underline{\mathcal{I}}$, we systematically incorporate countries until $V_{ij}(\varphi, \bar{\gamma}, \tilde{\gamma}(\varphi)) = 1$ is reached. This procedure yields the lower bound for the sourcing strategy. By adopting this approach, we circumvent the need to compute all potential sourcing strategies to address the firm's problem. This reduction in dimensionality enables the resolution of the problem for a larger number of countries. However, it's important to note that this method is applicable exclusively in the "complements" case, where $\sigma - 1 > \theta$. It is not suitable for the "substitutes" case, which would necessitate additional assumptions, such as a common fixed cost for all foreign countries.

Finally, we obtain the firm-level intermediate input purchases from any country $i \in \mathcal{I}_j(\varphi)$. This is an ex-post decision for firms, so, for $i \in \mathcal{I}_j(\varphi)$, this will be a fraction $(\sigma - 1)\mathcal{X}_{ij}(\varphi, \bar{\gamma}, \tilde{\gamma}(\varphi))$ of firm's ex-post profits

$$M_{ij}(\varphi, \bar{\gamma}, \tilde{\gamma}) = (\sigma - 1)\ \eta^{\frac{\sigma-1}{\theta}}\ \varphi^{\sigma-1}\ (\Theta_j(\varphi, \bar{\gamma}, \tilde{\gamma}(\varphi)))^{\left(\frac{\sigma-1}{\theta}-1\right)}\ T_i(\tau_{ij}\bar{\gamma}_{ij}\tilde{\gamma}_{ij}(\varphi)w_i)^{-\theta}\ B_j(\bar{\gamma}), \tag{15}$$

with $M_{ij}(\varphi, \bar{\gamma}, \tilde{\gamma}(\varphi)) = 0$ otherwise.

From equation (15), we observe that, for $(\sigma - 1) \geq \theta$, i.e., when there are complementarities in the sourcing decisions, and with fixed market demand, $B_j(\bar{\gamma})$, firm-level intermediate input purchases from any country $i \in \mathcal{I}_j(\varphi)$ are increasing in both sourcing potential, $T_i(\tau_{ij}\bar{\gamma}_{ij}\tilde{\gamma}_{ij}(\varphi)w_i)^{-\theta}$, and sourcing capability, $\Theta_j(\varphi, \bar{\gamma}, \tilde{\gamma}(\varphi)) = \sum_{k \in \mathcal{I}_j(\varphi)} T_k(\tau_{kj}\bar{\gamma}_{kj}\tilde{\gamma}_{kj}(\varphi)w_k)^{-\theta}$. This implies that, not only does the sourcing potential of country i contribute to firm-level intermediate input purchases, but also the sourcing potential from all other countries in the firm's sourcing strategy, $k \in \mathcal{I}_j(\varphi)$. In cases where $B_j(\bar{\gamma})$ is not fixed, idiosyncratic shocks impact solely the sourcing potential and capability. Consequently, both aggregate and idiosyncratic shocks for all countries affect the firm-level intermediate input purchase decision of firm φ in country j's through the sourcing capability and country i's shock through the sourcing potential too. Aggregate shocks for all countries influence the market demand too, resulting in the sourcing decision of all other firms also affecting firm φ's intermediate input purchases.

In the absence of a constant market demand term, $B_j(\bar{\gamma})$, the impact of an aggregate shock $\bar{\gamma}_{ij}$ on $M_{ij}(\varphi, \bar{\gamma}, \tilde{\gamma}(\varphi))$ becomes nuanced. Consider a scenario where only country $i \in \mathcal{I}_j(\varphi)$ experiences a negative shock. This would lead to a reduction in both the sourcing potential of country i and the sourcing capability from the point of view of a firm φ in country j. However, the equilibrium-determined market demand will be affected through the price change. It could even happen that there is a big enough increase in market demand to offset the negative effect of the shock. Conversely, if only country $k \in \mathcal{I}_j(\varphi)$ is shocked, the sourcing potential of country i from the viewpoint of country j remains unaffected, but the sourcing capability diminishes, while the market demand term rises. In this situation, it is plausible that the increase in market demand, triggered by the higher price of the alternative country i, could counterbalance the reduction in demand for intermediate inputs from country i due to the complementarities in sourcing capability. The outcome hinges on how big the shock is and the distribution of firms sourcing from each origin.

Consider an idiosyncratic shock occurring in a country $k \neq i$, with $k \in \mathcal{I}_j(\varphi)$, such that $B_j(\bar{\gamma})$ remains unaffected. This shock will diminish the sourcing capability of country j. Under the condition $(\sigma - 1)/\theta > 1$, this reduction will propagate to decrease firm-level intermediate input purchases from all countries, not limited to country k. In the case of a shock to i, the reduction will be even more pronounced due to the concurrent decrease in the sourcing potential of country i.

Nonetheless, except for the case of idiosyncratic shocks, the price index will adjust in equilibrium, which will affect the market demand. In the event of a shock to country k, the market demand term will rise, which could counterbalance the decrease of the sourcing capability or even increase the firm-level intermediate input purchases from country $i \neq k$. In sections 3.6-3.8, we will take a closer look at the effect of uncertainty in the expected profits of final-good firms.

3.3 Equilibrium

To solve for the equilibrium, we will assume that there is a perfectly competitive outside sector in which consumers spend $(1-\alpha)$ of their labor income on. This implies that they allocate α of their labor income to our relevant sector. The outside good, which is homogeneous and freely tradable across countries, utilizes labor linearly and serves as our numeraire. We assume that the share $(1-\alpha)$ is large enough that the labor productivity of this sector pins down the wage rate w_j in each country j. As previously noted, we only need to determine $P_j(\bar{\gamma})$ since wages are exogenous.

Because of our assumed timeline, firms make the decision to enter and pay the fixed cost of entry before learning their productivities. Consequently, firms will continue to enter until the expected profits from entry become zero. Therefore, the free-entry condition in our sector is expressed as:

$$\int_{\tilde{\varphi}_j}^{\infty} \int_{\bar{\gamma}} \int_{\tilde{\gamma}(\varphi)} \left[\varphi^{\sigma-1} (\eta \Theta_j(\varphi, \bar{\gamma}, \tilde{\gamma}(\varphi)))^{(\sigma-1)/\theta} B_j(\bar{\gamma}) - w_j \sum_{i \in \mathcal{I}_j(\varphi)} f_{ij} \right] d\tilde{\Psi}_{ij}^{\varphi}(\tilde{\gamma}) d\bar{\Psi}_{ij}(\bar{\gamma}) dG_j(\varphi) = w_j f_{ej}, \quad (16)$$

where $\tilde{\varphi}_j$ denotes the productivity of the least productive firm in country j.

Proposition 3: Equation (17) delivers a unique market demand level $B_j(\bar{\gamma})$ for each state of the world and for each country $j \in I$.

Proof: See Appendix. WIP.

Finally, we want to obtain the number of active firms in equilibrium so, using equations (16), (5), (11), and (12), as well as Fubini's theorem, and the fact that E_j is a share α of labor income, we find[3]

$$N_j = \frac{\alpha L_j}{\sigma\left(\int_{\tilde{\varphi}_j}^{\infty}\int_{\tilde{\gamma}(\varphi)}\sum_{i\in\mathcal{I}_j(\varphi)} f_{ij} d\Psi_{ij}^{\varphi}(\tilde{\gamma}) dG_i(\varphi) + f_{ej}\right)} \tag{17}$$

This leads to the equilibrium number of active firms denoted as $N_j[1 - G_j(\tilde{\varphi}_j)]$. This is obtained when the fixed cost of sourcing from domestic is non-zero, resulting in a positive measure of firms choosing not to produce. For our empirical strategy, we set the domestic fixed cost, f_{jj}, to be zero, so all firms will produce, since in our data we only observe firms that produce.

3.4 Gravity Equation

As final goods are not traded, all transactions occur at the intermediate goods level. Then, to find the aggregate volume of bilateral trade, or gravity equation, we only need to aggregate the firm-level intermediate input purchases from countries i across firms in country j. Given that trade in intermediate goods occurs ex-post, we formulate the gravity equation for a specific realization of the shocks $\bar{\gamma}_{ij}, \tilde{\gamma}_{ij}(\varphi)$. Substituting equation (15), we obtain:

$$\begin{aligned} M_{ij}(\bar{\gamma}) &= N_j \int_{\tilde{\varphi}_{ij}}^{\infty}\int_{\tilde{\gamma}(\varphi)} M_{ij}(\varphi,\bar{\gamma},\tilde{\gamma}(\varphi)) d\tilde{\Psi}_i^{\varphi}(\gamma) dG_i(\varphi) \\ &= N_j(\sigma-1)\eta^{\frac{\sigma-1}{\theta}} T_i(\tau_{ij}\bar{\gamma}_{ij}w_i)^{-\theta} B_j(\bar{\gamma}) \int_{\tilde{\varphi}_{ij}}^{\infty}\int_{\tilde{\gamma}(\varphi)} \mathbb{1}_{ij}(\varphi)\varphi^{\sigma-1}(\Theta_j(\varphi,\bar{\gamma},\tilde{\gamma}(\varphi)))^{\left(\frac{\sigma-1}{\theta}-1\right)}(\tilde{\gamma}_{ij}(\varphi))^{-\theta} d\tilde{\Psi}_i^{\varphi}(\gamma) dG_i(\varphi), \end{aligned} \tag{18}$$

so,

$$M_{ij}(\bar{\gamma}) = N_j(\sigma-1)\eta^{\frac{\sigma-1}{\theta}} T_i(\tau_{ij}\bar{\gamma}_{ij}w_i)^{-\theta} B_j(\bar{\gamma})\Lambda_{ij}(\bar{\gamma}), \tag{19}$$

with,

$$\Lambda_{ij}(\bar{\gamma}) \equiv \int_{\tilde{\varphi}_{ij}}^{\infty}\int_{\tilde{\gamma}(\varphi)} \mathbb{1}_{ij}(\varphi)\varphi^{\sigma-1}(\Theta_j(\varphi,\bar{\gamma},\tilde{\gamma}(\varphi)))^{\left(\frac{\sigma-1}{\theta}-1\right)}(\tilde{\gamma}_{ij}(\varphi))^{-\theta} d\tilde{\Psi}_i^{\varphi}(\gamma) dG_i(\varphi), \tag{20}$$

where, again, $\tilde{\varphi}_{ij}$ represents the productivity of the least productive firm in country j importing from country i. Notably, $B_j(\bar{\gamma})$ will not be a part of the definition of $\Lambda_{ij}(\bar{\gamma})$, since idiosyncratic shocks do not affect the price index. Using the definition of $B_j(\bar{\gamma})$ and $Q_i = \sum_k M_{ik}$ the total production of intermediate inputs in country j, for general shocks, we get,

$$M_{ij}(\bar{\gamma}) = \frac{E_j}{P_j(\bar{\gamma})/N_j} \times \frac{Q_i}{\sum_k \frac{E_k}{P_k(\bar{\gamma})/N_k}(\tau_{ik}\bar{\gamma}_{ik})^{-\theta}\Lambda_{ik}(\bar{\gamma})} \times (\tau_{ij}\bar{\gamma}_{ij})^{-\theta} \times \Lambda_{ij}(\bar{\gamma}), \tag{21}$$

[3] Fubini's theorem states that if the integral of the absolute value is finite, then the order of integration does not matter, so we can interchange the order of the integrals.

with,

$$P_j(\bar{\gamma}) = \left(N_j \int_{\tilde{\varphi}_{ij}}^{\infty} \int_{\tilde{\gamma}(\varphi)} p_i(\varphi,\gamma)^{1-\sigma} d\Psi_{ij}^{\varphi}(\tilde{\gamma}) dG_j(\varphi)\right)^{\frac{1}{1-\sigma}},$$

the ideal price index and E_j is expenditure in our sector, which is fixed as a proportion α of labor income.

This equation implies a relationship between bilateral trade flows and exporter fixed effects, importer fixed effects, and iceberg costs. However, it also includes the term $\Lambda_{ij}(\bar{\gamma})$, which varies for both i and j, unless all firms import from all countries. As shown in Antràs et al. (2017), this could happen if $f_{ij} = 0$ for all i, resulting in $\Lambda_{ij}(\bar{\gamma}) = \Lambda_j(\bar{\gamma})$. In this case, shocks shouldn't matter in terms of sourcing strategies, since firms are already importing from all countries, so after the shocks are realized they can just buy from the countries that were positively or least negatively affected. The parameter θ provides the elasticity of trade flows with respect to changes in these bilateral trade frictions and the aggregate elasticity coincides with the firm-level elasticity, which is not the case whenever $f_{ij} > 0$. As shown in Antràs et al. (2017), in this case, the elasticity of trade flows with respect to changes in the bilateral trade frictions is higher than θ.

To control for the extended gravity forces, we again follow Antràs et al. (2017) and define an importer-specific term: $\Xi_j(\bar{\gamma}) \equiv K_j(\bar{\gamma}) T_j(\tau_{jj}\bar{\gamma}_{jj}w_j)^{-\theta} N_j B_j(\bar{\gamma})$, with $K_j(\bar{\gamma}) = (\sigma-1)\eta^{(\sigma-1)/\theta} N_j B_j(\bar{\gamma})$ so we can write,

$$\Lambda_{ij}(\bar{\gamma}) = \frac{K(\bar{\gamma})}{\Xi_j(\bar{\gamma})} \int_{\tilde{\varphi}_{ij}}^{\infty} \int_{\tilde{\gamma}_{ij}(\varphi)} \mathbb{1}_{ij}(\varphi)\varphi^{\sigma-1}(\Theta_j(\varphi,\gamma))^{(\sigma-1)/\theta-1} T_j(\tau_{jj}\tilde{\gamma}_{jj}(\varphi)w_j)^{-\theta} d\tilde{\Psi}_{ij}^{\varphi}(\varphi) dG_j(\varphi), \tag{22}$$

where the second term on the right-hand side corresponds to the *domestic input purchases* aggregated over all firms based in j that import inputs from i, so now the elasticity of trade θ is closer to the firm-level estimates. How to obtain this expression can be found in the appendix.

3.5 Herfindahl-Hirschman Index (HHI)

As we aim to comprehend both the sourcing strategy (extensive margin) and the decision on how much to purchase from each available source (intensive margin), we are also concerned with the impact of supply chain risk on intermediate input purchases and market concentration. In our introduction, we used publicly available data at the product-origin level for Chile, classified using the harmonized-system (HS) at the 8-digit level, which is a standardized method of classifying traded products using numerical digits. We obtained Figure (1), which shows the unweighted average of the yearly country-level HHI from 2017 to 2023. Notably, there is a substantial increase in market concentration post-2020, coinciding with the heightened supply chain uncertainty due to Covid-19. The concentration subsequently exhibits a gradual decrease. This suggests that following Covid-19, the concentration of foreign suppliers increased. This phenomenon may arise from either a reduction in the set of countries Chile imports from or firms adjusting the intensive margin by subsequently purchasing from a smaller set of countries less affected by the shock.

We would like to be able to match this with our model and understand the mechanism in action. To do that, we need to obtain the model-implied HHI. Using equation (18), aggregating over all sources of import to obtain the total imports for country j, which gives us the market share, then squaring that and summing over all sources, we get the HHI for country j, which is:

$$
\begin{aligned}
HHI_j &= \sum_{i=1}^{I} (ms_{ij})^2 \\
&= \sum_{i=1}^{I} \left(\frac{M_{ij}(\bar{\gamma})}{\sum_{k=1}^{I} M_{kj}(\bar{\gamma})} \right)^2 \\
&= \sum_{i=1}^{I} \left(\frac{T_i(\tau_{ij}\bar{\gamma}_{ij}w_i)^{-\theta}\Lambda_{ij}(\bar{\gamma})}{\sum_{k=1}^{I} T_k(\tau_{kj}\bar{\gamma}_{kj}w_k)^{-\theta}\Lambda_{kj}(\bar{\gamma})} \right)^2
\end{aligned}
\tag{23}
$$

We are summing over all countries and not just the set of suppliers since we know that the value will be zero if no firm buys from that country. The term $\Lambda_{ij}(\bar{\gamma})$ is defined as detailed earlier. We can subsequently leverage our findings from the structural estimation process to obtain the model-implied HHI and assess the fit of our model.

3.6 Simple case: 2 countries with aggregate shock

To understand the mechanisms that are at play in our model, we develop a simple case with 2 countries and both aggregate and idiosyncratic uncertainty. We simplify everything as much as possible and assume that technology is the same in both Home and Foreign, wages, as well as iceberg costs, are 1 at Home, so $T_H = T_F = w_H = \tau_{HH} = 1$. We denote the countries as Home, H, and Foreign, F. Specifically, we consider the case where the fixed cost of sourcing domestically (f_H) is set to zero, implying that firms invariably prioritize sourcing from the Home country before considering buying from Foreign. Consequently, the sourcing strategy of exclusively procuring from Foreign is not an option. Instead, firms in this simplified setting face a binary choice: either they source solely from Home (H) or opt for a mixed strategy by sourcing from both Home and Foreign (FH).

To simplify things further, supply chain shocks, with $\bar{\gamma}_{ij}$ denoting the aggregate shocks, and $\tilde{\gamma}_{ij}(\varphi)$, denoting the idiosyncratic shocks, will follow an independent and identically distributed (i.i.d.) Binomial distribution. Specifically, we concentrate on the scenario of "non-positive" shocks, i.e., shocks that can only maintain or increase the price. This case is specified as follows:

$$
\bar{\gamma}_i = \begin{cases} 1 & \text{wp } 1 - \bar{\pi}_i \\ \bar{\delta}_i & \text{wp } \bar{\pi}_i \end{cases}, \qquad \tilde{\gamma}_i^{\varphi} = \begin{cases} 1 & \text{wp } 1 - \tilde{\pi}_i^{\varphi} \\ \tilde{\delta}_i^{\varphi} & \text{wp } \tilde{\pi}_i^{\varphi} \end{cases},
$$

with $i \in \{H, F\}$, $1 < \bar{\delta}_H < \bar{\delta}_F$, $1 < \tilde{\delta}_H^{\varphi} < \tilde{\delta}_F^{\varphi}$, and the probability of shock is higher for Foreign than for Home, $\bar{\pi}_F > \bar{\pi}_H$, and $\tilde{\pi}_F^{\varphi} > \tilde{\pi}_H^{\varphi}$. We now compare the expected profits for each of the strategies and understand how aggregate and idiosyncratic uncertainty affects the firm's decision of where to source from.

