Supply Chain Uncertainty and Diversification

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Abstract

How do firms adapt their sourcing strategies when faced with supply chain uncertainty? To answer this question, we develop a multi-country sourcing model, in which firms choose where to import from, accounting for the possibility of supply-chain disruptions. We show that uncertainty introduces a positive option value, that favors diversifying the set of suppliers. However, country-specific uncertainty creates hedging motives for firms, yielding on net ambiguous predictions about sourcing decisions. We estimate the model on Chilean Customs data and we study how the recent increase in trade risk, following the Covid-19 pandemic, affected firms' sourcing strategies. We find that the observed change in sourcing patterns results from both changes in expected costs and increased risk.

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1 Introduction

For most of this century, trade disruptions were relatively infrequent. However, the rise of protectionism, the Covid-19 pandemic, the Russia-Ukraine war, climate change, among others, have increased uncertainty about the reliability of supply chains.[1] Increased supply chain disruption risk has expressed itself as longer delivery times and higher shipping costs. For example, Alessandria et al. [2023] document 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.

There is an ongoing debate on the appropriate response of firms to this increased uncertainty. There are arguments in favor of reshoring the sources of inputs, in order to protect supply chains from disruptions occurring abroad, while others advocate for diversifying the portfolio of suppliers, so as to reduce overall sourcing risk (Javorcik [2020], Bonadio et al. [2021], IMF [2022]).[2] In Figure 1 we show how the number of sourcing origins per importing firm-product pair evolved on average over 2012-2024 in Chile. We can appreciate how the number of sourcing origins was relatively stable until 2017, moment in which Trump's first administration began. Later, when the trade war with China picks up, the number of sourcing origins goes drastically up, to then abruptly fall upon the impact of the Covid-19 pandemic. However, after the initial impact, the number of sourcing origins recovered quickly, to continue increasing up and above the levels observed during the trade war.

In this context, the objective of this paper is to understand the effect of supply chain uncertainty on the sourcing decisions of firms. More specifically, we want to know whether firms would adapt their sourcing strategies when faced with changes in uncertainty; and if so, if it would be by modifying the degree of diversification in their foreign suppliers, their extent of re-shoring, or their selectiveness of suppliers based on cost and risk considerations.

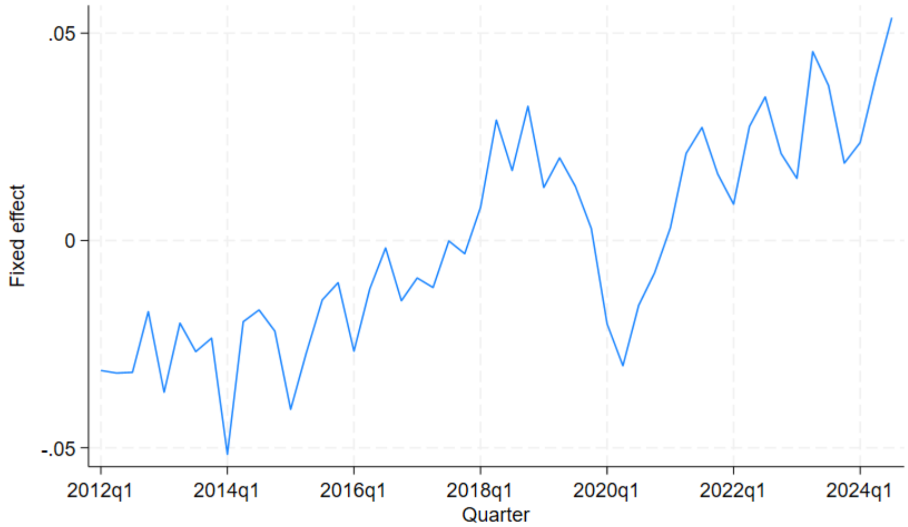
To answer these questions, we develop a multi-country sourcing model in the spirit of Antràs et al. [2017], in which heterogeneous firms choose where to import from, accounting for international supply-chain uncertainty. Supply-chain risk is represented as changes in trade costs, which may occur both at the firm-origin and at the trade partner levels. Firms decide their sourcing strategy by selecting the set of suppliers. The beginning of any relationship involves paying an initial fixed cost. Given heterogeneity in productivity among producing firms, firm-owners form expectations regarding supply-chain risk, and choose where to source from to maximize expected profits. After the selection of suppliers, trade shocks are realized, and firms decide how much to spend on the goods provided by each selected supplier.

We decompose the effect on final good firms' expected profits of adding an additional country to the set of sourcing options. There are five components of the total effect: (i) on the overall sourcing capability, which represents how cheap sourcing inputs from abroad are; (ii) on the option value over capability, since adding riskier countries allows firms to sell at a cheaper cost if countries in their sourcing

[1] The Business Continuity Institute (BCI) Supply Chain Resilience Report found that over 25% of the surveyed firms experienced ten or more disruptions in 2020, while the number in 2019 was under 5% (Baldwin and Freeman [2021])

[2] 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 sectoral shocks.

Figure 1: Evolution of the number of sourcing origins per firm-product pair



Note: The graph shows the time fixed effects from the following regression: $\log N_{fpt} = \alpha_{fp} + \delta_t + \epsilon_{fpt}$, where f is firm, p is HS6 product category, and t is quarter, N_{fpt} is number of sourcing regions, α_{fp} is a firm-product fixed effect, δ_t is the plotted time fixed effect, and ϵ_{fpt} is a random error.

strategy are hit with a positive shock; (iii) on the covariance between sourcing capability and market demand, which is the hedging dimension of adding sourcing countries whose trade disruptions co-move negatively with those of the countries that most firms add to their sourcing strategies; (iv) on market demand, which is affected by the prices of all firms and, hence, only by uncertainty that is common to all firms; and (v) on the fixed cost of sourcing. We utilize a numerical example to illustrate how these terms influence expected profits by relating expected profits to firm's productivity. The analysis suggests that the predominant driver of firms' ex-ante sourcing decisions seems to be the effect that countries have on the overall sourcing capability. The effect on the option value on capability is positive but small, while the effect on the covariance between capability and market demand is negative and even smaller.

Finally, we quantitatively explore the impact of uncertainty on sourcing decisions. We estimate the model using customs and tax data at the firm level for Chile. Our data span the period from the first quarter (q1) of 2012 to the fourth quarter (q4) of 2023. First, using the structure of the model, we estimate the time series of supply-chain shocks using the average sales and import shares between 2012q1 and 2019q4. Second, to analyze firms sourcing decisions, we estimate the structural model with the simulated method of moments, and we measure the fixed cost of sourcing from each country. Because sourcing decisions interact between countries and firms, the dimensionality of our problem is very high. However, we assume complementarity on these decisions to be able to use Jia [2008]'s algorithm and reduce the complexity of our problem.

Finally, we perform a counterfactual analysis, in which we ask ourselves what would have been the sourcing decisions of firms in the 2012q1-2019q4 period if they had faced the supply chain uncertainty of the 2020q1-2023q4 period. The change in the distribution of trade disruption shocks after the Covid-19 pandemic had strong reallocation effects across countries. The decline in average costs from China and the rise in US costs made Chilean firms change their sourcing choice from the latter to the former. As a result, cost minimization is still the primary driver of firms' import choices. However, the increase in the variance of trade risk in 2020q1-2023q4 still implied moderate diversification motives for firm sourcing. We see that the option value effect is more potent than the covariance effect, and firms are willing to tolerate higher uncertainty for the possibility of a beneficial trade shock. All these effects implied that more firms self-selected into importing, which diversified Chilean trade supply chains.

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 find that, under certain conditions, the inter-dependencies 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 input trade decreased manufacturing prices by around 27%. Antràs and Helpman [2004] write a model in which firms have to decide whether to produce intermediate goods or 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. We contribute by adding both aggregate and idiosyncratic supply chain uncertainty to an international sourcing model based on Antràs et al. [2017]. We are able to understand how this new channel affects both the decisions of who to source from, as well as how much to source from each of the importers they initiated a relationship with. To the best of our knowledge, we are the first ones to add supply chain uncertainty to a sourcing model and estimate it. We also contribute by recovering the moments associated with the supply chain uncertainty observed during the period 2012-2023.

Our work is also related to the theoretical literature on supply chain uncertainty and sourcing decisions. Grossman et al. [2023a] study 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 and find that for the CES case, the government should subsidize diversification. Grossman et al. [2023b] write 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, using 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 whether risk diversification can be a 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 inter-dependencies, and the separate effects of cost and aggregate and idiosyncratic uncertainties. Our model can also speak to features of the data, like the fact that most productive firms self-select into importing and source from more countries, which is relevant to understanding how they would react to uncertainty and how that would affect the aggregate economy.

Another literature we relate to is the literature on tariff policy uncertainty. Handley et al. [2020] write a sourcing model with policy uncertainty. Firms decide where 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 reduced 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. They find that firms that require more specific inputs produce more differentiated products, have higher market share, 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 uncertainty, and trade shocks.

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 delivery time in a world with idiosyncratic demand risk. 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 is uncertainty on supply chains, firms 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 justifies the role of uncertainty. In this paper, we abstract from the inventory holding decision to focus on the specific effect of uncertainty in sourcing decisions.

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, which we solve in Section 3. In Section 4, we make a theoretical investigation of the effects of uncertainty. In section 5, we introduce our data and provide descriptive evidence. In Section 6, we estimate our structural model. In Section 7, we perform our counterfactual analysis. Finally, in Section 8, we conclude.

2 Model

In this section, we construct a quantifiable multi-country sourcing model based on Antràs et al. [2017]. The world consists of I countries, with $i = 1, \dots, I$ denoting the origin country and $j = 1, \dots, I$ representing the destination country. In each destination country, there are L_j homogeneous individuals and a measure N_j of final good firms, owned by risk-neutral global managers. We incorporate supply chain uncertainty, which directly impacts the price dynamics of the intermediate inputs acquired by variety-producing firms.

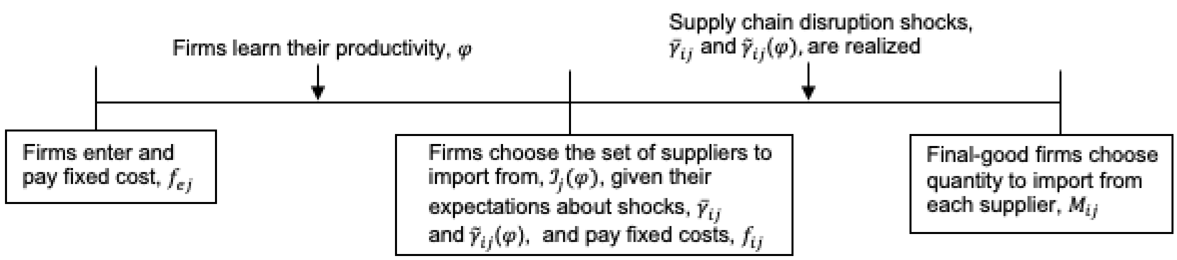
2.1 Preferences

Individuals consume a bundle of differentiated varieties and a homogeneous good produced in an outside sector, which serves as numeraire. The utility function is Cobb-Douglas. Differentiated varieties, denoted by ω, are imperfect substitutes, with an elasticity of substitution $\sigma > 1$. We assume these preferences to be the same for all individuals in the world.

2.2 Technology and Market Structure

Final-good varieties are produced according to a linear technology. There is free entry to produce and monopolistic competition. The decision-making process of firms is characterized by three stages. As illustrated in Figure 2, firms in country j commit to pay a fixed entry cost, f_{ej}, and enter the market prior to knowing their productivity, φ. Following entry, firms learn their productivity, which is drawn from a country-specific distribution $g_j(\varphi)$, with support $[\underline{\varphi}_j, \infty)$, and form expectations for both aggregate $(\bar{\gamma}_{ij})$ and idiosyncratic $(\tilde{\gamma}_{ij}(\varphi))$ supply chain shocks. Firms then select a set of suppliers, $\mathcal{I}_j(\varphi)$. To create any relation with a country i, firms must pay a relationship-specific fixed cost, f_{ij}, which is common across firms in j. Subsequently, shocks, $\bar{\gamma}_{ij}$ and $\tilde{\gamma}_{ij}(\varphi)$, are realized, and firms determine the quantity to import from each previously established supplier, $M_{ij}(\varphi, \gamma)$.

Figure 2: Timeline



Supply chain disruptions enter into the expectation of firms compounding each other, $\gamma_{ij}(\varphi) = \bar{\gamma}_{ij} \times \tilde{\gamma}_{ij}(\varphi)$. We assume $\bar{\gamma}_{ij} \sim_{\text{iid}} \Psi_{ij}(\bar{\gamma})$, $\tilde{\gamma}_{ij}(\varphi) \sim_{\text{iid}} \Psi_{ij}^{\varphi}(\tilde{\gamma})$, and that all shocks are uncorrelated. Examples of these shocks are a national level quarantine, wars, natural disasters, problems with input specificity, etc. We interpret these events as disturbances to iceberg costs, as they affect the price a country has to pay to import intermediates from the affected country, and assume they induce stochastic changes in the value of trade costs. There is imperfect substitutability across different intermediate inputs, and perfect substitutability across different origins for a given intermediate input. The elasticity of substitution between different inputs is constant and given by the parameter ρ.

In addition to final good producers, in every country there are firms that produce varieties of intermediate goods. These firms operate a constant returns to scale technology that uses solely labor. The unit labor requirement, $a_i(\nu, \varphi)$, is specific to the intermediate good variety $\nu \in [0, 1]$, the productivity of the customer firm, φ, and the origin country $i \in I$. There is perfect competition on the intermediate-good market, so intermediate-good firms sell at marginal cost. Thus, the price at which final-good firms in country j procure intermediate goods from country i encompasses the iceberg trade cost of shipping from country i to country j, τ_{ij}, the potential supply chain shocks, $\bar{\gamma}_{ij} \times \tilde{\gamma}_{ij}(\varphi)$, and the cost of labor. This implies that the final price paid by firm φ in country j for intermediate input ν is:

$$s(\nu, \varphi, \gamma(\varphi); \mathcal{I}_j(\varphi)) = \arg \min_{i \in \mathcal{I}_j(\varphi)} \left\{ w_i a_i(\nu, \varphi) \tau_{ij} \bar{\gamma}_{ij} \tilde{\gamma}_{ij}(\varphi) \right\} \tag{1}$$

Given the price schedules for intermediate goods, the marginal cost for firm φ in country j is:

$$c_j(\varphi, \bar{\gamma}, \tilde{\gamma}(\varphi)) = \frac{1}{\varphi}\left(\int_0^1 s(\nu, \varphi, \bar{\gamma}, \tilde{\gamma}(\varphi); \mathcal{I}_j(\varphi))^{1-\rho} d\nu\right)^{1/(1-\rho)} \tag{2}$$

We assume that the inverse of the labor unit requirement to produce intermediates, $1/a_i(\nu, \varphi)$, follows a Fréchet distribution, with T_i and θ being the scale and shape paremeters, respectively.[3] A higher T_i means a better state of technology in country i, while a higher θ a lower comparative advantage within intermediates across countries.

3 Sourcing Strategy and Equilibrium

The equilibrium of the competitive model is derived through a sequential backward induction process. First, we assume 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 the outside sector which 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, by minimizing $w_i a_i(\nu, \varphi)\tau_{ij}\bar{\gamma}_{ij}\tilde{\gamma}_{ij}(\varphi)$ 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

$$\mathcal{X}_{ij}(\varphi, \gamma) = \frac{T_i(\tau_{ij}\bar{\gamma}_{ij}\tilde{\gamma}_{ij}(\varphi)w_i)^{-\theta}}{\Theta_j(\varphi, \gamma)} \text{ if } i \in \mathcal{I}_j(\varphi) \tag{3}$$

[3] This implies $\mathbb{P}(a_i(\nu, \varphi) \geq a) = e^{-T_i a^{\theta}}$ with $T_i > 0$.

