Trade Intermediation and Resilience in Global Sourcing

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Abstract

Global sourcing exposes firms to disruptions and managing resilience can be costly. I study how firms use trade intermediaries to procure inputs and mitigate disruptions in risky locations. Using international transactions from Chile, I document that the share of intermediated imports rises with supply chain risk, as intermediaries maintain more diversified and robust supply networks compared to producers. I then develop a quantitative model of global sourcing with trade intermediation and insecure supply relationships. Producers trade off input costs against disruption probabilities when selecting source locations. To mitigate disruptions within locations, more productive firms engage with multiple suppliers, while less productive firms contract with intermediaries, accessing a resilient network at higher input prices. Model quantification reveals that intermediaries effectively protect mid-size producers, reducing their profit losses by 20 percentage points, as they access foreign markets but lack the scale to diversify. Intermediation thus broadens the set of producers that can hedge against disruptions, with their contribution ultimately depending on the extent of brokerage fees.

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1. Introduction

Global markets provide access to a variety of inputs for production, enhancing firm and aggregate productivity, but also expose manufacturers to disruptions overseas. Although these concerns intensified during the Great Recession and the COVID-19 pandemic, firms report frequent and recurrent disturbances in their supply chains (Baldwin and Freeman 2022; Elliott and Golub 2022). Examples range from strikes and industrial accidents to supplier bankruptcies, transportation failures, regulatory changes, and natural disasters. Recent studies have examined how firms adapt by diversifying or reallocating suppliers (Balboni et al. 2023; Blaum et al. 2023; Castro-Vincenzi et al. 2024), but the skewness of trade and production networks (Bernard and Moxnes 2018) suggests that these strategies are costly and often prohibitive for smaller players. In this context, trade intermediaries offer an alternative technology for input sourcing.

Intermediaries are firms specialized in distribution that emerge as a market response to buyer-supplier needs. They mediate a significant share of international and domestic trade (Blum et al. 2009; Bernard et al. 2010; Ganapati 2024) and are believed to reduce transaction costs (Ahn et al. 2011; Antràs and Costinot 2011). Although their business model requires specific sourcing capabilities, little is known about the characteristics of their supply networks and the implications for resilience. Yet, anecdotal evidence suggests that producers rely on intermediaries to access inputs from riskier locations, and intermediaries advertise their expertise in managing supply chain risk.[1]

This paper studies how producers use intermediation services to mitigate disruptions in global sourcing. Using international transactions from Chile, I show that the share of intermediated imports rises with supply chain risk, as intermediaries maintain more diversified and robust supply networks. These findings motivate a sourcing model with trade intermediation and insecure supply links, where heterogeneous producers trade off input costs against disruption probabilities across locations. More productive firms engage with multiple suppliers to mitigate disruptions in risky locations, while less productive firms contract with intermediaries, accessing a resilient network at higher input prices. Model quantification reveals sizable profit losses from disruptions, which intermediaries reduce by half for mid-size producers that lack the scale to diversify. Counterfactual analysis also suggests a role for industrial policy in enhancing resilience

[1]The leading chemicals intermediary, Univar, claims that *"safety and compliance are the foundation of our supply chain network"*, while Li & Fung in apparel *"focus on managing complexity and risk to maximize profitability"*. On the other hand, interviews with clothing supply chain actors suggest that firms use intermediaries in riskier markets (Vedel and Ellegaard 2013). As stated by one respondent, *"life goes on in these countries despite repeated riots and crises...but we don't establish ourselves"*. See Appendix A for details.

through lower brokerage fees.

My first contribution is to establish new facts on intermediated sourcing under supply chain risk. I use Chilean customs data on the universe of import transactions from 2005 to 2019, matched with tax records that report firms' business activities. This enables me to distinguish between Chilean producers and intermediaries, and to identify their foreign suppliers for each HS 6-digit product and origin country. Specifically, I focus on wholesale intermediaries that mediate firm-to-firm transactions, as opposed to retailers specializing in firm-to-consumer trade. The data reveal that wholesalers are prominent in global sourcing, representing only 7% of firms but nearly 40% of imports and operating across a wide range of sectors.

Fact 1 demonstrates that the share of intermediated imports from a given origin country and product increases with supply chain risk. I consider three measures to proxy for the probability of disruptions: the *Geopolitical Risk* index by Caldara and Iacoviello (2022), the *Economic Policy Uncertainty* index by Baker et al. (2016), and a *Trade Volatility* index, residualizing global trade flows to capture variation at the origin country-product level. I use a long differences specification to assess how risk changes, presumably orthogonal to economic conditions in Chile, influence the use of intermediaries. All risk measures deliver consistent estimates, with a one standard deviation increase raising the intermediation share by nearly one percentage point over a five-year horizon.

I next unpack differences in the supply networks of producers and intermediaries that explain this pattern. Fact 2 reveals that intermediaries maintain a greater number of suppliers for the same product and origin country, resulting in more diversified input purchases. In turn, consistent with the presence of disruptions, intermediaries hold more suppliers in riskier locations. Fact 3 shows that the supply links of intermediaries are less likely to break for a given product-country pair, exhibiting lower separation rates. These differences seem to arise from intermediaries' ability to screen suppliers, leverage their position as important customers, and source more products per supplier. Taken together, these facts suggest that intermediaries offer a resilient sourcing technology, leading producers to contract their services in response to risk.

My second contribution is to develop a model of global sourcing with trade intermediation and supply chain risk. I consider the problem of heterogeneous final goods producers facing uncertainty regarding the operability of supply links, with two sourcing modes available: directly from suppliers or indirectly through intermediaries. Producers trade off input costs and disruption probabilities across source locations, and optimally protect against disruptions in risky locations, selecting different mitigation mechanisms based on their productivity. More productive firms engage in *diversification*, incurring

higher matching costs to establish multiple direct links with suppliers, while less productive firms opt for *intermediation*, accessing a resilient network at the expense of a brokerage fee on input prices.

Producers define their global sourcing strategy in the expectation of disruptions and then make optimal input purchases from the supply links that remain operational. From an *ex-post* perspective, sourcing indirectly increases input costs at any given location. However, from an *ex-ante* perspective, expected input costs can be lower due to the greater resilience of the intermediation technology. The optimal sourcing mode thus depends on the extent of brokerage fees and the alternative network that producers could establish directly. While matching costs prevent low-productivity firms from diversifying suppliers, the resilience advantage of intermediaries diminishes for high-productivity firms, which are also more affected by input markups.

The model rationalizes changes in intermediation shares when supply chain risk increases in a particular location, driven by producers' adaptive responses. On the extensive margin, two competing effects emerge: some direct buyers switch to indirect sourcing as the attributes of intermediaries become more valuable, while others sourcing indirectly exit the location due to reduced profitability. On the intensive margin, the shift in the composition of indirect buyers drives up the intermediation share, as switching producers are more productive. As documented in stylized fact 1, the net effect is positive, indicating that the exit of indirect buyers is outweighed by the other forces.

This theoretical framework connects insights from separate literatures. Consistent with models of global value chains, more productive firms source directly from a greater number of locations (Antràs et al. 2017) and transact with more suppliers per location (Bernard et al. 2018b, 2022), with supply chain risk further amplifying their cost advantage. They are also less likely to source indirectly, as suggested by canonical intermediation models (Ahn et al. 2011; Bernard et al. 2015), but intermediaries play a broader role by offering a resilient sourcing technology. Moreover, disruptions affecting marginal costs induces diversification among risk-neutral producers (Blaum et al. 2023; Castro-Vincenzi et al. 2024), but optimal responses differ across firms when buyer-supplier matching is costly. I provide additional reduced-form evidence supporting producers' heterogeneous risk responses, alongside other key features of the model.

My third contribution is to quantify the role of trade intermediation in mitigating supply chain disruptions. The producers' *ex-ante* problem is a combinatorial discrete choice problem in expectations that can be solved numerically. To manage the dimensionality of the choice set, I build on recent computational tools developed for combinatorial settings (Arkolakis et al. 2023; Huang et al. 2024), while using Monte Carlo simulations to

approximate the high-dimensional expectation at each choice. Leveraging the detailed microdata, I operationalize this setting for Chile and five source regions: Latin America, China, the US, Europe, and the Rest of the World. I first estimate elasticity parameters, input costs, disruption probabilities, and brokerage fees, and then aggregate demand and matching costs using the simulated method of moments. I find that disruption probabilities are higher in regions with lower input costs, posing an efficiency-risk tradeoff for producers. Additionally, the estimated matching costs are convex in the number of suppliers, consistent with costly supplier diversification.

My main result is that trade intermediation substantially reduces the impact of disruptions for mid-size producers. Their profit losses from disruptions are around 20% in the baseline model, which would double in a counterfactual scenario without intermediaries, rising by nearly 20 percentage points. These producers are large enough to import but lack the scale to diversify suppliers in foreign locations, leaving them particularly vulnerable without intermediaries. In contrast, large firms experience similar profit losses of around 16% in both scenarios, as they can always diversify suppliers directly. Smaller producers, on the other hand, source mainly domestically and are not directly exposed to foreign disruptions.

I then evaluate the impact of changes in intermediation markups. My results show that reducing markups from 20% to 10% decreases the impact of disruptions by 5 percentage points for mid-size producers, as intermediation becomes more accessible across locations. Conversely, increasing markups to 30%, as documented in some developed countries (Ganapati 2024; Alexander et al. 2024), raises the effect of disruption by 3 percentage points. This suggests that industrial policies in sectors instrumental to trade, such as wholesaling, could have sizable effects on resilience.

The rest of the paper is organized as follows. Section 2 describes the data and presents the stylized facts. Section 3 develops the model with trade intermediation and supply chain risk. Section 4 provides reduced-form evidence on model features. Section 5 estimates the model and performs counterfactual analysis. The last section concludes.

Related Literature. This paper bridges and advances three strands of literature. First, I contribute to the emerging literature on supply chain resilience, considering the effects of disruptions through production networks (Carvalho et al. 2021; Elliott et al. 2022; Kopytov et al. 2022; Alessandria et al. 2023; Acemoglu and Tahbaz-Salehi 2024; Korovkin et al. 2024), optimal policy responses (Grossman et al. 2023, 2024), and firms' adaptive responses through various mechanisms (Castro-Vincenzi 2022; Khanna et al. 2022; Balboni et al. 2023; Blaum et al. 2023; Castro-Vincenzi et al. 2024). Also related are

studies focusing on export and FDI decisions under risk (Ramondo et al. 2013; Fillat and Garetto 2015; Esposito 2022). Of these works, my paper is most closely connected to Blaum et al. (2023) and Castro-Vincenzi et al. (2024), which study how firms adapt their sourcing strategies to shipping and climate risk. On the empirical side, the use of intermediaries in risky locations complements their findings on supplier diversification. Moreover, my model exhibits similar incentives for diversification, but I characterize heterogeneous producers' responses and focus on how intermediaries provide an alternative for those that cannot diversify.

A second line of research explores the role of intermediaries in facilitating trade. Intermediaries are responsible for a significant share of international trade in a diverse set of countries (Blum et al. 2009; Bernard et al. 2010; Abel-Koch 2013; Crozet et al. 2013; Utar 2017; Akerman 2018). They are believed to reduce transaction costs and exploit economies of scale (Ahn et al. 2011; Antràs and Costinot 2011; Bernard et al. 2015), although their market power can drive price wedges between firms (Dhingra and Tenreyro 2020). While the trade literature has focused mostly on the use of intermediaries for exporting, recent works on production and distribution networks highlight their role for input sourcing (Grant and Startz 2022; Blum et al. 2024; Ganapati 2024; Manova et al. 2024). I contribute to this literature by providing novel empirical evidence on the supply networks of intermediaries. As in previous models, intermediaries entail a trade-off between fixed costs and markups, but the characteristics of their sourcing technology are relevant in the context of supply chain disruptions.

Third, my paper contributes to works on global value chains and their implications for firm performance and aggregate welfare. This literature has shown that access to foreign inputs increases firms' productivity, product quality, and innovation, shaping multinational activity and the gains from trade (Amiti and Konings 2007; Goldberg et al. 2010; Manova and Zhang 2012; Garetto 2013; Gopinath and Neiman 2014; Bøler et al. 2015; Halpern et al. 2015; Blaum et al. 2018; Boehm and Oberfield 2020). Frontier work highlights the endogenous formation of firm-to-firm networks in the presence of search and matching frictions (Chaney 2014; Carballo et al. 2018; Bernard et al. 2018b, 2019; Eaton et al. 2022; Huang et al. 2024). I incorporate the role of trade intermediation and supply chain risk in determining global sourcing patterns. Formally, my theoretical framework builds on Antràs et al. (2017), but firms can choose their sourcing mode and number of suppliers at each location, and they trade off input costs and disruption probabilities when making sourcing decisions.

2. Stylized Facts

2.1. Data

I exploit rich data for Chile that includes the universe of firm-to-firm international transactions and detailed information on the business activity of domestic firms. First, the Chilean Customs Service provides the value, quantity, and unit value for all trade flows from 2005 to 2019, reporting the origin country, HS 6-digit product, and buyer-seller identities for each transaction. Second, the Chilean Tax Authority provides data on the primary industry, sub-industry, and activity of Chilean firms over the same period, along with additional firm-level characteristics such as sales and number of employees. I match these datasets using a unique firm tax identifier (RUT).

I classify Chilean firms into three types based on their main industry: producers, wholesalers, and retailers. At this level, the Chilean Tax Authority closely follows the International Standard Industrial Classification (ISIC, rev. 4) for the wholesale and retail sectors. Wholesalers specialize in the *"resale without transformation of new and used goods to retailers, to industrial, commercial, institutional or professional users, or to other wholesalers"*, and their operations may include trade-related services such as sorting, packaging, or storage. Retailers, on the other hand, specialize in the resale of goods to the general public for personal or household consumption. Thus, wholesalers focus on firm-to-firm transactions, while retailers carry out firm-to-consumer transactions.

Table 1 presents summary statistics for trade activity by firm type. Producers are the largest group in number (80%) and contribute nearly half of all imports (45%) and the majority of exports (85%). Wholesalers represent only 7% of firms and 14% of exports, but they are prominent in global sourcing, accounting for a disproportional share of imports (44%). Notably, 89% of imported products pass through wholesalers, indicating a significant overlap with producers in the types of goods imported. Moreover, wholesalers engage with nearly half of all foreign suppliers selling to Chile and conduct 41% of import transactions at the buyer-supplier-product (HS6) level.[2] Retailers, on the other hand, make up 13% of firms but are less relevant for international trade, accounting for 11% of imports and less than 1% of exports.