For a firm that decides to exit, the expected profits are zero. We then proceed to show the expected profits of a firm whose sourcing strategy is to buy only from Home, so the only shocks that affect this firm are the domestic aggregate shock and the firm-domestic specific shock, such that:

$$
\mathbb{E}(\pi(\varphi, \bar{\gamma}, \tilde{\gamma}^{\varphi})) = \varphi^{\sigma-1}\, \eta^{\frac{\sigma-1}{\theta}} \sum_{\gamma} \mathbb{P}(\bar{\gamma}_H, \bar{\gamma}_F, \tilde{\gamma}_F^{\varphi}, \tilde{\gamma}_H^{\varphi})(\bar{\gamma}_H \tilde{\gamma}_H^{\varphi})^{1-\sigma} B(\bar{\gamma}_H, \bar{\gamma}_F) \tag{24}
$$

where we don't have a fixed cost of sourcing from Home since we set it up to be equal to zero.

We now find the expected profits for a firm whose sourcing strategy includes both Home and Foreign countries. This firm will be affected by both domestic and foreign aggregate uncertainty as well as firm-origin specific uncertainty for both domestic and foreign. The expected profits for a firm with this sourcing behavior are:

$$\mathbb{E}(\pi(\varphi,\bar{\gamma},\tilde{\gamma}^{\varphi})) = \varphi^{\sigma-1}\eta^{\frac{\sigma-1}{\theta}} \sum_{\gamma} \mathbb{P}(\bar{\gamma}_H,\bar{\gamma}_F,\tilde{\gamma}_F^{\varphi},\tilde{\gamma}_H^{\varphi})\Big((\tau_F\bar{\gamma}_F\tilde{\gamma}_F^{\varphi}w_F)^{-\theta}+(\bar{\gamma}_H\tilde{\gamma}_H^{\varphi})^{-\theta}\Big)^{\frac{\sigma-1}{\theta}} B(\bar{\gamma}_H,\bar{\gamma}_F) - f_F \tag{25}$$

with $\Theta_H(\varphi,\bar{\gamma},\tilde{\gamma}^{\varphi}) = (\bar{\gamma}_H\tilde{\gamma}_H^{\varphi})^{-\theta}$, and $\Theta_{HF}(\varphi,\bar{\gamma},\tilde{\gamma}^{\varphi}) = (\tau_F\bar{\gamma}_F\tilde{\gamma}_F^{\varphi}w_F)^{-\theta}+(\bar{\gamma}_H\tilde{\gamma}_H^{\varphi})^{-\theta}$ the sourcing capabilities for each of the two sourcing strategy. Because shocks are distributed i.i.d Binomial, we have $2^4 = 16$ possible states of the world in this case. This means that we have 16 different probabilities of shocks, e.g., $\mathbb{P}(\bar{\delta}_H,\bar{\delta}_F,\tilde{\delta}_H^n,\tilde{\delta}_F^n) = \bar{\pi}_H\bar{\pi}_F\tilde{\pi}_H^{\varphi}\tilde{\pi}_F^{\varphi}$, or $\mathbb{P}(\bar{\delta}_H,\bar{\delta}_F,\tilde{\delta}_H^n,\tilde{\delta}_F^n) = (1-\bar{\pi}_H)\bar{\pi}_F\tilde{\pi}_H^{\varphi}\tilde{\pi}_F^{\varphi}$. Finally, since there is no domestic fixed cost, we only consider the foreign fixed cost.

Then, we take a look at the firm-level intermediate input purchases. This is an ex-post decision, so it happens after shocks have already been realized. For a firm that only sources from Home:

$$M_H(\varphi,\gamma) = (\sigma-1)\ \eta^{\frac{\sigma-1}{\theta}}\varphi^{\sigma-1}(\bar{\gamma}_H\tilde{\gamma}_H^{\varphi})^{1-\sigma+\theta}B(\bar{\gamma}_H,\bar{\gamma}_F) \tag{26}$$

and for the case of a firm that sources from both Foreign and Home:

$$M_H(\varphi,\gamma) = (\sigma-1)\ (\eta\varphi^{\theta})^{\frac{\sigma-1}{\theta}}\Big((\tau_F\bar{\gamma}_F\tilde{\gamma}_F^{\varphi}w_F)^{-\theta}+(\bar{\gamma}_H\tilde{\gamma}_H^{\varphi})^{-\theta}\Big)^{\frac{\sigma-1}{\theta}-1}(\bar{\gamma}_H\tilde{\gamma}_H^{\varphi})^{-\theta}B(\bar{\gamma}_H,\bar{\gamma}_F) \tag{27}$$

$$M_F(\varphi,\gamma) = (\sigma-1)\ (\eta\varphi^{\theta})^{\frac{\sigma-1}{\theta}}\Big((\tau_F\bar{\gamma}_F\tilde{\gamma}_F^{\varphi}w_F)^{-\theta}+(\bar{\gamma}_H\tilde{\gamma}_H^{\varphi})^{-\theta}\Big)^{\frac{\sigma-1}{\theta}-1}(\tau_F\bar{\gamma}_F\tilde{\gamma}_F^{\varphi}w_F)^{-\theta}B(\bar{\gamma}_H,\bar{\gamma}_F) \tag{28}$$

We will now take a closer look to what the market demand term includes. We have that

$$B(\bar{\gamma}_H,\bar{\gamma}_F) = K \times P(\bar{\gamma}_H,\bar{\gamma}_F)^{\sigma-1}$$

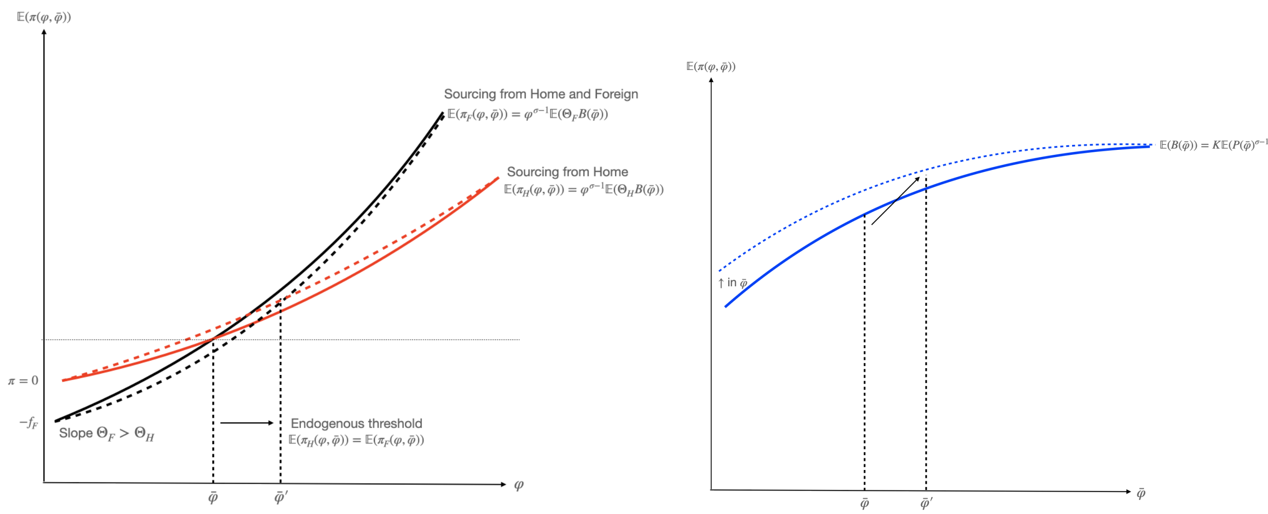
with $K \equiv \frac{1}{\sigma} \times \left(\frac{\sigma}{\sigma-1}\right)^{1-\sigma} \times E$ a constant.

Then, for each realization of the shocks, we will have different values of the price index $P(\bar{\gamma}_H,\bar{\gamma}_F)$: $P(\bar{\delta}_H,\bar{\delta}_F)$, $P(\bar{\delta}_H,1)$, $P(1,\bar{\delta}_F)$, $P(1,1)$. Writing them out, we have:

$$\begin{aligned}
P_H(\bar{\delta}_H,\bar{\delta}_F)^{\sigma-1} &= \left(\frac{\sigma-1}{\sigma}\right)\left(\frac{\eta^{\frac{1}{\theta}}}{s_1(\tilde{\varphi},\bar{\varphi})\ \bar{\delta}_H^{1-\sigma}+s_2(\bar{\varphi})\ (\bar{\delta}_H^{-\theta}+(\tau_{FH}\bar{\delta}_F w_F)^{-\theta})^{\frac{\sigma-1}{\theta}}}\right)\\
P_H(\bar{\delta}_H,1)^{\sigma-1} &= \left(\frac{\sigma-1}{\sigma}\right)\left(\frac{\eta^{\frac{1}{\theta}}}{s_1(\tilde{\varphi},\bar{\varphi})\ \bar{\delta}_H^{1-\sigma}+s_2(\bar{\varphi})\ (\bar{\delta}_H^{-\theta}+(\tau_{FH}w_F)^{-\theta})^{\frac{\sigma-1}{\theta}}}\right)\\
P_H(1,\bar{\delta}_F)^{\sigma-1} &= \left(\frac{\sigma-1}{\sigma}\right)\left(\frac{\eta^{\frac{1}{\theta}}}{s_1(\tilde{\varphi},\bar{\varphi})+s_2(\bar{\varphi})\ (1+(\tau_{FH}\bar{\delta}_F w_F)^{-\theta})^{\frac{\sigma-1}{\theta}}}\right)\\
P_H(1,1)^{\sigma-1} &= \left(\frac{\sigma-1}{\sigma}\right)\left(\frac{\eta^{\frac{1}{\theta}}}{s_1(\tilde{\varphi},\bar{\varphi})+s_2(\bar{\varphi})\ (1+(\tau_{FH}w_F)^{-\theta})^{\frac{\sigma-1}{\theta}}}\right)
\end{aligned} \tag{29}$$

The shares, denoted as $s_1(\tilde{\varphi}, \bar{\varphi})$ and $s_2(\bar{\varphi})$, represent the proportions of firms exclusively sourcing from Home and those diversifying and sourcing from both Home and Foreign, respectively. From the equation above, we can see that the effect of an aggregate shock on the price index depends on these shares which, at the same time, depend on the expectation of the shocks, as well as the productivity of the firm and fixed costs. We are interested in understanding what is the effect of expected shocks on the shares and, finally, what is the effect on the price index, which will allow us to comprehend what are the moving pieces that affect firm's sourcing decisions. To find the value of $\bar{\varphi}$ that determines the cutoff productivity level for firms that only import from Home versus firms that import from both Home and Foreign, we set the expected utility of sourcing from Home equal to that of sourcing from both Foreign and Home, with $\mathbb{E}(\pi_H) = \mathbb{E}(\pi_{FH})$. This equality allows us to recover $\bar{\varphi}$, i.e., the productivity value of the marginal firm, which is indifferent, in expectation, between the two sourcing strategies.

Figure 4: Simple 2 countries example



(a) Cutoff

(b) Effect of cutoff on market demand

In Figure 4, we plot the simple case of firms' profits, and expected profits, when there are only two countries in the world, Home and Foreign. We plot both the case with and without uncertainty, and where the productivity parameter, denoted as φ, follows a Uniform distribution. Figure 4a depicts the expected profits of firms that source from either only Home (red line) or Home and Foreign (black line) when there is no uncertainty (solid line) and when there is uncertainty (dotted line). In the absence of uncertainty, firms solely sourcing from Home initially exhibit higher expected profits due to a lower fixed cost. However, because the slope of the firms that diversify (i.e., source from both Home and Foreign) is higher, since higher productivity firms benefit more from sourcing from more countries, there is a productivity level after which the profits of diversifying surpasses those from sourcing only from Home. Passed that threshold, all firms with a productivity higher than that will source from both Home and Foreign because they obtain higher profits choosing that sourcing strategy than sourcing only from domestic. Now, when there is uncertainty, we know that the market demand will be affected, since firms that source from both Home and Foreign will have to increase their prices, either by sourcing more from Home, which is more expensive, or sourcing from a now more expensive, in expectation, Foreign country. For firms sourcing only from Home there is no direct effect in their sourcing capability. The only effect they face is through the expected change in the market demand, which increases if Foreign is shocked, so the profits, as well as the slope, increase with uncertainty in the Foreign country. This occurs because a higher uncertainty in Foreign affects the expected price of final goods and hence the overall demand for cheaper goods. This will increase the demand for final goods from firms that source only from Home because now the price difference will be less, i.e., they gain competitiveness. Now, for the firms that source from both Home and Foreign, the result is ambiguous. On the one hand, the increase in uncertainty reduces firms' sourcing capability, decreasing profits, and on the other hand, market demand increases, counteracting the decrease in profits. Then, it could happen that the increase in market demand is big enough ($\bar{\varphi}$ is low enough) that negative shocks do not affect firms' expected profits that much. The illustrated scenario in the figure represents the specific case where the expected profits end up decreasing due to the increase in Foreign uncertainty.

In Figure 4b, we examine the influence of the threshold on the market demand, denoted as $B_j(\bar{\gamma})$. This is a concave function that, for the case of no uncertainty (solid line), increases with the threshold, $\bar{\varphi}$. A higher threshold implies reduced diversification, leading to more firms exclusively relying on Home for inputs, which are costlier than those from Foreign. Consequently, these firms set higher prices, contributing to an increase in the price index, increasing the market demand for lower priced goods. Then, when there is an increase in uncertainty (dotted line), we observe from Figure 4a that this increases the threshold, and so the market demand, since there are more firms sourcing from the more expensive country, Home. However, this will decrease the impact of the uncertainty, since more firms won't be affected by it. Both the aggregate shock and uncertainty exert an influence on the price, or expected price, consequently affecting the overall price index.

In equation (25), and as depicted in Figure 4b, we observe that aggregate uncertainty affects both the sourcing capability of firm φ in country j as well as the market demand for country j, $B_j(\bar{\gamma})$. Specifically, heightened aggregate uncertainty at Home diminishes the sourcing capability of all firms acquiring inputs from Home. This effect is also observed for firms sourcing from both Home and Foreign, albeit to a lesser extent, as their sourcing capability depends not only on the Home country but also on Foreign, which allows them to substitute ex-post through the intensive margin. The higher uncertainty will also increase the market demand, which acts in the opposite direction as the effect on the sourcing capability. This occurs because, if the foreign country does not get shocked, firms that source from both the domestic and foreign countries can sell their goods at a lower cost than the ones that only source from domestic, so they get a higher market demand. From this, we learn that the effect of an increase in aggregate uncertainty at Home is ambiguous and depends on these two counteracting forces. Whereas, an increase in idiosyncratic uncertainty at Home only impacts the sourcing capability and does not affect the market demand. Then, ceteris paribus, if there is an increase in idiosyncratic uncertainty the sourcing capability will be reduced, as well as ex-ante profits.

Consider now the scenario where, all else equal, the foreign country experiences an increase in aggregate uncertainty. This change affects both the sourcing capability and the market demand for a firm that sources from both Foreign and Home. However, for a firm exclusively importing from Home, while its sourcing capability remains unaffected, the increase in market demand positively impacts expected profits through the rise in the price index. Consequently, firms capable of producing at a lower cost (i.e., those unaffected by the shocks) witness an increase in expected profits due to the heightened market demand. Conversely, if only idiosyncratic uncertainty intensifies, it does not influence the market demand, as idiosyncratic shocks are averaged out. Nevertheless, it diminishes the sourcing capability, leading to a reduction in expected profits. Then, if all countries increase their aggregate uncertainty and there's also an increase in idiosyncratic uncertainty, the first two will affect the market demand, increasing expected profits. However, the negative impact of the reduced sourcing capability counteracts these effects, and could even result in a net decrease in expected profits.

The impact of shocks on intermediate input purchases is different due to the ex-post nature of this decision, where uncertainty does not play a role in this case, but the realization of the shocks do. Given $B_j(\bar{\gamma})$, and $\sigma - 1 > \theta$, both idiosyncratic and aggregate shocks lead to a reduction in sourcing potential and subsequent decreases in intermediate input purchases from all sources. In contrast, an increase in aggregate shocks also results in an increase in $B_j(\bar{\gamma})$, partially mitigating the decline induced by the reduced sourcing potential and capability. Consequently, the negative effect of the shock on firms' profits decreases. Then, higher $\bar{\varphi}$ values lead to more firms exclusively sourcing from Home, resulting in a reduced susceptibility of the market demand to an increase in the shock from Foreign, decreasing the intermediate input purchases from all countries.