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

$$\Theta_j(\varphi, \gamma) \equiv \sum_{k \in \mathcal{I}_j(\varphi)} T_k(\tau_{kj}\bar{\gamma}_{kj}\tilde{\gamma}_{kj}(\varphi)w_k)^{-\theta} \tag{4}$$

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. Following Antràs et al. [2017], 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 $T_i \times (\tau_{ij}\bar{\gamma}_{ij}\tilde{\gamma}_{ij}(\varphi)w_i)^{-\theta}$ 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. This is country i's contribution to the sourcing capability of firm φ in country j. Then, 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 *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

$$c_j(\varphi, \bar{\gamma}, \tilde{\gamma}(\varphi)) = \frac{1}{\varphi}\left(\eta\Theta_j(\varphi, \bar{\gamma}, \tilde{\gamma}(\varphi))\right)^{-1/\theta} \tag{5}$$

with $\eta = \left[\Gamma\left(\frac{\theta+1-\rho}{\theta}\right)\right]^{\frac{\theta}{1-\rho}}$ and Γ the Gamma function. From equation (5) we learn that the overall marginal cost faced by the firm is positively affected by both aggregate and idiosyncratic supply chain shocks, which means that a shock higher than 1 increases costs, while a shock lower than 1 decreases them. 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

$$p_j(\varphi, \bar{\gamma}, \tilde{\gamma}) = \left(\frac{\sigma}{\sigma - 1}\right) c_j(\varphi, \bar{\gamma}, \tilde{\gamma}) \tag{6}$$

Analyzing the overall marginal cost for firm φ in country j, we observe that having a higher sourcing capability reduces the overall cost of intermediate inputs for the firm. Then, incorporating an additional country into a firm's sourcing strategy, for given shocks, 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 uncertainty, it also gives the firm a chance to draw on an extra marginal cost of a country that was positively affected by supply chain uncertainty. Examining a fixed sourcing strategy reveals that negative (positive) supply chain shocks 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

$$\pi(\varphi, \bar{\gamma}, \tilde{\gamma}(\varphi)) = \varphi^{\sigma-1} \left(\eta \Theta_j(\varphi, \bar{\gamma}, \tilde{\gamma}(\varphi))\right)^{\frac{\sigma-1}{\theta}} B_j(\bar{\gamma}) - w_j \sum_{i \in \mathcal{I}_j(\varphi)} f_{ij} \tag{7}$$

where we define $B_j(\bar{\gamma})$ as the market demand term for country j:

$$B_j(\bar{\gamma}) \equiv \frac{1}{\sigma} \left(\frac{\sigma}{\sigma-1}\right)^{1-\sigma} E_j P_j(\bar{\gamma})^{\sigma-1} \tag{8}$$

From this equation we learn that, 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 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. Then, there is an extra trade-off between adding more countries to be less influenced by particular shocks and paying the fixed cost of sourcing. 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. However, idiosyncratic shocks are washed away and do not affect the price index. Since this equation is ex-post, only actual shocks affect it, and not uncertainty, which affects ex-ante profits.

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

Firms form expectations about the outcome of supply chain shocks. Firms φ in country j use that anticipation to choose their optimal sourcing strategies $\mathcal{I}_j(\varphi) \subseteq I$, to maximize their ex-ante profits. We can write the ex-ante problem of the firm as:

$$\max_{\mathbb{1}_{ij} \in \{0,1\}_{i=1}^{I}} \mathbb{E}(\pi_j(\varphi, \bar{\gamma}, \tilde{\gamma}(\varphi))) = \mathbb{E}\left(\varphi^{\sigma-1} \Big(\underbrace{\eta \sum_{i=1}^{I} \mathbb{1}_{ij} T_i \big(\tau_{ij} \bar{\gamma}_{ij} \tilde{\gamma}_{ij}(\varphi) w_i\big)^{-\theta}}_{\equiv \Theta_j(\varphi, \bar{\gamma}, \tilde{\gamma}(\varphi))}\Big)^{\frac{\sigma-1}{\theta}} B_j(\bar{\gamma})\right) - w_j \sum_{i=1}^{I} \mathbb{1}_{ij} f_{ij} \ , \tag{9}$$

with $\mathbb{1}_{ij}$ an indicator function if country i is included in the sourcing strategy of firm φ in country j.

From the above equation, 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 for the aggregate risk case: Supply chain uncertainty affects both the sourcing capability $\Theta_j(\varphi, \bar{\gamma}, \tilde{\gamma}(\varphi))$ as well as the market demand $B_j(\bar{\gamma})$. The aggregate supply chain disruptions affect the market demand for country j, because the total expenditure in the sector and the ideal price index are positively affected by the increase in trade costs.

This can be viewed as an externality for the firm since the sourcing decisions of all other firms affect firm φ's expected profits, but this is not taken into account by the firms when they take their decisions. However, idiosyncratic uncertainty only affects expected profits through its effect on the sourcing capability and does not affect the market size. In the last subsections of section 3 we will dive deeper into the effect of aggregate uncertainty on the price index, and hence on the market demand, and how that affects firm's decisions on where to source from.

Examining equation (8), the firms face a combinatorial discrete choice optimization problem in expectation, introducing complexity due to uncertainty and the inherent interdependence in sourcing decisions. 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 each sourcing strategy, with an exhaustive enumeration, and choose the strategy that maximizes profit, we would have to compute 2^I expectations and choose the highest one. This is feasible for a small number of countries, under 10 approximately, but it becomes quickly unfeasible for a larger number of sourcing destinations. To address this computational challenge, we show 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.

In the firm problem, 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, without uncertainty, the profit function is supermodular in φ and $\Theta_j(\varphi, \bar{\gamma}, \tilde{\gamma}(\varphi))$. In the case under uncertainty with $\bar{\gamma}_{ij},\ \bar{\gamma}_{ij}(\varphi) > 0$ and the fact that the expectation is a weighted average, we are faced with a weighted average of supermodular functions, which is supermodular. Therefore, we 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 $\mathbb{E}\big(\Theta_j(\varphi, \bar{\gamma}, \tilde{\gamma}(\varphi))^{\frac{\sigma-1}{\theta}} B_j(\bar{\gamma})\big) = \mathbb{E}\big((\sum_{i=1}^{I} \mathbb{1}_{ij}(\varphi) T_i(\tau_{ij} w_i \bar{\gamma}_{ij} \tilde{\gamma}_{ij}(\varphi))^{-\theta})^{\frac{\sigma-1}{\theta}} B_j(\bar{\gamma})\big)$ 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 theoretical appendix.

Proposition 1, part (a), reveals that more productive firms exhibit a larger expected sourcing capability times market demand compared than 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, attributed to factors such as (i) high technology, (ii) low wages, (iii) low iceberg costs, (iv) small or positive shocks, or because (v) their shocks negatively correlate with the shocks affecting the market size. It could happen that high-productivity firms have a larger expected sourcing capability because they buy from one foreign country with lower wages, better technology, or higher uncertainty, which could ex post imply a smaller price, or that the shock covaries negatively with shocks from the countries that most firms source from. On the opposite side, low-productivity firms could be buying from two countries with a lower fixed cost of sourcing but have a higher marginal cost because of worse technology, higher wages, or less uncertainty, for example. Instead, it could happen 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.

As explained, 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 the sourcing decisions, more productive firms source from more 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 $\mathcal{I}_j(\varphi)$. When $(\sigma - 1)/\theta \geq 1$, we have complementarity which occurs for a high σ and/or a low θ. A high σ implies 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 these is true, lowering the price has higher benefits, so more productive firms will always want to add countries to their sourcing strategy to reduce costs through this mechanism.

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 the United States). 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 maintained in expectation. This is the case if we have fixed costs that are relationship specific but not relationship-firm specific.

Following Proposition 1, because of increasing differences, 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 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 theoretical appendix.

We exploit the insights of this proposition to employ the algorithm of Jia [2008], akin to Antràs et al. [2017]. This reduces the dimensionality of our problem by leveraging the expected hierarchical order of different countries. We initiate the process from the set comprising all countries, denoted as $\bar{\mathcal{I}}$, and 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 the point where $V_{ij}(\varphi, \bar{\gamma}, \tilde{\gamma}(\varphi)) = 1$ is reached. This procedure yields a 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 is 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 firm-level intermediate input purchases from country $i \in \mathcal{I}_j(\varphi)$. This is an ex-post decision for firms and will be a fraction $(\sigma-1)\mathcal{X}_{ij}(\varphi, \bar{\gamma}, \tilde{\gamma}(\varphi))$ of firm's ex-post profits, which gives:

$$M_{ij}(\varphi, \bar{\gamma}, \tilde{\gamma}(\varphi)) = (\sigma - 1)\ \eta^{\frac{\sigma-1}{\theta}}\ \varphi^{\sigma-1}\ (\Theta_j(\varphi, \bar{\gamma}, \tilde{\gamma}(\varphi)))^{\left(\frac{\sigma-1}{\theta}-1\right)}\ T_i(\tau_{ij}\bar{\gamma}_{ij}\tilde{\gamma}_{ij}(\varphi)w_i)^{-\theta}\ B_j(\bar{\gamma}), \tag{10}$$

with $M_{ij}(\varphi, \bar{\gamma}, \tilde{\gamma}(\varphi)) = 0$ if $i \notin \mathcal{I}_j(\varphi)$.

Equation (9) represents the gravity equation. For $(\sigma - 1) \geq \theta$, i.e. with complementarity in the sourcing decisions, and for a fixed market demand, $B_j(\bar{\gamma})$, firm-level intermediate input purchases from country $i \in \mathcal{I}_j(\varphi)$ are increasing in both the sourcing potential, $T_i(\tau_{ij}\bar{\gamma}_{ij}\tilde{\gamma}_{ij}(\varphi)w_i)^{-\theta}$, and the 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 the sourcing potential of country i not only contributes to firm-level intermediate input purchases, but also to the sourcing capability, increase the purchase from all other countries in the firm's sourcing strategy, $k \in \mathcal{I}_j(\varphi)$.

Moreover, both aggregate $\bar{\gamma}$ and idiosyncratic shocks $\tilde{\gamma}$ affect φ's firm intermediate input purchase decision through the sourcing capability and country i's sourcing potential. However, the market demand $B_j(\bar{\gamma})$ is not fixed. The realized aggregate shocks influence the market demand through the firms sourcing strategies and the equilibrium price index. Therefore, 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, through the change in the price index, a negative aggregate shock, $\bar{\gamma}_{ij} > 1$, implies an increase in the price for country i's good, and increase market demand. This second effect could offset the negative effect of the shock if i is the country where most firms are sourcing from.

3.3 Equilibrium

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

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

$$\int_{\tilde{\varphi}_j}^{\infty}\int_{\bar{\gamma}}\int_{\tilde{\gamma}(\varphi)}\left[\varphi^{\sigma-1}(\eta\Theta_j(\varphi, \bar{\gamma}, \tilde{\gamma}(\varphi)))^{\frac{\sigma-1}{\theta}}B_j(\bar{\gamma}) - w_j\sum_{i\in\mathcal{I}_j(\varphi)} f_{ij}\right]d\tilde{\Psi}^{\varphi}_{ij}(\tilde{\gamma})d\bar{\Psi}_{ij}(\bar{\gamma})dG_j(\varphi) = w_jf_{ej}, \tag{11}$$

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

Finally, we obtain the number of active firms in equilibrium $N_j[1 - G_j(\tilde{\varphi}_j)]$ by using equations (5), (6), (8), and (10), the fact that E_j is a share α of labor income [4] as well as Fubini's theorem. In our empirical strategy, we set the domestic fixed cost, f_{jj}, to zero[5] and all firms produce, since in our data we only observe firms that are producing.

Finally, the equilibrium price index is given by

$$\begin{aligned} P_j(\bar{\gamma}) &= \left(\int_{\omega \in \Omega_j} \int_{\tilde{\gamma}(\omega)} p_j(\omega, \bar{\gamma}, \tilde{\gamma}(\omega))^{1-\sigma} d\tilde{\Psi}_j^{\omega}(\tilde{\gamma}) d\omega \right)^{\frac{1}{1-\sigma}} \\ &= \left(\int_{\tilde{\varphi}_j}^{\infty} \int_{\tilde{\gamma}(\varphi)} \frac{\sigma \eta^{\frac{\sigma-1}{\theta}}}{(\sigma-1)\,\varphi} \, \Theta_j\big(\varphi, \bar{\gamma}, \tilde{\gamma}(\varphi)\big)^{\frac{\sigma-1}{\theta}} d\tilde{\Psi}_{ij}^{\varphi}(\tilde{\gamma}) dG_j(\varphi) \right)^{\frac{1}{1-\sigma}} \end{aligned} \tag{12}$$

where we see that idiosyncratic shocks $\tilde{\gamma}(\omega)$ do not affect the price index, but aggregate shocks $\bar{\gamma}(\omega)$ do.

4 Theoretical investigation – effects of uncertainty

To understand the influence of uncertainty on the sourcing decision, we study analytically and numerically how firms profit change with both aggregate and idiosyncratic supply chain risk. Through a theoretical decomposition, we see that mean-preserving spread shocks have ambiguous effects on firm sourcing.

4.1 Expected Profits' Decomposition

As firms choose sourcing to maximize profits, it becomes crucial to assess the influence of different factors affecting these decisions. 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 uncertainty on sourcing capability, (iii) expected market demand, (iv) covariance between sourcing capability and market demand, and (v) the fixed costs of sourcing. We first write the theoretical decomposition and then we explore the quantitative importance of each component through a numerical exercise.

$$\begin{aligned} \mathbb{E}\big[\pi_H(\varphi,\gamma)\big] = \varphi^{\sigma-1} \Big(&\underbrace{\Theta_H(\varphi, \mathbb{E}[\gamma])^{\frac{\sigma-1}{\theta}}}_{\substack{\text{Sourcing capability} \\ \text{for expected shock}}} + \underbrace{\mathbb{E}\big[\Theta_H(\varphi,\gamma)^{\frac{\sigma-1}{\theta}} - \Theta_H(\varphi, \mathbb{E}[\gamma])^{\frac{\sigma-1}{\theta}}\big]}_{\text{Effect of uncertainty on sourcing capability}} \Big) \times \underbrace{\mathbb{E}(B_H(\bar{\gamma}))}_{\substack{\text{Expected} \\ \text{market demand}}} \\ &+ \varphi^{\sigma-1} \underbrace{Cov(\Theta_H(\varphi,\gamma)^{\frac{\sigma-1}{\theta}}, B_H(\bar{\gamma}))}_{\substack{\text{Covariance btw sourcing capability} \\ \text{\& market demand}}} - \underbrace{w_j \sum_{i \in \mathcal{I}(\varphi)} f_{ij}}_{\text{Fixed cost of sourcing}} \end{aligned} \tag{13}$$

[4]We find $N_j = \alpha L_j / \sigma \left(\int_{\tilde{\varphi}_j}^{\infty} \int_{\tilde{\gamma}(\varphi)} \sum_{i \in \mathcal{I}_j(\varphi)} f_{ij} d\Psi_{ij}^{\varphi}(\tilde{\gamma}) dG_i(\varphi) + f_{ej} \right)$

[5]When the fixed cost of entry is non-zero, it results in a positive measure of firms choosing not to produce.