Figure 1 shows firms' import shares over time in Panel A and the share of wholesale imports across broadly-defined sectors in Panel B. The role of wholesalers in global sourcing has increased over the past decades, particularly since the Great Recession,

[2]The relative importance of wholesalers for imports in Chile is consistent with recent evidence from the US (Ganapati 2024) and Denmark (Utar 2017).

TABLE 1. Trade Activity by Firm Type

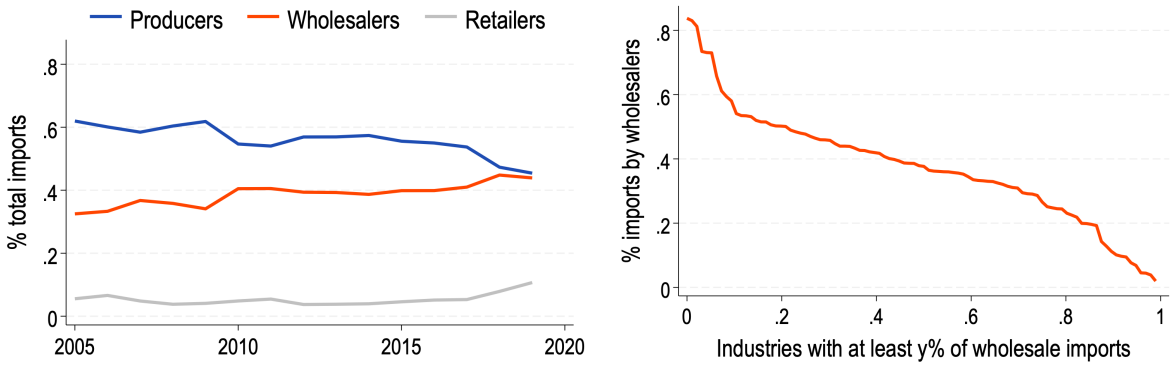
	Producers	Wholesalers	Retailers
# firms	528,617	43,084	86,627
% firms	0.803	0.065	0.132
% importers	0.439	0.302	0.259
% imported value	0.454	0.439	0.107
% imported products (HS6)	0.909	0.889	0.747
% foreign supplier links	0.448	0.444	0.242
% import transactions	0.331	0.405	0.264
% exporters	0.527	0.372	0.101
% exported value	0.852	0.141	0.008
% exported products (HS6)	0.874	0.722	0.382
% foreign customer links	0.682	0.352	0.058
% export transactions	0.566	0.382	0.052

Notes: Summary statistics are reported for the universe of Chilean firms with positive sales in 2019. Firms are classified by their main business activity according to the Tax Authority of Chile (SII), closely following ISIC, rev. 4. International transactions are defined at the buyer-supplier-product (HS6) level.

with their share rising from 33% in 2005 to 44% in 2019. Conversely, the import share of producers has steadily declined over the same period. Wholesalers also account for at least 20% of imports in 85% of all HS 2-digit sectors active in Chile, and for at least 40% in nearly half of these sectors, indicating that their sourcing activities are widely spread across the economy. Since I study how firms use intermediaries to mitigate supply chain disruptions, I restrict the analysis to producers and wholesalers, excluding retailers. Therefore, I use the terms 'wholesaler' and 'intermediary' interchangeably hereinafter.

In addition to Chilean administrative data, my analysis relies on three variables that proxy for supply chain risk. First, the *Geopolitical Risk* (GPRS) index developed by Caldara and Iacoviello (2022) provides a news-based measure of adverse events and threats associated with political tensions. This indicator has been linked to lower investment at the firm and industry levels, but its relevance for sourcing decisions remains unexplored. The second measure is the *Economic Policy Uncertainty* (EPU) index developed by Baker et al. (2016), which follows a similar methodology to capture overall economic uncertainty and specific issues related to legislation and regulations. In terms of coverage, the GPRS index provides information for 44 economies, representing 92% of Chilean imports in 2019, while the EPU index includes 29 countries that account for 78% of imports. Finally, I exploit data on trade flows across countries, products (HS 6-digit), and years from the *CEPII* database (Gaulier and Zignago 2010) to develop a measure of *Trade Volatility* that covers the universe of Chilean imports. As described below, I use a

FIGURE 1. Import Shares Over Time and Across Sectors



A. Import shares over time

B. Wholesale imports across HS2-sectors

Notes: Panel A displays import shares for producers, wholesalers and retailers from 2005 to 2019. Panel B considers data across HS 2-digit sectors for 2019, showing the share of sectors where wholesalers comprise at least y% of imports on the x-axis and the corresponding share of imports on the y-axis.

residualization procedure to isolate variation at the origin country-product level.

2.2. Facts on Intermediated Sourcing

I establish three novel facts that inform how producers use trade intermediaries to protect against disruptions. Fact 1 shows that the share of intermediated imports for a given product and origin country increases with measures of supply chain risk. I then use firm-to-firm transactions to explore differences in the supply networks of producers and intermediaries that help explain this pattern. Fact 2 reveals that intermediaries are more diversified, maintaining a greater number of suppliers for the same product and origin country. Fact 3 shows that the supply links of intermediaries are more robust, exhibiting lower separation rates with suppliers. Taken together, these facts suggest that intermediaries offer a resilient sourcing technology, leading producers to contract their services as supply chain risk increases.

Stylized Fact 1: *The share of intermediated imports increases with supply chain risk for a given origin country and product.*

To explore how the use of intermediaries varies with supply chain risk, I consider the empirical specification described in equation (1). Y_{opt} indicates the share of intermediated imports for a given origin country c and HS 6-digit product p in year t, while $Risk_{opt}$ is a time-varying measure of supply chain risk. I estimate this equation in long differ-

ences, considering the 5-year period from 2014 to 2019.[3] Identification then comes from risk changes within units, which are presumably orthogonal to economic conditions in a small economy like Chile. This approach also rules out the effect of time-constant origin country and product characteristics that may confound the relationship between risk and intermediation, since riskier locations can differ systematically from safer ones. Moreover, Z_{opt} controls for time-varying covariates affecting firms' sourcing decisions.

$$\Delta_{t,t+5} Y_{op} = \alpha \left(\Delta_{t,t+5} Risk_{op}\right) + \Delta_{t,t+5} Z'_{op} \gamma + \epsilon_{op} \tag{1}$$

Regarding supply chain risk measures, I first consider the *Geopolitical Risk* (GPR) index and the *Economic Policy Uncertainty* (EPU) index introduced in Section 2.1, which are defined at the origin-country level. I expand this analysis by building a measure of *Trade Volatility* at the origin country-product level using global trade flows. Specifically, I consider exports X_{opdt} of product p from origin country o to destination d in year t, excluding Chile, during the period 2010 to 2019. To isolate the variation corresponding to an origin country and product over time, I residualize export flows using product-destination-year and origin-destination-year fixed effects.[4] Finally, I compute the log-standard deviation of origin country-product flows within 5-year windows, as indicated in equation (2). Note that, for this measure, $\Delta_{t,t+5} Risk_{op}$ captures the log-change in trade volatility for the period 2015 - 2019 relative to the previous window 2010 - 2014.

$$X_{opdt} = \delta_{opt} + \delta_{pdt} + \delta_{odt} + \varepsilon_{opdt} \ , \qquad Risk_{opt} = \log\left(SD_{[t-4,t]}\left(\hat{\delta}_{opt}\right)\right) \tag{2}$$

Table 2 shows that the share of intermediated imports increases with all measures of supply chain risk. The coefficients are normalized to indicate the effect of a one standard deviation increase in each of these measures. Column (1) shows that an increase in *Geopolitical Risk* expands the intermediation share by about 1 percentage point (pp) over a 5-year period. Column (2) confirms this result when controlling for changes in origin-country productivity and trade costs, and for changes in total imports by product to account for industry conditions.[5] Columns (3) and (4) report effects of similar magnitude

[3] This specification is equivalent to stacking years t and $t+5$ and including origin country-product and year fixed effects: $Y_{op\tau} = \alpha Risk_{op\tau} + \delta_{op} + \delta_{\tau} + Z'_{op\tau} \gamma + \epsilon_{op\tau}$.

[4] Similar results are obtained when using a less-demanding residualization procedure. For instance, one could extract only the variation corresponding to destination-product pairs in each year, δ_{pdt}.

[5] I control for changes in total factor productivity (*Penn World Table 9.1*) and the number of trade procedures (*World Development Indicators*). It is worth noting that there are almost no changes in Chilean import tariffs during the period of analysis, such that their inclusion does not affect the results. Additionally, the role of time-constant trade barriers, such as distance or cultural differences, is subsumed under the long differences approach.

under higher *Economic Policy Uncertainty*. Furthermore, columns (5) and (6) show that the intermediation share also increases with changes in *Trade Volatility* at the origin country-product level, with effects in the range of 0.5 to 0.7 pp.

TABLE 2. Trade Intermediation and Supply Chain Risk

	Δ % Intermediated imports					
	(1)	(2)	(3)	(4)	(5)	(6)
Δ Geopolitical risk	0.010***	0.011***				
	(0.003)	(0.003)				
Δ Economic policy uncertainty			0.010	0.013**		
			(0.006)	(0.005)		
Δ Trade volatility					0.007***	0.005**
					(0.002)	(0.002)
Δ Origin-country productivity	No	Yes	No	Yes	No	Yes
Δ Origin-country trade costs	No	Yes	No	Yes	No	Yes
Δ Product total imports	No	Yes	No	Yes	No	Yes
Observations	33,074	32,768	23,791	23,791	35,155	34,393

Notes: This table considers changes in the share of intermediated imports at the origin country-product level over 5 years. Supply chain risk is measured by the Geopolitical Risk index (Caldara & Iacoviello, 2022) and the Economic Policy Uncertainty index (Baker, Bloom & Davis, 2016) at the origin-country level, and by trade flow volatility at the origin country-product level. The coefficients are normalized to reflect the effect of one standard deviation. Controls include changes in the origin country's total factor productivity and number of trade procedures, and changes in total imports by product. The sample includes all import transactions for years 2014 and 2019. Standard errors are clustered at the level of the risk measure.

These results indicate that intermediaries play a greater role in input sourcing under supply chain risk. While the findings are consistent with some producers switching to intermediaries, increased risk may also lead some indirect buyers to stop sourcing inputs from that location. Therefore, the estimated coefficients capture net changes in intermediation shares driven by various selection effects, which are then rationalized by the model proposed in Section 3.

Stylized Fact 2: *Intermediaries have a greater number of suppliers within specific products and countries, resulting in more diversified input purchases compared to producers.*

I now explore how the supply networks of intermediaries compare to those of producers. Columns (1) - (3) in Table 3 regress the log number of suppliers at the firm-product (HS6)-origin country level on a dummy variable indicating whether the firm is an intermediary. Since wholesalers may operate at a larger scale, I control for firm size by including 10 bins based on total sales. Similarly, I control for transaction size, ensuring

that differences in the number of suppliers are not driven by wholesalers purchasing larger amounts. Moreover, product and country fixed effects account for the possibility of intermediaries specializing in different input markets. My results show that intermediaries systematically source from more suppliers compared to producers. Columns (4) - (6) present analogous results for the concentration of input purchases across suppliers. On average, intermediaries have 5% more suppliers and a Herfindahl-Hirschman index (HHI) that is 2 pp lower for the same product and origin country.[6]

TABLE 3. Number of Suppliers and Concentration of Input Purchases

	(log) # suppliers			HHI suppliers		
	(1)	(2)	(3)	(4)	(5)	(6)
Intermediary dummy	0.061***	0.046***	0.049***	-0.024***	-0.018***	-0.019***
	(0.006)	(0.005)	(0.006)	(0.002)	(0.002)	(0.002)
Firm size (sales)	Yes	Yes	Yes	Yes	Yes	Yes
Imported value	Yes	Yes	Yes	Yes	Yes	Yes
Product FE (HS6)	No	Yes	No	No	Yes	No
Country FE	No	Yes	No	No	Yes	No
Product - country FE	No	No	Yes	No	No	Yes
Observations	371,200	370,834	346,949	371,200	370,834	346,949

Notes: This table compares the supply networks of producers and intermediaries. All regressions are at the firm-HS6 product-origin country level. The dependent variable in columns (1) - (3) is the (log) number of suppliers, and in columns (4) - (6) is a Herfindahl-Hirschman index (HHI) across suppliers. The independent variable is a dummy indicating whether the firm is a wholesaler. Controls include firm sales (10 bins) and the import value of the transaction. The sample includes all import transactions by producers and wholesalers in 2019. Standard errors are clustered at the firm level.

One potential concern is that intermediaries may be buying different varieties instead of holding multiple suppliers for the same product. While the HS 6-digit codes are narrowly defined for some goods, they allow for substantial heterogeneity within others. A standard way to alleviate this concern is to restrict the analysis to homogeneous goods according to the Rauch classification (i.e., goods traded in organized exchanges or with reference prices). Table A1 in the Appendix confirms that the differences between intermediaries and producers remain valid in this case. However, a more direct test is to relate the number of suppliers of intermediaries to supply chain risk. Table 4 shows that intermediaries match with more suppliers in countries with higher geopolitical risk or economic uncertainty, or when there is greater trade volatility for a particu-

[6]Figure A3 provides a visualization of the (weighted) average number of suppliers per product and origin country across producers and intermediaries of varying sizes.

lar product and country.[7] These findings are consistent with supplier diversification among intermediaries and complement recent evidence for the supply networks of manufacturers.[8]

TABLE 4. Intermediaries' Suppliers and Supply Chain Risk

	(log) # suppliers					
	Geopolitical risk		Economic uncertainty		Trade volatility	
	(1)	(2)	(3)	(4)	(5)	(6)
Supply chain risk	0.040**	0.054***	0.042***	0.032***	0.057***	0.066***
	(0.015)	(0.011)	(0.008)	(0.011)	(0.002)	(0.002)
Firm size	Yes	Yes	Yes	Yes	Yes	Yes
Imported value	Yes	Yes	Yes	Yes	Yes	Yes
Product FE (HS6)	No	Yes	No	Yes	No	Yes
Origin-country productivity	No	Yes	No	Yes	No	Yes
Origin-country trade costs	No	Yes	No	Yes	No	Yes
Observations	190,945	189,323	166,198	165,679	189,742	186,800

Notes: This table shows how the number of suppliers of intermediaries varies with supply chain risk. All regressions are at the firm-HS6 product-origin country level. Geopolitical Risk and Economic Policy Uncertainty are measured at the origin-country level, while Trade Volatility is at the origin country-product level. Controls include the import value of the transaction and the origin country's total factor productivity and number of trade procedures. The sample includes all import transactions by wholesalers in 2019. Standard errors are clustered at the level of the risk measure.