3.7 Expected Profits' Decomposition

As firms aim to maximize expected profits in our multi-country model with supply chain uncertainty, it becomes crucial to discern the factors influencing these expected profits and their respective effects. To achieve this, we decompose the components that contribute to firms' expected profits into five key elements: (i) sourcing capability for expected shocks, (ii) the impact of risk on sourcing capability, (iii) expected market demand, (iv) covariance between sourcing capability and market demand, and (v) the fixed costs of sourcing. This decomposition allows us to scrutinize each factor's influence on firms' expected profits comprehensively. We will first do the theoretical decomposition and then we will use a numerical exercise to explore the specific effects of each of these components.

$$\begin{aligned}\mathbb{E}\big[\pi(\varphi,\gamma)\big] = \varphi^{\sigma-1}\Big(& \underbrace{\Theta_H(\varphi,\mathbb{E}[\gamma])^{\frac{\sigma-1}{\theta}}}_{\text{Sourcing capability for expected shock}} \\ & + \underbrace{\mathbb{E}\big[\Theta_H(\varphi,\gamma)^{\frac{\sigma-1}{\theta}} - \Theta_H(\varphi,\mathbb{E}[\gamma])^{\frac{\sigma-1}{\theta}}\big]}_{\text{Risk effect on capability}}\Big) \times \underbrace{\mathbb{E}(B_H(\bar{\gamma}))}_{\text{Expected market demand}} \\ & + \varphi^{\sigma-1} \underbrace{Cov(\Theta_H(\varphi,\gamma)^{\frac{\sigma-1}{\theta}}, B_H(\gamma))}_{\text{Covariance btw sourcing capability \& market demand}} - \underbrace{w_j \sum_{i\in\mathcal{I}(\varphi)} f_{ij}}_{\text{Fixed cost of sourcing}}\end{aligned} \tag{30}$$

The first term, the sourcing capability for the expected shock, encapsulates the impact on expected profits when incorporating an additional country into the set of sourcing options. This increase in expected profits results from the additional cost draw, heightening competition between countries in the sourcing strategy and thereby reducing overall costs, as observed in Antràs et al. (2017). Notably, this term is affected by the shock itself but remains unaffected by the uncertainty surrounding it, given its dependence on the average rather than the variance. Then, this term gives us the effect of an additional country because of increase competition and not because of reduced uncertainty. The second term, the risk effect on the sourcing capability, introduces the first effect of uncertainty through an option value, representing the expected difference between the sourcing capability for a specific shock and the sourcing capability for the expected shock. This term reflects the influence of the variance of the shocks on the variance of the sourcing capability, contributing to the overall expected profits. In this case, firms prefer to add countries with a high level of uncertainty because the option value term implies that firms have the chance to sell cheap if one of the countries is positively shocked. Because firms can ex-post adjust their intensive margin, they can buy mostly from the country that is positively shocked and then sell at a lower cost. Both the sourcing capability for the expected shock term and the option value term are then multiplied by the expected market demand term. Another effect that the uncertainty has on the sourcing decision of firms comes from the covariance between the sourcing capability and the market demand, since firms would want to hedge and source from countries that are negatively correlated with the countries most other firms source from. While the sourcing capability term is influenced by both aggregate and idiosyncratic uncertainty, the market demand is affected solely by aggregate uncertainty. This term likely exhibits a negative impact, as a negative covariance suggests that the countries firm φ sources from experience positive shocks when most firms source from countries undergoing negative shocks, or vice versa. This allows firm φ to hedge and capture a higher market demand by being able to offer a lower price whenever most other firms get negatively shocked. Lastly, the expected profits decrease due to the fixed cost of adding a country to the sourcing strategy, $w_j f_{ij}$ per country i in the sourcing strategy. The existence of these fixed cost of sourcing is the reason why firms don't just source from all countries and more productive firms, who have higher earnings, can source from more, and more expensive, countries.

3.8 Numerical Experiment

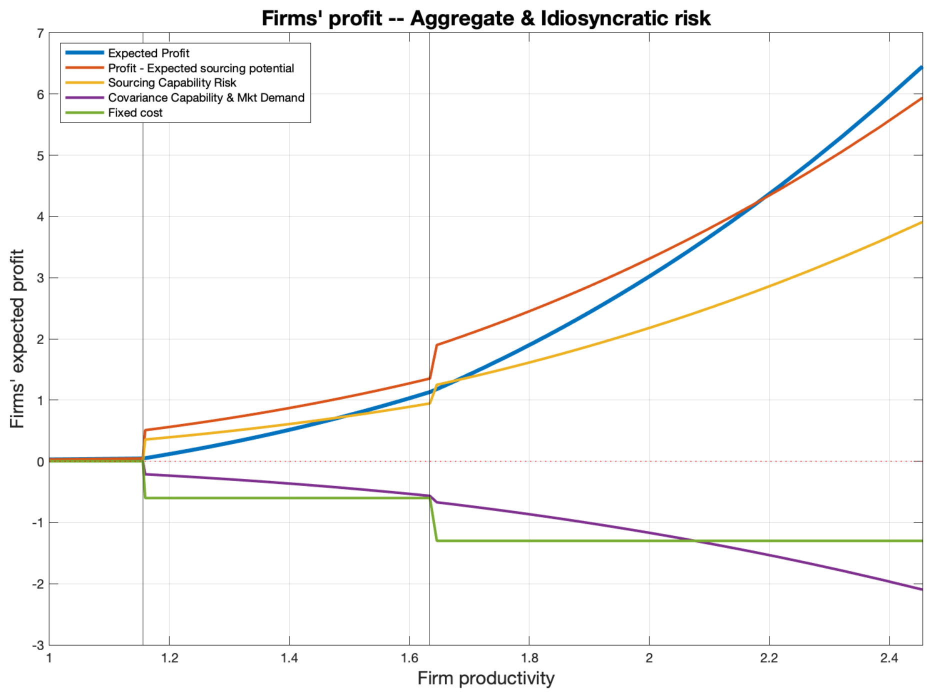
To comprehend the behavior of our model, we have solved it using specific numerical values. Table 1 presents the parameter values employed in our model to generate figures that will allow us to understand the mechanisms of our model. The numerical specifications used for our experiments are as follows:

Table 1: Values for numerical experiment

Variable	Definition	Value
SD(γ)	Standard deviation of shock	25%
ρ	Substitutability accross intermediates varieties	2
I_j	Number of countries	3
$T_D(\tau_D w_D)^{-\theta}$	Domestic sourcing potential	1
$T_{F1}(\tau_{F1} w_{F1})^{-\theta}$	Sourcing potential F1	3.5
$T_{F2}(\tau_{F2} w_{F2})^{-\theta}$	Sourcing potential F2	1
N_j	Number of domestic firms	150
Calibration for complementarity $(\sigma-1)/\theta = 1.58$ following Antràs et al. (2017)		
σ	Elasticity of final demand	3.85
θ	Productivity Fréchet distribution shape	1.789

Using these specified values, we initially plot the expected profits of firms across various productivity levels and sourcing strategies, in a world with 3 countries: Home, Foreign 1, and Foreign 2. We are interested in learning how different sourcing strategies affect the expected profits of firms. We then decompose the contribution of each component to the overall expected profits, discerning variations across different sourcing strategies. This will allow us to understand the overall effect of uncertainty. For this, we take draws from a uniform distribution for the productivity levels and obtain the sourcing strategy that maximizes their expected profits and then decompose the terms of their maximized expected profits. Subsequently, we obtain a plot that shows the expected profits of firms, examining their impact on the sourcing decisions of these firms. We will mostly focus on the marginal firms for the decision of only buying from the domestic country versus buying from domestic and foreign 1, and then the decision of buying from domestic and foreign 1 versus domestic, foreign 1, and foreign 2. We want to understand how different types of uncertainty – none, only aggregate, only idiosyncratic, and both aggregate and idiosyncratic uncertainty – affect differently the sourcing decisions of marginal firms.

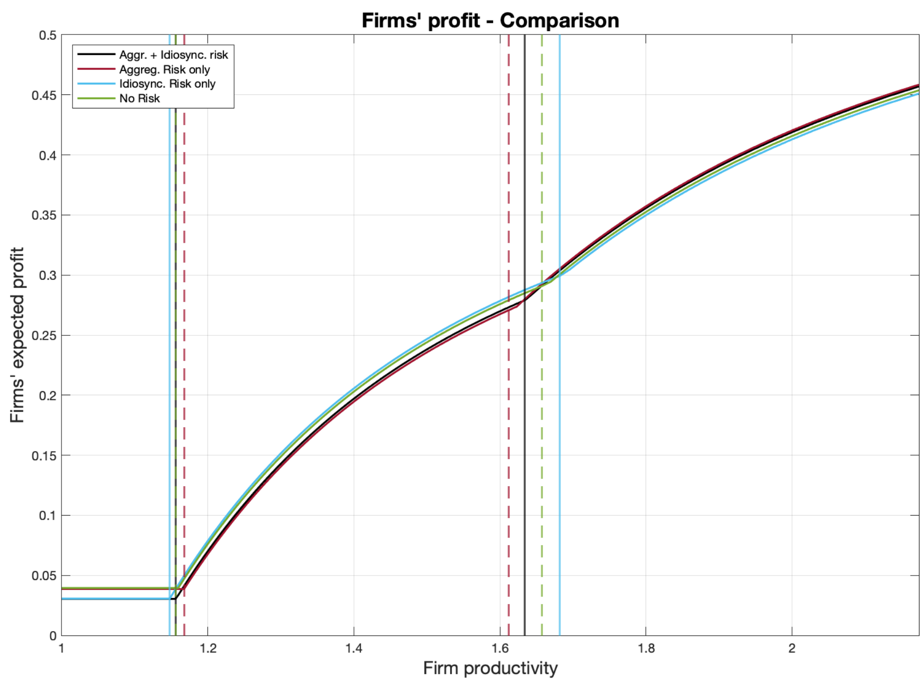
Figure 5: Three countries - Profit decomposition



In Figure 5, the impact of each term from the decomposition on expected profits is displayed, with the respective distinct colors representing each term. The x-axis illustrates firms' productivity levels, while the y-axis denotes expected profits. The vertical lines show the cutoff productivity for the different sourcing strategies. Firms to the left of the first vertical line source inputs solely from Home, while those between the first and second vertical lines obtain inputs from both Home and Foreign 1, and those to the right-hand side of the second vertical line source from Home, Foreign 1, and Foreign 2. The red line indicates the effect on expected profits stemming from the sourcing capability for the expected shock, emphasizing the desire to add more countries to the sourcing strategy to reduce costs through the extra draw of a lower cost and the heightened competition between countries that reduces all costs. The option value effect, portrayed by the blue line, demonstrates how the variance of the shock influences expected profits by providing the option to source from cheaper countries when they experience positive shocks. This means that firms gain from buying from countries that have a higher variance because of the option of getting a lower cost and being able to buy and sell at a lower price. Firms are willing to buy from countries with a higher variance because they can ex-post buy from the countries that were non-negatively affected by the shocks and have the option to sell at a lower price. Whereas, if the countries are negatively affected, they can ex-post decide not to source much from them. The purple line represents the covariance term between the sourcing capability and market demand, or hedging effect, which is negative due to the fact that expected profits decrease if the firm gets hit when every other firm gets hit too. However, a negative covariance, i.e., the firm being negatively (positively) shocked while most other firms experience positive (negative) shocks increases expected profits. Lastly, the green line illustrates the fixed cost of adding a country to the sourcing strategy, acting as a deterrent for adding more countries, and reducing expected profits.

The insights from looking at Figure 5 highlight that the primary driver of expected profits is the sourcing capability for expected shocks. Subsequently, uncertainty's impact manifests through the risk effect on capability, or option value effect, and the covariance between the sourcing capability and market demand, or hedging effect. As these two effects pull in opposing directions, a trade-off emerges between incorporating countries with higher variance and those displaying a negative covariance with the shocks experienced by countries favored by most firms. This implies that there is a trade-off between the option value and the hedging effects when firms decide where to source from.

Figure 6: Expected profits and sourcing strategies



In Figure 6, the different expected profits are illustrated for various risk scenarios: no risk (green line), idiosyncratic risk only (blue line), aggregate risk only (red line), and both idiosyncratic and aggregate risk (black line). For this figure, we divide the expected profits by $\phi^{\sigma-1}$. Same as in Figure 5, the vertical lines delineate the sourcing strategies for different productivity firms in each scenario, where the colors denote the same as before. In the case of no risk, firms experience increasing expected profits as they incorporate more countries into their sourcing strategy, establishing a baseline for productivity levels sourcing from Home, followed by those sourcing from both Domestic and Foreign 1, and finally those incorporating Domestic, Foreign 1, and Foreign 2 in their sourcing strategy compared to the case of uncertainty. The blue line represents the impact of solely idiosyncratic uncertainty, featuring the option value effect, incentivizing diversification, since uncertainty in this case is more profitable because of the option to buy from countries that might get positively shocked, and hence reduce the cost. However, the resulting decrease in price prevents marginal firms from sourcing from Foreign 2 since they are now unable to pay the fixed cost. All of this occurs because idiosyncratic uncertainty does not affect the market demand, and so has no hedging effect, only option value effect. Focusing now on the red line, which depicts the effect of aggregate uncertainty on expected profits and sourcing decisions, both the option value and covariance terms, or hedging, influence expected profits. Most firms being affected by the uncertainty of Foreign 1 leads less productive firms to re-shore, while more productive firms diversify further to hedge against risk. This happens because less productive firms cannot "risk" paying the fixed cost of diversifying and then getting negatively hit by the shock. Since most firms in our example our buying inputs from domestic and Foreign 1, if Foreign 1 gets negatively hit, then the market demand gets affected and firms will not want to buy from foreign 1, so less productive firms will end up buying only from domestic but still paying the fixed cost, so they rather only source from Domestic. Since most firms are buying from Foreign 1, the more productive firms want to diversify more because of the option value of getting positively hit as well as the hedging effect of getting positively hit by Foreign 2 and getting the increase in market demand. Finally, taking a look at the black line, considering both aggregate and idiosyncratic uncertainty, we learn that the option value effect outweighs the covariance effect. We end up with a very similar, but less strong, effect than in the case of only aggregate uncertainty. Consequently, less productive firms avoid Foreign 1 by sourcing from Home, while more productive firms diversify more than in the case with only aggregate uncertainty, since the bulk of the firms are sourcing from both Domestic and Foreign 1. The termination points of the lines depend on the chosen parameters.

Leveraging the ex-ante profits equation we observe that, everything else equal, firms' profits increase when sourcing from riskier countries in the sense of having a higher variance of idiosyncratic shocks. This happens because a higher variance of idiosyncratic shocks increases the option value effect, hence giving the chance of reducing costs. However, the numerical experiments also demonstrate that firms with varying levels of productivity respond distinctively to different types of uncertainty. We observe that higher productivity firms' obtain higher profits when sourcing from riskier countries, in terms of idiosyncratic shocks, than lower productivity firms. This is the case because revenues are multiplied by the productivity of the firm ($\varphi^{\sigma-1}$). We also find that, everything else equal, more productive firms benefit more from adding a country that is riskier to their sourcing strategy, in terms of a higher variance for idiosyncratic shocks, since in this case the option value effect outweighs the hedging effect. Finally, for the case of aggregate uncertainty, the results are ambiguous. A higher variance for aggregate shocks increases expected profits through the option value effect, i.e., the option of having a lower cost because of a positive aggregate shock. However, adding countries that every other firm is adding reduces expected profits through the hedging effect, since this will increase the market demand for lower price goods that are positively shocked when other firms are negatively shocked. These effects occur to both high and low productivity firms, but lower productivity firms are more affected by the hedging effect, while higher productivity firms are more affected by the option value effect.

4 Data

In the previous section we showed our theoretical model for firms' sourcing decision under supply chain uncertainty. This model provides a way for us to estimate aggregate and idiosyncratic supply chain uncertainty. We will next describe the data we use in the paper and show descriptive evidence that supports the use of our model.

4.1 Data Description

We utilize Customs data from Chile, which has product-origin-firm level data encompassing all import transactions that enter Chile. The products are classified using the Harmonized System (HS) at the 6-digit level (HS-6), a globally recognized product classification system. Additionally, we leverage tax forms that offer firm-to-firm level insights into sales based on VAT records from the Servicio de Impuestos Internos (SII) in Spanish, equivalent to the IRS in English, acquired through the Central Bank of Chile. Furthermore, access to the unemployment insurance fund at the firm level allows us to extract information regarding employment and wage bills based on contributions. Our dataset primarily focuses on the Mining, Manufacturing, and Trade sectors, including Restaurants and Hotels. This compilation covers approximately 80% of the total import value in Chile and spans the period from 2012 to 2023 on a quarterly basis[4]. We drop firm's with negative or zero sales and those with 5 employees or less. Moreover, we create a category denoted as "rest of the world" (RoW), encompassing all countries with 100 or fewer firms engaged in importing from them. After doing this, our dataset includes approximately 50 countries each quarter. In our data, around 24% of our firms are importers, which is consistent with the pattern found in the literature for other countries.

To capture the dynamics predicted by the model, we construct a dataset on country characteristics spanning the years 2012 to 2021. This dataset is instrumental in determining country-level fixed costs and sourcing potential. Country attributes, such as distance and language variables, are sourced from CEPII. Additionally, data on the control of corruption is extracted from the World Bank's Worldwide Governance Indicators. This comprehensive dataset enables us to incorporate critical country-specific factors into our analysis, aligning with the model's emphasis on the role of these characteristics in shaping fixed costs and sourcing potential.

4.2 Descriptive Evidence

We use the data from the first quarter of 2012 to the fourth quarter of 2023 to identify the aggregate and idiosyncratic uncertainty, while we use the average data from the first quarter of 2012 to the

[4]We take quarterly data because the time frame is long enough to avoid lumpiness but short enough that it is credible that firms are not changing their suppliers. This is based on Carvalho et al. (2021) who find that firms weren't able to quickly adjust their suppliers in the aftermath of the Japan earthquake

fourth quarter of 2019 to obtain the value for the firm-level fixed costs. In the Data Appendix, we show that, as in Antràs et al. (2017), both the extensive and intensive margins differ for all quarters in our data.