The first term, the sourcing capability for the expected shock $\Theta_H(\varphi, \mathbb{E}[\gamma])$, encapsulates the expected impact of incorporating an additional country into the set of sourcing options. Adding a country allows the firms to draw an additional variety that can have lower costs, given the fat-tail of the Fréchet distribution of productivity across varieties. This heightens the competition between countries and thereby reduces 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. This expected change in profit is at the heart of deterministic models of trade.

The second term, the risk effect on the sourcing capability, introduces a first effect of uncertainty, that we denote the "option value of trade risk". Given by the difference between the realized sourcing capability after a shock $\Theta_H(\varphi, \gamma)$ and the sourcing capability for the average shock $\Theta_H(\varphi, \mathbb{E}[\gamma])$, this term reflects the influence of the variance of trade cost shocks on the variance of the sourcing capability. Since a higher sourcing capability implies lower cost and higher revenues, it contributes to the overall expected profits. Indeed, firms prefer to add countries with high risk to their sourcing strategy for the chance to sell cheap if one of them is positively shocked, i.e. $\gamma < 1$. Because firms can ex-post adjust their intensive margin, they can increase the share they buy from the country that is positively shocked and then sell at a lower cost, even if the other countries are negatively shocked. Both the sourcing capability for the expected shock term and the option value term are then multiplied by the expected market demand $B_H(\bar{\gamma})$. Overall, firms have higher expected profits from higher variance of shocks, i.e. higher uncertainty.

Another impact comes from the covariance between the sourcing capability and the market demand, which we call the "hedging effect". 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 $\bar{\gamma}$ and idiosyncratic uncertainty $\tilde{\gamma}$, the market demand is affected solely by aggregate uncertainty $B_H(\bar{\gamma})$. This term exhibits a negative impact on profit: if a firm sources from a country from which all other firms source from, the firm's price correlates with the average price $P(\bar{\gamma})$. As a result, it reduces the demand for that particular firm if this country has a higher uncertainty. In this case, a negative covariance suggests that a firm would like to hedge and capture a higher market share by being able to offer a lower price compared to other firms.

Lastly, 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 costs of sourcing is the reason why firms do not just source from all countries. More productive firms, which have higher earnings, can source from more countries at the extensive margin.

4.2 Numerical Experiment with three countries

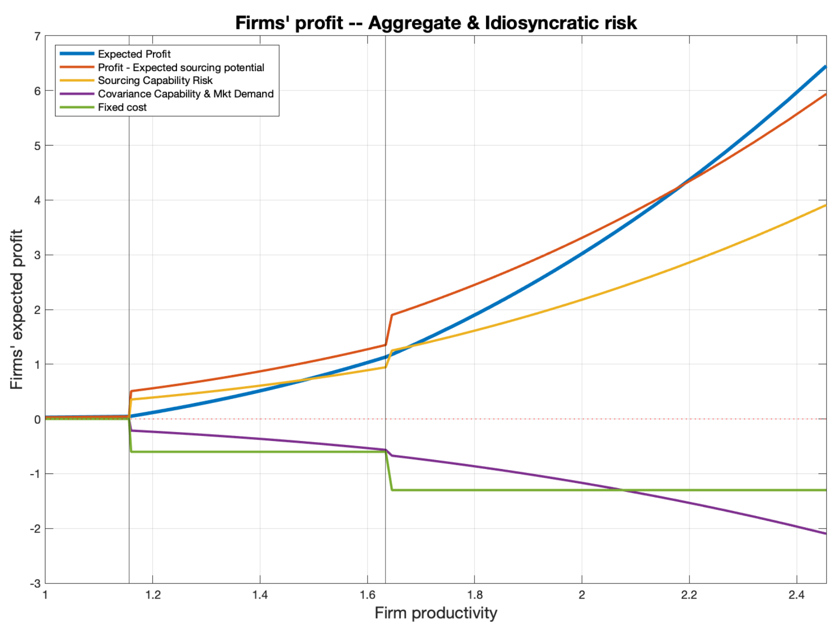
To understand the mechanisms at play in our model and the effect of uncertainty, we simulate an example with three countries: the domestic country and two foreign countries with different sourcing potentials.

We plot firms' expected profits across various productivity levels φ and their sourcing strategies. The numerical values are in Appendix B. We then decompose the contribution of each component of the above decomposition to the overall expected profits, discerning the different channels at play in the sourcing decisions. In Figure 14, we plot expected profits, as well as the differences between firms that source only from the domestic country, or from Home and Foreign 1, or from Home, Foreign 1, and Foreign 2.

Each term of the decomposition of expected profits is displayed with the respective distinct colors. The x-axis illustrates firms' productivity levels φ, while the y-axis denotes firms' expected profits $\mathbb{E}\big(\pi_H(\varphi, \bar{\gamma}, \tilde{\gamma})\big)$. The vertical lines show the cutoff productivity levels for different sourcing strategies in the case where there are both aggregate and idiosyncratic shocks. Firms to the left of the first vertical line source inputs solely from Home, while those between the first and second lines have sourcing relationships with both Home and Foreign 1, and those to the right of the second vertical line include Home, Foreign 1, and Foreign 2 in their sourcing strategy.

First, the blue line displays the firms' total expected profits, which accounts for all the different effects. Second, the red line indicates the effect on expected profits stemming from the sourcing capability for expected shocks, emphasizing the desire to add more countries to the sourcing strategy to reduce costs. Third, the "option value" effect, in yellow, shows how risk provides the ex-post option to source from cheaper countries if they experience positive shocks. This means that firms gain from buying from countries that have a higher variance because of the option of getting lower costs. Firms are willing to start a relationship with countries that have a higher variance because they can ex-post buy more from the countries that were positively affected by the shocks, and have the option to sell at a lower price. Instead, if countries are negatively affected, firms can ex-post change their inputs purchase.

Figure 3: Three countries - Profit decomposition



Fourth, the purple line represents the covariance term between the sourcing capability and market demand, the "hedging effect", which is negative due to the fact that expected profits decrease if the firm gets hit when every other firm also gets hit. Fifth, the green line illustrates the fixed cost of adding a country to the sourcing strategy, acting as a deterrent for adding more countries at the extensive margin as it reduces expected profits.

Figure 14 highlights that the primary driver of expected profits is the sourcing capability for expected shocks. Sourcing from more countries reduces overall costs through increased competition. Subsequently, uncertainty impacts 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. However, in terms of levels, the option value effect is more relevant for the expected profits than the hedging effect. This is driven by the uncertainty on sourcing capability, which makes firms want to increase diversification. However, the impact of risk is small compared to the expected sourcing potential.

We contrast the results for different types of uncertainty: (i) the baseline with both idiosyncratic and aggregate risk, (ii) a case with only aggregate risk, (iii) a case with only idiosyncratic risk, and (iv) a case without any risk. From the decomposition, we see how all the cases differ in their understanding of supply chain uncertainty. The second case with only aggregate risk features both the "option-value" effect – positive on profit – and the "hedging effect" which is negative. However, the option-value term changes quantitatively, being subject to one channel of risk, instead of two. The third case, with only idiosyncratic risk, only features the "option-value" effect due to firm-specific uncertainty, while the hedging term disappears. The case without risk maps our model to the framework of Antràs et al. [2017], balancing the cost margin on sourcing capability and the fixed cost of sourcing.

We now study how the risk affect the extensive margin on the firms decision to import, diversify or reshore input production. In Figure 4, we compare the share of firms sourcing from countries Foreign 1 and Foreign 2. By definition, all firms source from Home which has no fixed cost of sourcing. First, in the baseline case, 35% of firms source from Foreign 1, and 12% from both Foreign 1 and Foreign 2. This follows from the pecking-order logic discussed above.

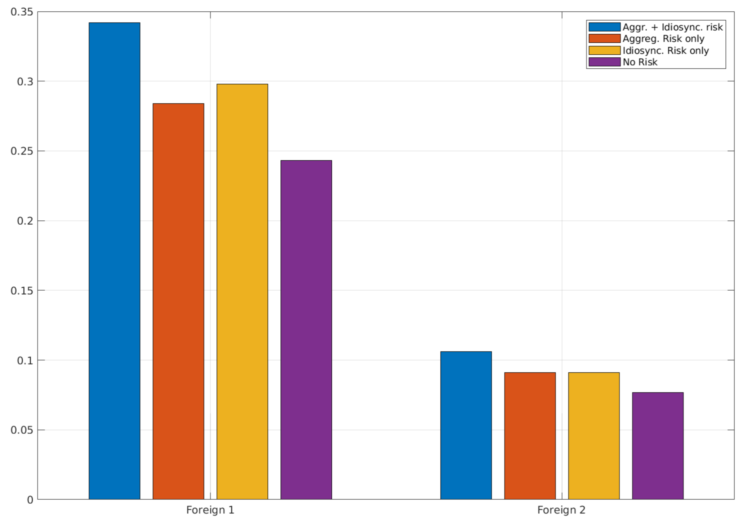
In the second case, with only aggregate risk, the option-value effect on sourcing capability is lower, but the hedging term is still negative. This reduction in profit from a lower uncertainty makes most firms reduce imports: very productive firms switch from two countries to one country, while smaller firms re-shore production instead of importing from Foreign 1. This second channel is stronger added to the fact that the hedging motive is still present lowering profits for firms importing from Foreign 1. As a result, there is a larger drop in the extensive margin for Foreign 1, reducing the number from 35% to 28%, while the number of firms sourcing from Foreign 2 only went from 11% to 9%.

In the third case, with only idiosyncratic risk, the hedging term disappears, making the Foreign country 1 more profitable. Indeed, without aggregate risk, the market demand and aggregate price are not stochastic. This makes the sourcing capability of Foreign 1 uncorrelated with the aggregate price level, resulting in its increased profitability. More firms source from Foreign 1 than in the aggregate risk only case, 30% compared to 28%, while the number of firms sourcing from country 1 is the same.

Finally, without risk, only the marginal-cost vs. fixed-cost trade-off is at play. There is no option value of risk, and less firms source from foreign countries – 25% from Foreign 1, and 7.5% from both.

We run comparative statics to understand how expected profits and sourcing strategies for different types of uncertainty are affected by different levels of complementarity. The lower the level of complemen-

Figure 4: Firms' sourcing strategies and extensive margin



tarity, the higher the effect of uncertainty. Moreover, complementarity creates a motive for diversification, reinforcing the willingness of firms to source from Foreign 1.

We also compare models with different levels of risk. Leveraging the ex-ante profits equation we show that, everything else equal, firms get higher expected profits from higher idiosyncratic uncertainty. It increases the option value effect, giving a higher chance of reducing costs. However, the numerical experiments also demonstrates that firms with varying levels of productivity respond distinctively to different types of uncertainty. Ceteris paribus, higher productivity firms gain more from adding countries with higher idiosyncratic uncertainty to their sourcing strategy than less productive firms. This occurs because higher productivity firms gain more from "better" countries, for a given number of countries in their sourcing strategy, than low productivity firms. This is the case because revenues are multiplied by the productivity of the firm $\varphi^{\sigma-1}$.

Finally, for the case of aggregate uncertainty, or both aggregate and idiosyncratic uncertainty together, the results are ambiguous. A higher aggregate shock variance 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 sources from reduces expected profits through the hedging effect, since it increases the market demand for 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 sourcing decisions are more affected by the option value effect. However, if the option value effect is bigger than the hedging effect, then the effect is similar to the idiosyncratic case. If not, then the overall effect is uncertain.

5 Data

5.1 Description

We utilize administrative data from the Chilean Customs office, which has product-origin-firm level information about all import transactions. The products are classified using the Harmonized System (HS) at the 6-digit level (HS6). Additionally, we use VAT records from the Chilean Internal Revenue Service (SII, in Spanish), which provide information on sales and materials purchases. Finally, we have access to employer-employee data from the Unemployment Fund Administrator (AFC, in Spanish), institution that manages the contributions that every worker must make to her own unemployment insurance fund. With this last database, we are able to extract information over employment and wage bills of firms belonging to the formal private sector.

We cover the Mining, Manufacturing, and Trade sectors. These sectors' imports represent approximately 80% of the total import value in Chile. Our sample spans the 2012-2023 period at a quarterly frequency. We drop firms with negative or zero sales or with less than 5 employees. 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. Our dataset includes approximately 50 countries each quarter, including Chile, and around 24% of firms are importers.

We also construct an auxiliary dataset on yearly country characteristics, spanning the years 2012 to 2019, that combines information from CEPII and the World Bank's Worldwide Governance Indicators. This dataset provides information on origin country-specific attributes, such as distance, language, and corruption enforcement.

5.2 Descriptive Evidence

Since in our model firms source multiple products from multiple countries, we show here that this is the case for our dataset too. We define a product as a distinct HS6 code. We find that, for the 2012q1-2023q4 period, firms import approximately 9 distinct products from 2 countries on average. The median number of imported products is around 2, while the 95^{th} percentile is around 33. The median number of countries from which firms import from is approximately 1, while the 95^{th} percentile is around 6 countries. [6]

Table 1: Descriptive statistics

Date	nb of firms	employment	wage bill	imports	inputs	sales	domestic	imp 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.

[6] In the data appendix, Table 7, we show that the extensive and intensive margins of sourcing generate different orderings for origin countries in our dataset. For example, Spain is 4^{th} for the number of importing Chilean firms but 12^{th} for the value of imports.

Table 1 shows that the number of firms in our data increases with time, starting with an average of 35,742 firms between 2012q1 and 2015q4, to an average of 43,819 firms between 2020q1 and 2023q4. This situation also holds for the number of employees, the value of imports, the value of inputs, the value of sales, and the value of domestic input purchases.

We also check if our dataset follows a sourcing pecking order. This is done by counting the number of firms that import from the number one destination only (in our case, China), then the number of firms that import from the number one and number two destinations only (in our case, China and the U.S.), and we keep going until we have the ordering for the first top ten importing origins. 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 compare those results with those obtained from assuming that firms select their suppliers randomly. This is done by using the share of importers from origin country i as the probability that any firm will source from i. 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 stronger pecking order than the one that would be generated by assuming randomness in sourcing. However, as the percentage of the data following a pecking order is still around just one third, there might be firm-relationship-specific costs of sourcing, and not just relationship-specific.

Table 2: Pecking Order

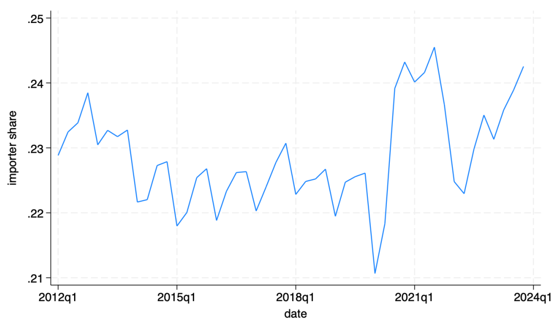
String of countries	Data		Random Entry	
	Firms	% of Importers	Firms	% of Importers
CHN	7,970	23.68	1,865	5.54
CHN-USA	2,201	6.54	2,034	6.04
CHN-USA-RoW	348	1.03	664	1.97
CHN-USA-RoW-ESP	75	0.22	209	0.63
CHN-USA-RoW-ESP-DEU	58	0.17	60	0.18
CHN-USA-RoW-ESP-DEU-ITA	98	0.29	17	0.05
CHN-USA-RoW-ESP-DEU-ITA-BRA	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.