A final note concerns the economic relevance of these differences. My analysis compared producers and intermediaries with similar characteristics to assess whether the latter possess distinct sourcing capabilities. However, producers using intermediaries may be smaller in scale, as suggested by the literature on export intermediation. Consequently, the differences would be more pronounced for firms actually using this technology, given that the number of suppliers is positively related to firm size. This underscores the importance of a theoretical framework where producers endogenously sort into different sourcing modes. Equipped with such a model, I assess the quantitative significance of intermediaries' supplier diversification in Section 5.

[7] As before, I control for firm and transaction size to account for scale effects. I do not include product-country fixed effects as they would absorb all the variation in the risk measures, but I include product fixed effects and controls for origin-country productivity and trade costs.

[8] Blaum et al. (2023) connects the number of suppliers of US manufacturers to shipping risk, while Castro-Vincenzi et al. (2024) focus on geographic diversification under climate risk in India. I also find a positive correlation between the number of suppliers and supply chain risk for producers (Table A2), although the effects are smaller than those of intermediaries (Table A3).

Stylized Fact 3: *The supply relationships of intermediaries are less likely to break compared to those of producers for the same product and origin country.*

Table 5 compares the robustness of supply links established by producers and intermediaries with foreign suppliers. The dependent variable is a dummy indicating whether supply links in period t will break in $t+1$, while the independent variable denotes whether the firm is an intermediary.[9] Columns (1) to (3) perform the analysis at the firm-product (HS6)-origin country level, controlling for the initial number of suppliers, such that the coefficients reflect differences in the probability of a separation. Columns (4) to (6) repeat the analysis at the firm-product-country-supplier level, where the dependent variable is defined for individual relationships. As before, I control for firm and transaction size to compare firms of similar scale and include fixed effects to compare firms within product-country pairs, ensuring they face similar supply conditions. The results indicate significant differences between producers and intermediaries, with intermediated supply links being around 10 percentage points less likely to break.

TABLE 5. Probability of Supply Link Separations: $\mathbb{D}$(separation = 1)

	Firm-product-country			Firm-product-country-supplier		
	(1)	(2)	(3)	(4)	(5)	(6)
Intermediary dummy	-0.115***	-0.114***	-0.113***	-0.094***	-0.095***	-0.092***
	(0.008)	(0.008)	(0.008)	(0.008)	(0.008)	(0.008)
Firm size (sales)	Yes	Yes	Yes	Yes	Yes	Yes
Imported value	Yes	Yes	Yes	Yes	Yes	Yes
Number of suppliers	Yes	Yes	Yes	No	No	No
Product FE (HS6)	No	Yes	No	No	Yes	No
Country FE	No	Yes	No	No	Yes	No
Product - country FE	No	No	Yes	No	No	Yes
Observations	312,724	312,346	289,355	427,739	427,390	406,481

Notes: This table compares the probability of a separation with foreign suppliers for producers and intermediaries. The dependent variable is a dummy indicating whether supply links break from period t to $t+1$, and the independent variable is a dummy indicating whether the firm is an intermediary. Columns (1) - (3) perform the analysis at the firm-HS6 product-origin country level, controlling for the log-number of suppliers. Columns (4) - (6) are at the firm-HS6 product-origin country-supplier level. Controls include firm sales (10 bins) and the import value of the transaction. The sample considers all import transactions in 2018 for firms active in 2018 and 2019. Standard errors are clustered at the firm level.

These patterns are consistent with intermediaries having more robust supply net-

[9] Supply link separations are defined on a yearly basis for this analysis. However, similar patterns emerge when considering breaks over longer intervals (t to $t+k$ with $k>1$), although the number of observations decreases significantly.

works. However, separations can also result from changes in demand conditions that induce firms to stop purchasing from their suppliers. This could affect my results if such shocks differ systematically between producers and intermediaries, as would be the case, for example, if intermediaries also hold more diversified customer portfolios. To address this possibility, I control for changes in firm-level outcomes that respond to changes in downstream conditions, such as firms' total imports and number of suppliers. Table A5 shows that the differences between producers and intermediaries remain significant in this case.[10] Furthermore, Table A4 reports that the average separation rate at the origin country-product level rises with all measures of supply chain risk (geopolitical, economic uncertainty, and trade volatility), highlighting the role of supply-side factors.

Although my focus is on how producers use intermediation services for risk mitigation, rather than microfounding the business model of intermediaries, I discuss potential mechanisms here. One option is that intermediaries match with safer suppliers as they have better *screening* capabilities, which can be explored by introducing supplier fixed effects. Another possibility is that intermediaries are more important customers, allowing them to be placed *first-in-line* when suppliers face disruptions. This can be assessed by controlling for the share of buyers in suppliers' total sales. Furthermore, intermediaries may source different products from the same supplier, allowing them to keep relationships alive in the presence of *product-specific shocks*. This can be tested by defining supply links at the supplier-product level. Table 6 shows that each channel individually reduces the differences between intermediaries and producers by about 3 pp. When all three are accounted for simultaneously, the probability of a separation is only 2 pp lower for intermediaries, explaining a significant part of the results in Table 5.

3. Theoretical Framework

I develop a general equilibrium model of global sourcing with supply chain risk and trade intermediation. Specifically, I model the problem of final goods producers sourcing inputs from discrete sets of locations and suppliers. Producers trade off input costs and disruption probabilities when choosing source locations. At each location, producers have two mechanisms to mitigate disruptions: matching directly with multiple suppliers (diversification) or sourcing inputs indirectly (intermediation), where the intermediation technology inherits the features documented in the data. The model characterizes producers' optimal sourcing strategies and rationalizes higher intermediation shares in

[10] These demand factors are also incorporated when calibrating disruption probabilities for model estimation in Section 5.

TABLE 6. Potential Mechanisms for Differences in Link Separations

	Firm-product-country-supplier				
	(1)	(2)	(3)	(4)	(5)
Intermediary dummy	-0.092***	-0.060***	-0.068***	-0.069***	-0.024***
	(0.008)	(0.008)	(0.007)	(0.007)	(0.007)
Supplier FE	No	Yes	No	No	Yes
Share in supplier's sales	No	No	Yes	No	Yes
Firm-supplier-product links	No	No	No	Yes	Yes
Firm size (sales)	Yes	Yes	Yes	Yes	Yes
Imported value	Yes	Yes	Yes	Yes	Yes
Product - country FE	Yes	Yes	Yes	Yes	Yes
Observations	406,481	352,770	406,481	406,481	352,770

Notes: This table explores mechanisms behind the lower supplier separation rates of intermediaries. Column (1) is identical to column (6) in Table 5. Column (2) includes supplier fixed effects to account for the possibility that intermediaries are better at screening suppliers. Column (3) controls for the share of buyers in suppliers' total sales to address whether intermediaries are more important customers. Column (4) defines supply links at the buyer-supplier-product level to assess if differences are driven by intermediaries sourcing multiple products per supplier. Column (5) combines all potential mechanisms.

response to risk.

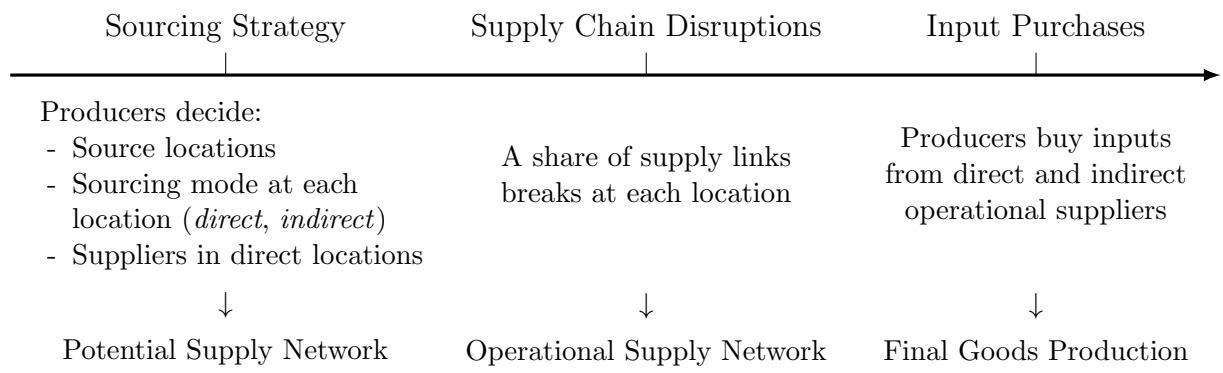
3.1. Setup

Timing. The model is static but producers make decisions in sequential stages. In the first stage, producers define their sourcing strategies to maximize expected profits. This includes the set of source locations, the sourcing mode at each location (i.e., directly or indirectly through an intermediary), and the set of suppliers when sourcing directly. These choices involve sunk investments and define a *potential network* of direct and indirect suppliers. Secondly, supply chain disruptions are realized, such that a share of supply links break at each location. Finally, producers make optimal input purchases and production decisions conditional on their *operational network*. Figure 2 summarizes the timeline of events.[11]

Input Markets. There is a discrete set of source locations $\mathcal{L}$, each populated by a discrete set of suppliers $\mathcal{S}_l$. Locations differ in trade and production costs ($\tau_{il}\alpha_l$), the

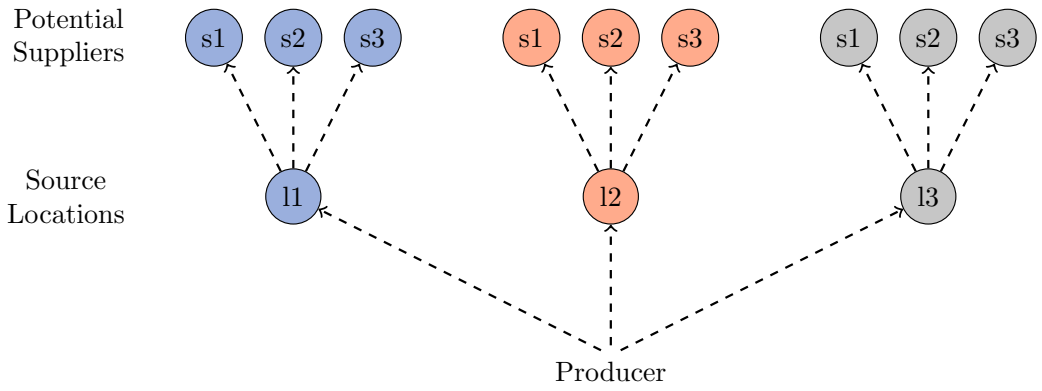
[11]Note that the concept of *location* can accommodate different geographic and industry partitions. In my context, *locations* can be thought of as markets defined by the origin country and HS-sector of the intermediate goods.

FIGURE 2. Timeline of Events



probability of disruptions (ζ_l), and fixed sourcing costs (f_l). As long as these dimensions are not perfectly correlated, supply chain risk imposes additional trade-offs for producers in sourcing decisions. I assume that each location offers a differentiated input x_l that can be produced by all local suppliers. I first consider suppliers with homogeneous productivity, normalized to one, such that input prices are simply $p^x_{il} = \tau_{il}\alpha_l$.[12] In this case, suppliers are perfect substitutes and precautionary motives are the only reason to establish multiple links in the same location. I then consider variety-specific efficiencies that generate imperfect substitution across suppliers. Figure 3 illustrates the structure of input markets.

FIGURE 3. Input Markets with Discrete Locations and Suppliers



[12] I abstract from providing a detailed microfoundation of input markets. However, α_l can be rationalized as the unit cost of production in a setting with perfect competition (e.g., $\alpha_l = \frac{w_l}{\phi_l}$ for wages w_l and labor productivity ϕ_l when inputs use only labor under constant returns to scale). It can also account for constant markups in settings with monopolistic competition.

Supply Chain Risk. I model supply chain disruptions as shocks that break the links established with suppliers in the first stage. This captures any failures in production and distribution that prevent suppliers from serving their customers. Thus, if a link is disrupted in location l, the firm cannot purchase l-inputs unless it has another link operational.[13] Formally, I consider a discrete shock Z_l^M that disrupts supply links with an exogenous probability ζ_l^M and leaves them operational otherwise, allowing for differences across locations l and sourcing modes M. The assumption of independent disruptions affecting supply links adds tractability and is consistent with the low correlation across supplier separations observed in the data.[14] However, it is straightforward to accommodate location-level disruptions that introduce some degree of correlation across suppliers, which is considered as an extension.

Sourcing Modes. Producers have two modes to buy inputs from a given location l. Under direct sourcing, producers select a set of suppliers S_l^D, face disruption probability ζ_l^D, and incur matching costs $f_l^D(S_l^D)$ that increase with the number of supply relationships. Under indirect sourcing, intermediaries charge a brokerage fee κ on input prices and offer a sourcing technology $\{S_l^I \geq S_l^D,\ \zeta_l^I \leq \zeta_l^D\}$, consistent with the empirical evidence in Section 2.2. The fixed cost of contracting with intermediaries is assumed to be lower than that of matching with suppliers directly, $f_l^I \leq f_l^D(\cdot)$.[15] Thus, producers have two risk mitigation strategies: they can engage in *diversification* by transacting directly with multiple suppliers, which involves higher matching costs, or they can opt for *intermediation*, accessing a resilient network at the expense of higher input prices. Figure 4 illustrates both sourcing modes before and after the realization of disruptions.