Since in our model we assume that firms source multiple products from multiple countries, we show that this is the case for our dataset. To do that, we define a distinct product as a distinct Harmonized System six-digit code. In our data, we find that, for the period from 2012 to 2023, firms import approximately 9 distinct products on average from 2 countries. The median number of imported products is around 2, while the 95$^{\text{th}}$ percentile is around 33. The median number of countries from which firms import from are approximately 1, while the 95$^{\text{th}}$ percentile is around 6 countries. In the Data Appendix, Table 7, we also show that, as assumed in our model, the extensive and intensive margin differ in our dataset. For example, Spain is 4$^{\text{th}}$ in terms of the number of firms that import from them but 12$^{\text{th}}$ in terms of the value of imports.

Table 2: Descriptive statistics

Date	nb of firms	employment	wage bill	imports	inputs	sales	domestic	importers share
2012q1-2015q4	35,742	1,393	4,640	13,717	63,353	27,731	45,059	0.238
2016q1-2019q4	40,706	1,566	5,454	12,720	62,993	27,822	44,908	0.239
2020q1-2023q4	43,819	1,588	5,734	16,272	75,464	36,170	53,485	0.255

Notes: Table reports the unweighted average for the number of firms, the total number of employees in thousands, wage bill, value of imports, value of inputs, value of sales, value of domestic inputs, all in millions of USD, and the share of importers obtained using the number of firms that import over the total number of firms.

From Table 3 we learn that the number of firms in our data increases with time, starting with an average of 35,742 firms between the first quarter of 2012 and the last quarter of 2015, to an average of 43,819 firms between the first quarter of 2020 and the fourth quarter of 2023. We observe that all other variables, number of employees in hundreds, value of imports, value of inputs, value of sales, value of domestic input purchases, all in millions of USD, and the share of importing firms, they all experience an increase with time in our data.

We now check if our dataset follows a pecking order by following Antràs et al. (2017) and Eaton et al. (2011) and count the number of firms that import from the number one destination only (in our case, China), and then the number of firms that import from the number one and number two destinations only, and not others (in our case, China and the United States), and we keep going until the we have the ordering for the first top ten destinations. We find that, more than 12,000 firms, or 35.67% of importers who import from the top-10 countries, follow a pecking order. We then proceed to compare that with what the number of firms and percentage of importers would have been if the firms selected randomly by using the share of importers from country i as the probability that any firm will source from i, independently. Doing this, we find that only 4,855 firms follow a pecking order, or 14.42% of importers, which is less than the 35.67% we find in our data. This means that we find a pecking order above the randomly generated one, even if not perfect, which supports our assumption.

This is similar to what Antràs et al. (2017) and Eaton et al. (2011) find for American and French firms, respectively. This implies that our data follows a pecking order over what would be randomly generated. However, because the percentage of the data following a pecking order is still pretty low, this implies that there might be firm-specific fixed costs of sourcing. We will take this into consideration for our empirical analysis.

Table 3: Pecking Order

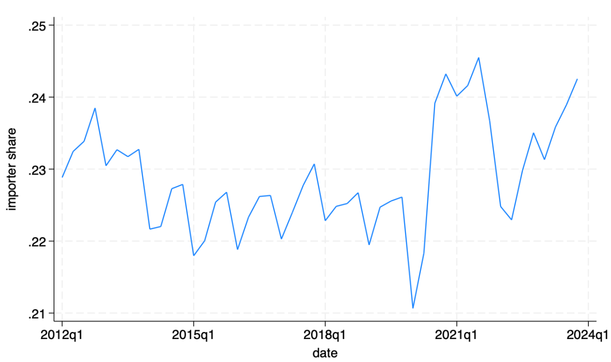
String of countries	Data		Random Entry	
	Firms	% of Importers	Firms	% of Importers
CHN	7,970	23.68	1,865	5.54
CHN-USA	2,201	6.54	2,034	6.04
CHN-USA-RoW	348	1.03	664	1.97
CHN-USA-RoW-ESP	75	0.22	209	0.63
CHN-USA-RoW-ESP-DEU	58	0.17	60	0.18
CHN-USA-RoW-ESP-DEU-ITA	98	0.29	17	0.05
CHN-USA-RoW-ESP-DEU-ITA-BRA	102	3.03	5	0.01
CHN-USA-RoW-ESP-DEU-ITA-BRA-ARG	301	0.89	1	0.00
CHN-USA-RoW-ESP-DEU-ITA-BRA-ARG-HKG	133	0.40	0	0.00
CHN-USA-RoW-ESP-DEU-ITA-BRA-ARG-HKG-TWN	719	2.14	0	0.00
TOTAL Following Pecking Order	12,005	35.67	4,855	14.42

Notes: The string CHN means importing from China but no other among the top 10; CHN-USA means importing from China and the United States of America but no other; and so forth. % of Importers shows percent of each category relative to all firms that import from top 10 countries.

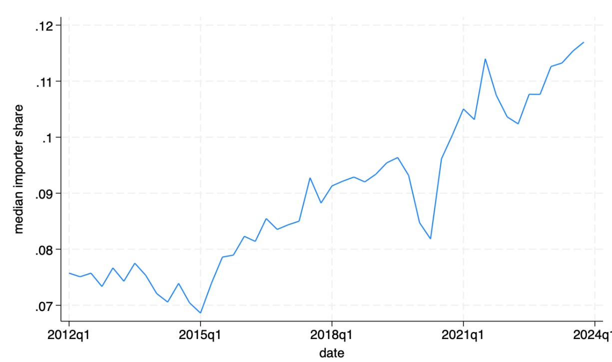
We then obtain the share of importer for all firms and for firms with sales below the median. From Figure 7, we observe that the share of importers for all firms have been slowly trending downwards in time, it does trends upwards after 2020. We also see an upward trend in the share of importers with firm sales below the median. In both cases, the share of importers is not constant over time.

Figure 7: Share of importers

(a) Share of importers for all firms



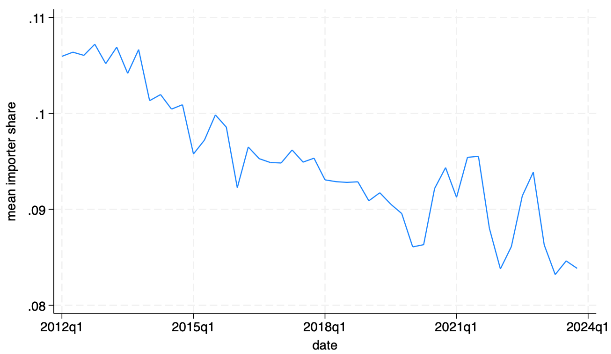
(b) Share of importers w/firm sales below median



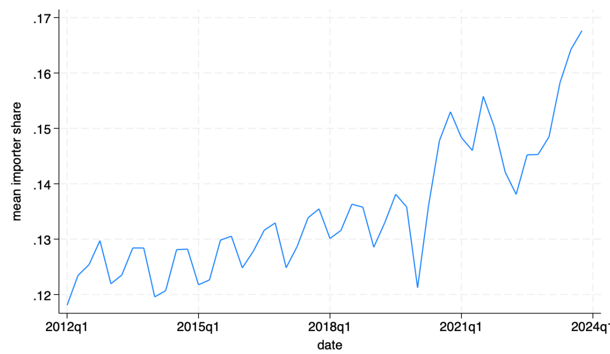
Finally, we plot the share of importers by country of origin. We show the case for the United States of America and China because they have opposite trends. We learn from Figure 8 that while the share of importers in the USA seem to be going downwards, and less firms are importing from them, the share of importers from China is trending upwards.

Figure 8: Share of importers by country of origin

(a) USA



(b) China



These figures motivate our structural analysis, where we leverage the time difference in import shares between countries, as well as total countries, to identify both aggregate and idiosyncratic shock moments in our model.

5 Structural Analysis

Given the static nature of our model, we opt to utilize the panel data available to us by leveraging averages over a specific period. For step 3 of our structural estimation, we focus on the years spanning from the first quarter of 2012 to the fourth quarter of 2019. This timeframe, prior to the onset of the supply chain uncertainty induced by Covid-19, and wars, serves as our basis for analysis. However, the panel structure of our data also allows us to estimate both idiosyncratic and aggregate supply chain uncertainty. The Covid-19 pandemic stands out as a crucial event that introduced substantial uncertainty into global supply chains, so for that case we utilize all the available data, from the first quarter of 2012 to the third quarter of 2023. This approach facilitates a comprehensive understanding of supply chain dynamics by encompassing the pre-, during-, and post-Covid-19 periods, during which significant supply chain uncertainty was prevalent.

Our estimation procedure involves three main steps, focusing on a firm, denoted as n, to estimate the parameters $[\bar{\gamma}_{ij}, \tilde{\gamma}_{ij}^{n}, f_{ij}^{n}]$ in our model:

(i) **Step 1. Estimate average country's sourcing potential.** We start by considering firm n's sourcing strategy as given. Employing equation (9), we leverage differences in the shares of sourcing across countries. This allows us to re-write the firm-level equation for country i with a country fixed effect and a firm-relationship-level error term. Taking the difference between country i and Chile, which takes care of the sourcing capability of firm n, and setting the domestic sourcing potential to 1, we employ Ordinary Least Squares (OLS) to estimate the average country's sourcing potential of country i with respect to Chile.

(ii) **Step 2. Estimate aggregate and idiosyncratic uncertainty.** We proceed by taking the time difference for the same quarter in the previous year, accounting for seasonality. This allows us to re-write the equation with a country-time fixed effect and a firm-relationship-time-level error term. Using this result, our model-implied relationship, and making assumptions on the initial values, we can recover both the aggregate as well as the idiosyncratic shock moments.

(iii) **Step 3. Estimate firm-level fixed costs of sourcing for each country pair.** Finally, we relax the assumption that fixed costs of sourcing are homogeneous across firms. We apply the Simulated Method of Moments (SMM) to estimate the firm-level fixed costs of sourcing and other distributional parameters. To achieve this, we utilize Jia (2008)'s algorithm, which facilitates the estimation for a larger number of countries.

Since the focus of our paper is on the effect of uncertainty, we don't estimate the parameters θ and σ and we take their values from the literature instead. Following Antràs et al. (2017), we set σ to be 3.85 and θ to be 1.789. This implies a value of 1.583 for $(\sigma-1)/\theta$, indicating the presence of complementarity between countries in our model, which allows us to use Jia (2008)'s algorithm. In subsequent analyses, we will conduct robustness checks to explore the implications of varying these parameter values.

5.1 Step 1. Estimate average country's sourcing potential

To estimate the sourcing potential of country i from the perspective of country j (in our case, Chile), we leverage firm-level sourcing strategies as given and exploit differences in the shares of sourcing between the two countries. The sourcing potential of country i concerning country j is given by $T_i(\tau_{ij}\bar{\gamma}_{ij}\tilde{\gamma}_{ij}^n w_i)^{-\theta}$, which can be decomposed into an origin-specific term, $T_i(\tau_{ij}\bar{\gamma}_{ij}w_i)^{-\theta}$, and an origin-firm-specific term, $(\tilde{\gamma}_{ij}^n)^{-\theta}$. Given the ex-post nature of the firm's sourcing decisions in our model, the sourcing strategy is fixed for firms, and shocks have already been realized. To find the sourcing potential of country i from the point of view of country j, we normalize Equation (9) by the domestic sourcing strategy, canceling out the sourcing capability term. Taking the logarithm of this normalized equation yields the difference between the sourcing potentials. Since we are normalizing by the domestic sourcing potential but are interested in the sourcing potential of country i for country j, we set the domestic sourcing potential equal to one, i.e. $T_j(\tau_{jj}\bar{\gamma}_{jj}\tilde{\gamma}_{jj}^n w_j)^{-\theta} = 1$, and assume no domestic aggregate and idiosyncratic supply chain shocks. This approach allows us to estimate the sourcing potential by comparing the share of intermediates sourced from each country relative to the domestic sourcing strategy. Since in our case the domestic country is Chile, we can get rid of j on the right-hand side of the equation because the origin i will change but the destination j won't.

$$\log \mathcal{X}_{ij}^n - \log \mathcal{X}_{jj}^n = \log \bar{\xi}_i + \log \epsilon_i^n \tag{31}$$

where ϵ_i^n is a firm-country-specific shock. To measure the difference between a firm's share of inputs bought from country i and the firm's share of inputs sourced domestically, we leverage our dataset on the total value of imports from each of the countries from which firms' in Chile source their inputs from, wage bill, and the inputs each of these firms use. Our analysis is restricted to countries included in the firm's sourcing strategy, namely those from which the firm actively sources inputs from. Since the third step of the estimation is very computationally intensive, to reduce the dimensionality of the problem we created a country called rest of the world, or RoW, that includes all the countries from which 100 firms or less source from.

This specification allows us to identify a country's average sourcing potential, $\bar{\xi}_i$. For this to be consistent, we need that there is no selection based on the errors, ϵ_i^n. Because in our case we are getting rid of the sourcing capability term and our model timeline states that firms learn their firm-country-specific shocks after they choose their sourcing strategy, then there cannot be selection of firms based on the errors. Alternatively, we could also treat ϵ_i^n as a measurement error.

To estimate Equation (31), we will employ Ordinary Least Squares (OLS) with fixed effects at the country level. The coefficients associated with these fixed effects, along with the residual term, will provide insights into the average origin-country-specific component of the estimated sourcing potential for each country, which we will later use for our estimation.

In the Data Appendix, Figure 14, we see that China has the highest sourcing potential for Chilean firms, and then the United States followed by Brazil and Paraguay. This shows that the fixed cost of sourcing might differ between countries, since, as we showed in the Data Appendix Table 7, more firms are sourcing from the rest of the world than Brazil and more firms are sourcing from Spain than Paraguay. This implies that the cost of sourcing from Spain might be lower than the cost of sourcing from Paraguay.

5.2 Step 2. Estimate aggregate and idiosyncratic uncertainty

We now utilize our panel data structure to estimate the moments for our aggregate and idiosyncratic shocks. To estimate this, we need to take a stance on what is time varying and what is not. We assume that any change in time is a supply chain disruption. This is a strong assumption, however, we are not assuming what is producing this supply chain disruption. As seen in recent events, supply chain disruptions can happen because of a lack of labor supply, which affects wages, as well as a rise in fuels, which affects iceberg costs, or could even be because of a natural disaster like the Japanese Earthquake, which shocks productivity. Considering this, we have

$$\mathcal{X}_{ij,t}(\varphi,\gamma) = \frac{T_i(\tau_{ij}\bar{\gamma}_{ij,t}\tilde{\gamma}_{ij,t}(\varphi)w_i)^{-\theta}}{\Theta_{j,t}(\varphi,\gamma)} \text{ if } i \in \mathcal{I}_j(\varphi)$$

Recalling our simplification from Step 1, we can decompose $\xi_{it} = T_i(\tau_{ij}\bar{\gamma}_{ij,t}w_i)^{-\theta}$ and $\epsilon_{i,t}^n = (\gamma_{ij,t}^n)^{-\theta}$.

Utilizing the panel structure of our quarterly data to find the moments for our aggregate and idiosyncratic uncertainty, we can express the following first-difference equation:

$$(\log \mathcal{X}^n_{ij,t} - \log \mathcal{X}^n_{jj,t}) - (\log \mathcal{X}^n_{ij,t-4} - \log \mathcal{X}^n_{jj,t-4}) = \log \xi_{i,t-(t-4)} + \log \epsilon^n_{i,t-(t-4)} \tag{32}$$

so we have that $\log \xi_{i,t-(t-4)} = -\theta \log(\bar{\gamma}_{i,t}/\bar{\gamma}_{i,t-4})$ and $\log \epsilon_{i,t-(t-4)} = -\theta \log(\tilde{\gamma}^n_{i,t}/\tilde{\gamma}^n_{i,t-4})$. We take the difference between t and $t-4$ because we compare the same quarter in different years to control for seasonality. This takes care of time unobservables.

Subsequently, we perform an OLS estimation for the specified model using origin-country-time fixed effects and panel data on firm's total input usage, wage bill, and total imports from each country from which it sources.

To obtain the time difference aggregate and idiosyncratic shocks from this regression, we make the assumption that technology, iceberg costs, and wages are not changing yearly. This can be seen as a strong assumption, nonetheless we are modeling supply chain shocks as anything that affects the cost of importing. It will be irrelevant for us if this occurs because of a change in TFP, iceberg costs, or wages. The only case that affects our interpretation slightly is the case of TFP shock, since this is the only term not affected by θ, which governs the heterogeneity of inputs. This will be taken into account when interpreting the results.

For this strategy to be consistent, we need, again, that there is no selection based on the errors, $\epsilon^n_{i,t-(t-4)}$. For this to be the case, we also exploit the timeline of our model which states that idiosyncratic supply chain shocks are learn by the firms after their sourcing strategies have been decided. We also assume multiplicatively exponential shocks that are independent in time and with respect to home.

This regression allows us to obtain $-\theta \log(\bar{\gamma}_{ij,t}/\bar{\gamma}_{ij,t-4})$, and $-\theta \log(\tilde{\gamma}^n_{ij,t}/\tilde{\gamma}^n_{ij,t-4})$, however, we are not interested in this. We want to recover the distribution of $\bar{\gamma}_{ij,t}$ and $\tilde{\gamma}^n_{ij,t}$. To do that, we first need to divide our results from the estimation by $-\theta$ and take the exponential of that. This means we now have the value of $\bar{\gamma}_{ij,t}/\bar{\gamma}_{ij,t-4}$ and $\tilde{\gamma}^n_{ij,t}/\tilde{\gamma}^n_{ij,t-4}$, so we need to make some assumptions to be able to recover the aggregate and idiosyncratic shocks from this and then make parametric assumptions to recover the distribution of shocks.

To recover the aggregate and idiosyncratic shocks, we assume that the shocks follow a linear trend process, i.e., $\gamma_{ij,t} = \gamma_{ij,t-4} \times (\gamma_{ij,t}/\gamma_{ij,t-4})$. In order to estimate the values of the shocks, we set initial values, assuming that for every quarter, the initial value for a firm-, or country-, level shock is 1, indicating no shock in the first observation for every quarter. Additionally, we make a parametric assumption, specifying that the shocks follow a log-normal distribution. Utilizing these assumptions, we can then recover the mean, variance, skewness, and kurtosis for both aggregate and idiosyncratic uncertainty.