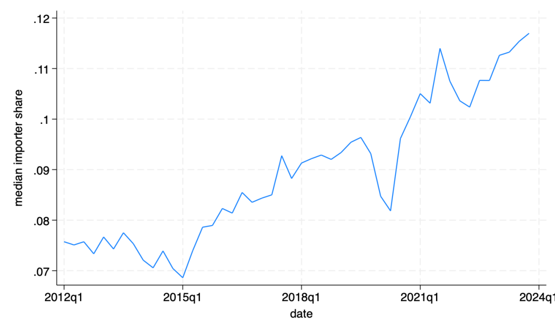
We then obtain the share of importers among all firms and among firms with sales below the median, since we will use these for our empirical strategy. From Figure 5, we observe that the share of importers among all firms have been slowly trending downwards in time, but starts trending upwards after 2020. We also see an upward trend in the share of importers among firms sales below the median. In both cases, we observe that the share of importers is not constant over time. The average share of importers among all firms from 2012q1 to 2019q4 is 0.2264, while the average share of importers among firms with sales below the median is 0.0819.

Figure 5: Share of importers

(a) Share of importers for all firms



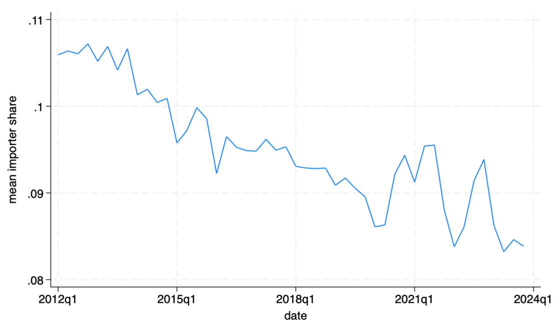
(b) Share of importers w/firm sales below median



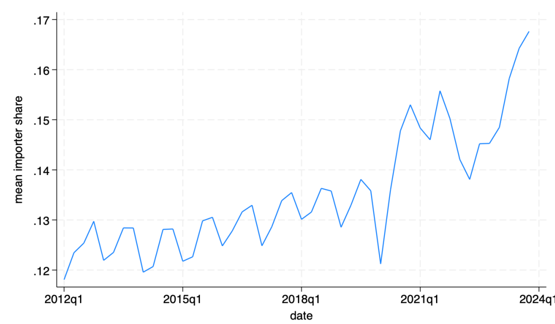
Finally, we plot the share of importers by country of origin. We show the U.S. and China because they are the top sourcing countries for Chile. From Figure 6 we learn that while the share of importers from the U.S. seem to be going downwards, the share of importers from China is trending upwards, which suggests that firms are replacing one country for the other. The average share of importers from the U.S. in the 2012q1-2023q4 period is 0.098, while for China is 0.128.

Figure 6: Share of importers by country of origin

(a) USA



(b) China



6 Structural Analysis

Given the static nature of our model, we decide to use the panel data available to us by leveraging averages over specific periods. For step 3 of our structural estimation, we focus on the first quarter of 2012 to the fourth quarter of 2019. This time frame, 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 2012 to 2023. This approach facilitates a comprehensive understanding of supply chain dynamics by encompassing the pre- and post-Covid-19 periods, during which significant supply chain uncertainty was prevalent.

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

We do not estimate the parameters for the demand elasticity, θ, and for the dispersion of productivities in input production, σ. Instead, we take their values from the literature. Following Antràs et al. [2017], we set σ to be equal to 3.85 and θ to be equal to 1.789. This implies a value of 1.583 for $(\sigma - 1)/\theta$, which is higher than 1, indicating the presence of complementarity between countries in our model, which allows the use of Jia [2008]'s algorithm.

6.1 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 average sourcing potential of country i from the point of view of country j, we normalize equation (3) by the domestic sourcing strategy and then take the logarithm of this normalized equation. Since we are interested in the sourcing potential of country i for country j, we set the domestic sourcing potential equal to one and assume no domestic aggregate and idiosyncratic supply chain uncertainty. 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. In our case we only have one domestic country, Chile, so the destination country j will be fixed and we can get rid of j on the right-hand side of the equation. Then,

$$\log \mathcal{X}_{ij}^n - \log \mathcal{X}_{jj}^n = \log \bar{\xi}_i + \log \epsilon_i^n \tag{14}$$

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, which reduces the number of countries to 50.

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 we take the difference between the share of intermediate input purchases from country i and country j, the sourcing capability term, which is affected by the ex-ante decision on the sourcing strategy, is not relevant in our regression. Then, because our model timeline states that firms learn their firm-country-specific shocks after they choose their sourcing strategy, there is no selection of firms based on the errors. Alternatively, we could also treat ϵ_i^n as a measurement error, in which case we assume that we accurately observe the set of countries from which firms source from and they have positive imports for all the countries in their sourcing strategy.

To estimate equation (14), 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 structural analysis.

In the estimation appendix, Figure 17, we see that China has the highest sourcing potential for firms in Chile, 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 learn also from Table 7 in the estimation appendix, more firms are sourcing from the rest of the world than Brazil and more firms are sourcing from Spain than Paraguay, even though their average sourcing strategies are higher. This implies that the cost of sourcing from Spain might be lower than the cost of sourcing from Paraguay, for example.

6.2 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 do this, we assume that any change in time is produced by supply chain shocks, which is a strong assumption. However, we are not making assumptions on what the mechanisms behind this supply chain uncertainty are, we model it as anything that affects the cost of importing. As seen in recent events, supply chain uncertainty can occur because of labor supply issues, which affects wages, as well as changes in the prices of fuels, which affect iceberg costs, or could even be caused by natural disasters, like the Japanese Earthquake, which was a shock to productivity. Then, we have to be careful with the interpretation we give to the parameters in each of these different scenarios since, for example, technology is not affected by the heterogeneity of inputs, i.e. the parameter θ. Considering this, we can write

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

Then, we can decompose the time-dependent sourcing potential of country i into a origin-specific term, $\xi_{it} = T_i(\tau_{ij}\bar{\gamma}_{ij,t}w_i)^{-\theta}$, and a firm-origin specific term, $\epsilon_{i,t}^n = (\gamma_{ij,t}^n)^{-\theta}$.

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:

$$(\log \mathcal{X}_{ij,t}^n - \log \mathcal{X}_{jj,t}^n) - (\log \mathcal{X}_{ij,t-4}^n - \log \mathcal{X}_{jj,t-4}^n) = \log \xi_{i,t-(t-4)} + \log \epsilon_{i,t-(t-4)}^n \tag{15}$$

where, using our model implied relationship and our assumption that only the shocks change in time, we have that $\log \xi_{i,t-(t-4)} = -\theta \log(\bar{\gamma}_{i,t}/\bar{\gamma}_{i,t-4})$ and $\log \epsilon_{i,t-(t-4)} = -\theta \log(\tilde{\gamma}_{i,t}^n/\tilde{\gamma}_{i,t-4}^n)$. We take the difference between t and $t-4$ because we compare the same quarter in different years to control for seasonality and take 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 the firm imports from.

For this strategy to be consistent, we again exploit the timeline of our model which states that firms learn their supply chain shocks after their sourcing strategies have been decided. We also assume that shocks are multiplicative, exponential and independent in time and with respect to home. These assumptions give us independence between the independent variables and the errors.

This regression allows us to obtain the average value of $-\theta \log(\widehat{\bar{\gamma}_{ij,t}/\bar{\gamma}_{ij,t-4}})$, as well as $-\theta \log(\widehat{\tilde{\gamma}^{n}_{ij,t}/\tilde{\gamma}^{n}_{ij,t-4}})$. So, to recover the distribution of $\hat{\bar{\gamma}}_{ij,t}$ and $\hat{\tilde{\gamma}}^{n}_{ij,t}$, we divide by $-\theta$ and take the exponential to obtain the estimated value of $\widehat{\bar{\gamma}_{ij,t}/\bar{\gamma}_{ij,t-4}}$ and $\widehat{\tilde{\gamma}^{n}_{ij,t}/\tilde{\gamma}^{n}_{ij,t-4}}$.

To be able to recover the aggregate and idiosyncratic shocks from this, we need to make some assumptions on the trend and initial values, so we assume that shocks follow a random walk. We then set initial values, assuming that for every country, the initial value for a firm-, or country-, level shock is 1, indicating no shock during the first quarter in which we observe a value for that firm-country pair. 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.

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

Following the approach from Antràs et al. [2017], we estimate the fixed costs of sourcing using the simulated method of moments (SMM). The estimation process involves simulating production and sourcing decisions of firms. We generate simulated moments from the endogenous values of the model, from which we obtain moments when averaged across all firms. By comparing the simulated moments with the real data, we determine the parameter values that minimize the difference between the two sets of moments. 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 origin-specific fixed costs. Instead, we introduce firm-origin-specific fixed costs of sourcing, f^{n}_{ij}, with the index n representing the firm. We assume that these fixed costs follow a log-normal distribution with scale parameters $\log \beta^{f}_{c} + \beta^{f}_{d} \log \text{distance}_{ij} + \log \beta^{f}_{l} \text{language}_{ij} + \beta^{f}_{C} \text{control of corruption}_{i}$ and a dispersion parameter β^{f}_{disp}. As active firms must use domestic inputs, we set the fixed cost of sourcing from home to be zero, so $f^{n}_{jj} = 0$. For the rest of the world, we take the average values using population weight.

Due to the computational challenges associated with solving the firm's problem for a large number of countries, we rely on Proposition 2 and 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.

Next, following Jia [2008] and Antràs et al. [2017], we explain the algorithm for our model. Given a core productivity φ, a guess $\mathcal{I}$ for the firm n'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

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

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.

However, adding uncertainty to this procedure is computationally intensive. Indeed, computing the model equilibrium at every step of the Simulated Method of Moments requires (i) drawing a large number of I-dimensional shocks $\bar{\gamma}$ and $\tilde{\gamma}(\varphi)$ to compute expectation of sales and profits using Quasi Monte Carlo methods, (ii) simulating a large number of fixed-cost draws f_{ij}^n also using Quasi Monte Carlo methods, (iii) solving the firms' sourcing decisions using combinatorial discrete choice algorithm following Jia [2008], and (iv) solving for the fixed-point equilibrium for $B(\bar{\gamma})$, since the price index aggregates the individual pricing decisions:

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

and finally (v) repeat these four steps for every iteration of the parameters β.

Since steps (i) and (iii) are particularly slow, we simulate the problem with certainty-equivalence, computing the profit of expected shocks $\mathbb{E}[\bar{\gamma}]$ and $\mathbb{E}[\tilde{\gamma}(\varphi)]$. We then check that our results are not far from the expected case. This causes an upward bias in the estimation of the fixed-costs. However, our estimation with risk does not imply sourcing shares that are significantly different from the data.

To estimate the structural model, we adopt distributional assumptions for the model parameters. Following the approach of Antràs et al. [2017] and Melitz and Redding [2015], we assume that the productivity φ follows a Pareto distribution with a shape parameter $\kappa = 4.25$. For the estimation of the remaining parameters $\delta = [E, \beta_{c,f}^n, \beta_{d,f}^n, \beta_{l,f}^n, \beta_{C,f}^n, \beta_{\text{disp},f}^n]$, we simulate a large number of firms. We draw φ from a uniform distribution and invert 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-verify process, iteratively adjusting the values to match the log-normal firm-origin specific fixed costs obtained from the simulation. Therefore, we consider a continuum of final-good firms, each characterized by different combinations of productivity levels φ^n, fixed costs f_{ij}^n, aggregate and idiosyncratic supply chain shocks $\bar{\gamma}_{ij}, \tilde{\gamma}_{ij}^n$.

We simulate firms to generate four sets of moments that compare with the actual data. These moments are crucial to estimate the structural model's parameters. The four sets of moments are as follows:

i. The first moment is the share of importers for all firms. This is a scalar. We denote the data counterpart as m_1 and simulated moment as $\hat{m}_1(\delta)$.

ii. The second one is the share of importers with firm sales below the median. This is also a scalar, denoted m_2 for the actual data and $\hat{m}_2(\delta)$ for the simulated data.

iii. The third set of moments includes the shares of firms that import from each country. This is an $(I-1)$ vector, and the actual data is denoted as m_3 and the simulated data as $\hat{m}_3(\delta)$.

iv. The fourth moment is 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, denoted m_4 in the data and $\hat{m}_4(\delta)$ in the simulated model.

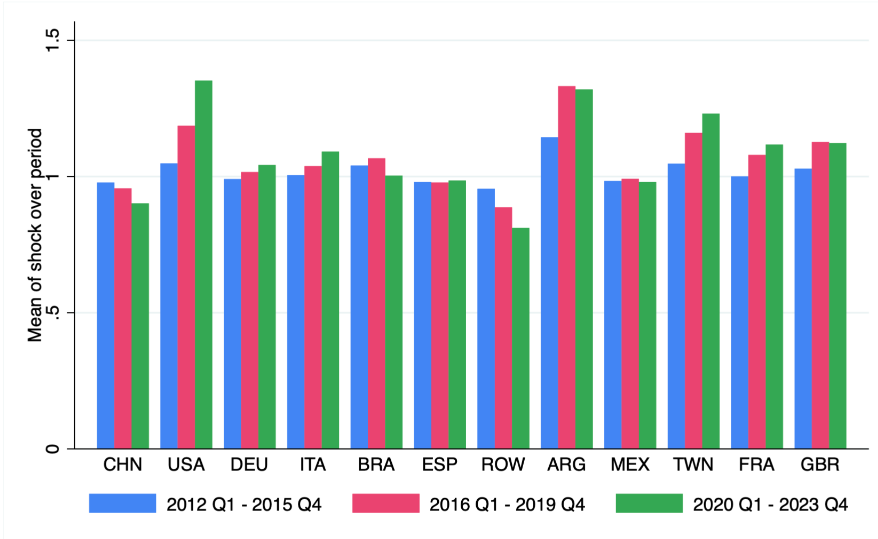
The first three sets of moments inform us about the magnitude of the fixed costs of sourcing, and how they vary with distance, language, and control of corruption. The share of importing firms from the most popular country relative to the total share of importers serves as an indicator of the fixed cost 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 insight into the dispersion parameter. The fourth moment helps determine the level of input purchases as it determines the scale parameter E.

6.4 Results

Next, we show the results obtained from our structural analysis. In the estimation appendix, Figure 17 and 18 we plot the country sourcing potential, obtained from step 1 of our structural analysis, against the extensive and intensive margins. 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 probably differ across countries, which supports the assumption we make in our model.

Next, we plot our estimates for the mean of the aggregate shocks, their standard deviation, and the idiosyncratic standard deviation. We plot these values for 12 countries, which represent 68% of the total value of imports. Since our model is computationally intensive, we obtain the firm-origin-level fixed costs with the gravity relation, except for China, the United States, and the Rest of the world region, which we estimate separately to improve the fit of the model. We then use these 12 countries to obtain our counterfactual and study the Covid-19 crisis. In the estimation appendix, we plot the average aggregate shock and uncertainty, as well as the average idiosyncratic standard deviation for all our available countries.