3.2. Final Demand

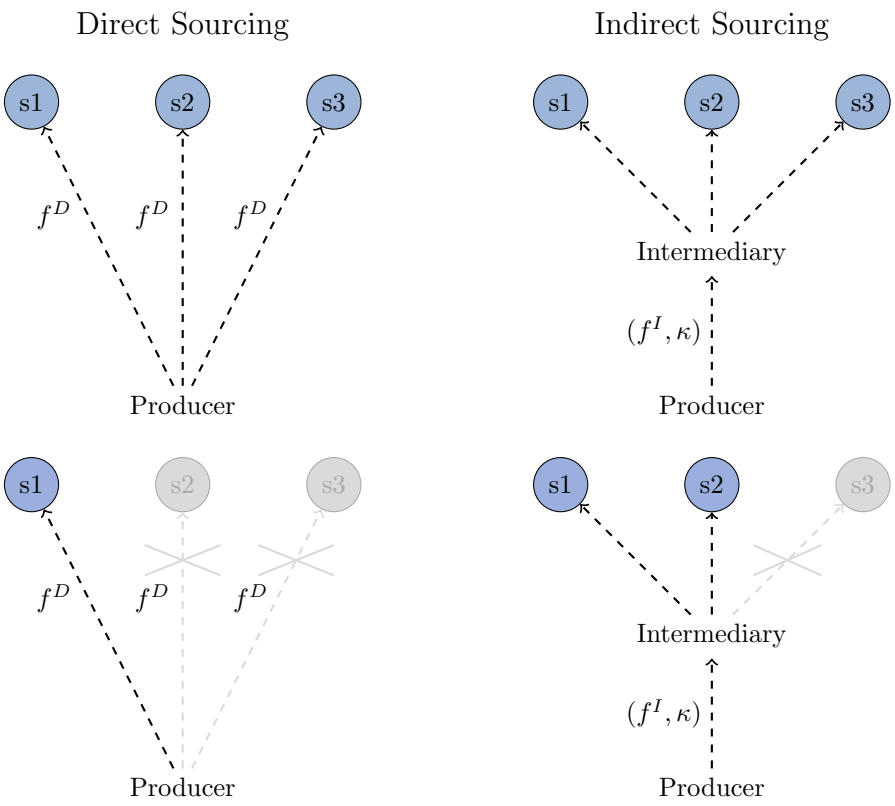
Consumers in country i have Cobb-Douglas preferences over homogeneous and differentiated final goods. The homogeneous good q_{i0} is freely traded and produced using labor under constant returns to scale, such that one unit of labor generates w_i units of

[13] This *on-and-off* approach is analogous to *percolation analysis* in graph theory (i.e., disabling edges at random). While my model considers supply networks that are bi-partite in nature, Elliott et al. (2022) implement this approach in the context of complex networks with multiple layers.

[14] The correlation for supplier separations within the same buyer-product-origin country is around 0.09, suggesting that a substantial part of disruptions can be treated as idiosyncratic (Table A6). This aligns with business reports indicating that idiosyncratic failures are the most frequent disruptions (McKinsey 2020).

[15] The idea of intermediaries reducing fixed costs in exchange for a markup is well-established in the trade literature (Ahn et al. 2011; Bernard et al. 2015) and underlies recent works on intermediated production networks (Blum et al. 2024; Manova et al. 2024). My setting follows this insight but emphasizes the role that the characteristics of the intermediation technology play in the context of supply chain risk.

FIGURE 4. Sourcing Modes and Disruptions within Locations



output. Using the homogeneous good as *numeraire* sets wages to w_i. Consumers exhibit CES preferences for varieties $\omega \in \Omega_i$ of the non-tradable differentiated final good:

$$U_i = q_{i0}^{1-\beta}\left(\int_{\Omega_i} q_i(\omega)^{\frac{\sigma-1}{\sigma}} d\omega\right)^{\beta\sigma/(\sigma-1)}$$

where β is the expenditure share on differentiated goods, and $\sigma > 1$ is the elasticity of substitution across varieties. Given aggregate expenditure E_i and the price index P_i for differentiated goods, demand for variety ω with price $p_i(\omega)$ is:

$$q_i(\omega) = p_i(\omega)^{-\sigma} P_i^{\sigma-1} E_i \tag{3}$$

3.3. Producers

Country i contains a continuum of heterogeneous final goods producers. They own a blueprint for a single variety ω under monopolistic competition, and draw productivity $\varphi \in [\underline{\varphi}_l, \overline{\varphi}_l]$ from some distribution $G(\varphi)$. The production technology transforms

intermediate inputs into final goods under constant returns to scale:

$$q_i(\omega) = \varphi(\omega) X_i(\omega), \qquad X_i(\omega) = \left(\sum_{l \in \mathcal{L}(\omega)} x_{il}(\omega)^{\frac{\eta-1}{\eta}} \right)^{\frac{\eta}{\eta-1}} \tag{4}$$

where $X(\omega)$ is a composite intermediate combining inputs with an elasticity of substitution $\eta > 1$, and $x_{il}(\omega)$ is the quantity purchased from each location to which the producer has access, as indicated by $\mathcal{L}(\omega)$.[16] The marginal cost of producers thus depends on their own productivity and their input cost $C(\omega)$, which aggregates the prices $p_{il}^{x,M}(\omega)$ paid for inputs across locations given a sourcing mode M:

$$c_i(\omega) = \frac{C_i(\omega)}{\varphi(\omega)}, \qquad C_i(\omega) = \left(\sum_{l \in L(\omega)} p_{il}^{x,M}(\omega)^{1-\eta} \right)^{\frac{1}{1-\eta}} \tag{5}$$

Producers pay the price set by suppliers under direct sourcing, while the brokerage fee takes the form of a constant markup, thereby increasing indirect input prices:

$$p_{il}^{xI} = \kappa \, p_{il}^{xD} \tag{6}$$

Input prices are not affected by the number of suppliers as they are initially assumed to be perfect substitutes within locations. Thus, the only reason for having multiple suppliers is to ensure input access, focusing the analysis on precautionary motives before incorporating additional mechanisms. Across locations, on the other hand, the CES structure generates variety gains. This assumption is reasonable if locations offer differentiated inputs that are imperfect substitutes in production, but analogous insights are obtained under perfect substitutability.[17] Note that heterogeneous producers will optimally make different decisions regarding the set of source locations and the sourcing mode and suppliers within them. Moreover, even if producers make identical decisions, the realization of disruptions may lead to different outcomes.[18]

[16] I assume that inputs are the only factor of production for differentiated final goods. Although incorporating labor in a technology of the form $q(\omega) = \varphi(\omega) L(\omega)^{\beta} X(\omega)^{1-\beta}$ is straightforward, it adds complexity to the derivations without providing additional insights into sourcing responses.

[17] In this case $\eta \to \infty$ and the production function is $q_i(\omega) = \varphi(\omega) \left(\sum_{l \in \mathcal{L}(\omega)} x_{il}(\omega) \right)$, such that the only incentive for having multiple locations is to ensure that at least one remains active. However, even if not necessarily driven by variety effects, the literature on global value chains suggests that firms benefit from sourcing inputs in multiple origins (Antràs et al. 2017; Huang et al. 2024).

[18] I consistently use ω to index producers to avoid confusion on this matter. However, note that two producers with the same productivity φ will make the same sourcing decisions *ex-ante*.

3.4. Optimal Sourcing in One Location

I start by characterizing the producer's problem when only one input location is available. I then extend this analysis to the general case with an arbitrary set of locations. Given the timing of events, producers make decisions in two steps. First, they select their optimal sourcing strategy internalizing the probability of disruptions. After disruptions materialize, they make optimal input purchases and production decisions. I work in reverse order, starting with the *ex-post* problem followed by the *ex-ante* problem given the *ex-post* solution.

Ex-Post Problem. Producers have already selected a sourcing mode $M_l(\omega)$ and a set of suppliers $S_l^D(\omega)$ when sourcing directly, and supply chain disruptions Z_l have materialized in the single location l. Conditional on these choices and realizations, producers make input purchases and production decisions to maximize their *ex-post* operating profits:

$$\max_{p_i(\omega),\, q_i(\omega),\, x_{il}(\omega)} \pi_i^{\text{ex-post}}\left(\omega \,\middle|\, M_l, S_l^D, Z_l\right) = \left[p_i(\omega) - c_i\left(\omega \,\middle|\, M_l, S_l^D, Z_l\right)\right] q_i(\omega)$$

Given final demand (3) and monopolistic competition, producers optimally set a constant markup over their marginal cost such that $p_i(\omega) = \frac{\sigma}{\sigma-1} c_i(\omega \,|\, M_l, S_l^D, Z_l)$, which determines downstream quantities and therefore input purchases according to the production technology (4). The marginal production cost depends on the *ex-ante* sourcing strategy and disruption realizations. Conditional on direct sourcing, producer ω has access to inputs at a price p_{il}^{xD} if at least one direct link remains operational. Similarly, under indirect sourcing, inputs can be bought at p_{il}^{xI} if the intermediary has at least one operational supplier. In other scenarios, $p_{il}^{x} \to \infty$ as the supply network of the producer is not operational.[19] The solution to the *ex-post* profits can then be expressed as:

$$\pi_i^{\text{ex-post}}\left(\omega \,\middle|\, M_l, S_l^D, Z_l\right) = \begin{cases} \varphi(\omega)^{\sigma-1}\left(p_{il}^{x,M}\right)^{1-\sigma} \frac{1}{\sigma}\left(\frac{\sigma}{\sigma-1}\right)^{1-\sigma} P_i^{\sigma-1} E_i & \text{if operational} \\ 0 & \text{otherwise} \end{cases} \tag{7}$$

Indirect sourcing reduces *ex-post* profits conditional on network operability. The

[19] While losing access to l-inputs leads to zero operational profits in this simplified setting, the impact of disruptions is smoother in the general case with multiple locations. This is particularly true when a *safer* location is available (e.g., inputs sourced domestically may be less prone to some disruptions). In that case, disruptions increase marginal production costs without forcing firms out of the market.

brokerage fee increases input costs as stated by (6), which raises producers' marginal costs and is passed on to consumers in the form of higher final good prices. This, in turn, reduces producers' competitiveness and market shares downstream. On the other hand, inspection of (7) reveals a *negative* complementarity between firm productivity and input costs. This implies that even if intermediaries charge constant markups, the intermediation cost is higher for more productive firms.

PROPOSITION 1. *Conditional on network operability, producers' ex-post profits are lower under indirect sourcing, and the cost of intermediation increases with producer productivity.*

Proof. *See Appendix C.*

Ex-Ante Problem. Before disruptions are realized, producers define their optimal sourcing strategy $\left(M_l(\omega),\, S_l^D(\omega)\right)$ at location l to maximize expected profits, where $M_l(\omega) \in \{D, I\}$ and $S_l^D(\omega) \in \mathcal{S}_l$. Considering the solution to the *ex-post* problem in (7), the producer's *ex-ante* problem can be expressed as:

$$\max_{\mathtt{M}_l(\omega)\in\{D,I\},\; S_l^D(\omega)\in\mathcal{S}_l} \mathbb{E}\Big[\pi_i^{\text{ex-ante}}\big(\omega, M_l, S_l^D, Z_l\big)\Big] = \mathbb{E}\Big[\pi_i^{\text{ex-post}}\big(\omega, M_l, S_l^D, Z_l\big)\Big] - \mathbb{I}_{\{M_l(\omega)=D\}}\, f_l^D\big(S_l^D(\omega)\big) - \mathbb{I}_{\{M_l(\omega)=I\}}\, f_l^I$$

where $\mathbb{I}_{\{M_l\}}$ are indicator variables for the selected sourcing mode, f_l^D is the cost of matching directly with suppliers, and f_l^I is the cost of contracting with an intermediary. Given the irreversible nature of these payments, the expectation operates over *ex-post* profits, specifically over the input costs that determine producers' marginal cost $c_i(\omega)$.[20]

Sourcing decisions represent a combinatorial discrete choice problem, where firms have $2^{|\mathcal{S}_l|+2}$ possibilities at location l. The cardinality of the supplier set in l indicates the number of options under direct sourcing, in addition to the options of using intermediaries or not sourcing inputs from l. However, if suppliers are at least *ex-ante* homogeneous from the producer's perspective, the dimensionality of the problem is reduced to $|\mathcal{S}_l| + 2$ choices. While there is no closed-form solution to this problem, Proposition 2 characterizes producers' optimal sourcing decisions.

[20] In principle, we have $\mathbb{E}[\pi_i^{\text{ex-post}}(\omega, M_l, S_l^D, Z_l)] = \mathbb{E}[c_i(\omega, M_l, S_l^D, Z_l)^{1-\sigma} B]$, where $B \equiv \frac{1}{\sigma}\left(\frac{\sigma}{\sigma-1}\right)^{1-\sigma} P^{\sigma-1} E$ summarizes final demand. Under idiosyncratic disruptions and atomistic firms, we can assume that producers only internalize their own disruptions and treat B as given, although this assumption may not hold under correlated shocks. The numerical solution of the model allows for both possibilities.

PROPOSITION 2. *Producers' ex-ante sourcing problem is such that:*

a. *Diversification ($M_l = D$, $S_l^D > 1$) and intermediation ($M_l = I$) increase supply network operability for producers.*
b. *The optimal number of direct suppliers (weakly) increases with firm productivity: $S_l^D(\varphi^H) \geq S_l^D(\varphi^L)$ for $\varphi^H \geq \varphi^L$.*
c. *The choice of direct sourcing (weakly) increases with firm productivity: $\mathbb{I}_{\{M_l=D\}}(\varphi^H) \geq \mathbb{I}_{\{M_l=D\}}(\varphi^L)$ for $\varphi^H \geq \varphi^L$.*

Proof. *See Appendix C.*

Sourcing from location l requires that at least one supply link remains operational after disruptions. A larger number of direct suppliers naturally increases the probability of network operability, while intermediaries offer both more suppliers and less frequent disruptions. Part (b) states that more productive firms are more likely to diversify when sourcing directly. Higher productivity amplifies the gains from network operability, leading to selection among producers in the presence of matching costs. Part (c), on the other hand, indicates that more productive firms are more likely to source directly.[21] These firms can protect themselves by diversifying directly and avoid the brokerage fee, which, as stated in Proposition 1, imposes a greater penalty on them. Note that this setting rationalizes heterogeneous risk responses among firms that are intrinsically risk-neutral.[22]

Direct and Indirect Sourcing. I further characterize how producers sort into different sourcing modes. The expected *ex-ante* profits of producer ω under direct sourcing, given a particular choice of suppliers $S_l^D(\omega)$, and the equivalent expression for indirect sourcing are:

$$\mathbb{E}\left[\pi_i^{\text{ex-ante}}(\omega) \,\middle|\, D, S_l^D(\omega)\right] = \mathbb{E}\left[\left(p_{il}^x\right)^{1-\sigma} \,\middle|\, D, S_l^D(\omega)\right]\varphi(\omega)^{\sigma-1}B_i - f_l^D\left(S_l^D\right) \tag{8}$$

$$\mathbb{E}\left[\pi_i^{\text{ex-ante}}(\omega) \,\middle|\, I\right] = \mathbb{E}\left[\left(p_{il}^x\right)^{1-\sigma} \,\middle|\, I\right]\varphi(\omega)^{\sigma-1}B_i - f_l^I \tag{9}$$

[21] High-productivity firms may use intermediaries in locations where low-productivity firms refrain from sourcing. This is consistent with Proposition 2, which only rules out the case where low-productivity firms source directly and high-productivity firms source indirectly from the same location. The choice of the sourcing mode is thus monotonic with respect to firm productivity.