5.3 Step 3. Estimate firm-level fixed costs of sourcing for each country pair

Following the approach of Antràs et al. (2017), we estimate the fixed costs of sourcing using the simulated method of moments. The estimation process involves simulating production and sourcing decisions of firms based in our model. We generate simulated data and use it to derive endogenous values, from which we obtain moments. These moments are then averaged across all simulations. By comparing the simulated moments with the real data, we determine the parameter values that minimize the difference between the two sets of moments. In our estimation, we allow the fixed cost of sourcing from a country to depend on gravity variables such as distance and language, as well as on a measure of the source country's control of corruption.

To address the discrepancy between the number of importing firms and the number of firms that source from the most popular country, we relax the assumption of country-specific fixed costs. Instead, we introduce firm-country-specific fixed costs of sourcing, denoted as f_{ij}^n. We assume these fixed costs follow a log-normal distribution with scale parameters $\log\beta_c^f + \beta_d^f \log \text{distance}_{ij} + \log\beta_l^f \text{language}_{ij} - \beta_C^f \text{control of corruption}_i$ and a dispersion parameter β_{disp}^f. As active firms must use domestic inputs, we set $f_{jj}^n = 0$. For the rest of the world, we take the average values using population weight. For our robustness checks, we instead use GDP weight for the average.

Due to the computational challenges associated with solving the firm's problem for a large number of countries, we implement Jia (2008)'s algorithm to reduce the dimensionality of the problem. In our timeline, the sourcing strategy decision is made before the realization of supply chain disruptions is known. Consequently, the decision is based on maximizing expected profits, requiring a Quasi-Monte Carlo simulation of the shocks, which uses a Sobol sequence of low-discrepancy quasi-random numbers for this simulation. While the firm's problem is manageable for up to 10 countries, the complexity increases significantly beyond that, as there are 2^I possible sourcing strategies for I countries from which the firm can source. To reduce the dimensionality of the firm's problem, we rely on our Proposition 2 and adopt Jia (2008)'s algorithm.

Next, following Jia (2008) and Antràs et al. (2017), we explain the algorithm for our case. Given a core productivity φ, a guess $\mathcal{I}$ for the firm's sourcing strategy, $\mathcal{I}^n$, and distributions of the supply chain shocks, we define the expected marginal benefit of including country i in the sourcing strategy $\mathcal{I}$ as

$$\begin{cases} \varphi^{\sigma-1}\ \eta^{(\sigma-1)/\theta}\ [\mathbb{E}(B_j(\bar{\gamma})\Theta_j(\mathcal{I}\cup i,\bar{\gamma},\tilde{\gamma}(\varphi))) - \mathbb{E}(B_j(\bar{\gamma})\Theta_j(\mathcal{I},\bar{\gamma},\tilde{\gamma}(\varphi)))] - f_{ij}^n, & \text{if } i \notin \mathcal{I} \\ \varphi^{\sigma-1}\ \eta^{(\sigma-1)/\theta}\ [\mathbb{E}(B_j(\bar{\gamma})\Theta_j(\mathcal{I},\bar{\gamma},\tilde{\gamma}(\varphi))) - \mathbb{E}(B_j(\bar{\gamma})\Theta_j(\mathcal{I}\setminus j,\bar{\gamma},\tilde{\gamma}(\varphi)))] - f_{ij}^n, & \text{if } i \in \mathcal{I} \end{cases}$$

As in Proposition 2, we introduce a mapping, $V_i^n(\mathcal{I})$ equal to 1 if the expected marginal benefit is positive and zero if not. We showed that for $(\sigma-1)/\theta > 1$, this is an increasing function of $\mathcal{I}$. When we start from the set that contains no countries, $\underline{\mathcal{I}}$, and iterate the V-operator by adding each country one-by-one to the set it gives us the lower bound of the firm's sourcing strategy. Alternatively, if we start from the set that contains all countries, $\bar{\mathcal{I}}$, and, again iterate the V-operator by taking each country one-by-one out of the set, this provides us with the upper bound of the set. If these sets are not exactly the same, then we only need to evaluate the expected profits from all the possibilities in the upper bound set.

Continuing with the structural estimation, we adopt the distributional assumptions for the model parameters. Following the approach of Antràs et al. (2017) and Melitz and Redding (2015), we assume that the productivity parameter φ follows a Pareto distribution with a shape parameter $\kappa = 4.25$, consistent with the value used in Melitz and Redding (2015)'s study. We conduct robustness checks by varying this parameter. For the estimation of the remaining parameters $\delta = [E, \beta^n_{c,f}, \beta^n_{d,f}, \beta^n_{l,f}, \beta^n_{C,f}, \beta^n_{\text{disp},f}]$, we simulate a large number of firms. This involves drawing φ from a uniform distribution, inverting it to obtain the Pareto distribution given κ. Additionally, we draw aggregate and idiosyncratic shocks from their specified distributions and obtain an I-dimensional vector of fixed costs from a standardized normal distribution. The parameter vector δ is then estimated through a guess-and-check process, iteratively adjusting the values to match the log-normal firm-country specific fixed cost levels obtained from the simulation. In the model, we consider a continuum of final-good firms, each characterized by different combinations of productivity, fixed costs, supply chain disruptions, and country-specific efficiency shocks. The distributional features of these parameters are assessed through the simulated firms, providing insights into the distributions of the model's key variables.

In the structural estimation process, we utilize simulated firms to generate three sets of moments for comparison with the actual data. These moments are crucial for the calibration of the model's parameters. The three sets of moments are as follows:

i. The first set of moments includes the share of importers for all firms as well as the share of importers with firm sales below the median. This is a 2×1 vector of moments. We denote the first set of moments in the actual data as m_1 and in the simulated data as $\hat{m}_1(\delta)$.

ii. The second set of moments includes the share of firms that import from each country. This is an $(I - 1) \times 1$ vector of moments. Then, we denote the second set of moments in the actual data as m_2 and in the simulated data as $\hat{m}_2(\delta)$.

iii. The third set of moments includes the share of firms whose input purchases from Chile are less than the median input purchases from Chile in the data, which is a scalar. We denote the third set of moments in the actual data as m_3 and in the simulated data as $\hat{m}_3(\delta)$.

The first two sets of moments inform us about the magnitude of fixed costs of sourcing, as well as on how they vary with distance, language, and control of corruption. Furthermore, the share of importing firms from the most popular country relative to the total share of importers serves as an indicator of the fixed cost dispersion parameter. In the absence of dispersion in fixed costs across firms, the total share of importers would match the share of importers from the most popular sourcing country. Similarly, the share of importers among firms with sales below the median firm provides insights into the dispersion parameter. The third moment helps determine the scale parameter $B(\bar{\gamma})$, as $B(\bar{\gamma})$ determines the level of input purchases.

Then, we proceed to explain the method of simulated moments, which is a method that selects the model parameters that minimize

$$\hat{\delta} = \text{arg min}_{\delta}[\hat{y}(\delta)]^T \mathbf{W}[\hat{y}(\delta)]$$

where $\mathbf{W}$ is a weighting matrix and $\hat{y}(\delta)$ is given by

$$\hat{y}(\delta) = m - \hat{m}(\delta) = \begin{bmatrix} m_1 - \hat{m}_1(\delta) \\ m_2 - \hat{m}_2(\delta) \\ m_3 - \hat{m}_3(\delta) \end{bmatrix}$$

For the weighting matrix, $\mathbf{W}$, we can use either the inverse of the estimated variance-covariance matrix of the moments or weight each moment equally and use the identity matrix. We decide to follow the later and weight each moment equally.

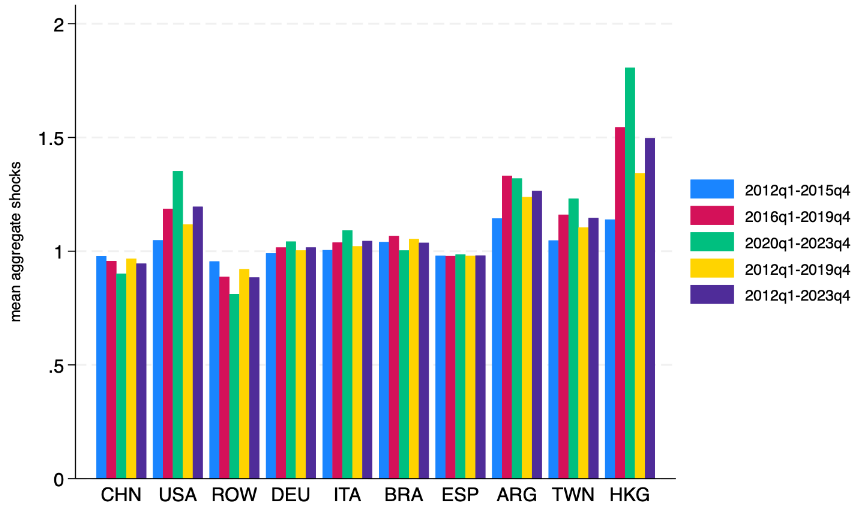
Finally, the following moment condition is assumed to hold at the true parameter value δ_0:

$$\mathbb{E}[\hat{y}(\delta_0)] = 0$$

5.4 Results

Next, we show the results obtained from our structural analysis. In the Data Appendix, Figure 14 and 15 we plot the country sourcing potential obtained from Step 1 against the extensive and intensive margin. We find that China, USA, Brazil, Paraguay, and Korea have the highest sourcing potentials for Chile. However, not many firms import from Paraguay, compared to Germany, Spain, or Argentina. This, again, suggests that fixed costs differ across countries, which is the assumption we make in our model.

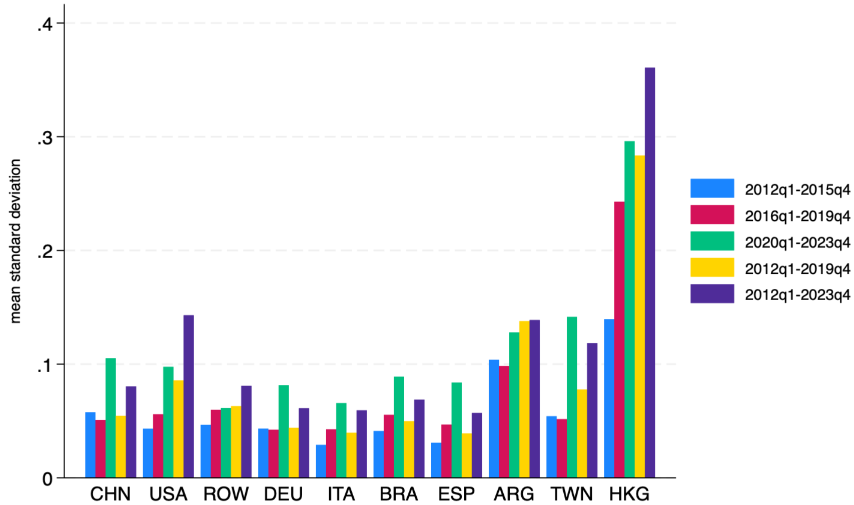
Figure 9: Average aggregate shock for different time periods



Notes: Figure constructed using the fixed effects obtained from equation (32), dividing by $-\theta$, taking exponential, using a linear assumption, and 1 as the initial value, to obtain the aggregate shocks by country relative to Chile. We show the top-10 countries sorted by the importing share.

In Figure 9, we plot the average aggregate shock for the top-10 importing countries, for different time periods, and sort it by their importing share. We learn that Hong Kong has a high average aggregate shock compared to other countries and the difference increases even more during Covid-19. Surprisingly, we find a very low aggregate (i.e., positive shock) shock for China, which is even lower compared to the other countries during Covid, while the US has negative shocks on average and even bigger negative shocks during 2020 to 2023. In the Data Appendix, Figure 10, we show a similar figure but for the average standard deviation of the aggregate shocks. We find again that Hong Kong has the highest standard deviation for all periods, while USA's standard deviation strongly increased during the Covid-19 period.

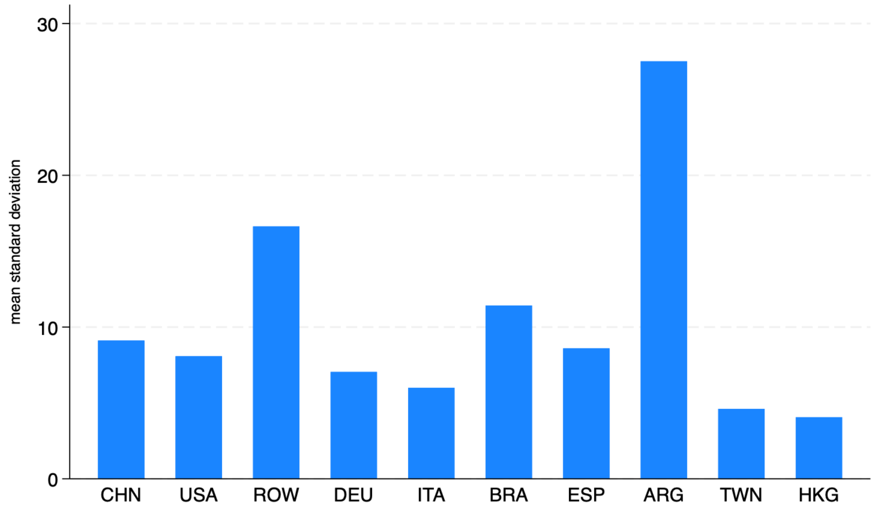
Figure 10: Average standard deviation for aggregate shocks, top-10 countries



Notes: Figure constructed using the fixed effects obtained from equation (32), dividing by $-\theta$, taking exponential, using a linear assumption, and 1 as the initial value, to obtain the aggregate shocks by country relative to Chile. We then get the standard deviation over time for these shocks. We show the top-10 countries sorted by the importing share.

In Figure 10, instead of plotting the average aggregate shock for the top-10 importing countries, we plot the average standard deviation of aggregate shocks, so the mean-preserving aggregate uncertainty, for the top-10 countries. We observe that Hong-Kong has the highest average standard deviation for aggregate shocks, followed by Argentina. The United States had a relatively small standard deviation of aggregate shocks initially but it increased strongly when considering 2020q1-2023q4. China's aggregate uncertainty is surprisingly low, even when considering 2020q1-2023q4 however, relatively, it has a big increase for that period. Finally, almost every country experienced their biggest increase in uncertainty during the Covid-19 period.

Figure 11: Average standard deviation for idiosyncratic shock



Notes: Figure constructed using the value of the residuals obtained from equation (32), dividing by $-\theta$, taking exponential, using a linear assumption, and 1 as the initial value, to obtain the idiosyncratic shocks by firm-country relative to Chile. We take the standard deviation across time, 2012q1-2023q3, for each firm-origin observation and then we average over all firms that import from that origin. We show the top-10 countries sorted by the importing share.

In Figure 11, we show the standard deviation across time for each firm-origin idiosyncratic shock and then we average over all firms that import from the top-10 countries. From this we learn that Argentina has the highest average standard deviation of idiosyncratic shocks, followed by Brazil. Surprisingly, Hong-Kong, which has a very high aggregate uncertainty, has the smallest average idiosyncratic uncertainty of all the top-10 countries. We also learn that idiosyncratic uncertainty is around 100 times bigger than aggregate uncertainty, which means that there is a bigger volatility at the firm level than at the origin level. For disclosure avoidance, this is the lowest level of aggregation that we are able to show, so we cannot reproduce the figure obtained for aggregate shocks in the case of idiosyncratic shocks.

Using our fixed cost strategy, but estimating specific fixed costs separately for China, USA, and RoW, we obtain the parameter estimates without uncertainty for 13 countries. We first show the resulting average fixed cost for China, USA, and RoW, and then the estimated parameters to obtain the mean and standard deviation of our log-normal distribution.

Table 4: Estimated parameters: separate FC

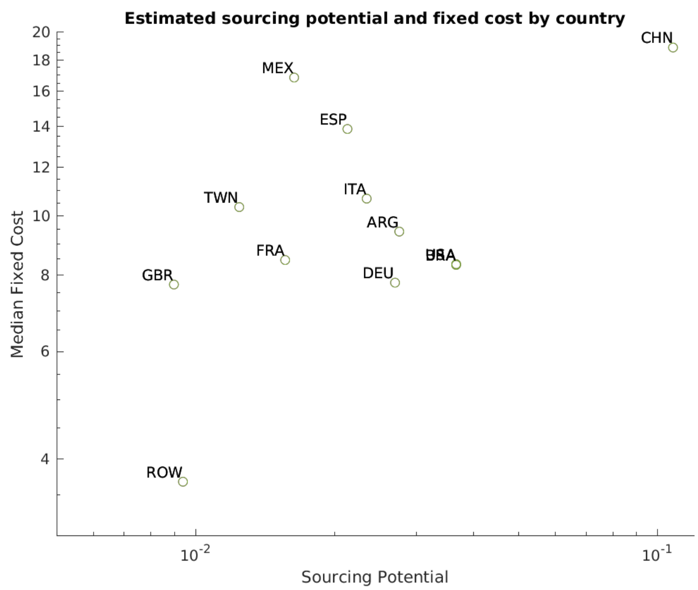
mean FC CHN	mean FC USA	mean FC RoW
19.00	8.37	3.66

Table 5: Estimated parameters

E	β_c^f	β_d^f	β_l^f	β_C^f	β_{disp}^f
195.00	0.924	0.265	1.492	-0.200	0.742

In Table 4 we show the average estimated values for the fixed cost for China, the US, and the rest of the world. These are in thousand of USDs, which means that the average fixed cost for China is 19,000 USD, while for the US it is 8,370 USD, and for the rest of the world it is 3,660 USD. From Table 5 we learn that the fixed costs of sourcing increases with a common language by around 4 percent, increases with distance with an elasticity of 0.265, and decreases with corruption with an elasticity of 0.2 percent.