Figure 7: Mean aggregate shock $\mathbb{E}(\bar{\gamma}_j)$ for different periods



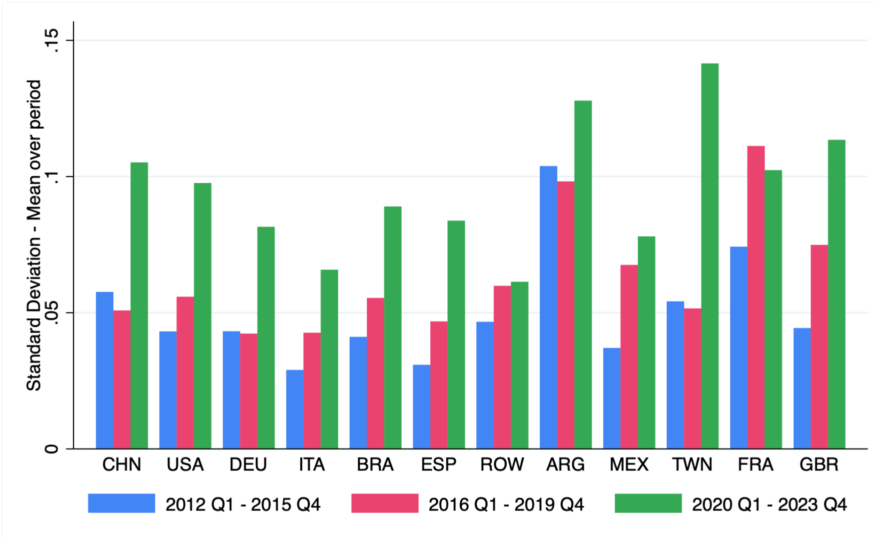
Notes: Figure constructed using the fixed effects from equation (15), dividing by $-\theta$, taking exponential, using a linear assumption, and setting 1 as the initial value, to obtain the aggregate shocks by country. We show the top-12 countries sorted by their importing share.

In Figure 7, we plot the mean aggregate shock for the top-12 importing countries, sorted by importing share, for different time periods. Most countries had a lower average aggregate shock for the period 2012q1-2015q4, which has increased for the period 2016q1-2019q4 and 2020q1-2023q4. Notable exceptions are China and Brazil, whose shocks decreased for the 2020q1-2023q4 period, and Mexico, whose average aggregate shocks have been relatively constant over different periods. Argentina, Taiwan, and the US have the highest average aggregate shocks compared to other countries, and the change made it even higher during Covid-19. Surprisingly, the aggregate shock for China has the strongest decline compared to other countries during Covid-19, while the US has the highest proportional increase in trade costs during the 2020 to 2023 period.

In Figure 8, we show the average standard deviation of aggregate shocks for the top-12 importing countries, i.e the change in aggregate variance. Overall, most countries have a lower level of uncertainty for the period 2012q1-2015q4 and 2016q1-2019q4 compared to 2020q1-2023q4. The average variance of aggregate shocks goes from around 3% for the period of lowest uncertainty for countries like Italy or Spain, to up to almost 15% after Covid-19 for countries like Taiwan, the USA, and Argentina. Again, Taiwan and Argentina have the highest average standard deviation for aggregate shocks. The United States and China, instead, have a relatively low risk of aggregate shocks initially, but it increases strongly when considering the period 2020q1-2023q4. From both Figure 7 and Figure 8, we learn that, even though for some countries the average aggregate shocks are stable over time, the standard deviation is not, as underlying the aftermath of the Covid crisis and the subsequent supply-chains disruptions.

In Figure 9, we show the standard deviation across time from 2012 to 2023 for each firm-origin idiosyncratic shock for the top-12 countries. Since we compute the idiosyncratic risk for every firm and every

Figure 8: Average standard deviation for aggregate shocks, top-12 countries



Notes: Figure constructed using the fixed effects obtained from equation (15), dividing by $-\theta$, taking exponential, using a linear assumption, and 1 as initial value. We then get the standard deviation over time for these shocks. We sort the top-12 countries by their importing share.

country, we show the median – over firm – standard deviation of that shock. Overall the idiosyncratic average is 0.6, which is roughly one order of magnitude higher than aggregate uncertainty – around $0.05 - 0.1$: there is greater volatility at the firm level than at the origin level. Moreover, there are trends over time of that idiosyncratic risk, which indicates that the post-2020 supply chain disruptions are driven mainly by changes in aggregate conditions and not firms-specific relationship with importers. For that reason, we set the idiosyncratic risk to be constant at the average level 2012-2023 in the counterfactual analysis. For disclosure purposes, this is the lowest level of aggregation that we are able to show for the idiosyncratic shocks. In future work, we perform comparative statics with the level of idiosyncratic risk.

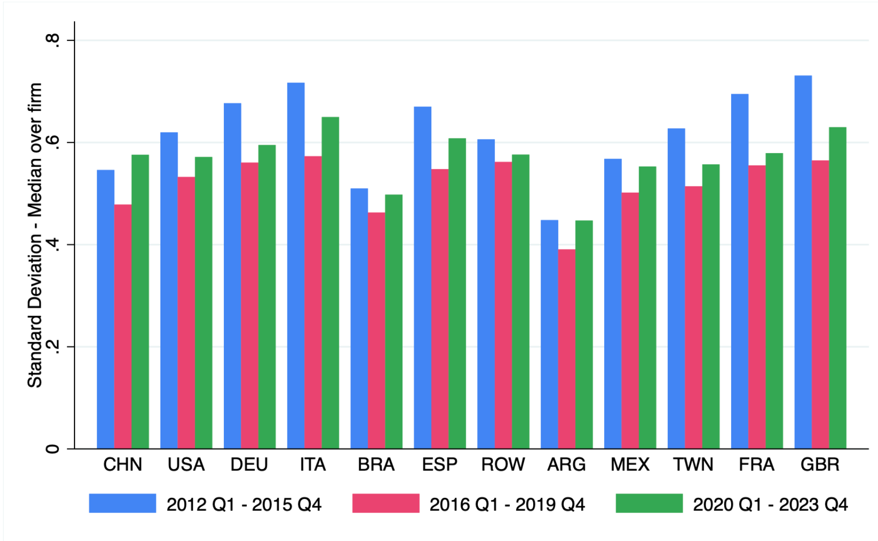
We use the simulated method of moments (SMM) to obtain our firm-level fixed costs, estimating the model without uncertainty for 13 countries, including Chile. The estimated parameters allow us to then simulate the model with stochastic trade costs, using the estimated mean and standard deviation of our log-normal distribution, as well as the separate average fixed costs for China, USA, and RoW. We need these estimates because we are assuming that the firm-level fixed costs follow a log-normal $f_{ij}^n \sim \log \beta_c^f + \beta_d^f \log \text{distance}_{ij} + \log \beta_l^f \text{language}_{ij} + \beta_C^f \text{control of corruption}_i, \beta_{\text{disp}}^f$.

Table 3: Estimated parameters

E	f_{CHN}	f_{USA}	f_{ROW}	β_c^f	β_d^f	β_l^f	β_C^f	β_{disp}^f
222.42	19.258	7.635	2.624	1.272	0.255	1.093	-0.368	0.691

In Table 3, we show the average estimated values for the fixed cost for China, the US, and the Rest of the world region. These are in thousands of USDs, which means that the estimated average fixed cost for China is 19,258 USD, while for the United States, it is 7,635 USD, and for the rest of the world, it is

Figure 9: Standard deviation for idiosyncratic shock - Median over firms



Notes: Figure constructed using the value of the residuals ϵ_j^n from equation (14), dividing by $-\theta$, taking exponential, using a linear assumption, and setting 1 as the initial value. We then take the standard deviation across time for each firm-origin and then take the median firm. We sort top 12 countries by their importing share.

2,624 USD. We also learn that the fixed costs of sourcing increase with a common language by around 8.9 percent, increase with distance with an elasticity of 0.255, and decrease with corruption with an elasticity of 0.368 percent.

Figure 10: Estimated sourcing potential and median fixed cost by country

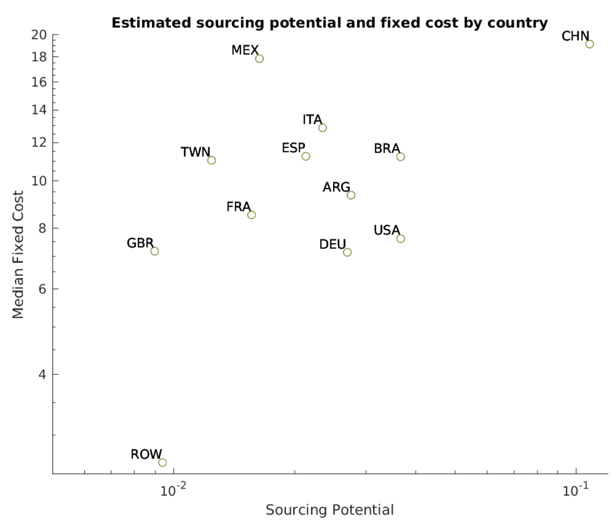


Figure 10 shows the estimated median fixed cost and sourcing potential. We observe that China has both one of the highest sourcing potentials as well as the highest fixed cost, while Mexico has a smaller sourcing potential but a median fixed cost as high as China's. Something similar arises with the United States, which has a high sourcing potential, and Italy, which has a smaller sourcing potential but a higher median fixed cost. These results are helpful in making sense of the difference found between countries' extensive and intensive margins. They also show that heterogeneous fixed costs across countries are relevant to matching the model to the data.

6.5 Fit of the model

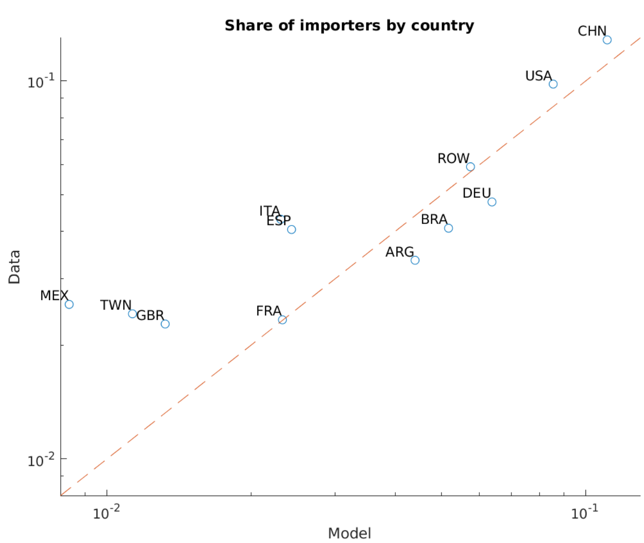
We now show how our model fits the data. From Table 4 we learn that for the case of the second moment, i.e., the share of importers with sales below the median, the model fits the data reasonably well. There is only a 3% difference between the data and the model. Something similar occurs for the case of the fourth moment, which is the median firm's input purchases from Chile, where the difference is bigger than for the second moment, but it is less than 10%. However, the model could do a better job at matching the first moment, i.e., the share of importers. For the third moment, we plot the difference between the data and the model-implied share of importers by country.

Table 4: Fit of the model

Moments	Data	Model
Share of importers	0.226	0.1959
Share imp. w/sales below median	0.082	0.0848
Median input purchases	124.430	112.56

From Figure 11, we observe that some countries' share of importers, like the case of China, the United States, France, Argentina, Brazil, Germany, and the rest of the world, are well fitted with our model. However, for some other countries, like Mexico, Taiwan, the United Kingdom, Italy, and Spain, we could improve the fit. However, overall, the fit of the model is reasonable for the number of countries we are evaluating.

Figure 11: Model fit: share of importers by country



7 Counterfactual – Covid-19 Supply Chain Uncertainty

We now proceed to evaluate the effect of changes in uncertainty and how it affects firms' sourcing decisions at the extensive and intensive margin. We focus on the variation of risk that occurred after the Covid-19 crisis, 2020-2023, compared to the uncertainty levels from 2012 to 2019. As shown in Figure 8, it provides large shocks to supply chain uncertainty and allows us to compare with the predictions of our model. These shocks also differ across countries, giving us some variation in our counterfactual and helps us to understand the different channels of transmission of aggregate uncertainty.

7.1 Changes in the mean and variance of aggregate shocks.

In our counterfactual, we put emphasis on the change in the distribution of aggregate supply chain disruption shocks $\bar{\Psi}_{ij}(\bar{\gamma})$. In particular, we are interested in changes in the mean $\mathbb{E}(\bar{\gamma})$, as in Figure 8, as well as the change in variance $\sigma(\bar{\gamma})$, as in Figure 9. We investigate how the change in either the mean or the variance changes sourcing decisions and expected profits through cost reduction, the option value, and the hedging effect, so we maintain the average idiosyncratic uncertainty from 2012 to 2023 constant.

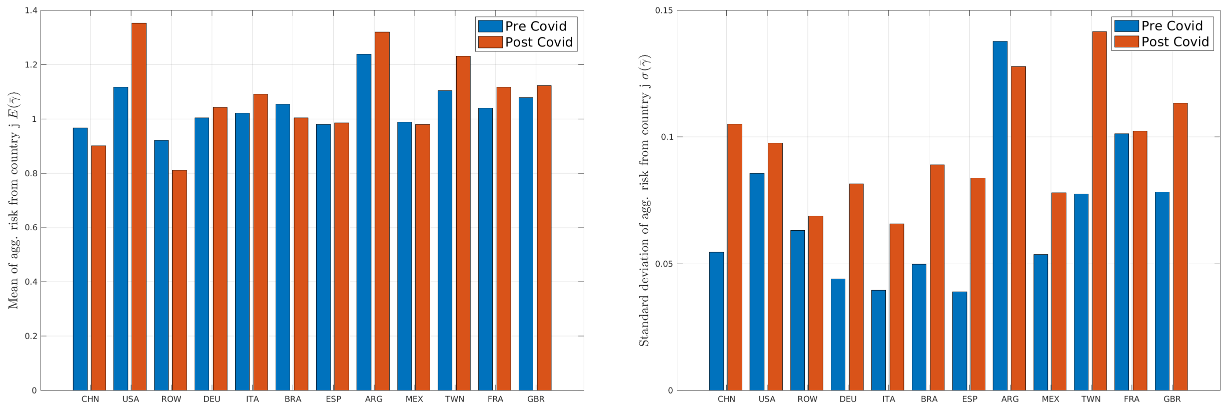
Our baseline specification uses the estimated parameters and the average values of $\mathbb{E}(\bar{\gamma})$ and $\sigma(\bar{\gamma})$ for aggregate shocks for the period starting the first quarter of 2012 up to the fourth quarter of 2019. To obtain our counterfactual, we apply our model with the change in mean $\mathbb{E}(\bar{\gamma})$, the change in variance $\sigma(\bar{\gamma})$ to the mean values for the period 2020 Q1 - 2023 Q4 instead. We hold all exogenous variables constant and solve for the price indices in every state of the world $P(\bar{\gamma})$ and the mass of entering firms. For our counterfactual, we do not take a stance on what is producing the change in the distribution of aggregate shocks for each country and just focus on the effect of this change in the mean and variance of the supply chain disruptions on sourcing. We observe those changes in Figure 12.

First, in Figure 12a, we see that China, Mexico, and the Rest of the world region all have a decline in cost where $\mathbb{E}[\bar{\gamma}]$ is lower after 2020. All the other countries show an increase in costs, in particular in the United States, Argentina and Taiwan, which were already the most costly sourcing countries. Second, in Figure 12b, the standard deviation $\sigma(\bar{\gamma})$ and hence the risk of trade disruption increases for all countries except Argentina post-Covid-19. However, there is a lot of heterogeneity in the change of mean and uncertainty for the period 2020-2023 compared to 2012-2019. While countries like China, Germany, Italy, Spain, Mexico, and Great Britain highly increased their aggregate risk, countries like the United States, the Rest of the world, and France did not had a significant increase in aggregate uncertainty.