[22] Although the baseline model considers independent disruptions on supply links, Proposition 2 also holds under correlated shocks. For instance, producers may face location-level shocks that affect all local suppliers with some probability ξ_l.

which depend on expected input costs and fixed matching costs under each mode, firms' core productivity, and final demand $B_i \equiv \frac{1}{\sigma}\left(\frac{\sigma}{\sigma-1}\right)^{1-\sigma} P^{\sigma-1}E$. Under idiosyncratic disruptions, the number of operational suppliers follows a Binomial distribution, which provides a simple expression for the probability that a network is operational. Expected input costs for each case can be expressed as:

$$\mathbb{E}\left[\left(p_{il}^{x}\right)^{1-\sigma} \middle| D, S_l^D(\omega)\right] = \left(1 - \left(\zeta_l^D\right)^{S_l^D(\omega)}\right)\left(p_{il}^{x}\right)^{1-\sigma} \tag{10}$$

$$\mathbb{E}\left[\left(p_{il}^{x}\right)^{1-\sigma} \middle| I\right] = \frac{\left(1 - \left(\zeta_l^I\right)^{S_l^I}\right)}{\kappa^{\sigma-1}}\left(p_{il}^{x}\right)^{1-\sigma} \tag{11}$$

To analyze how this expectation varies with the sourcing mode, I define a mapping $\widetilde{S}_l^I$ that transforms the intermediation technology $\{S_l^I, \zeta_l^I, \kappa\}$ into an *equivalent* number of direct suppliers:

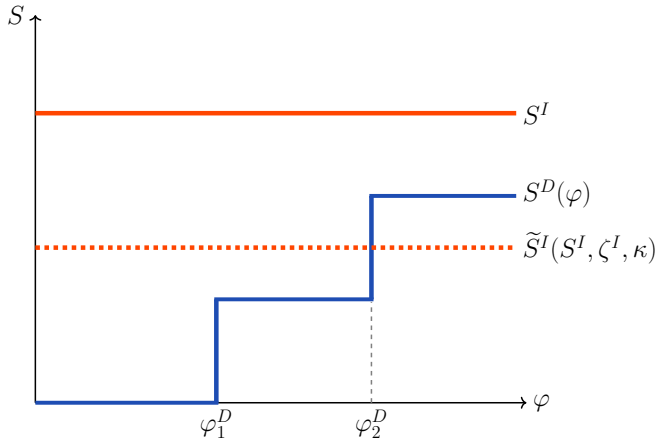
$$\begin{aligned}\widetilde{S}_l^I\left(S_l^I, \zeta_l^I, \kappa\right) &\equiv \left\{S : \mathbb{E}\left[\left(p_{il}^{x}\right)^{1-\sigma} \middle| D, S\right] = \mathbb{E}\left[\left(p_{il}^{x}\right)^{1-\sigma} \middle| I\right]\right\} \\ &= \frac{\left|\ln\left(1 - \frac{1 - (\zeta^I)^{S^I}}{\kappa^{\sigma-1}}\right)\right|}{\left|\ln(\zeta^D)\right|}\end{aligned} \tag{12}$$

A producer that can match directly with $S_l^D(\omega) > \widetilde{S}_l^I$ suppliers would incur higher expected input costs by using intermediaries, while the opposite is true if $S_l^D(\omega) < \widetilde{S}_l^I$. Although indirect sourcing always implies higher input costs *ex-post*, from an *ex-ante* perspective, expected input costs can be lower or higher depending on the direct alternative and the resilience of the intermediation technology. It follows that $\widetilde{S}_l^I$ increases with a greater number of indirect suppliers S^I and less frequent indirect disruptions ζ^I, and decreases with a higher brokerage fee κ.[23]

Figure 5 illustrates these patterns across the distribution of producers. The blue line depicts the optimal choice of direct suppliers, which, as described in Proposition 2, follows a step function on firm productivity. The solid red line shows the number of suppliers that all producers access when sourcing indirectly, while the dashed line indicates the *equivalent* number of direct suppliers. Producers with productivity $\varphi_1^D < \varphi <$

[23] I assume that the resilience of the intermediation technology does not fully compensate for the brokerage fee, such that $\widetilde{S}^{P,I} < S^{P,I}$. The contribution of a direct supplier in reducing expected input costs is thus greater than that of indirect suppliers. This assumption is consistent with the data, as all producers would source through intermediaries otherwise.

FIGURE 5. Direct and Indirect Sourcing



Notes: The blue line shows the optimal number of suppliers under direct sourcing, $S^D(\varphi)$. The solid red line shows the intermediation technology, which provides access to S^I indirect suppliers. The dashed red line indicates the *equivalent* number of indirect suppliers $\widetilde{S}^I(S^I, \zeta^I, \kappa)$, after accounting for indirect disruption probabilities and the brokerage fee. Producers are sorted by productivity on the x-axis.

φ_2^D match with one supplier when sourcing directly, whereas producers with productivity $\varphi > \varphi_2^D$ diversify suppliers. Consequently, intermediaries decrease expected input costs for the former, while the latter can achieve lower input costs by diversifying directly.

To make optimal sourcing decisions, producers compare expected *ex-ante* profits under direct sourcing (8), evaluating each possible choice of direct suppliers, with those under indirect sourcing (9). Figure 6 plots these curves and displays producers' optimal sourcing modes. Since contracting with intermediaries is cheaper than matching suppliers directly, $f^I < f_l^D(S_l^D)$, indirect sourcing reduces both expected input costs and fixed costs for firms below φ_2^D, while imposing a trade-off for more productive ones. Firms in the productivity range $[\varphi^I, \varphi^*]$ source indirectly, while firms with productivity $\varphi > \varphi^*$ opt for direct sourcing.[24] Note that firms between φ_2^D and φ^* could further reduce expected input costs through direct diversification, but source indirectly to save on matching costs. Proposition 3 formalizes the role of input intermediation.

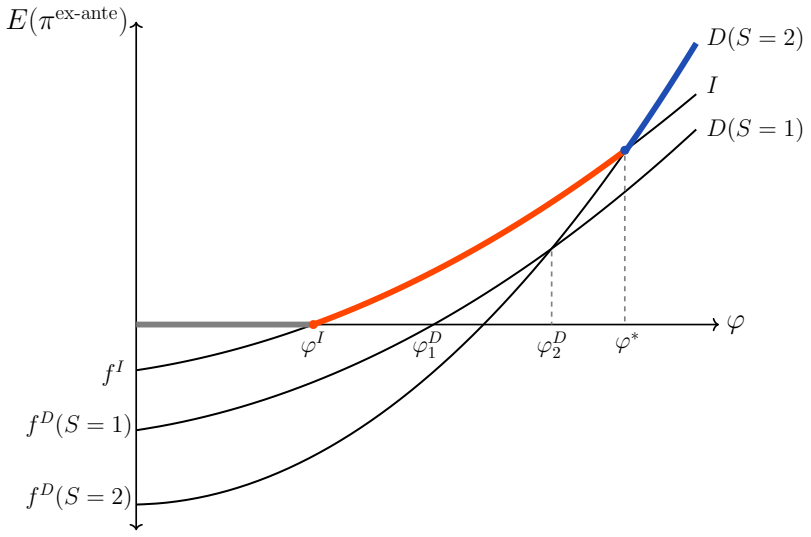
PROPOSITION 3. *Given final demand B, input intermediation in source location l:*

a. *Reduces (increases) expected input costs for producers that can match fewer (more) than* $\widetilde{S}_l^I(S_l^I, \zeta_l^I, \kappa)$ *suppliers directly.*

b. *Takes place if the technological condition* $\frac{1-(\zeta_l^I)^{S_l^I}}{1-(\zeta_l^D)^{S_l^D}} > \frac{\kappa^{\sigma-1} f_l^I}{f_l^D(S_l^D)}$ *is satisfied for* $S_l^D \in |S_l|$.

[24] While this strict sorting pattern is unlikely to hold in the data, deviations can be rationalized if producers exhibit heterogeneous matching costs that are not perfectly correlated with their productivity (Bernard et al. 2022; Manova et al. 2024). I allow for this possibility in the numerical solution.

FIGURE 6. Optimal Sourcing Strategy



Notes: This figure illustrates sourcing modes from a given location l. Each curve displays expected *ex-ante* profits under a given strategy: sourcing directly from one ($D(S=1)$) or two ($D(S=2)$) suppliers, or sourcing indirectly (I). Firms are sorted by productivity on the x-axis. Firms on the gray segment do not source from l, those on the red segment source indirectly, and those on the blue segment source directly.

c. *Implies a productivity threshold φ^* where firms switch from indirect to direct sourcing:*

$$\varphi_l^* = \min_{S_l^D} \left[\frac{f_l^D(S_l^D) - f_l^I}{\left(1 - (\zeta_l^D)^{S_l^D} - \frac{1-(\zeta_l^I)^{S^I}}{\kappa^{\sigma-1}}\right)\left(P_{il}^x\right)^{1-\sigma} B} \right]^{\frac{1}{\sigma-1}} \quad \text{for } S_l^D \in |\mathcal{S}_l|$$

Proof. *See Appendix C.*

Part (a) explains how intermediaries affect expected input costs, given the number of suppliers that the firm could match directly. As discussed above, more productive firms can achieve lower expected costs by diversifying on their own, incurring higher matching costs but avoiding the brokerage fee. Parts (b) and (c) characterize the productivity range where firms source indirectly. Part (b) specifies a technological condition that must be satisfied for this range to be active. Intuitively, the greater resilience of the intermediation technology must compensate for the brokerage fee once adjusted for reductions in matching costs. Part (c) provides a closed-form expression for the productivity threshold where firms switch from indirect to direct sourcing.[25] This threshold is determined by the minimum choice of direct suppliers required to equalize *ex-ante* expected profits for

[25]Although downstream demand B is taken as given, Proposition 3 offers meaningful insights into the forces behind producers' sourcing decisions. In practice, the productivity thresholds are general-equilibrium objects that will depend on the decisions made by all producers.

direct and indirect sourcing. As expected, the threshold increases with greater matching costs, a more resilient intermediation technology, and higher input costs.

Supply Chain Risk. I analyze how producers adapt to changes in the frequency of disruptions. These changes shift the productivity thresholds defined above, as producers re-optimize their sourcing strategies. Ultimately, these responses determine how the share of intermediated inputs varies with supply chain risk.

Proposition 4 describes the effect of a proportional increase in direct and indirect disruption probabilities.[26] Part (a) states that some firms previously sourcing indirectly stop sourcing from l. Higher supply chain risk reduces the profitability of inputs from l, thereby increasing the minimum productivity required to source indirectly, φ_l^I.[27] Part (b) demonstrates that some producers previously sourcing directly switch to intermediaries. An increase in disruption probabilities reduces expected profits under both sourcing modes, but the impact is more pronounced for direct sourcing, increasing the switching threshold φ_l^*. Intuitively, the attributes of the intermediation technology are more valuable when disruptions are frequent, amortizing the cost of the brokerage fee. Part (c) shows that firms continuing to source directly have greater incentives for diversification. In this case, the value of backup suppliers increases in relative terms, reducing the productivity cutoffs where firms add another match, φ_S^D for $S \geq 2$.[28]

PROPOSITION 4. *Given final demand B and moderate disruption probabilities $\zeta_l \equiv \{\zeta_l^D, \zeta_l^I\}$ in source location l, a proportional increase in ζ_l:*

a. *Induces firms previously sourcing indirectly to stop sourcing from l: $\varphi^I(\zeta_l') \geq \varphi^I(\zeta_l)$*

b. *Induces firms previously sourcing directly to switch sourcing modes: $\varphi^*(\zeta_l') \geq \varphi^*(\zeta_l)$*

c. *Induces firms that keep sourcing directly to diversify suppliers: $\varphi_S^D(\zeta_l') \leq \varphi_S^D(\zeta_l)$ for $S \geq 2$*

Proof. *See Appendix C.*

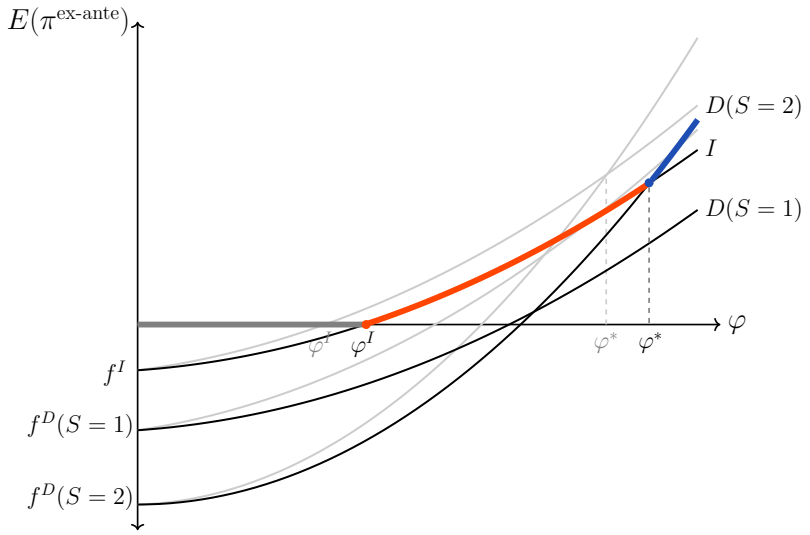
Figure 7 illustrates these patterns. The difference in slopes for expected profits under direct (8) and indirect sourcing (9), given a particular choice of direct suppliers, is

[26] One can think of intermediaries as being able to lower the probability of disruptions by some factor $\mu < 1$, such that $\zeta^I = \mu\zeta^D$. Therefore, changes in ζ^D generate proportional changes in ζ^I.

[27] Higher disruption probabilities make direct sourcing even less profitable for these firms. Therefore, in this single-location setting, producers in the productivity range $[\varphi_l^I(\zeta_l), \varphi_l^I(\zeta_l')]$ are driven out of the market. These firms may be able to substitute inputs in the general, multi-location case.

[28] Since disruptions reduce expected profits, they increase the productivity level φ_1^D at which sourcing from one direct supplier is profitable. Conditional on direct sourcing, this implies that fewer firms will source directly as supply chain risk increases, but those that source will be more likely to diversify.

FIGURE 7. Higher Probability of Disruptions



Notes: This figure illustrates how *ex-ante* expected profits evolve with an increase in the probability of disruptions. Each curve represents a sourcing strategy: sourcing directly from one ($D(S=1)$) or two ($D(S=2)$) suppliers, or sourcing indirectly (I). The lighter curves indicate profits before the increase in supply chain risk. Firms are sorted by productivity on the x-axis. Firms in the gray segment do not source from l, those in the red segment source indirectly, and those in the blue segment source directly.