Figure 12: Estimated sourcing potential and median fixed cost

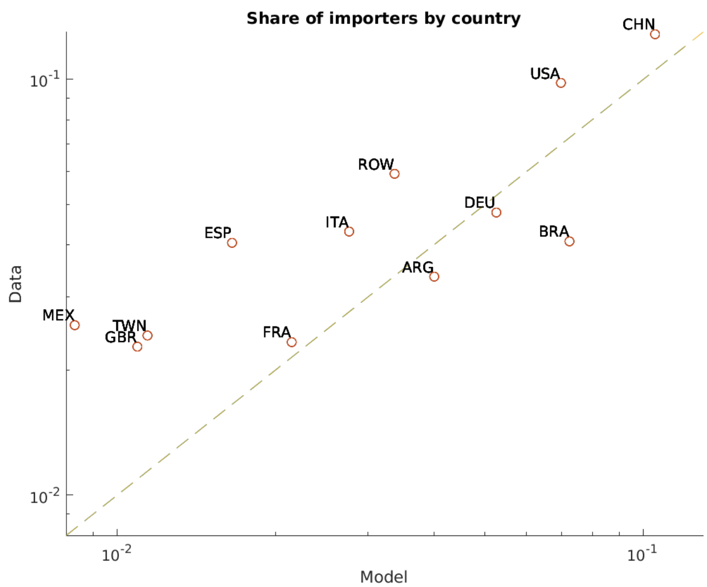


6 Fit of the model

Table 6: Estimated parameters

Moments	Data	Model
Share of importers	0.226	0.180
Share imp. sales below median	0.082	0.083
Median input value	124.43	102.73

Figure 13: Model fit: share of importers by country



WIP

7 Robustness checks

WIP

8 Counterfactual

WIP

9 Conclusions

We develop a multi-country sourcing framework, inspired by Antràs, Fort, and Tintelnot (2017), where firms self-select into importing based on productivity, cost minimization, and trade disruption risk that increases the cost of importing. Using this structural model that we take to firm level data from Chile, we show quantitatively that the decrease in marginal cost is still the main driver of firms' sourcing decisions, but risk affects this choice in a non-trivial way.

In our model, heterogeneous firms face two stages problems: ex-ante, these final-good producers decide the set of countries to import from, subject to a fixed-cost of initiating the sourcing relationship. This creates an extensive margin of firms' import decision as well as an interdependent choice of where to source from: adding an additional country to the sourcing set depends on which countries the firm is already importing from and to which extent it decreases their marginal cost. Ex-post, trade-disruption increases the cost of importing from a particular country in two ways: first, idiosyncratic shocks affect the firm-specific cost for that good, and second, an aggregate shock also change that price but for all the firms importing from that country as well as the aggregate price level and market demand of the economy. Based on these costs, firms make their ex-post quantity decisions as in Eaton and Kortum (2002), which affects ex-ante decisions where firms maximize expected profits. As in Antràs, Fort, and Tintelnot (2017), we find that even with aggregate or idiosyncratic uncertainty, a pecking order exists, and more productive firms self-select into importing from a larger set of suppliers.

Theoretically, we show that aggregate or idiosyncratic uncertainty affect firms' choice in opposite ways. Firm idiosyncratic import risk creates a positive option value of diversifying the set of suppliers, as firm profit is convex in sourcing cost and firms' decision exhibit risk-loving properties. However, country-specific aggregate shocks also affect market demand, which changes the co-movement between the firms' cost and the aggregate price of other firms. In the states-of-the-world where a firm is hit by a negative shock from a foreign country, the fact that the rest of the economy is very exposed to that same country lower very strongly their profit, incentivizing the firm to hedge against such a risk. As a result, outsourcing and diversification objectives can lead to non-trivial sourcing decisions depending on the price and risk-structure of each country.

Nevertheless, in numerical examples, we see that these two effects counteract each other, and the firm's sourcing decision is principally driven by a decrease in expected marginal cost, leaving firm particularly exposed to disruption risk.

To evaluate the importance of this supply-chain uncertainty, we estimate this model using firm-level customs and IRS data from the Chilean Central Bank from 2012-2023 at the quarter level. We then recover the variance of aggregate and idiosyncratic risk using firms' import share and evaluate their relative importance in firms' decision. Moreover, we recover the fixed costs of sourcing from each country using Simulated Method of Moments and show how accounting for risk affect this result. Since the sourcing choice interact between countries, the dimensionality of our problem is thus very high as it involves solving a combinatorial problem over all possible combination of import sources. However, exploiting the complementarity between countries in firms' marginal cost, we can leverage Jia (2008)'s algorithm to reduce the dimensionality of our problem.

Finally, We are currently working on obtaining the values for the firm level fixed costs of sourcing, and then producing counterfactuals as well as doing robustness checks. We plan to study what would have happened if Covid-19 wouldn't have happened, i.e., all countries would have maintained their uncertainty levels from pre first quarter of 2020. We plan to understand how that would have affected both the extensive and intensive margin. Another counterfactual we are interested in is studying how different risk scenarios, related to climate change, would affect the sourcing decision of firms. Then, we plan to do some robustness check for different values of κ, θ, and σ, since we take these values from the literature and do not estimate it using our data.

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A Theoretical Appendix

A.1 Proof of Proposition 1

(a) Two firms with productivity $\varphi_H > \varphi_L$. Denote $\mathcal{I}_j(\varphi_H) = \{i : \mathbb{1}_{ij}(\varphi_H) = 1\}$ and $\mathcal{I}_j(\varphi_L) = \{i : \mathbb{1}_{ij}(\varphi_L) = 1\}$, and $\mathcal{I}_j(\varphi_H) \neq \mathcal{I}_j(\varphi_L)$ (if $\mathcal{I}_j(\varphi_H) = \mathcal{I}_j(\varphi_L)$, it holds trivially). For firm φ_H to prefer $\mathcal{I}_j(\varphi_H)$ over $\mathcal{I}_j(\varphi_L)$:

$$\mathbb{E}(\varphi_H^{\sigma-1}(\eta\Theta_j(\mathcal{I}_j(\varphi_H, \gamma(\varphi_H))))^{\frac{\sigma-1}{\theta}} B_j(\gamma)) - w_j \sum_{i\in\mathcal{I}_j(\varphi_H)} f_{ij} > \mathbb{E}(\varphi_H^{\sigma-1}(\eta\Theta_j(\mathcal{I}_j(\varphi_L, \gamma(\varphi_L))))^{\frac{\sigma-1}{\theta}} B_j(\gamma)) - w_j \sum_{i\in\mathcal{I}_j(\varphi_L)} f_{ij} \tag{33}$$

and

$$\mathbb{E}(\varphi_L^{\sigma-1}(\eta\Theta_j(\mathcal{I}_j(\varphi_H, \gamma(\varphi_H))))^{\frac{\sigma-1}{\theta}} B_j(\gamma)) - w_j \sum_{i\in\mathcal{I}_j(\varphi_H)} f_{ij} < \mathbb{E}(\varphi_L^{\sigma-1}(\eta\Theta_j(\mathcal{I}_j(\varphi_L, \gamma(\varphi_L))))^{\frac{\sigma-1}{\theta}} B_j(\gamma)) - w_j \sum_{i\in\mathcal{I}_j(\varphi_L)} f_{ij}$$

Combining these two, we find

$$[\varphi_H^{\sigma-1} - \varphi_L^{\sigma-1}][\mathbb{E}(\Theta_j(\mathcal{I}_j(\varphi_H, \gamma(\varphi)))^{\frac{\sigma-1}{\theta}} B_j(\gamma)) - \mathbb{E}(\Theta_j(\mathcal{I}_j(\varphi_L, \gamma(\varphi)))^{\frac{\sigma-1}{\theta}} B_j(\gamma))]\eta^{\frac{\sigma-1}{\theta}} > 0$$

Given that $\varphi_H > \varphi_L$, $\eta > 0$, and the fact that γ's are the same and the expectations formed about these shocks are the same, and shocks are i.i.d, $\mathbb{E}(\Theta_j(\mathcal{I}_j(\varphi_H, \gamma(\varphi_H)))^{\frac{\sigma-1}{\theta}} B_j(\gamma)) > \mathbb{E}(\Theta_j(\mathcal{I}_j(\varphi_L, \gamma(\varphi_L)))^{\frac{\sigma-1}{\theta}} B_j(\gamma))$.

(b) When $(\sigma - 1)/\theta > 1$, the expected profit function features increasing differences in $\mathbb{1}_{ij}, \mathbb{1}_{kj}$ for $i, k \in \{1, \ldots, I\}$ with $i \neq k$. To prove this, we show it first for the case without risk and then we include uncertainty:

$$\begin{aligned}
&(T_i(\tau_{ij}\gamma_{ij}(\varphi)w_i)^{-\theta} + T_k(\tau_{kj}\gamma_{kj}(\varphi)w_k)^{-\theta}))^{\frac{\sigma-1}{\theta}} - T_k(\tau_{kj}\gamma_{kj}(\varphi)w_k)^{-\theta})^{\frac{\sigma-1}{\theta}} \geq T_i(\tau_{ij}\gamma_{ij}(\varphi)w_i)^{-\theta})^{\frac{\sigma-1}{\theta}} \\
&(T_i(\tau_{ij}\gamma_{ij}(\varphi)w_i)^{-\theta} + T_k(\tau_{kj}\gamma_{kj}(\varphi)w_k)^{-\theta}))^{\frac{\sigma-1}{\theta}} \geq T_i(\tau_{ij}\gamma_{ij}(\varphi)w_i)^{-\theta})^{\frac{\sigma-1}{\theta}} + T_k(\tau_{kj}\gamma_{kj}(\varphi)w_k)^{-\theta})^{\frac{\sigma-1}{\theta}}
\end{aligned}$$

which is true for $(\sigma - 1)/\theta > 1$ since, for $\alpha > 1$:

$$\begin{aligned}
x^\alpha + y^\alpha &= (x+y)^\alpha \left[\left(\frac{x}{x+y}\right)^\alpha + \left(\frac{y}{x+y}\right)^\alpha\right] \\
&\leq (x+y)^\alpha \left[\left(\frac{x}{x+y}\right) + \left(\frac{y}{x+y}\right)\right] \\
&= (x+y)^\alpha
\end{aligned}$$

Now, because this true almost surely, and since $\bar{\gamma}_{ij}, \tilde{\gamma}_{ij}(\varphi) > 0$, we can just take the expectation and this is still valid.

Furthermore, it also features increasing differences in $(\mathbb{1}_{ij}, \varphi)$ for any $i \in I$, since

$$(\varphi_H^{\sigma-1} - \varphi_L^{\sigma-1})(T_i(\tau_{ij}\gamma_{ij}(\varphi)w_i)^{-\theta} + T_k(\tau_{kj}\gamma_{kj}(\varphi)w_k)^{-\theta})^{\frac{\sigma-1}{\theta}} \geq (\varphi_H^{\sigma-1} - \varphi_L^{\sigma-1})(T_k(\tau_{kj}\gamma_{kj}(\varphi)w_k)^{-\theta})^{\frac{\sigma-1}{\theta}}$$

Then, again, we can just take expectation and it is still true.

We use Topki's theorem, which states that if f is supermodular in (x, θ) and D is a lattice, then $x^*(\theta) = \text{argmax}_{x\in D} f(x, \theta)$ is nondecreasing in θ, we can then conclude that $\mathcal{I}_j(\varphi_L) \subseteq \mathcal{I}_j(\varphi_H)$ for $\varphi_H \geq \varphi_L$.

A.2 Proof of Proposition 2

Consider first the case, $i \neq \mathcal{I}_j(\varphi)$. The mapping defined in Proposition 2 is such that $V_{ij}(\varphi, \gamma, \mathcal{I}) = 1$ if

$$\varphi^{\sigma-1}\gamma^{\frac{\sigma-1}{\theta}}[\mathbb{E}(B_j(\gamma)\Theta_j(\mathcal{I}\cup i)^{\frac{\sigma-1}{\theta}}) - \mathbb{E}(B_j(\gamma)\Theta_j(\mathcal{I})^{\frac{\sigma-1}{\theta}})] > f_{ij}$$

and $V_{ij}(\varphi, \gamma, \mathcal{I}) = 0$ otherwise. Because of increasing differences, the term $\mathbb{E}(\Theta_j(\mathcal{I}\cup i)^{\frac{\sigma-1}{\theta}}B_j(\gamma)) - \mathbb{E}(\Theta_j(\mathcal{I})^{\frac{\sigma-1}{\theta}}B_j(\gamma))$ is increasing by the addition of elements to the set $\mathcal{I}$ (for $(\sigma-1)/\theta > 1$). As a result, for $\mathcal{I} \subseteq \mathcal{I}'$, we cannot possibly have $V_{ij}(\varphi, \gamma, \mathcal{I}) = 1$ and $V_{ij}(\varphi, \gamma, \mathcal{I}') = 0$. Instead, we must have either $V_{ij}(\varphi, \gamma, \mathcal{I}) = V_{ij}(\varphi, \gamma, \mathcal{I}') = 0$, $V_{ij}(\varphi, \gamma, \mathcal{I}) = V_{ij}(\varphi, \gamma, \mathcal{I}') = 1$ or $V_{ij}(\varphi, \gamma, \mathcal{I}) = 0$ and $V_{ij}(\varphi, \gamma, \mathcal{I}') = 1$.

Second, consider the case $i \in \mathcal{I}$. The mapping $V_{ij}(\varphi, \gamma, \mathcal{I})$ defined in Proposition 2 is such that

$$\varphi^{\sigma-1}\gamma^{\frac{\sigma-1}{\theta}}[\mathbb{E}(B_j(\gamma)\Theta_j(\mathcal{I})^{\frac{\sigma-1}{\theta}}) - \mathbb{E}(B_j(\gamma)\Theta_j(\mathcal{I}\setminus i)^{\frac{\sigma-1}{\theta}})] > f_{ij}$$

and $V_{ij}(\varphi, \gamma, \mathcal{I}) = 0$ otherwise. Similarly to above, the term $\mathbb{E}(\Theta_j(\mathcal{I})^{\frac{\sigma-1}{\theta}}) - \mathbb{E}(\Theta_j(\mathcal{I}\setminus i)^{\frac{\sigma-1}{\theta}})$ is increased by the addition of elements to the set $\mathcal{I}$. As a result, for $\mathcal{I} \subseteq \mathcal{I}'$, we cannot possibly have $V_{ij}(\varphi, \gamma, \mathcal{I}) = 1$ and $V_{ij}(\varphi, \gamma, \mathcal{I}') = 0$. Instead, we must have either $V_{ij}(\varphi, \gamma, \mathcal{I}) = V_{ij}(\varphi, \gamma, \mathcal{I}') = 0$, $V_{ij}(\varphi, \gamma, \mathcal{I}) = V_{ij}(\varphi, \gamma, \mathcal{I}') = 1$ or $V_{ij}(\varphi, \gamma, \mathcal{I}) = 0$ and $V_{ij}(\varphi, \gamma, \mathcal{I}') = 1$.

Thus, we can conclude that $V_{ij}(\varphi, \gamma, \mathcal{I}') \geq V_{ij}(\varphi, \gamma, \mathcal{I}')$ for $\mathcal{I} \subseteq \mathcal{I}'$ as stated in the proposition.

A.3 Proof of Proposition 3 (WIP)

Given a vector of wages, equation (17) and (18) determine the equilibrium values of $B_j(\gamma)$ and N_j. Notice that the firm-level global sourcing problem depends on $B_j(\varphi)$, w_j, and exogenous parameters, and not directly on N_j. As a result, if a unique solution for $B_j(\gamma)$ exists, all thresholds $\tilde{\varphi}_{ij}$ for any pair of countries (i, j) will be pinned down uniquely, given wages, and an expectation of the shocks. Hence, if a unique solution for $B_j(\gamma)$ in equation (17) exists, we can ensure that there will be a unique value of N_j solving (18). Let us then focus on studying whether equation (17) indeed delivers a unique solution for $B_j(\gamma)$.

For given wages, and formed expectations over the shocks, the equilibrium condition (17) can be rearranged:

$$w_j f_e = \int_{\tilde{\varphi}_{\vartheta(j)j}}^{\infty} \int_{\bar{\gamma}} \int_{\tilde{\gamma}(\varphi)} B_j(\bar{\gamma})(\eta\Theta_j(\varphi, \gamma(\varphi)))^{\frac{\sigma-1}{\theta}}\varphi^{\frac{\sigma-1}{\theta}} d\Psi_{ij}(\gamma) dG_j(\varphi) - w_j \int_{\tilde{\varphi}_{\vartheta(j)j}}^{\infty} \int_{\gamma} \sum_{i\in\mathcal{I}_j(\varphi)} f_{ij} d\tilde{\Psi}_{ij}^{\varphi}(\tilde{\gamma}) d\bar{\Psi}_{ij}(\bar{\gamma}) dG_j(\varphi) \tag{34}$$

where $\vartheta(j)$ denotes the location from which the least productive active firm in country j sources its inputs, or formally, $\vartheta(j) = \{i \in I : \tilde{\varphi}_{ij} \leq \tilde{\varphi}_{kj} \text{ for all } k \in I\}$. Note that $\vartheta(j)$ satisfies

$$\int_{\bar{\gamma}} \int_{\tilde{\gamma}(\varphi)} (\tilde{\varphi}_{\vartheta(j)j})^{\sigma-1} B_j(\gamma)(\eta T_{\vartheta(j)j}(\tau_{\vartheta(j)j}\gamma_{\vartheta(j)j}(\tilde{\varphi}_{\vartheta(j)j})w_{\vartheta(j)})^{-\theta}) d\tilde{\Psi}_{ij}^{\varphi}(\tilde{\gamma}) d\bar{\Psi}_{ij}(\bar{\gamma}) = w_j f_{\vartheta(j)j} \tag{35}$$

This means that the least productive active firm in country j sources its inputs from one location, but it would be easily written for more locations. Remember also that $\Theta_j(\varphi, \gamma(\varphi)) \equiv \sum_{k\in\mathcal{I}_j(\varphi)} T_k(\tau_{kj}\gamma_{kj}(\varphi)w_k)^{-\theta}$, and $\mathcal{I}_j(\varphi) \subseteq \mathcal{I}$ is the set of countries for which a firm based in j with productivity φ has paid the associated fixed cost of offshoring $w_j f_{ij}$.