We compute three moments to understand the sourcing strategies of firms. First, we show the change in the number of firms sourcing – i.e. choosing to establish a relationship – with different countries, and display these changes in Figure 13. We plot the share of importers, denoted by the variable λ_{ij}, which is the share of firms in j that import from origin i, pre- and post-Covid-19. We also compute the share of importers from *any* country abroad λ_j.

$$\lambda_{ij} = \int_{\varphi} \mathbb{1}_{ij}(\varphi) dG(\varphi) = \int_{\varphi} \mathbb{1}\{i \in \mathcal{I}_j(\varphi)\}\ dG(\varphi) \qquad\qquad \lambda_j = \int_{\varphi} \mathbb{1}\{\cup_i\ (i \in \mathcal{I}_j(\varphi))\} dG(\varphi)$$

Figure 12: Change in the mean and standard deviation of aggregate shock



(a) Change in $\mathbb{E}(\bar{\gamma}_{ij})$

(b) Change in $\sigma(\bar{\gamma}_{ij})$

Second, we are interested in the number of countries firms source from, conditional on importing. We denote that $\mathcal{N}_j(\varphi)$ for firm with productivity φ and $\mathcal{N}_j$ across firms:

$$\begin{aligned}\mathcal{N}_j &= \mathbb{E}\big[\#\mathcal{I}_j(\varphi) \,\big|\, \#\mathcal{I}_j(\varphi) > 0\big] \\ &= \int_{\varphi} \mathbb{1}\{\#\mathcal{I}_j(\varphi) > 0\}\#\mathcal{I}_j(\varphi) dG(\varphi) \Big/ \int_{\varphi} \mathbb{1}\{\#\mathcal{I}_j(\varphi) > 0\} dG(\varphi) \ ,\end{aligned}$$

where $\mathcal{I}_j(\varphi)$ is the sourcing set for firm φ and $\#\mathcal{I}$ is its cardinal, i.e. the number of elements in that set.

Finally, we explore the extent of the concentration and diversification of imports across sources. We measure it with the Herfindahl–Hirschman index which summarizes the concentration of import shares and is defined as:

$$HHI_j = \mathbb{E}_{\bar{\gamma},\tilde{\gamma}}\Big[\int_{\varphi} \sum_{i \in \mathcal{I}_j(\varphi)} \chi_{ij}\big(\varphi, \bar{\gamma}, \tilde{\gamma}(\varphi)\big)^2 dG(\varphi)\Big] \ .$$

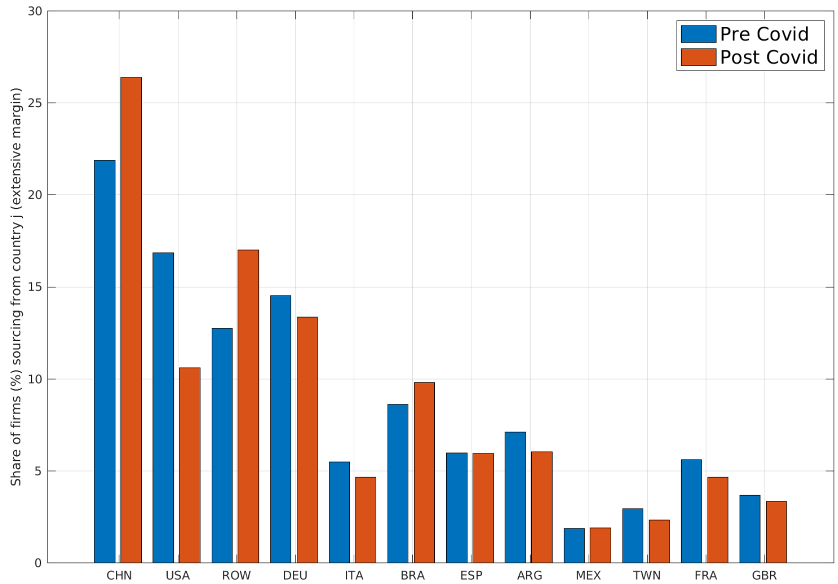
This index is measured ex-ante given expectation of future shocks γ. Since this index is ultimately a sum of square, the higher and closer to 1 this index is, the more the imports are concentrated in few import sources, and conversely the lower bound $HHI_j \to (1/I)$ implies that firms import exactly $1/I$ from each sources, perfectly diversifying across sourcing countries.

7.2 The effects of Covid on firm sourcing

We simulate our model economy for the cases with pre-Covid uncertainty as in 2012-2019, and post-Covid as in 2020-2023. The value of idiosyncratic uncertainty and all other parameters from 2012 to 2023 remains unchanged. We are interested in understanding how firms' extensive and intensive margin decisions were affected by this change in the distribution.

First, the share of importing firms by country increased with the change in uncertainty. As indicated in table 5, in the first two rows, the change in risk increases from 35.6% to 37.2% the number of firms that

Figure 13: Share of importing firms by country



decide to source from abroad. Figure 13 provides an explanation: more firms source from China, and from Brazil and the Rest of the world to a lesser extent, due to the change in the distribution of costs. Post-Covid 27% of firms source from China, compared to around 23% before the Covid-19 crisis. This is mainly due to a decline in the average costs from China as we will see below. However, we see a decline in the extensive margin for countries where very few Chilean firms import, such as Taiwan, Great Britain, Italy, or France. This implies a reallocation that is summarized by the number of sourcing conditional on importing: before the Covid-19, importing firms were importing from 2.93 countries, while it is down to 2.89 after the Covid crisis. Lastly, these two effects imply that overall firms diversify more their sourcing with heightened risk: the HHI is lower which indicated that imports quantities are more spread across inputs sources. This is both due to additional firms sourcing from abroad and selecting into importing and the reallocation effect across sources due to the change in costs.

Table 5: Sourcing decisions – summary statistics

	Share of importing firms λ_j	Number of countries (cond. on importing) $\mathcal{N}_j$	Average HHI_j
Average Pre Covid, 2012-2019	35.59%	2.93	0.9061
Average Post Covid, 2020-2023	37.18%	2.89	0.8987
Post Covid, change in $\mathbb{E}(\bar{\gamma})$ only	36.72%	2.88	0.9013
Post Covid, change in $\sigma(\bar{\gamma})$ only	36.73%	2.99	0.9020
No risk $\sigma(\bar{\gamma}) = 0$	18.41%	2.03	0.966

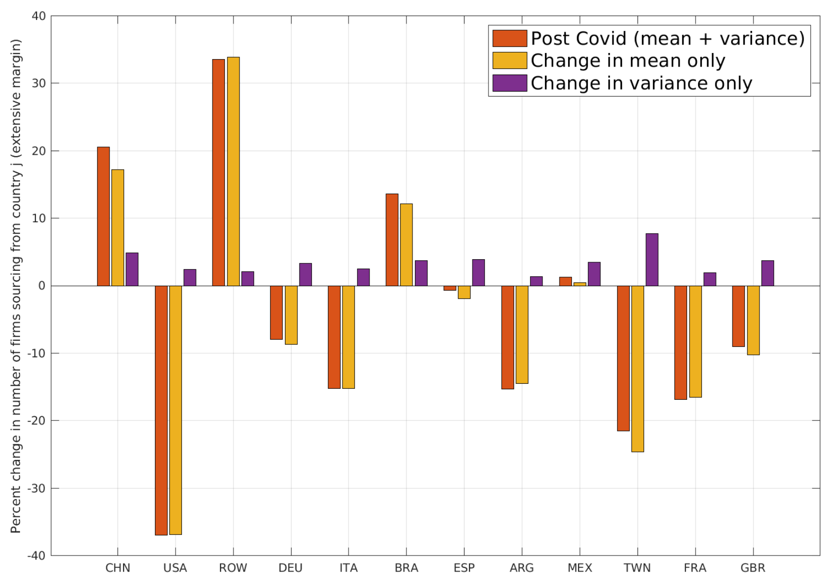
We compare this to the case without aggregate uncertainty. In such a situation, the share of importing firms – solely determined by average sourcing potential and fixed cost – is much lower. Indeed, the combination of large idiosyncratic risk and the additional aggregate risk compounds and firms find it profitable to source from more countries and diversify their sourcing sets.

Figure 28 in the estimation appendix compare the deterministic setting, as in Antràs et al. [2017] and the stochastic case with pre- and post-Covid-19 aggregate uncertainty. There, we learn that the absence of risk unambiguously decreases the share of firms importing for each country – which decrease to 18% and the number of countries firm import from – which falls to 2.0. As we saw in the theoretical section, the risk and variance of trade cost create an option value for firms that now choose to pay the fixed cost and expand their sourcing set to have access to cheaper products and diversify to maximize profit.

7.3 The relative effects of Mean and Variance

To explain the mechanisms at play during the Covid crisis, we now decompose what part of the change in sourcing is due to the change in mean, i.e. the changes in $\mathbb{E}(\bar{\gamma})$, and the changes in mean-preserving uncertainty, i.e. variations in $\sigma(\bar{\gamma})$. As we write in the table 5, in the 3rd and 4th row, where we change each of these moments in turn. We see that the change in the mean of trade cost shocks and the variance of this risk, both have equal contribution to the number of importing firm, and that despite the heterogeneity across countries. Indeed, both increase the number of importing by 1.2% compared to pre-Covid.

Figure 14: Relative effects of Mean and Variance



The relative effect of mean and variance are ambiguous for the number of countries $\mathcal{N}_j$. The change in average cost $\mathbb{E}(\bar{\gamma})$, decreasing for China and increasing for the US, among other things, decrease the number of countries $\mathcal{N}$ firms source from to 2.88 from 2.93 before Covid: more firms source from China only and less from other European and American sources. However, the change in risk, increase that number to 2.99, meaning that diversification is at play and the option value of risk increase the sourcing set of many productive firms. Both these effects, the change in mean and variance, play equal part in the decline in the HHI, which can be explained by the fact that the extensive margin effects of additional importers counteract the fact that more firms source from less countries. As a result, the import sources are less concentrated indicating an overall diversification of sourcing.

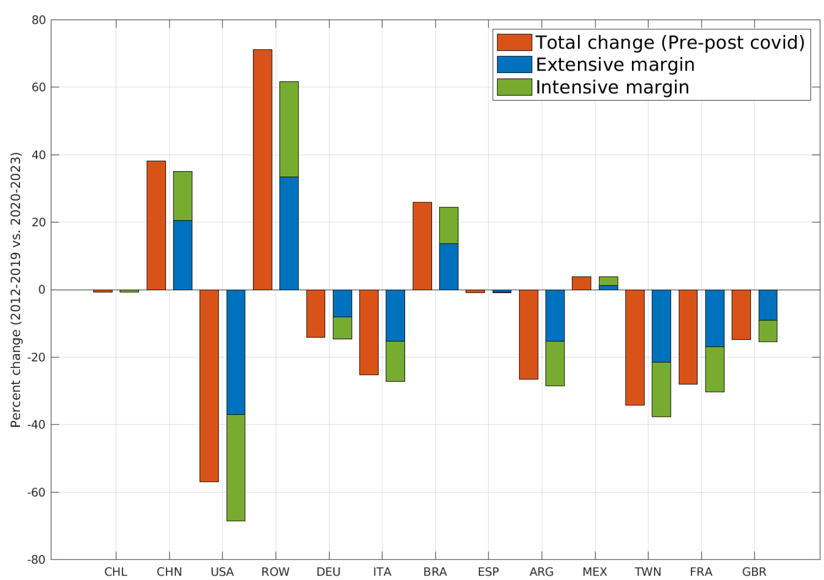
These relative effects are displayed in Figure 14. The heterogeneous changes in mean across countries are the strongest explaining factor to the change in sourcing patterns, again expanding the number of firms sourcing from China, Brazil and the Rest of the world and diverting firms from the other countries. However, as explained before, the effect of the change in variance of the risk mitigate those effects by promoting diversification across sources.

7.4 Extensive vs. Intensive margin

We investigate the relative forces of the extensive margin and the intensive margin on the choice of sources and the quantity imported. To disentangle the change in the number of firms sourcing from foreign countries, vs. the quantity imported *per firm* sourcing from those countries, we do the following decomposition:

$$\bar{\chi}_{ij} := \mathbb{E}_{\bar{\gamma},\tilde{\gamma}}\left[\int_{\varphi} \chi_{ij}(\varphi,\gamma)\ dG_j(\varphi)\right] = \underbrace{\lambda_{ij}}_{\substack{\text{extensive}\\ \text{margin}}} \times \underbrace{\frac{\bar{\chi}_{ij}}{\lambda_{ij}}}_{\substack{\text{intensive}\\ \text{margin}}}$$

Figure 15: Percentage change extensive v/s intensive margin



In the figure 15, we plot, for each country i, the decomposition of $\Delta\%\bar{\chi}_{ij}$ in percentage:

$$\Delta\%\bar{\chi}_{ij} \approx \Delta\%\lambda_{ij} + \Delta\%\frac{\bar{\chi}_{ij}}{\lambda_{ij}}$$

which separates what is due to the change in the number of firms, the extensive margin $\Delta\%\lambda_{ij}$ in dark blue, and what is due to the quantity per firm, the intensive margin $\Delta\%\frac{\bar{\chi}_{ij}}{\lambda_{ij}}$ in light green. Note that since the model is strongly non-linear, this decomposition is not exact and only hold up to the first order.

In Figure 15, we plot the percentage change of the two forces as well as the total change of import shares from the change in uncertainty after the Covid-19. From this figure, we investigate the reason for the reallocation of import across countries. We see that most firms increase their exposure to China, Brazil and the Rest of the World, and decrease their imports from the US, Latin American partners and European countries. Note that this change is almost perfectly equally explained by the extensive and intensive margins. The negative effect of the extensive margin is relatively stronger for the US and Europe. It accounts for more than 60% of the decline, indicating that the fixed cost of sourcing and the change in distribution of trade cost have a stronger influence when reshore and reallocating production.

8 Conclusion

We develop a multi-country sourcing framework, where firms make their sourcing decisions based on productivity, cost minimization, and trade disruption considerations. We theoretically show that mean-preserving uncertainty affect firms' choices in opposite ways. Import risk that is idiosyncratic to the firm creates a positive option value of diversifying the set of suppliers. Aggregate trade risk to the origin-destination country pair, on the other hand, also affects market demand for final goods, on top of creating the same positive option value. This market demand effect changes the co-movement between the firms' costs and the prices charged by other competing firms, creating incentives for the firm to hedge against such a risk by having a different sourcing portfolio. As a result, supply chain uncertainty leads to non-trivial sourcing decisions, that depend on the price and risk-structure of each country.

In numerical examples, we see that uncertainty affects profits mostly via changes changes in marginal costs. A higher level of risk thus induces firms to add more countries to their sourcing strategy, in order to get an extra cost draw and increase competition among suppliers. However, uncertainty is not innocuous, and it is driven mostly by the option value effect.

To quantitatively evaluate the importance of supply-chain uncertainty on sourcing decisions, we estimate the model using firm-level customs and tax data from Chile for the period 2012-2023. We study how different firms' sourcing decisions would have been in 2012-2019 had they faced the supply chain uncertainty prevalent in the 2020-2023 period. We find that the change in the mean of the trade shocks its variance have different impact. We see that the decline in average cost from China and the increase in the US cost imply a large change in sourcing decision of Chilean firms, both at the intensive and extensive margin. However, the increase in uncertainty also had a milder effect on sourcing: it incentivized firms to diversify, thanks to the option value of expanding the sourcing set.

Despite large supply chain disruptions, individual firms make their sourcing decision primarily to minimize costs, and hence do not internalize the trade risk for other downstream firms and households. As a result, it generates inefficient sourcing externalities that could be addressed through resilience policies. In future research, we study how to design these optimal policies along the supply chain.