$m^*(\zeta_l) \equiv \left(1-(\zeta_l^D)^{S_l^D} - \frac{1-(\zeta_l^I)^{S^I}}{\kappa^{\sigma-1}}\right)\left(p_{il}^x\right)^{1-\sigma}\varphi^{\sigma-1}B_i$. Considering the characteristics of the intermediation technology, $m^*(\zeta_l)$ shrinks as supply chain risk increases, which shifts the intersection between indirect profits and that direct curve to the right.[29] Note that if $m^*(\zeta_l) < 0$ for all possible choices of direct suppliers, then all producers would use intermediaries, as indirect profits would exhibit both a lower intercept and a higher slope than direct alternatives. On the other hand, the slope difference for direct profits under supplier choices $S+1$ and S is $m^D(\zeta_l) \equiv \left((\zeta_l^D)^S - (\zeta_l^D)^{S+1}\right)\left(p_{il}^x\right)^{1-\sigma}\varphi^{\sigma-1}B_i$, which expands with supply chain risk as long as $\zeta_l^D \leq \frac{S}{S+1}$. This shifts the intersection between direct profit curves to the left.

Equation (13) provides an expression for the share of intermediated inputs as a function of disruption probabilities. This object depends on the productivity cutoffs $\varphi_l^I(\zeta_l)$ and $\varphi_l^*(\zeta_l)$ and the productivity distribution more broadly. On the extensive margin, producers' risk responses affect the intermediation share in opposite directions, as both productivity thresholds $\varphi^I(\zeta)$ and $\varphi^*(\zeta)$ increase. On the intensive margin, the change in the composition of indirect buyers increases the intermediation share.

[29] Under a realistic calibration of the intermediation technology, this condition is always satisfied. More generally, this expression shrinks as long as the probability of disruptions is not particularly high. It can be shown that $\zeta_l \leq 0.5$ is a sufficient condition for this (see Appendix C.4 for details).

Producers exiting indirect sourcing are in the productivity range $[\varphi_l^I(\zeta_l), \varphi_l^I(\zeta_l')]$, which is below that of new indirect buyers, $[\varphi_l^*(\zeta_l), \varphi_l^*(\zeta_l')]$. These forces jointly determine the effect of supply chain risk, which is positive according to the empirical evidence presented in Section 2.

$$\frac{\widetilde{X}_{il}^I(\zeta_l)}{\widetilde{X}_{il}(\zeta_l)} = \frac{1}{1 + \dfrac{\int_{\varphi_l^*(\zeta_l)}^{\overline{\varphi}_l} \varphi^{\sigma-1}\, dG(\varphi)}{\kappa^{1-\sigma} \int_{\varphi_l^I(\zeta_l)}^{\varphi_l^*(\zeta_l)} \varphi^{\sigma-1}\, dG(\varphi)}} \tag{13}$$

3.5. Optimal Sourcing with Multiple Locations

The one-location setting allowed me to characterize how producers choose sourcing modes in the presence of supply chain risk. I now present producers' global sourcing problem when they can access a discrete set of $\mathcal{L}$ locations offering differentiated inputs. A sourcing strategy is a triplet $\left\{L(\omega), M_l(\omega), S_l^D(\omega)\right\}$ that includes the producer's set of source locations, the sourcing mode at each location, and the number of suppliers per location under direct sourcing. Producers thus have an additional margin of adjustment to supply chain risk, as they trade off input prices $p_{il}^{x,M}$ and disruption probabilities ζ_l^M across locations.

As before, producers make decisions in two steps, selecting their sourcing strategies before disruptions materialize, and making input purchases and production decisions after disruptions. The *ex-post* solution is analogous to that of the single-location case (7), but the producer's input cost incorporates the prices obtained in each operational location, as described by (5). Therefore, producers' *ex-post* profits can be expressed as:

$$\pi_i^{\text{ex-post}}\left(\omega \,\middle|\, L, M_l, S_l^D, Z_l\right) = \begin{cases} \varphi(\omega)^{\sigma-1} \left(\sum_{L(\omega)} \left(p_{il}^{x,M}(\omega) \right)^{1-\eta} \right)^{\frac{1-\sigma}{1-\eta}} B & \text{if operational} \\ 0 & \text{otherwise} \end{cases} \tag{14}$$

where $B \equiv \frac{1}{\sigma} \left(\frac{\sigma}{\sigma-1} \right)^{1-\sigma} P_i^{\sigma-1} E_i$ and $\eta > 1$ is the elasticity of substitution across inputs from different locations. Conditional on the *ex-post* solution, the producer's *ex-ante* problem is:

$$
\begin{aligned}
\max_{\substack{L(\omega)\in\mathcal{L}\\ \{M_l(\omega)\in\{D,I\}\}\\ \{S_l^D(\omega)\in\mathcal{S}_l\}}} \quad & \mathbb{E}\Big[\pi_i^{\text{ex-ante}}\big(\omega, L, M_l, S_l^D, Z_l\big)\Big] = \mathbb{E}\Big[\pi_i^{\text{ex-post}}\big(\omega, L, M_l, S_l^D, Z_l\big)\Big] \\
& - \sum_{L(\omega)} \mathbb{I}_{\{M_l(\omega)=D\}} f_l^D\big(S_l^D(\omega)\big) - \sum_{L(\omega)} \mathbb{I}_{\{M_l(\omega)=I\}} f_l^I
\end{aligned} \tag{15}
$$

In the spirit of Antràs et al (2017), expected *ex-post* profits are an increasing function of the producer's expected *sourcing capability*:

$$
\mathbb{E}\Big[\pi_i^{\text{ex-post}}\big(\omega, L, M_l, S_l^D, Z_l\big)\Big] = \varphi(\omega)^{\sigma-1}\,\mathbb{E}\left[\Theta\Big(\omega, L, M_l, S_l^D, Z_l\Big)^{\frac{\sigma-1}{\eta-1}}\right] B \tag{16}
$$

where $\Theta \equiv \sum_L \left(p_{il}^{x,M}\right)^{1-\eta}$. Sourcing decisions influence this capability through various channels. At the outer level, a larger set of locations generates input variety gains and increases network operability, with more efficient and less risky locations making a greater contribution. At the inner level, the sourcing mode affects expected input prices as in the one-location case, which also applies to the number of suppliers under direct sourcing. However, the global sourcing problem entails interdependent decisions, as the choices made in locations l and l' jointly determine producers' marginal costs and the probabilities underlying their expected value.

The producer's *ex-ante* global sourcing problem is a high-dimensional, combinatorial discrete-choice problem. The one-location case involved $2^{|\mathcal{S}_l|+2}$ choices, which were reduced to $|\mathcal{S}_l| + 2$ due to the assumption of perfect substitution across suppliers. The number of choices grows to $\prod_{l\in\mathcal{L}} \left(|\mathcal{S}_l|+2\right)$ with multiple locations, making the numerical solution more demanding. The following proposition characterizes producers' optimal sourcing strategy.

PROPOSITION 5. *Producers' global sourcing problem is such that:*

a. *The expected sourcing capability is non-decreasing in firm productivity:* $\mathbb{E}\Big[\Theta(\varphi^H)^{\frac{\sigma-1}{\eta-1}}\Big] \geq \mathbb{E}\Big[\Theta(\varphi^L)^{\frac{\sigma-1}{\eta-1}}\Big]$ *for* $\varphi^H \geq \varphi^L$.

b. *If* $\sigma > \eta$, *the optimal sets of source locations and direct suppliers per location are non-contracting in firm productivity:* $\mathcal{L}(\varphi^L) \subseteq \mathcal{L}(\varphi^H)$, $S_l^D(\varphi^L) \leq S_l^D(\varphi^H)$ *for* $\varphi^H \geq \varphi^L$.

c. *If* $\sigma > \eta$, *the choice of direct sourcing at each location (weakly) increases with firm productivity:* $\mathbb{I}_{\{M_l=D\}}(\varphi^H) \geq \mathbb{I}_{\{M_l=D\}}(\varphi^L)$ *for* $\varphi^H \geq \varphi^L$.

Proof. *See Appendix C.*

Proposition 5 states that the choices made by high-productivity firms grant them a greater expected *sourcing capability*, amplifying their productivity advantage. This can occur through any of the channels described above, including the number and characteristics of source locations, sourcing modes, and the number of direct suppliers. Parts (b) and (c) assert that, under the parametric restriction $\sigma > \eta$, more productive firms actually select a larger number of locations and direct suppliers per location, and are more likely to source directly. Intuitively, this condition holds when final goods are closer substitutes in consumption than intermediate inputs in production, generating complementarities in sourcing decisions.[30] As in previous sourcing models, producers follow a *pecking order* of locations (Antràs et al. 2017; Huang et al. 2024), but locations are ranked based on both input costs and disruption probabilities. Moreover, the pattern of direct suppliers is consistent with the skewness of buyer-supplier networks (Bernard et al. 2018b, 2022), while sourcing modes resemble canonical intermediation models where firms sort by productivity (Ahn et al. 2011; Bernard et al. 2015).

Given an optimal sourcing strategy and a particular realization of disruptions, we can compute producers' input purchases across locations, $\widetilde{X}_i(\omega)$. Since intermediate inputs are the only factor of production, this follows from the producer's marginal cost (5) and its optimal production implicit in (14):

$$\widetilde{X}_i(\omega) = c(\omega)q(\omega) = \Big(\varphi(\omega)\Big)^{\sigma-1}\Big(\Theta(\omega)\Big)^{\frac{\sigma-1}{\eta-1}}(\sigma-1)B \tag{17}$$

Considering the CES production technology (4), input purchases from each operational location $l \in L(\omega)$ are given by:

$$\widetilde{X}^M_{il}(\omega) = \Big(\varphi(\omega)\Big)^{\sigma-1}\Big(p^{x,M}_{il}(\omega)\Big)^{1-\eta}\Big(\Theta(\omega)\Big)^{\frac{\sigma-\eta}{\eta-1}}(\sigma-1)B \tag{18}$$

More productive firms face greater final demand, which increases input purchases from all their operational locations. A higher input price in location l reduces purchases of l-inputs, as the effect on quantities dominates when $\eta > 1$. Moreover, under $\sigma > \eta$, a greater sourcing capability increases input purchases everywhere, as the gains from complementarities outweigh the lower competitiveness of specific locations.

[30] The mechanisms driving sourcing mode decisions and risk responses in the one-location case are amplified in the global sourcing setting. More productive firms have greater incentives to source directly, diversify suppliers, and avoid the brokerage fee, as the sourcing capability increases with productivity and the profit function is supermodular in productivity and the sourcing capability.

3.6. Imperfect Supplier Substitution

Until now I have assumed that suppliers are identical within locations, selling the local input x_l at the location-specific price $p^x_{il} = \tau_{il}\alpha_l$, which makes them perfect substitutes for producers. Under this assumption, supply chain risk is the only reason for producers to match with multiple suppliers, and operational suppliers fully compensate for disrupted ones. It also implies that producers consider the number but not the identity of suppliers at each location, reducing the dimensionality of the combinatorial problem. To incorporate imperfect supplier substitution in a tractable manner, I consider suppliers that are *ex-post heterogeneous* but remain *ex-ante homogeneous* when producers define their sourcing strategies.

Formally, I assume that each x_l is now a unit-measure bundle of intermediate varieties ν, with constant elasticity of substitution $\lambda > 1$, such that the cost of x_l under sourcing mode M is:

$$p^{x,M}_{il} = \left(\int_0^1 p^{x,M}_{il}(\nu)^{1-\lambda} \, d\nu \right)^{\frac{1}{1-\lambda}}$$

Suppliers in l can produce all local varieties $\nu \in [0,1]$ at the location-specific costs $\tau_{il}\alpha_l$ plus a supplier-variety specific cost $\xi_s(\nu)$ that is learned after supply links are formed. I treat the (infinite-dimensional) vector of variety-specific costs as independent realizations from a Fréchet distribution with dispersion parameter $\theta > 0$, which governs the degree of substitution across suppliers.[31] The prices set by a supplier s for each variety ν are then:

$$p^x_{sl}(\nu) = \tau_l \, \alpha_l \, \xi_s(\nu) \qquad \Pr(\xi_s(\nu) \geq t) = e^{-t^\theta} \tag{19}$$

Under direct sourcing in location l, producers purchase each variety from their lowest-cost operational supplier $S^{O,D}_l(\omega)$. Similarly, under indirect sourcing, the intermediary buys each variety from its lowest-cost operational option in $S^{O,I}_l$ on behalf of the producer.

$$p^{x,D}_{il}(\nu) = \min_{s \in S^{O,D}_l(\omega)} \left\{ \tau_{il} \, \alpha_l \, \xi_{sl}(\nu) \right\} \qquad p^{x,I}_{il}(\nu) = \kappa \min_{s \in S^{O,I}_l} \left\{ \tau_l \, \alpha_l \, \xi_{sl}(\nu) \right\}. \tag{20}$$

Since variety-specific costs are *iid* over a continuum of measure one, the share of inputs sourced from each operational supplier is given by the probability that a supplier is the lowest-cost option. Using the properties of the Fréchet distribution, the average prices

[31] Note that *ex-ante* supplier heterogeneity can be incorporated by adding supplier-level production costs α_{ls}, or by including a supplier-specific technological parameter T_s in the Fréchet distribution.

faced by the producer in location l can be expressed as:

$$p_{il}^{x,D} = \gamma\,\tau_l\,\alpha_l\left(S_l^{O,D}(\omega)\right)^{-1/\theta} \qquad p_{il}^{x,I} = \gamma\,\tau_l\,\alpha_l\left(\frac{S_l^{O,I}}{\kappa_l^{\theta}}\right)^{-1/\theta} \tag{21}$$

where γ is a constant defined by the gamma function $\Gamma(\cdot)$.[32]

There are three key implications from this approach. First, producers benefit from a larger supply network not only to hedge against disruptions but also by having additional cost draws, which reduces input prices through better matches. As shown in (21), the input cost in l depends on the number of operational suppliers under direct sourcing, and on the *fee-adjusted* equivalent under indirect sourcing.[33] Second, since suppliers are not perfectly interchangeable, supply chain disruptions are costly for producers even if their overall network remains operational. Third, producers' optimal risk responses are shaped by the degree of substitution across suppliers within locations (θ) and across inputs from different locations (η). Intuitively, when supply chain risk increases in a location, producers have stronger incentives to diversify if suppliers are more homogeneous or if other locations specialize in different products. These elements add realism to the model at a low computational costs, as producers still focus on the number of suppliers when making sourcing decisions.