Computing the derivative of the RHS of (A1) with respect to $B_j(\gamma)$, and using (A2) to eliminate the effects of working through changes in $\vartheta(j)$, we can write this derivative simply as:

$$\int_{\tilde{\varphi}_{\vartheta(j)j}} \frac{\partial \mathbb{E}((\varphi^{\sigma-1}\Theta_j(\varphi,\gamma(\varphi)))^{\frac{\sigma-1}{\theta}} B_j(\gamma)) - w_j \sum_{i\in\mathcal{I}_j(\varphi)} f_{ij}}{\partial B_j(\varphi)} dG_j(\varphi) > 0 \tag{36}$$

The fact that this derivative is positive follows directly from the firm's global sourcing problem (14). In particular, holding constant the firm's sourcing strategy $\mathcal{I}_j(\varphi)$ - and thus $\Theta_j(\varphi,\gamma)$ -, it is clear that an increase in $B_j(\varphi)$ will increase firm-level expected profits $\mathbb{E}(\varphi^{\sigma-1}(\eta\Theta_j(\varphi,\gamma(\theta)))^{\frac{\sigma-1}{\theta}} B_j(\gamma)) - w_j \sum_{i\in\mathcal{I}_j(\varphi)} f_{ij}$. Now, such an increase in $B_j(\varphi)$ might well affect the expected profit-maximizing choice of $\mathcal{I}_j(\varphi)$ - and thus $\Theta_j(\varphi,\gamma(\varphi))$ - but firm expected profits could not possibly be reduced ex-ante by those changes, since the firm can always decide not to change the global sourcing strategy in light of the higher $B_j(\gamma)$ and still obtain higher expected profits. We can thus conclude that the RHS of (B1) is monotonically increasing in $B_j(\varphi)$.

It is also clear that when $B_j(\gamma) \to \infty$, all firms will find it optimal to source from everywhere and the RHS of (B1), using Fubini's theorem, becomes

$$\int_{\bar{\gamma}} B_j(\gamma) \int_{\underline{\varphi}_j}^{\infty} \int_{\tilde{\gamma}(\varphi)} (\eta \sum_{k\in I} T_k(\tau_{kj} w_k \gamma_{kj}(\varphi))^{-\theta})^{\frac{\sigma-1}{\theta}} \varphi^{\sigma-1} d\tilde{\Psi}^{\varphi}_{ij}(\gamma) dG_j(\varphi) d\bar{\Psi}_{ij}(\gamma) - w_j \sum_{i\in I} f_{ij} \tag{37}$$

and thus goes to infinity. Conversely, when $B_j(\gamma) \to 0$, no firm can profitably source from any location, given the positive fixed costs of sourcing, and thus the RHS of (B1) goes to 0.

It thus only remains to show that the RHS of (B1) is a continuously non-decreasing function of $B_j(\gamma)$. This may not seem immediate because firm-level expected profits jump discontinuously with $B_j(\gamma)$ whenever such changes in $B_j(\gamma)$ lead to changes in the global sourcing strategy of firms. It can be shown, however, that:

$$\int_{\tilde{\varphi}_{\vartheta(j)j}} \frac{\partial \mathbb{E}(B_j(\gamma)\varphi^{\sigma-1}(\eta\Theta_j(\varphi,\gamma(\varphi)))^{\frac{\sigma-1}{\theta}})}{\partial B_j(\gamma)} dG_j(\varphi) \tag{38}$$

is continuously differentiable in $B_j(\gamma)$. We first show that $\Theta_j(\varphi,\gamma(\varphi);B_j(\gamma))$ must be non-decreasing not only in φ, but also in $B_j(\gamma)$ and $\varphi^{\sigma-1}B_j(\gamma)$. We can then represent $\mathbb{E}(\Theta_j(\varphi,\gamma(\varphi))^{\frac{\sigma-1}{\theta}} B_j(\gamma)\varphi^{\sigma-1})$ as a non-decreasing step function in φ, in which the jumps occur at different levels of $B_j(\gamma)\varphi^{\sigma-1}$. This is analogous to writing:

$$\mathbb{E}((\Theta_j(\varphi,\gamma(\varphi)))^{\frac{\sigma-1}{\theta}} B_j(\gamma)\varphi^{\sigma-1}) = \begin{cases} \mathbb{E}(\theta_1 B_j(\gamma)\varphi^{\sigma-1}), & \text{if } \varphi < \mathbb{E}(b_1/B_j(\gamma)^{1/(\sigma-1)}) \\ \mathbb{E}(\theta_2 B_j(\gamma)\varphi^{\sigma-1}), & \text{if } \mathbb{E}(b_1/B_j(\gamma)^{1/(\sigma-1)}) \le \varphi < \mathbb{E}(b_2/B_j(\gamma)^{1/(\sigma-1)}) \\ \vdots & \\ \mathbb{E}(\theta_I B_j(\gamma)\varphi^{\sigma-1}), & \text{if } \mathbb{E}(b_{I-1}/B_j(\gamma)^{1/(\sigma-1)}) \le \varphi \end{cases} \tag{39}$$

Hence,

$$\int_{\tilde{\varphi}_{\vartheta(j)j}}^{\infty} \mathbb{E}((\Theta_j(\varphi,\gamma(\varphi)))^{\frac{\sigma-1}{\theta}} B_j(\gamma)\varphi^{\sigma-1}) dG_j(\varphi) = \int_{\tilde{\varphi}_{\vartheta(j)j}}^{\mathbb{E}(b_1/B_j^{1/(\sigma-1)})} \mathbb{E}(\theta_1 B_j(\gamma)\varphi^{\sigma-1}) dG_j(\varphi) + \int_{\mathbb{E}(b_1/B_j^{1/(\sigma-1)})}^{\mathbb{E}(b_2/B_j^{1/(\sigma-1)})} \mathbb{E}(\theta_2 B_j(\gamma)\varphi^{\sigma-1}) dG_j(\varphi)$$
$$+ \cdots + \int_{\mathbb{E}(b_{I-1}/B_j^{1/(\sigma-1)})}^{\infty} \mathbb{E}(\theta_I B_j(\gamma)\varphi^{\sigma-1}) dG_j(\varphi)$$

It is then clear that the derivative of this expression with respect to $B_j(\gamma)$ is a sum of continuous functions of $B_j(\gamma)$, and thus is continuous in $B_j(\gamma)$ itself. Using similar arguments, we can next show that

$$\int_{\tilde{\varphi}_{\vartheta(j)j}}^{\infty} \frac{\partial(w_j \sum_{i\in\mathcal{I}_j(\varphi)} f_{ij})}{\partial B_j(\gamma)} dG_j(\gamma) \tag{40}$$

is also continuously differentiable in $B_j(\gamma)$. First, a simple proof by contradiction can be used to show that $\sum_{i\in\mathcal{I}_j(\varphi)} f_{ij}$ is non-decreasing in $\mathbb{E}(B_j(\gamma)\varphi^{\sigma-1})$. More specifically, suppose that for $\mathbb{E}(B_j(\gamma)\varphi^{\sigma-1})_H > \mathbb{E}(B_j(\gamma)\varphi^{\sigma-1})_L$, we also had $\sum_{i\in\mathcal{I}_{Hj}} f_{ij} < \sum_{i\in\mathcal{I}_{Lj}} f_{ij}$. Given the non-decreasing dependence of $\Theta_j(\varphi,\gamma(\varphi))$ on $B_j(\gamma)\varphi_j^{\sigma-1}$, we would then have

$$\mathbb{E}((\eta\Theta_{Hj}(\varphi,\gamma(\varphi)))^{\frac{\sigma-1}{\theta}}(B_j(\gamma)\varphi^{\sigma-1})_L) - \sum_{i\in\mathcal{I}_{Hj}} f_{ij} > \mathbb{E}((\eta\Theta_{Lj}(\varphi,\gamma(\varphi)))^{\frac{\sigma-1}{\theta}}(B_j(\gamma)\varphi^{\sigma-1})_L) - \sum_{i\in\mathcal{I}_{Lj}} f_{ij} \tag{41}$$

which contradicts $\mathcal{I}_{Lj}$ being optimal given $\mathbb{E}(B_j(\gamma)\varphi^{\sigma-1}) = \mathbb{E}(B_j(\gamma)\varphi^{\sigma-1})_L$. With this result, $\sum_{i\in\mathcal{I}_j(\varphi)} f_{ij}$ can then be expressed as a step function analogous to that in (A4), in which the position of the steps is continuously differentiable in $B_j(\gamma)$. This, in turn, ensures that (A1) is continuous in $B_j(\gamma)$ and concludes the proof that there exists a unique $B_j(\gamma)$ for each state of the world that solves equation (17).

B Data Appendix

Table 7: Extensive and intensive margin

origin	number of firms	value of imports	rank by firms	rank by value
CHN	24755	153955	1	12
USA	17556	140322	2	2
RoW	8286	26033	3	5
ESP	8055	12507	4	12
DEU	7520	25660	5	6
ITA	7493	11571	6	14
BRA	6964	70063	7	3
ARG	6103	36515	8	4
HKG	5652	238	9	45
TWN	5313	2732	10	28