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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 $\mathcal{I}_j(\varphi_L)$:

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

and

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

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 $\alpha > 1$:

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

Where we take $\alpha = (\sigma - 1)/\theta$, $x = (T_i(\tau_{ij}\gamma_{ij}(\varphi)w_i)^{-\theta}$, and $y = T_k(\tau_{kj}\gamma_{kj}(\varphi)w_k)^{-\theta}$.

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

Finally, 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 non-decreasing 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 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 origin country i across firms in destination 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 (14), we obtain:

$$\begin{aligned} M_{ij}(\bar{\gamma}) &= N_j \int_{\tilde{\varphi}_{ij}}^{\infty} \int_{\tilde{\gamma}(\varphi)} M_{ij}(\varphi, \bar{\gamma}, \tilde{\gamma}(\varphi)) d\tilde{\Psi}_i^{\varphi}(\gamma) dG_i(\varphi) \\ &= N_j(\sigma - 1)\eta^{\frac{\sigma-1}{\theta}} T_i(\tau_{ij}\bar{\gamma}_{ij}w_i)^{-\theta} B_j(\bar{\gamma}) \times \\ &\quad \int_{\tilde{\varphi}_{ij}}^{\infty} \int_{\tilde{\gamma}(\varphi)} \mathbb{1}_{ij}(\varphi)\varphi^{\sigma-1}(\Theta_j(\varphi, \bar{\gamma}, \tilde{\gamma}(\varphi)))^{\left(\frac{\sigma-1}{\theta}-1\right)}(\tilde{\gamma}_{ij}(\varphi))^{-\theta} d\tilde{\Psi}_i^{\varphi}(\gamma) dG_i(\varphi), \end{aligned} \tag{16}$$

so,

$$M_{ij}(\bar{\gamma}) = N_j(\sigma - 1)\eta^{\frac{\sigma-1}{\theta}} T_i(\tau_{ij}\bar{\gamma}_{ij}w_i)^{-\theta} B_j(\bar{\gamma})\Lambda_{ij}(\bar{\gamma}), \tag{17}$$

with,

$$\Lambda_{ij}(\bar{\gamma}) \equiv \int_{\tilde{\varphi}_{ij}}^{\infty} \int_{\tilde{\gamma}(\varphi)} \mathbb{1}_{ij}(\varphi)\varphi^{\sigma-1}(\Theta_j(\varphi, \bar{\gamma}, \tilde{\gamma}(\varphi)))^{\left(\frac{\sigma-1}{\theta}-1\right)}(\tilde{\gamma}_{ij}(\varphi))^{-\theta} d\tilde{\Psi}_i^{\varphi}(\gamma) dG_i(\varphi), \tag{18}$$

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,

$$M_{ij}(\bar{\gamma}) = \frac{E_j}{P_j(\bar{\gamma})/N_j} \times \frac{Q_i}{\sum_k \frac{E_k}{P_k(\bar{\gamma})/N_k}(\tau_{ik}\bar{\gamma}_{ik})^{-\theta}\Lambda_{ik}(\bar{\gamma})} \times (\tau_{ij}\bar{\gamma}_{ij})^{-\theta} \times \Lambda_{ij}(\bar{\gamma}), \tag{19}$$

with,

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

the ideal price index and E_j the 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 their paper, 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: $\Xi_j(\bar{\gamma}) \equiv K_j(\bar{\gamma})T_j(\tau_{jj}\bar{\gamma}_{jj}w_j)^{-\theta}N_jB_j(\bar{\gamma})$, with $K_j(\bar{\gamma}) = (\sigma - 1)\eta^{(\sigma-1)/\theta}N_jB_j(\bar{\gamma})$ so we can write,

$$\Lambda_{ij}(\bar{\gamma}) = \frac{K(\bar{\gamma})}{\Xi_j(\bar{\gamma})} \int_{\tilde{\varphi}_{ij}}^{\infty} \int_{\tilde{\gamma}_{ij}(\varphi)} \mathbb{1}_{ij}(\varphi)\varphi^{\sigma-1}(\Theta_j(\varphi, \bar{\gamma}, \tilde{\gamma}(\varphi))^{\frac{\sigma-1}{\theta}-1} T_j(\tau_{jj}\tilde{\gamma}_{jj}(\varphi)w_j)^{-\theta} d\tilde{\Psi}^{\varphi}_{ij}(\varphi) dG_j(\varphi), \tag{20}$$

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. We obtain this expression in the following way.

Using equation (19), $\sigma - 1 = \theta$ (entry decisions are independent), and the formula for the Pareto distribution, $G_j(\varphi) = 1 - (\underline{\varphi}_j/\varphi)^{\kappa}$, to solve for the integral in equation (20) and plug it back in equation (19):

$$M_{ij}(\bar{\gamma}) = (\sigma - 1)\eta^{\frac{\sigma-1}{\theta}} N_j B_j(\bar{\gamma}) T_i(\tau_{ij} w_i \gamma_{ij}(\varphi))^{-\theta} \kappa \underline{\varphi}_j^{\kappa} \frac{(\tilde{\varphi}_{ij})^{\sigma-1-\kappa}}{\kappa - \sigma + 1}$$

With $\sigma - 1 = \theta$, we have that the threshold is now given by

$$\tilde{\varphi}_{ij}^{\sigma-1} = \frac{w_j f_{ij}}{\eta \mathbb{E}(B_j(\bar{\gamma}) T_i(\tau_{ij} w_i \gamma_{ij}(\varphi))^{-\theta})}$$

Then, we plug this back in our equation for $M_{ij}(\bar{\gamma})$ with $\sigma - 1 = \theta$ and after some manipulation, we find:

$$M_{ij}(\bar{\gamma}) = \frac{N_j B_j(\bar{\gamma})^{\frac{\kappa}{\sigma-1}} (\tau_{ij})^{-\kappa} (w_i \tilde{\gamma}_{ij}(\varphi)\bar{\gamma}_{ij})^{1-\frac{\kappa}{\sigma-1}} (\underline{\varphi_j})^{\kappa} Q_i}{\sum_k N_k B_k(\bar{\gamma})^{\frac{\kappa}{\sigma-1}} (\tilde{\varphi}_k)^{\kappa} (w_k \tilde{\gamma}_{ik}(\varphi)\bar{\gamma}_{ik} f_{ik})^{1-\frac{\kappa}{\sigma-1}}}$$

Using the definition of $B_j(\bar{\gamma})$ and using the resulting N_j of equilibrium obtained for the Pareto case with shape parameter κ, and defining

$$\Phi_j = \frac{f_{ej}}{L_j} \underline{\varphi_j}^{-\kappa} P_j(\bar{\gamma})^{-\kappa} w_j^{\frac{\kappa}{\sigma-1}-1} \tag{21}$$

we obtain equation (21).

A.4 Herfindahl-Hirschman Index (HHI)

As we aim to understand 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 **??**, which shows the unweighted average of the yearly country-level HHI from 2017 to May 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, or positively, 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 (19), 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:

$$
\begin{aligned}
HHI_j &= \sum_{i=1}^{I} (ms_{ij})^2 \\
&= \sum_{i=1}^{I} \left(\frac{M_{ij}(\bar{\gamma})}{\sum_{k=1}^{I} M_{kj}(\bar{\gamma})} \right)^2 \\
&= \sum_{i=1}^{I} \left(\frac{T_i(\tau_{ij}\bar{\gamma}_{ij}w_i)^{-\theta}\Lambda_{ij}(\bar{\gamma})}{\sum_{k=1}^{I} T_k(\tau_{kj}\bar{\gamma}_{kj}w_k)^{-\theta}\Lambda_{kj}(\bar{\gamma})} \right)^2
\end{aligned}
\tag{22}
$$

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 in section 3.4. We can subsequently leverage our findings from the structural estimation process to obtain the model-implied HHI and assess the fit of our model.

A.5 Simple Case: 2 Countries with Aggregate Shocks

To understand the mechanisms that are at play in our model, we develop a simple case with 2 countries where there can be both aggregate and idiosyncratic uncertainty. We simplify everything as much as possible and assume that technology is the same in bot Home and Foreign, and wages, as well as iceberg costs, at Home are all equal to 1 at Home, so $T_H = T_F = w_H = \tau_H = 1$. We denote the countries as Home, H, and Foreign, F, but we only add the country for the origin, and not the destination, since the destination country is always Home. 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), i.e., they diversify.

To simplify things further, supply chain shocks, with $\bar{\gamma}_{ij}$ denoting aggregate shocks, and $\tilde{\gamma}_{ij}^{\varphi}$, denoting 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, so $\tilde{\gamma}_i^{\varphi}, \bar{\gamma}_i > 1$. 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.

We 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:

$$\mathbb{E}(\pi(\varphi, \bar{\gamma}, \tilde{\gamma}^{\varphi})) = \varphi^{\sigma-1} \, \eta^{\frac{\sigma-1}{\theta}} \sum_{\gamma} \mathbb{P}(\bar{\gamma}_H, \bar{\gamma}_F, \tilde{\gamma}_F^{\varphi}, \tilde{\gamma}_H^{\varphi})(\bar{\gamma}_H \tilde{\gamma}_H^{\varphi})^{1-\sigma} B(\bar{\gamma}_H, \bar{\gamma}_F) \tag{23}$$

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 the domestic and foreign countries' aggregate uncertainty as well as firm-origin specific uncertainty for both domestic and foreign countries. The expected profits for a firm with this sourcing behavior are:

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

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 $\mathbb{P}(\bar{\delta}_H, \bar{\delta}_F, \tilde{\delta}_H^n, \tilde{\delta}_F^n) = (1 - \bar{\pi}_H) \bar{\pi}_F \tilde{\pi}_H^{\varphi} \tilde{\pi}_F^{\varphi}$, and so on. 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:

$$M_H(\varphi, \bar{\gamma}, \tilde{\gamma}^{\varphi}) = (\sigma - 1) \, \eta^{\frac{\sigma-1}{\theta}} \varphi^{\sigma-1} (\bar{\gamma}_H \tilde{\gamma}_H^{\varphi})^{1-\sigma+\theta} B(\bar{\gamma}_H, \bar{\gamma}_F) \tag{25}$$

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

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

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

with $A \equiv (\sigma-1)\eta^{\frac{\sigma-1}{\theta}}$ a constant. We now take a closer look to what the market demand term includes. We have that

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

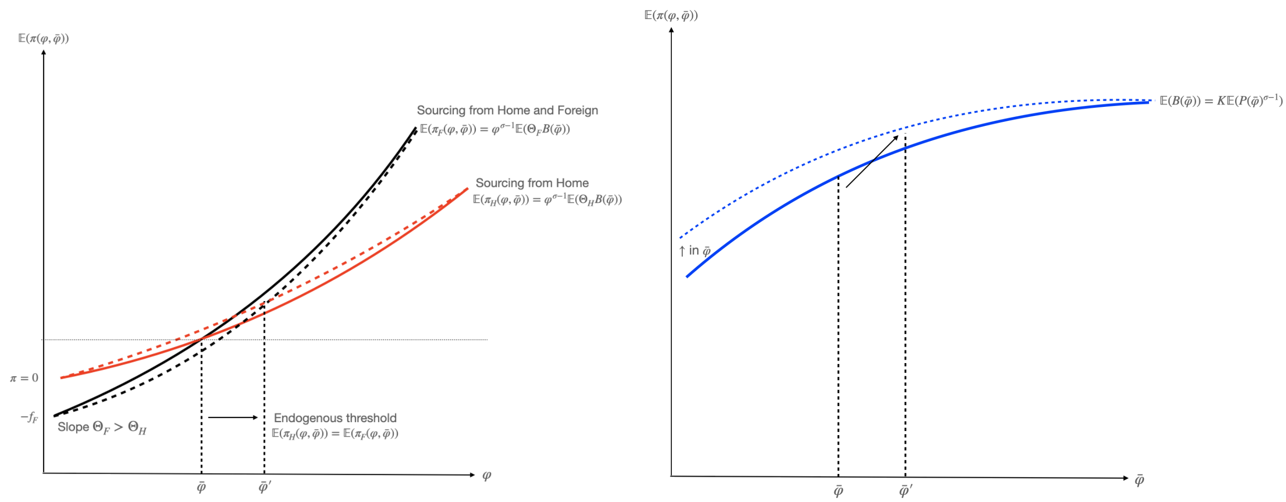
with $K \equiv \left(\frac{1}{\sigma}\right) \times \left(\frac{\sigma}{\sigma-1}\right)^{1-\sigma} \times E$ a constant.

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:

$$\begin{aligned}
P_H(\bar{\delta}_H, \bar{\delta}_F)^{\sigma-1} &= \left(\frac{\sigma-1}{\sigma}\right)\left(\frac{\eta^{\frac{1}{\theta}}}{s_1(\tilde{\varphi}, \bar{\varphi})\ \bar{\delta}_H^{1-\sigma} + s_2(\bar{\varphi})\ (\bar{\delta}_H^{-\theta} + (\tau_{FH}\bar{\delta}_F w_F)^{-\theta})^{\frac{\sigma-1}{\theta}}}\right) \\
P_H(\bar{\delta}_H, 1)^{\sigma-1} &= \left(\frac{\sigma-1}{\sigma}\right)\left(\frac{\eta^{\frac{1}{\theta}}}{s_1(\tilde{\varphi}, \bar{\varphi})\ \bar{\delta}_H^{1-\sigma} + s_2(\bar{\varphi})\ (\bar{\delta}_H^{-\theta} + (\tau_{FH} w_F)^{-\theta})^{\frac{\sigma-1}{\theta}}}\right) \\
P_H(1, \bar{\delta}_F)^{\sigma-1} &= \left(\frac{\sigma-1}{\sigma}\right)\left(\frac{\eta^{\frac{1}{\theta}}}{s_1(\tilde{\varphi}, \bar{\varphi}) + s_2(\bar{\varphi})\ (1 + (\tau_{FH}\bar{\delta}_F w_F)^{-\theta})^{\frac{\sigma-1}{\theta}}}\right) \\
P_H(1, 1)^{\sigma-1} &= \left(\frac{\sigma-1}{\sigma}\right)\left(\frac{\eta^{\frac{1}{\theta}}}{s_1(\tilde{\varphi}, \bar{\varphi}) + s_2(\bar{\varphi})\ (1 + (\tau_{FH} w_F)^{-\theta})^{\frac{\sigma-1}{\theta}}}\right)
\end{aligned} \tag{28}$$

where 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. $\tilde{\varphi}$ and $\bar{\varphi}$ denote the cutoff productivity levels for firms that do not leave the market, and those who buy from both Foreign and Home, 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 better what are some of the moving pieces that affect firm's sourcing decisions in the case of uncertainty. 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 16: Simple 2 countries example



(a) Cutoff

(b) Effect of cutoff on market demand

In Figure 16, 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 16a 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 obtained from diversifying surpass those from sourcing only from Home. Passed that threshold, all firms with a productivity higher than the cutoff will source from both Home and Foreign because they obtain higher profits choosing to diversify instead of sourcing only from domestic. Now, when there is aggregate 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 expected market demand is big enough ($\bar{\varphi}$ is low enough) that high uncertainty does 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 16b, 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 in expectation 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 16a 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 expected price index.