3.7. General Equilibrium

In equilibrium, free-entry implies that *ex-ante* expected profits must equal the fixed cost of entry, f_i^e, such that only producers above a productivity threshold $\overline{\varphi}_i$ begin operations.

$$\int_{\overline{\varphi}_i}^{\infty} \mathbb{E}\left(\pi_i^{\text{ex-ante}}(\varphi)\right) dG_i(\varphi) = w_i f_i^e \tag{22}$$

It can be shown that equation (22) delivers a unique demand shifter B_i, and that producers' combinatorial discrete choice problem has a unique solution given B_i.[34] The

[32] As in Eaton and Kortum (2002), $\gamma = \left[\Gamma\left(\frac{\theta+1-\lambda}{\theta}\right)\right]^{\frac{1}{\lambda-1}}$ so I need $\lambda < \theta + 1$ to have a well-defined price index. As long as this restriction is satisfied, λ appears only in a constant term without affecting any relevant outcomes.

[33] One can also think about these price reductions as being the result of pro-competitive effects. Recent empirical and theoretical work highlights that buyers with more suppliers obtain lower input prices in trade and production networks (Alviarez et al. 2023; Huang et al. 2024).

[34] Recall that consumers spend a constant share β of their income on differentiated final-goods, and the remaining share $1-\beta$ on the perfectly competitive, freely-traded homogeneous good. I assume that $1-\beta$ is large enough to guarantee that the wage rate w_i is pinned down by labor productivity in that sector. I thus can treat wages as exogenous in solving for the equilibrium.

equilibrium mass of producers in country i is then given by:

$$N_i = \frac{\beta L_i}{\sigma\left[\int_{\underline{\varphi}_i}^{\infty} \sum_{l \in \mathcal{L}(\varphi)} \left(\mathbb{I}_{\{M_l(\varphi)=D\}} f_l^D\left(S_l^D(\varphi)\right) + \mathbb{I}_{\{M_l(\varphi)=I\}} f_l^I\right) dG_i(\varphi) + f_i^e\right]} \tag{23}$$

where $\mathbb{I}_{\{M_l(\varphi)\}}$ are indicator variables for the selected sourcing modes at each location l in the sourcing set $\mathcal{L}(\varphi)$ of a producer with productivity φ.

3.8. Extensions

I have assumed that producers access an intermediation technology characterized from the data, while abstracting from market dynamics in the intermediation sector. A natural next step would be to introduce an endogenous brokerage fee determined in equilibrium. This can be achieved by assuming monopolistic intermediaries that are segmented across source locations, which purchase inputs at the prices set by suppliers and then optimally determine markups for downstream producers. In doing so, intermediaries take into account how the brokerage fee influences the demand for inputs among their buyers, as well as the extensive margin of firms using intermediaries, since the brokerage fee affects the productivity thresholds defined above. It is worth noting that these mechanisms would not qualitatively alter producers' sourcing responses. In fact, since the brokerage fee can be inferred from the data, its quantitative relevance is also limited. However, a formal intermediation sector could offer valuable insights when assessing industrial policies aimed at facilitating access to intermediaries.

I have also assumed that producers face independent disruptions on their supply links. Although the data suggest a low correlation across link separations, some real-world shocks operate at a broader level. In practice, it is straightforward to incorporate location-level disruptions that occur with some exogenous probability, thereby introducing a correlation across disruptions affecting supply links within the same market. Although the number of operational suppliers would no longer follow a binomial distribution, the model remains tractable and all propositions hold. Furthermore, alternative shock structures can be explored numerically within this framework. At some computational cost, the numerical solution can accommodate multiple disruption patterns, even if a theoretical characterization is not always feasible.

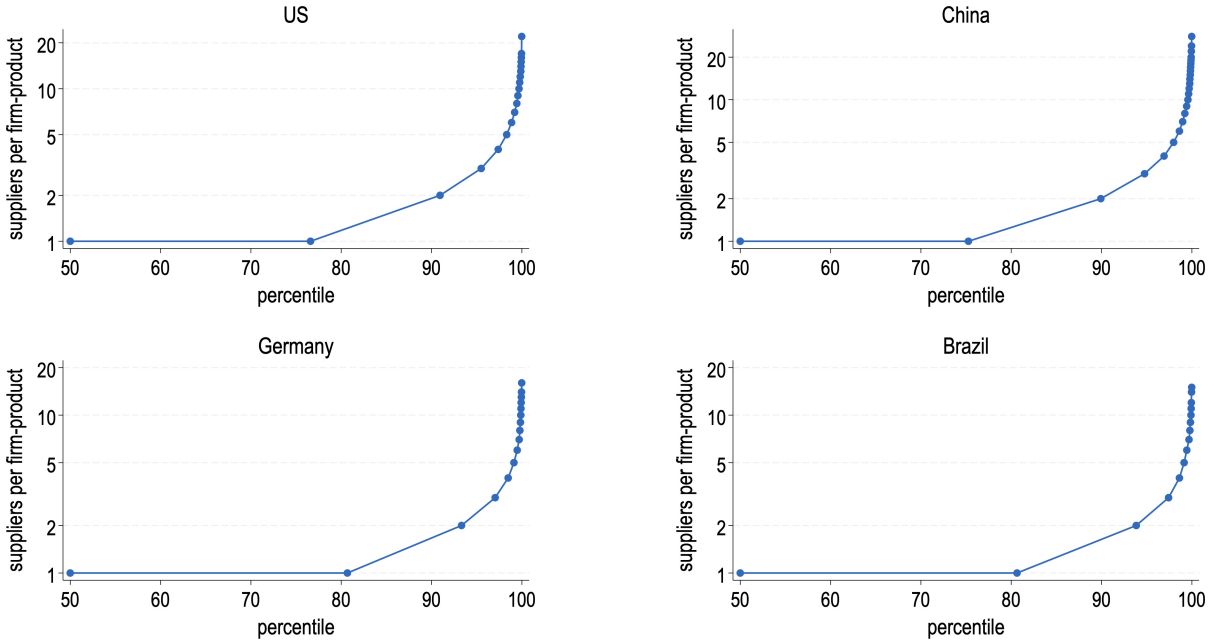
4. Reduced-Form Evidence

Considering an intermediation technology as unveiled in facts 2 and 3, my model characterizes producers' sourcing strategies and explains the intermediation patterns in fact 1. The value of the intermediation technology increases with risk, but its resilience advantage diminishes with firm productivity, leading to heterogeneous responses among producers. While larger firms may expand their set of direct suppliers, smaller firms switch to intermediaries, ultimately reducing the mass of direct importers. A key feature is the presence of matching costs preventing supplier diversification. I provide additional empirical evidence supporting these mechanisms. First, I present descriptive evidence showing that most producers transact directly with a single supplier. Notably, those multisourcing exhibit lower input cost volatility, consistent with disruptions in the model. I then exploit changes in supply chain risk to document that larger producers expand their supplier base while the count of direct importers decreases.

Supplier Diversification. Figure 8 plots the distribution of the number of suppliers at the firm-product level, considering the top origin countries for Chilean producers: the United States, China, Germany, and Brazil. The data reveals that about 20% of producers source products from multiple suppliers, while a few producers have many supply relationships. In turn, the subset of producers multisourcing in the same location accounts for two-thirds of total imports, indicating that they are larger on average. These numbers align with recent evidence for US firms, where 21% of importers source from multiple suppliers in the same origin country and account for three-quarters of imports (Blaum et al. 2023). They are also consistent with data on Colombian importers, where the share of firms with more than one supplier is around 30% (Bernard et al. 2018a). My evidence confirms the skewness of the number of suppliers in the Chilean data when only producers are considered in the sample. Moreover, these patterns are consistent with the presence of sizable matching costs preventing direct supplier diversification.

In the model, the combination of a discrete set of suppliers and independent disruptions across supply links imply that input cost volatility decreases with a firm's number of suppliers. Figure 9 confirms this relationship in the Chilean data. The x-axis displays the average number of suppliers firms have for a given product and origin country over a 5-year period (2014–2019), while the y-axis shows input price volatility, measured by the standard deviation of unit values over the same period. Firms are grouped into 20 equal-sized bins, with dots indicating values for a representative firm. Both variables are demeaned using product-origin country fixed effects. The figure reveals a clear negative

FIGURE 8. Number of Direct Suppliers in Selected Countries



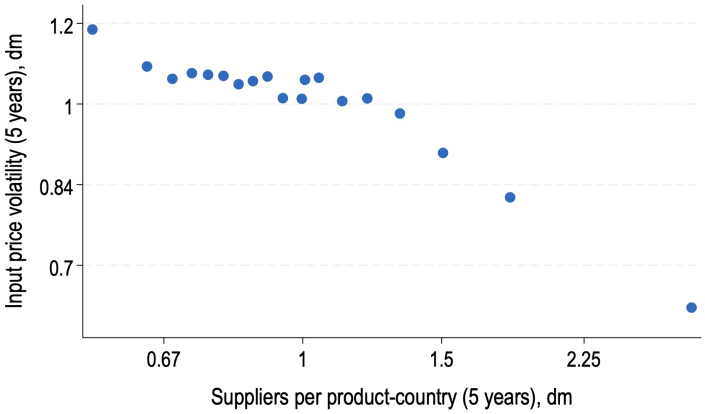
Notes: This figure plots the distribution of the number of suppliers at the firm-product level, considering the main source locations for Chilean importers. The sample includes all Chilean producers importing directly in 2019.

relationship between the number of suppliers and input cost volatility, with a linear slope of -0.33. This supports the idea of producers mitigating disruptions by maintaining multiple supply relationships.

Heterogeneous Sourcing Responses. I examine the risk responses of heterogeneous producers sourcing directly. Specifically, I assess how producers adjust the number of direct suppliers for a given location (origin country-HS6 product) as risk increases over time, incorporating interactions with terciles of firm size, defined by total imports in the initial period. The empirical strategy is analogous to that in Section 2, but implemented at the firm-country-product level using stacked data for periods t and $t+5$.[35] Table 7 shows a negative main effect for changes in *Trade Volatility*, while other risk measures have insignificant coefficients. However, interactions by firm size reveal that large producers increase the number of suppliers in response to both *Geopolitical Risk* and *Trade Volatility*, while the effect of *Economic Uncertainty* is insignificant. Note that country-product fixed

[35]Since the analysis is conducted at a more granular level, employing long-differences would require that the same firm sources the same input from the same origin country over five years, significantly reducing observations. Instead, I use stacked periods and include fixed effects to control for product, origin country, and firm characteristics.

FIGURE 9. Number of Direct Suppliers and Input Cost Volatility



Notes: Firms are sorted into 20 equal-sized bins. The x-axis shows the average number of suppliers that a producer has for a given product and origin country over a 5-year period. The y-axis displays the corresponding standard deviation of input prices over the same period. Both variables are demeaned using product-origin country fixed effects. The linear slope is -0.33.

effects ensure that comparisons are made within the same location over time, while firm fixed effects subsume the level effects of size dummies and cross-sectional heterogeneity among producers. Overall, these results support that, if any, large producers are the ones that can afford precautionary diversification.

Number of Direct Importers. Since some producers switch to intermediaries with higher risk, and the productivity thresholds for direct importing generally increase, the model unambiguously predicts a decrease in the count of direct importers. To assess this implication, Table 8 examines how the number of producers sourcing directly in a given location (origin country-HS6 product) varies with risk shocks over a 5-year period, replicating the approach used in Section 2. As predicted, I find that the count of direct importers systematically decreases with all measures of supply chain risk. These results are robust to controlling for changes in origin-country productivity and trade costs, as well as changes in total imports by product to account for downstream conditions.[36] While fact 1 documented that intermediation shares increased with supply chain risk, my results are consistent with these effects being driven by the selection of producers into different sourcing modes.[37]

[36]There were no significant changes in import tariffs in Chile during the analysis period. Meanwhile, time-constant trade barriers such as distance and cultural differences are absorbed by using long differences at the origin country-product level.

[37]An additional empirical test would be to examine whether the probability of producers switching to intermediaries increases with supply chain risk. This requires information on VAT domestic transactions between producers and intermediaries, contained in Form 29 of the Tax Authority of Chile. While access

TABLE 7. Number of Direct Suppliers by Producer Size

	(log) # direct suppliers					
	Geopolitical Risk		Economic Uncertainty		Trade Volatility	
	(1)	(2)	(3)	(4)	(5)	(6)
Supply chain risk	-0.058	-0.068	-0.022	-0.019	-0.024***	-0.026***
	(0.049)	(0.047)	(0.025)	(0.024)	(0.005)	(0.005)
× 2nd size tercile	0.041**	0.042**	0.018	0.018	0.025***	0.025***
	(0.018)	(0.018)	(0.025)	(0.025)	(0.004)	(0.004)
× 3rd size tercile	0.069***	0.070***	-0.010	-0.009	0.062***	0.062***
	(0.017)	(0.018)	(0.031)	(0.031)	(0.008)	(0.008)
Origin country - product FE	Yes	Yes	Yes	Yes	Yes	Yes
Firm FE	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes	Yes
Origin-country productivity	No	Yes	No	Yes	No	Yes
Origin-country trade costs	No	Yes	No	Yes	No	Yes
Product total imports	No	Yes	No	Yes	No	Yes
Observations	269,913	269,251	235,431	235,431	269,958	268,416

Notes: All regressions consider the (log) number of direct suppliers at the firm-product-origin country-year level, stacking periods t and $t+5$. Size terciles are defined using total imports at the firm level in period t. Supply chain risk is measured by the Geopolitical Risk (GPR) and Economic Policy Uncertainty (EPU) indexes at the origin-country level, and by Trade Volatility at the origin country-product level. Controls include changes in total factor productivity, trade procedures, and total imports by product. The sample includes all import transactions by Chilean producers for years 2014 and 2019. Standard errors are clustered at the level of the risk measure.

5. Quantitative Analysis

The theory developed in Section 3 allows me to quantify the role of trade intermediaries in mitigating supply chain disruptions. Leveraging the detailed microdata at hand, I operationalize this setting for Chile, five source regions (Latin America, China, the United States, Europe, and Rest of the World), and one sector per region. My main result is that trade intermediation substantially reduces the impact of disruptions for producers in the middle of the size distribution, which access inputs from foreign markets but cannot afford to diversify. I then show that reductions in brokerage fees enhance access to intermediaries and further increase overall supply chain resilience. I interpret this exercise as industrial policy aimed at promoting competition in wholesaling.

to this data has been requested, it is not yet operational and represents a natural next step for this section.