Figure 14: Country sourcing potential and extensive margin

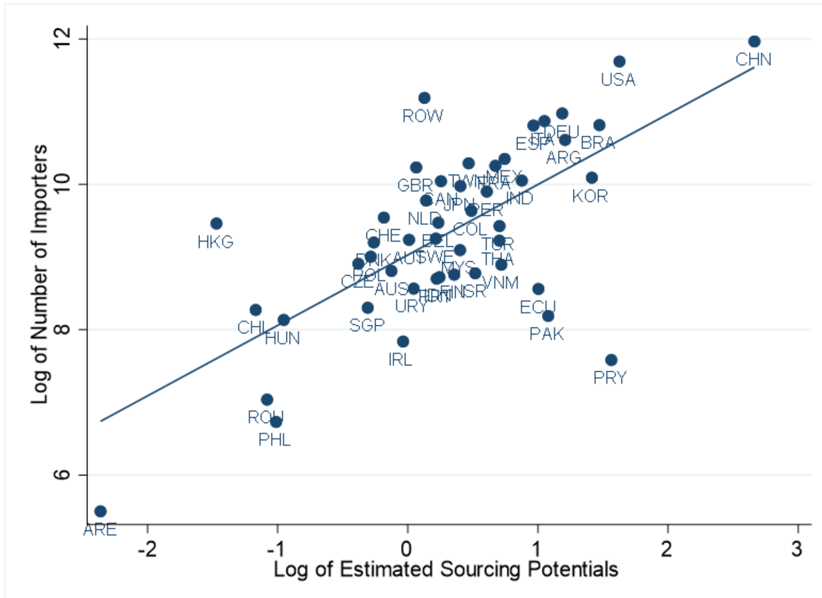

Figure 15: Country sourcing potential and intensive margin

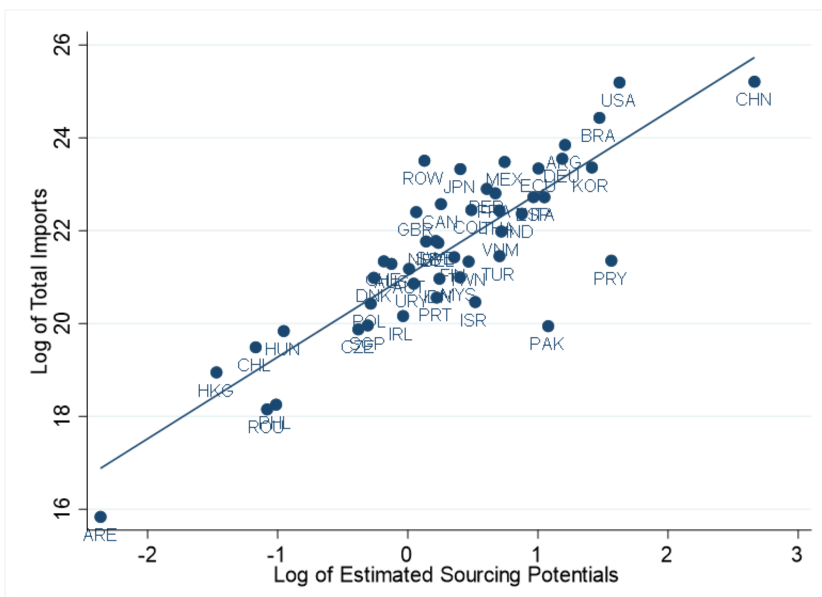

Figure 16: Average aggregate shock all countries, 2012q1-2019q4

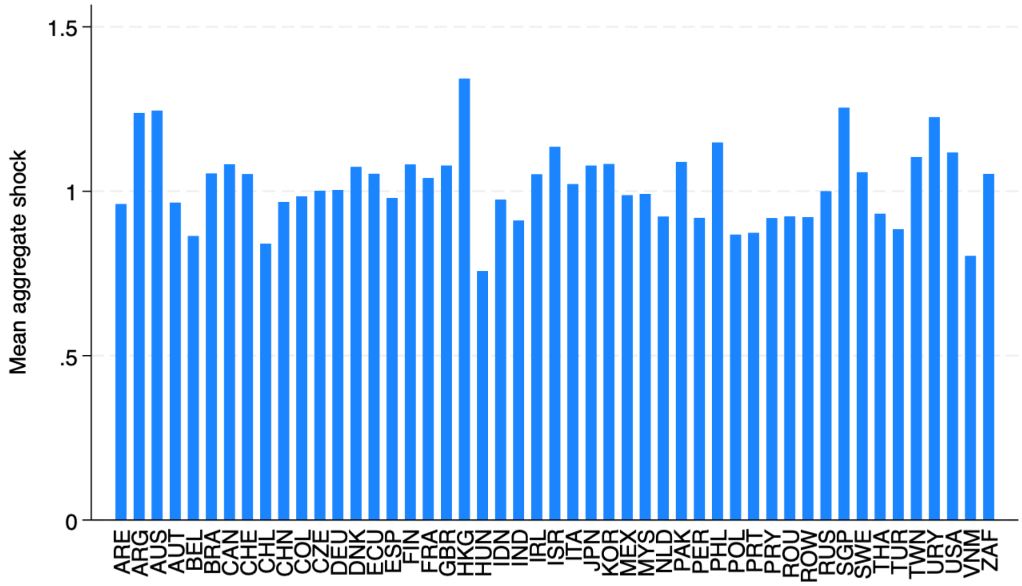

Figure 17: Average aggregate shock all countries, 2012q1-2023q4

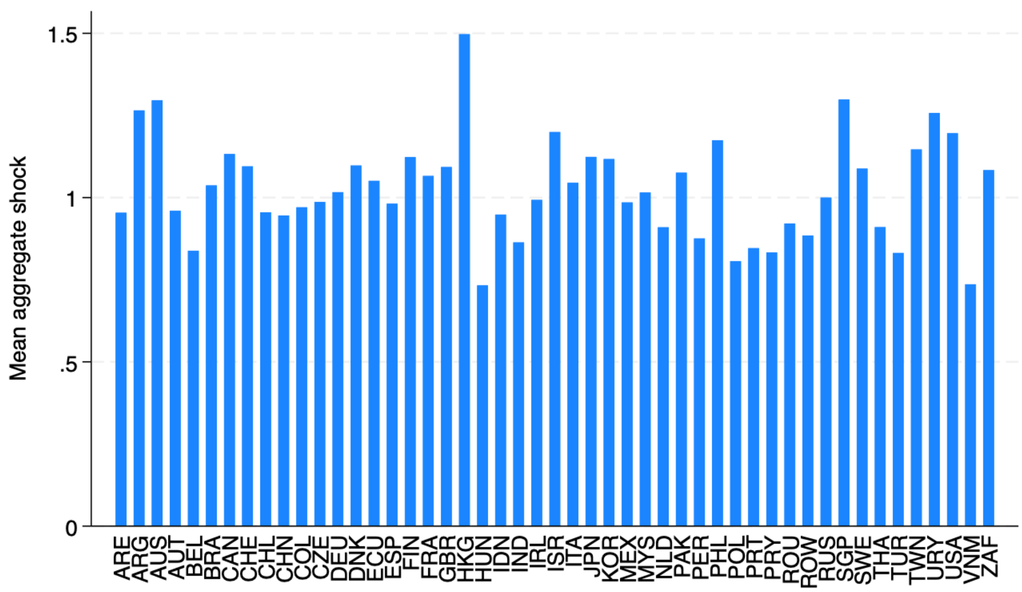

Figure 18: Average aggregate shock all countries, 2012q1-2015q4

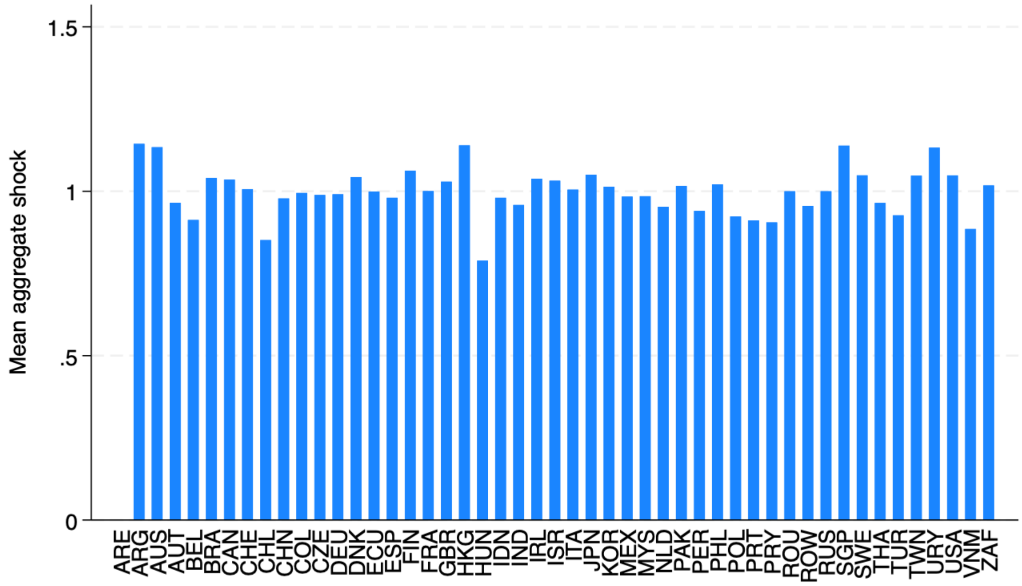

Figure 19: Average aggregate shock all countries, 2016q1-2019q4

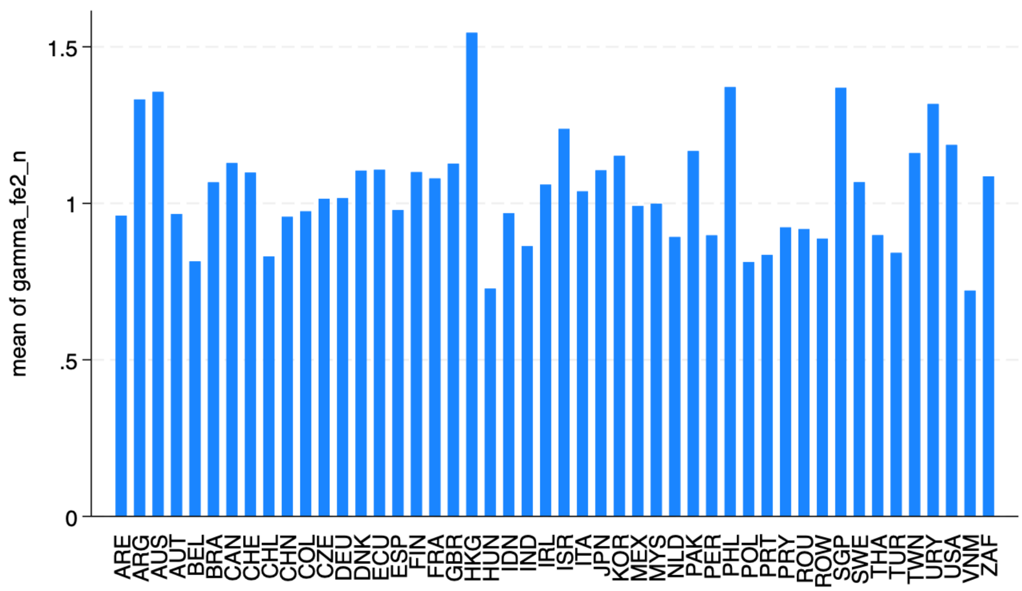

Figure 20: Average aggregate shock all countries, 2020q1-2023q4

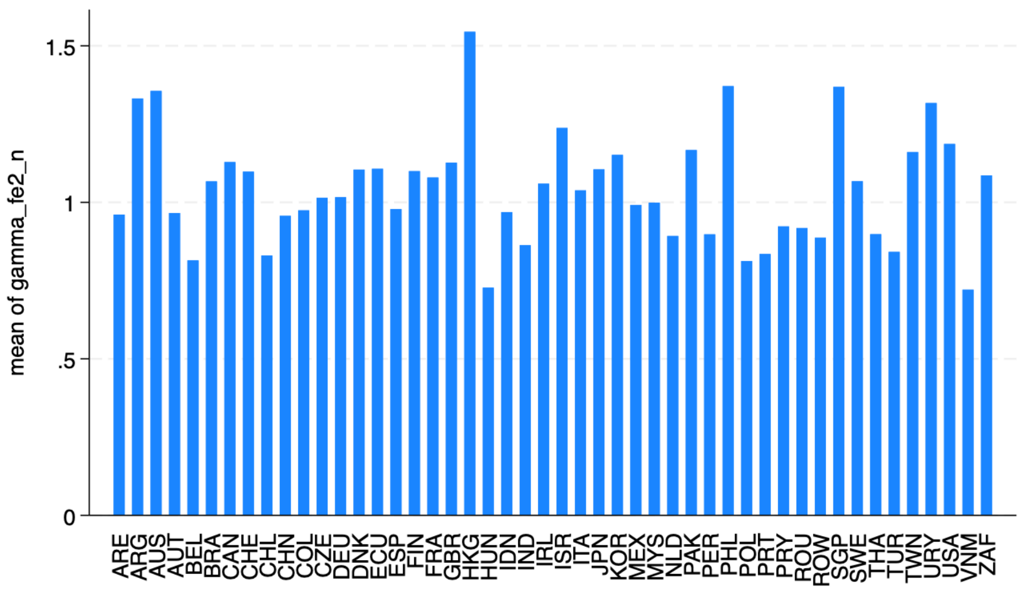

Figure 21: Average standard deviation for aggregate shocks, 2012q1-2019q4

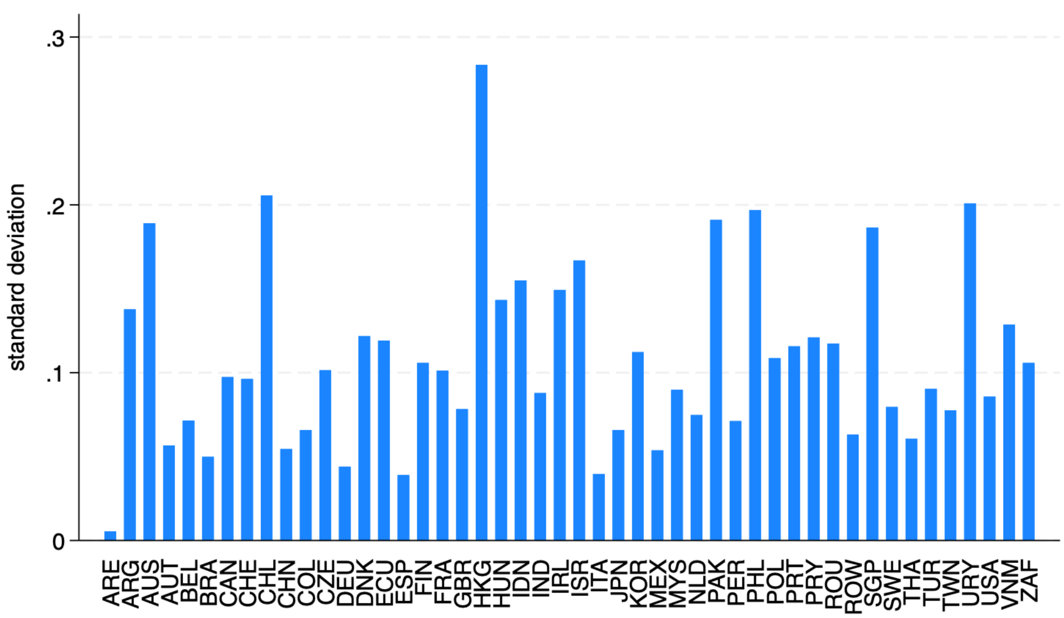

Figure 22: Average standard deviation for aggregate shocks, 2012q1-2023q4

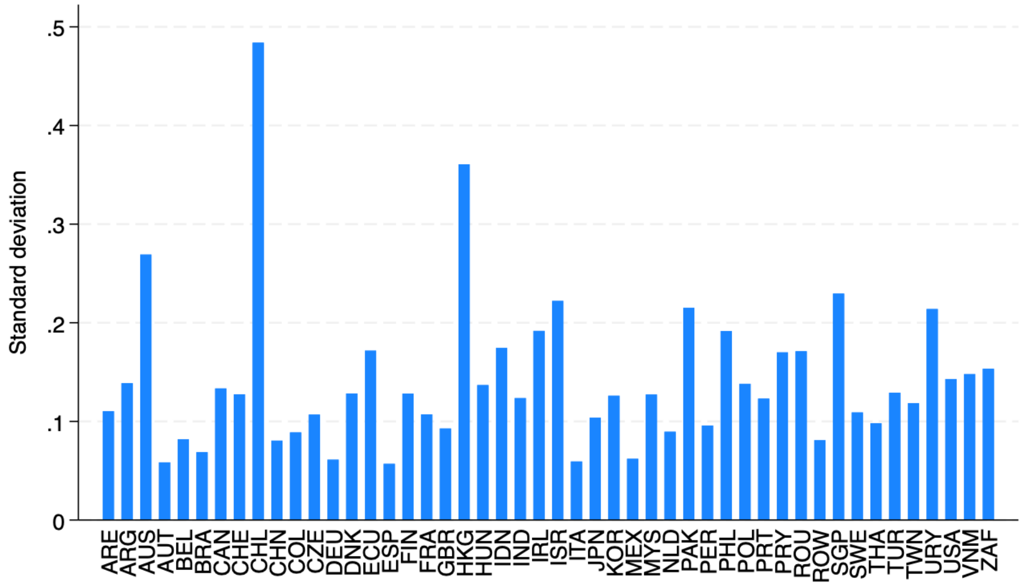

Figure 23: Average standard deviation for aggregate shocks, 2012q1-2015q4

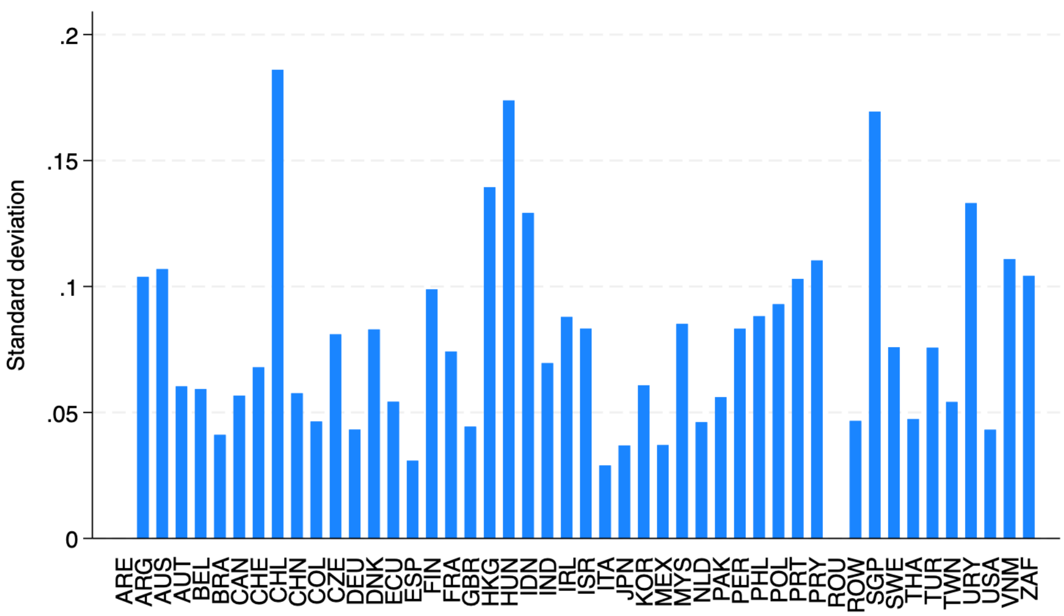

Figure 24: Average standard deviation for aggregate shocks, 2016q1-2019q4

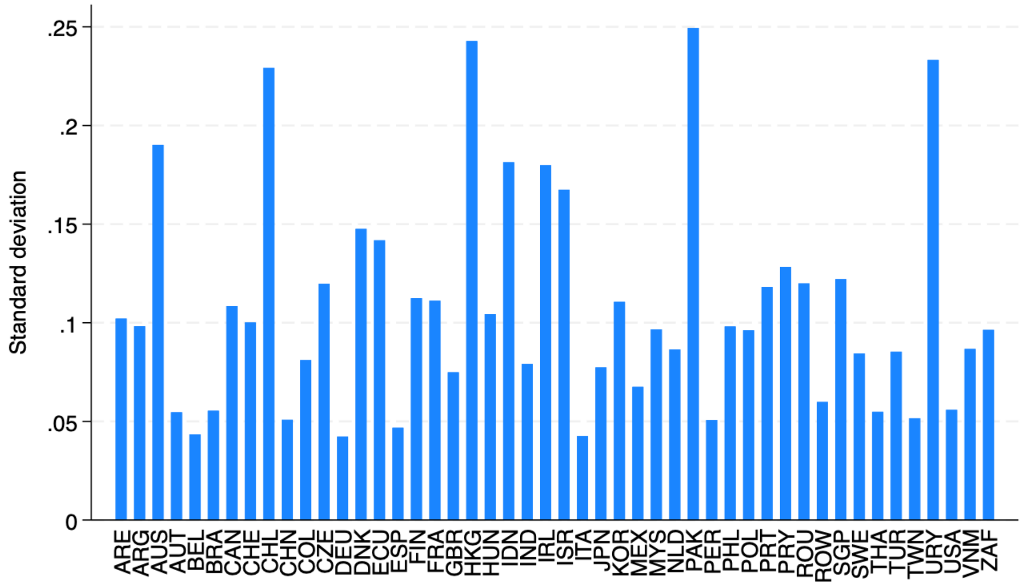

Figure 25: Average standard deviation for aggregate shocks, 2020q1-2023q4

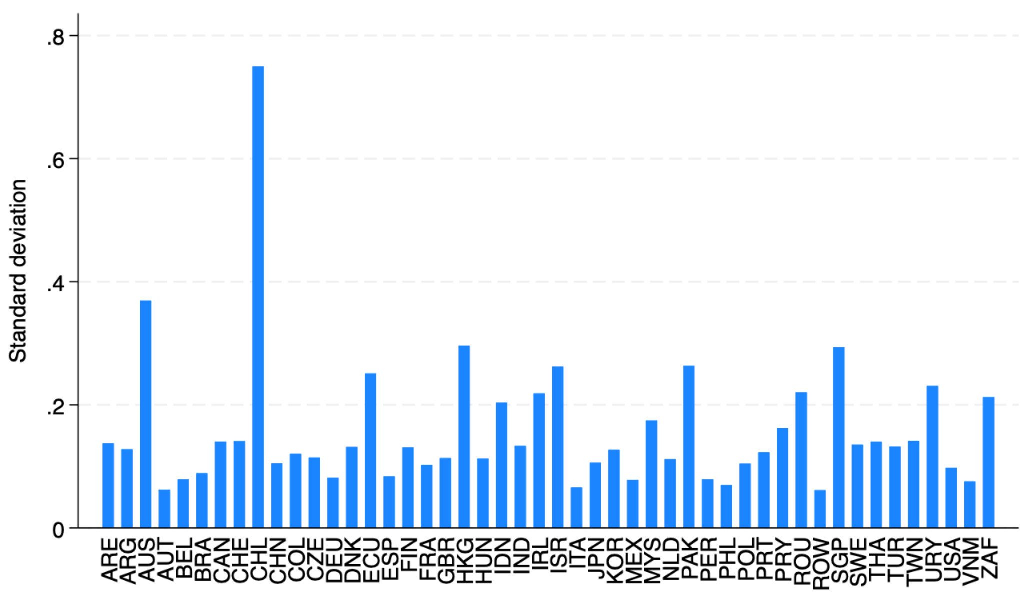

Figure 26: Aggregate shocks in time for China and USA

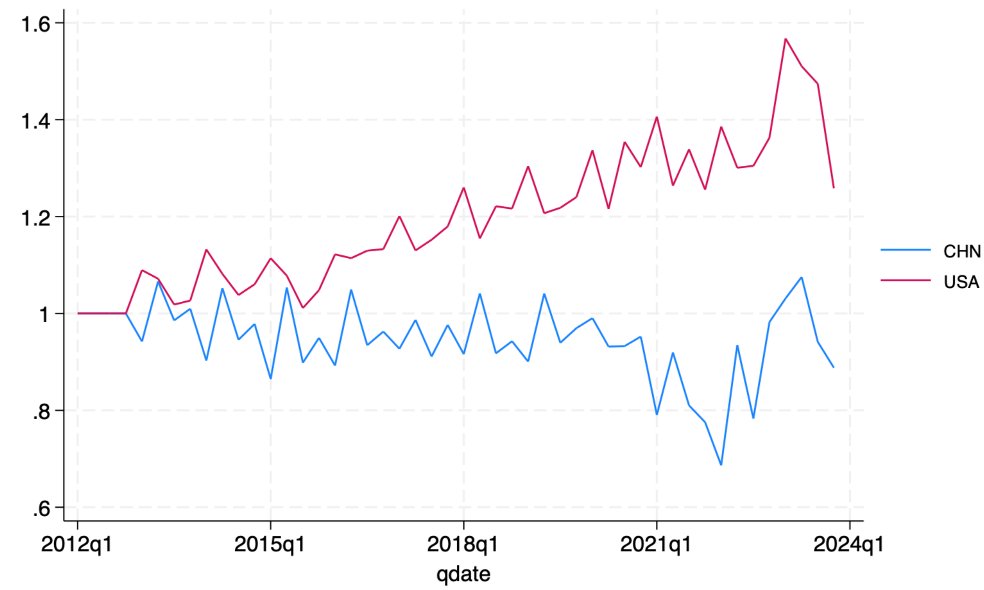

Figure 27: Average standard deviation for idiosyncratic shocks