In equations (24) and (25), and as depicted in Figure 16b, 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, $B_j(\bar{\gamma})$. However, idiosyncratic uncertainty affects the sourcing capability but not the market demand. Specifically, heightened aggregate uncertainty at Home diminishes the expected 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 expected sourcing capability depends not only on the Home country but also on Foreign, which allows them to substitute ex-post through the intensive margin, and the increased competition that reduces expected costs. The higher uncertainty will also increase the expected market demand, which acts in the opposite direction as the effect on the expected sourcing capability. This occurs because, if the foreign country does not get negatively 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 expected market demand. From this, we learn that the effect of an increase in aggregate uncertainty at Home is ambiguous and depends on these counteracting forces. Whereas, an increase in idiosyncratic uncertainty at Home only impacts the expected sourcing capability and does not affect the expected market demand. Then, ceteris paribus, if there is an increase in idiosyncratic uncertainty the expected 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 (i.e., increase in the variance of aggregate shock). This change affects the expected sourcing capability and market demand for a firm that sources from both Foreign and Home. However, for a firm exclusively importing from Home, while its expected sourcing capability remains unaffected, the increase in market demand positively impacts expected profits through the rise in the price index. Conversely, if only idiosyncratic uncertainty intensifies, it does not influence the expected market demand, as idiosyncratic shocks are averaged out. Nevertheless, it diminishes the sourcing capability, leading to a reduction in expected profits. Then, if both Home and Foreign 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 decreased in expected sourcing capability counteract these effects, and could even result in a net decrease in expected profits.

Taking a look at equations (26), (27), and (28), we observe that the impact 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 to Foreign lead to a reduction in sourcing potential and sourcing capability and subsequently decreases intermediate input purchases from all sources for firms that diversify, while it does not affect purchases from Home for firms that only source from the domestic country. However, the reduction of intermediate input purchases is higher for the foreign intermediate inputs than for the domestic ones. However, an increase in negative aggregate shocks, i.e., $\bar{\gamma}_{ij} > 1$, also results in an increase in $B_j(\bar{\gamma}_H, \bar{\gamma}_F)$, 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 increasing sourcing from Home, resulting in a reduced susceptibility of the market demand to an increase in the shock from Foreign ex-post, decreasing the intermediate input purchases from all countries. This ex-post mechanism allows firms to change the quantity they obtain from each country they start a sourcing relationship with so that, if the foreign country is hit by a negative (positive) aggregate shock, then the firms' that source from both domestic and foreign countries decreases (increases) the quantity they import from the foreign country and might either increase or decrease the quantity they buy from the domestic country depending on how big the effect is on the market demand. This increases (reduces) the quantity bought from Home by firms that only buy intermediate inputs from the domestic country, because of the increase (decrease) in market demand.

B Numerical Experiment Appendix

Table 6 presents the parameter values used in our toy 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 6: Numerical Experiment Values

Variable	Definition	Value
SD(γ)	Standard deviation of shock	0.25
ρ	Substitutability accross intermediates varieties	2.00
I	Number of countries	3.00
$T_D(\tau_D w_D)^{-\theta}$	Domestic sourcing potential	1.00
$T_{F1}(\tau_{F1} w_{F1})^{-\theta}$	Sourcing potential Foreign 1	0.10
$T_{F2}(\tau_{F2} w_{F2})^{-\theta}$	Sourcing potential Foreign 2	0.03
N	Number of domestic firms	150
f_D	Fixed cost of sourcing Domestic	0.00
f_{F_1}	Fixed cost of sourcing Foreign 1	0.22
f_{F_2}	Fixed cost of sourcing Foreign 2	0.12
Calibration for high 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

C 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

D Estimation Appendix

Figure 17: Country Sourcing Potential and Extensive Margin

Figure 18: Country Sourcing Potential and Intensive Margin

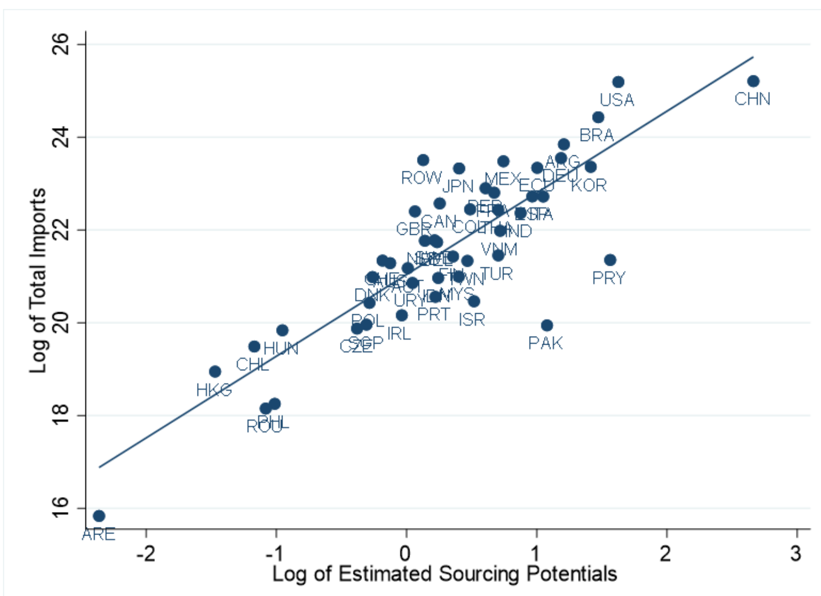


Figure 19: Average Aggregate Shocks All Countries, 2012q1-2023q4

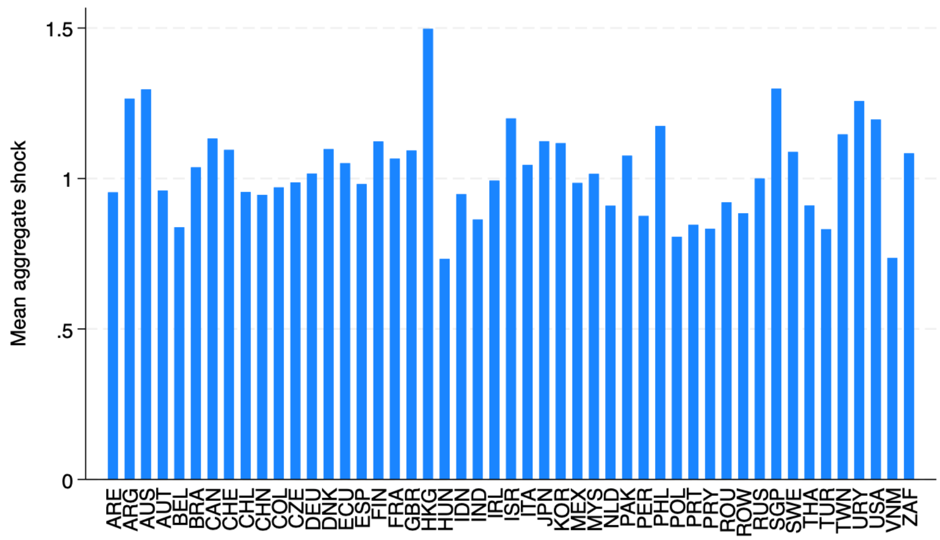


Figure 20: Average aggregate shock all countries, 2012q1-2015q4

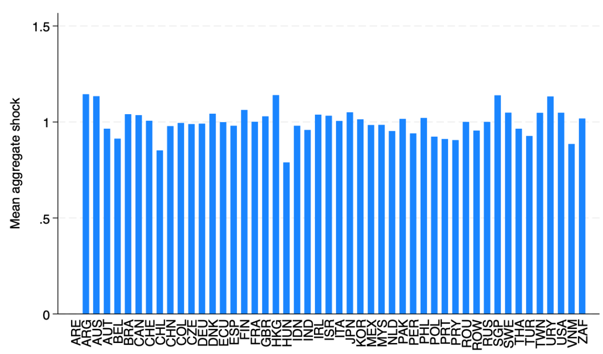


Figure 21: Average Aggregate Shocks All Countries, 2016q1-2019q4

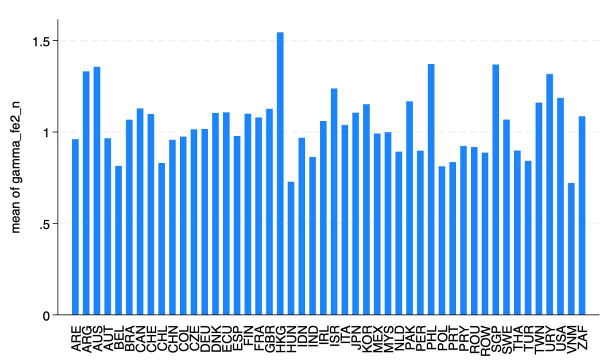


Figure 22: Average Aggregate Shocks All Countries, 2020q1-2023q4

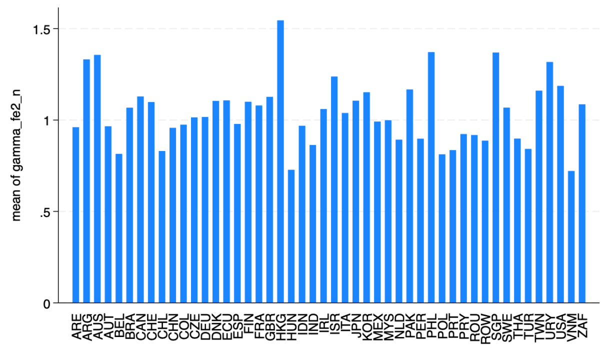


Figure 23: Average Standard Deviation for Aggregate Shocks, 2012q1-2023q4

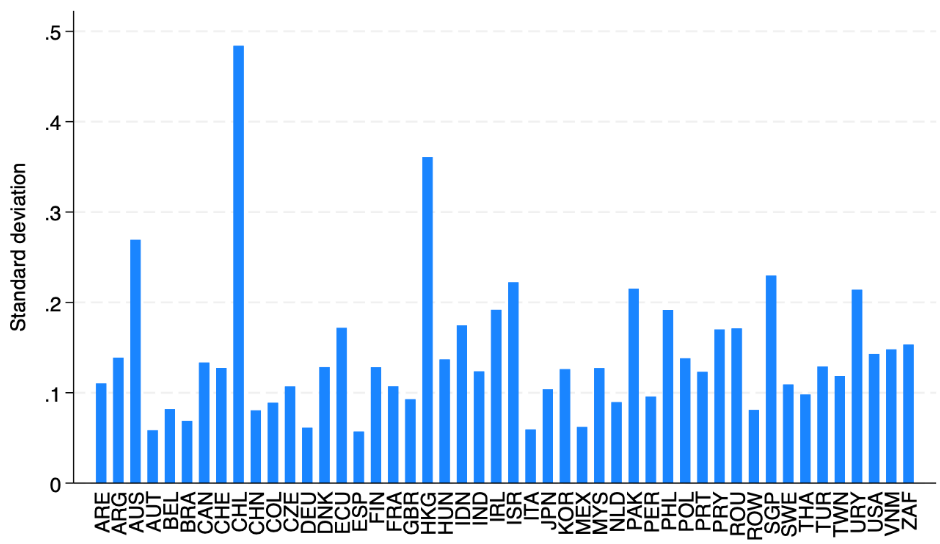


Figure 24: Average Standard Deviation for Aggregate Shocks, 2012q1-2015q4

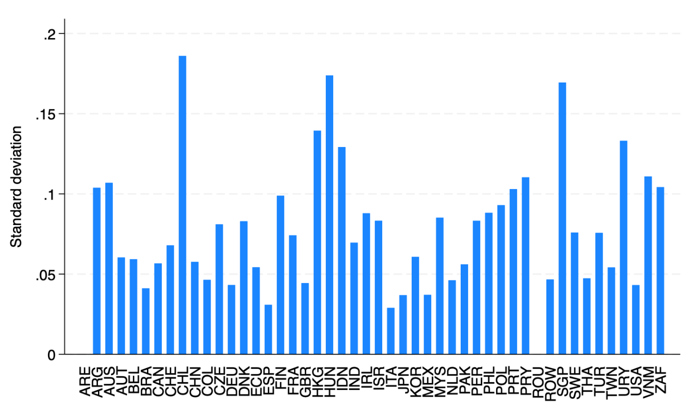


Figure 25: Average Standard Deviation for Aggregate Shocks, 2016q1-2019q4

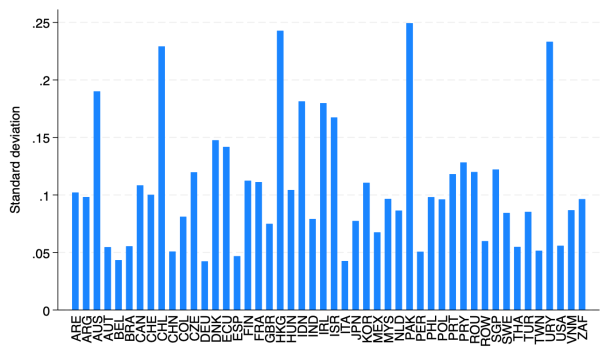


Figure 26: Average Standard Deviation for Aggregate Shocks, 2020q1-2023q4

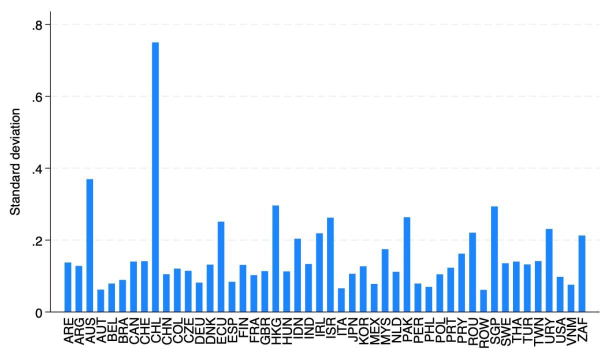


Figure 27: Aggregate Shocks in Time for China and USA

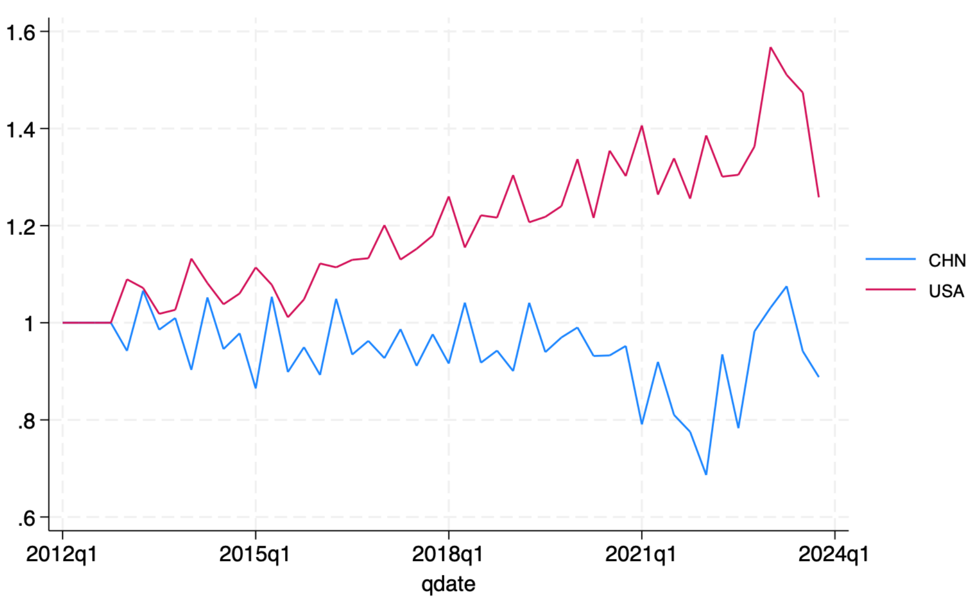


Figure 28: Change in the share of value of imports by importing firms