TABLE 8. Number of Producers Importing Directly

	Δ (log) # Direct Importers					
	(1)	(2)	(3)	(4)	(5)	(6)
Δ Geopolitical Risk	-0.037***	-0.035***				
	(0.009)	(0.012)				
Δ Economic Policy Uncertainty			-0.041***	-0.044***		
			(0.010)	(0.015)		
Δ Trade Volatility					-0.007**	-0.005*
					(0.003)	(0.003)
Δ Origin-country productivity	No	Yes	No	Yes	No	Yes
Δ Origin-country trade costs	No	Yes	No	Yes	No	Yes
Δ Product total imports	No	Yes	No	Yes	No	Yes
Observations	33,074	32,768	23,791	23,791	35,155	34,393

Notes: All regressions consider changes in the (log) number of direct producers sourcing a given product from a given origin country over a 5-year period. Supply chain risk is measured by the Geopolitical Risk (GPR) and Economic Policy Uncertainty (EPU) indexes at the origin-country level, and by Trade Volatility at the origin country-product level. Controls include changes in total factor productivity, the number of trade procedures, and total imports by product. The coefficients are normalized to reflect the effect of one standard deviation. The sample includes all import transactions in Chile for years 2014 and 2019. Standard errors are clustered at the level of the risk measure.

5.1. Numerical Solution

To solve the model numerically, the first challenge is the dimensionality of the choice set. In principle, the firm's maximization problem (15) involves decisions over $|\mathcal{L}|$ locations and $2^{|\mathcal{S}_l|+2}$ options at each of them. However, the assumption of *ex-ante* homogeneous suppliers reduces the latter to $|\mathcal{S}_l| + 2$ options. Even in a tractable setting with 5 locations and 4 suppliers per location, this contracts the choice set from nearly a billion combinations to less than ten thousand. I further reduce dimensionality using the model. The *equivalent* number of suppliers $\widetilde{S}_l^I$ defined in (12) allows me to compare direct choices with the intermediation technology, ruling out strictly dominated options at each location.[38] Finally, I apply a squeezing procedure to avoid evaluating all remaining options, following recent methods for combinatorial discrete choice problems (Arkolakis et al.

[38]In the model, I assumed $f_l^D(\cdot) \leq f_l^I$ for all locations, ensuring that matching with $S_l^D \leq \widetilde{S}_l^I$ direct suppliers cannot be optimal. In the numerical solution, however, I allow for heterogeneous matching costs that exceed f_l^I on average (see Section 5.2). In this case, the discard rule becomes more nuanced, depending on how f_l^I compares to $f_l^D(\cdot)$ for direct choices near $\widetilde{S}_l^I$. Firms with high matching costs still reduce their choices as before, intermediation is ruled out for firms with very low matching costs, while it is not always possible to reduce choices for firms in between.

2023; Huang et al. 2024).[39]

The second challenge is that forward-looking producers anticipate the possibility of disruptions, which involves a high-dimensional expectation over each choice. There are up to $|\mathcal{S}_l| + 1$ possible realizations at each location l in $L(\omega)$, which jointly determine producer ω's expected sourcing capability in (16). I address this issue by approximating these complex expectations using Monte Carlo simulations. As shown in (10) and (11), the pattern of disruptions implies that, given a set of potential suppliers at l, the number of operational suppliers follows a Binomial distribution. I use these distributions to generate random draws under each sourcing strategy and compute expected profits.[40]

5.2. Estimation Strategy

Elasticities. I calibrate the parameters governing substitution across final goods in consumption (σ), across inputs from different locations in production (η), and across suppliers within locations (θ). I take $\hat{\sigma} = 5$ as a median estimate from the trade literature (Broda and Weinstein 2006; Feenstra and Romalis 2014; Antràs et al. 2017) and infer η and θ using model-consistent equations.

First, I consider a log-linear version of (18) indicating firm f's input purchases from source location l, conditional on direct sourcing:

$$\log \widetilde{X}^{D}_{fl} = (\sigma - 1)\log \varphi_f + (1-\eta)\log p^{x,D}_{fl} + \left(\frac{\sigma-\eta}{\eta-1}\right)\log \Theta_f + \log\left(\sigma-1\right)B$$

To back out η, I take the following empirical counterpart to the data:

$$\log \widetilde{X}^{D}_{flt} = \delta_{ft} + (1-\eta)\log p^{x,D}_{flt} + u_{flt} \tag{24}$$

where δ_{ft} absorbs differences in producers' marginal costs due to their core productivity and sourcing capability. Identification then comes from price variation across locations for the same firm and year. To address reverse causality concerns, I also estimate (24) for the last sample year (2019) using geographic distance from Chile as an instrument for input prices.[41] Table A7 reports estimates around $\hat{\eta} = 1.3$, which aligns with the results

[39] A key condition for this procedure is that producers' *ex-ante* expected profits satisfy single-crossing differences. In the next section, I show that the parametric condition $\sigma > \eta$ holds for standard values of σ and the estimated value of η, ensuring single-crossing differences from below.

[40] I use 100,000 simulations when estimating the model and implementing counterfactuals. As shown in 16), I assume that the expectation operates only over producers' own sourcing capability, given the pattern of independent disruptions across supply links. This assumption speeds up the estimation process, as expected sourcing capabilities for each sourcing strategy can be computed and stored in advance.

[41] In the model, input prices are unaffected by the amount purchased by atomistic producers. In reality,

of Huang et al. (2024) in the context of oligopolistic input markets ($\hat{\eta} = 1.4$).

For θ, I consider a log-linear version of (21) that relates input prices to firms' number of suppliers under imperfect substitution, expressed empirically as:

$$\log p^D_{flt} = \delta_{lt} - \frac{1}{\theta} \log S^D_{flt} + u_{flt} \tag{25}$$

where δ_{lt} captures location-specific trade and production costs. Identification thus arises from variation in the number of suppliers across firms sourcing from the same location (origin country - HS6 product) and year, and I also include firm-year fixed effects to account for changes in firm-level conditions.[42] Table A8 presents results considering the full panel (2005–2019) and the last sample year, with values for $\hat{\theta}$ ranging from 3.4 to 3.9, where the upper bound is equivalent to the estimates in Huang et al. (2024).

Panel A of Table 9 summarizes the estimated elasticities. There is greater substitution across inputs in production relative to final goods in consumption ($\sigma > \eta$), which is consistent with sourcing complementarities. Furthermore, substitution is easier among suppliers within locations than across different input locations ($\theta > \eta$).

Location Input Costs. Consider the cost structure defined in (19), which separates the cost of input varieties into location ($\tau_l \alpha_l$) and supplier-variety ($\xi_s(\nu)$) multiplicative factors. I assume that the average price charged by a foreign supplier to Chilean buyers follows this structure, and exploit the time dimension of the data to infer the location-specific component. The empirical specification is:

$$\log \bar{p}_{slt} = \delta_{lt} + \delta_{st} + e_{slt} \tag{26}$$

where δ_{lt} is interpreted as the average trade and production cost in each location (origin country - HS6 product) and year, which are then aggregated across source regions. The normalized version of these estimates (relative to Chile) is reported in Panel B of Table 9 for the last sample year (2019).[43] As expected, the estimated costs are significantly higher

producers may obtain quantity discounts, or their purchases may affect market prices when they are large players. While tariffs are a standard time-varying instrument in the trade literature, their flat structure in Chile prevents their use. I then exploit geographic distance from Chile, which is positively related to import prices and unlikely to be correlated with other origin country conditions.

[42] The main econometric concern is that input prices influence firms' supplier choices through their impact on firms' sourcing capabilities. In a time-varying specification, this concern is reduced to the extent that moderate price changes are less likely to induce discrete changes in suppliers, especially in the presence of sizable matching costs. Moreover, the results in Table 9 also include δ_{ft} to absorb changes in firm-level conditions.

[43] Since domestic input sourcing is not observed, I assume similar production costs in Chile and Latin America, attributing all differences to iceberg trade costs. These costs are estimated to be around a factor

TABLE 9. Estimation Parameters

Panel A. Elasticities of substitution

σ *(final goods)*	5	η *(input locations)*	1.3	θ *(suppliers)*	3.6

Panel B. Input costs, disruption probabilities, and suppliers per region

	LAT	CHN	USA	EUR	ROW
$\tau_l \alpha_l$: *trade and production costs*	2.7	3.1	16.1	16.4	10.2
ζ_l^D: *direct disruption probability*	0.23	0.26	0.19	0.18	0.22
ζ_l^I: *indirect disruption probability*	0.17	0.21	0.13	0.13	0.16
$\mathcal{S}_l$: *(potential) direct suppliers*	4	4	4	4	4
S_l^I: *(intermediary) indirect suppliers*	3	4	3	3	3

Panel C. Sourcing costs and demand shifter

κ *(brokerage fee)*	1.2	β^0	1.39	$\beta^{Institutions}$	-2.79
ψ *(indirect contracting)*	0.05	$\beta^{Distance}$	3.07	$\beta^{Suppliers}$	9.49
$\beta^{Dispersion}$	1.02	$\beta^{Language}$	0.96	B *(final demand)*	1.11

Notes: This table summarizes the calibrated parameters used in the quantification. Panel A presents the elasticities of substitution. Panel B reports input costs, disruption probabilities, and supplier sets across regions. Panel C provides the demand shifter and sourcing costs, including the brokerage fee, (relative) indirect contracting costs, and the matching cost parameters from (29). Additionally, I assume a Pareto shape parameter of 1.5 for the distribution of producers, with the scale parameter normalized to 1.

in Europe and the US compared to Latin America and China. Table A9 reports the raw cost estimates in USD and examines a longer time period, revealing similar patterns.

Disruption Probabilities. I parameterize the probability that producer-supplier links break in a given location using a nonlinear (logit) functional form. Specifically, I consider a vector of observable location characteristics, Z_l, which includes the supply chain risk indexes from Section 2 (*Geopolitical Risk*, *Economic Uncertainty*, and *Trade Volatility*), and a set of dummies classifying countries into low-, middle-, and high-income levels. This allows countries at different stages of development to differ in baseline probabilities, which then vary based on the risk measures within groups. Additionally, I include a vector D_b to control for changes in buyer-level downstream conditions, which are then

of 2.7, following Anderson and Van Wincoop (2004). To facilitate comparisons, I normalize input costs in Chile to 1, such that, by construction, Latin America has an input cost of 2.7 in Table 9.

excluded from the projected probabilities.[44] The empirical specification is:

$$\mathbb{D}(separation)_{bslt} = \frac{e^{Z'_{lt}\gamma + D'_{bt}\delta}}{1 + e^{Z'_{lt}\gamma + D'_{bt}\delta}} \tag{27}$$

where $\mathbb{D}(separation)_{bslt}$ is a dummy that equals 1 when a bs-link in location l and period t will break in $t+1$.

Table 9 presents the results aggregated at the level of source regions. Direct disruption probabilities range from 0.18 to 0.26, with Europe being the safest region and China the riskiest for Chilean producers. More generally, disruption probabilities are higher in regions with lower input costs, posing an efficiency-risk tradeoff in the choice of source locations.[45] Table A10 reports the estimates for vectors Z_l and D_b. All coefficients are statistically significant and operate in the expected direction: the frequency of disruptions increases with the risk measures, and decreases in more developed countries or when buyers experience favorable downstream conditions.

For indirect disruption probabilities, I compare the supplier separation rates of producers and intermediaries in each source region. As in Section 2, the analysis considers supply links within the same product and origin country (when there is more than one country in the region), while incorporating the demand controls mentioned above. Table A11 reports these results, which are then used to adjust the direct probabilities. As shown in Table 9, indirect disruptions are about 6 pp less likely on average, representing a 25% reduction in the probability of disruptions relative to direct sourcing.[46]

Suppliers per Location. I use import transactions to compute the number of indirect suppliers offered by intermediaries. Specifically, I compute the average number of suppliers that wholesalers have per product (HS6)-region, weighting by wholesalers' import shares. Table 9 reports that the intermediation technology exhibits multisourcing in all regions: when producers source indirectly, they access 4 suppliers per product in China and 3 in the remaining regions. On the other hand, I assume that producers

[44] Following the analysis in Section 2, I include the changes in producers' total imports and number of suppliers from period $t-1$ to t. Without controlling for these factors, I find similar relative patterns for disruption probabilities across locations, but the average probability is about 9 pp higher.

[45] In the baseline scenario, I consider disruptions in global sourcing but *safe* domestic links. This can be rationalized as producers facing lower matching costs in the home country, allowing them to find replacements within a reasonable time frame. However, it is straightforward to incorporate risk in the home country. The probability of disruptions in Chile could be inferred by extrapolating the coefficients estimated in (27). Alternatively, this probability can be estimated using VAT data on domestic transactions.

[46] These differences are smaller than those reported in Section 2 due to the demand-side controls. However, I consider my approach to be conservative in terms of the resilience advantage of intermediaries, as these buyer-level controls may partially absorb supply-side conditions.

can match with up to 4 suppliers per region when sourcing directly. This corresponds to the 95th percentile in the distribution of direct suppliers per producer, and allows producers to build a diversified network if they can afford the associated matching costs.

Brokerage Fee. In principle, one would like to observe the prices charged by import intermediaries to local producers and compare them to those charged by foreign suppliers in the same industry. I take a similar approach by using customs data on Chilean exports, which allows me to compare the prices charged by producers and export intermediaries for the same destination and sector.[47] I run the following empirical specification:

$$\log p_{flt}^{Exp} = \delta_{lt} + (\kappa - 1)\, D^{Exp}(Intermediary = 1)_{ft} + \epsilon_{flt} \tag{28}$$

where p_{flt}^{Exp} denotes the price charged by firm f in location l (destination-sector), and $D(\text{Intermediary} = 1)_{ft}$ is a dummy indicating whether the exporter is an intermediary. I find intermediation markups to be around 11%. This is similar to the *accounting* markups documented in the US wholesaler sector (13.5%), although theory-consistent estimates suggest markups up to 30% in that market (Ganapati 2024). Likewise, recent evidence from microdata in Canada finds wholesale markups above 30% (Alexander et al. 2024). Thus, I take a middle point in the baseline estimation ($\kappa = 1.2$) and then evaluate scenarios with lower and higher markups.

Matching Costs and Demand Shifter. The last objects to estimate are the aggregate demand shifter B, the matching costs of sourcing directly in each region $f_l^D(S_l^D)$, and the costs of contracting with intermediaries f_l^I. To reduce the parameter space, I assume the intermediation costs are a constant share ψ of the cost of matching directly with suppliers. I then parameterize matching costs as a function of the number of direct suppliers and proxies for shipping, communication, and contracting costs: bilateral distance, common language, and control of corruption. These costs are drawn from a log-normal distribution with dispersion parameter β^{Disp} and the following scale parameter:[48]

$$\log f_l^D\left(S_l^D\right) = \log \beta^0 + \beta^{Dist} \log \text{Dist}_l + \text{Lang}_l \cdot \log \beta^{Lang} + \beta^{Inst}\, \text{Inst}_l + \beta^{Supp} \log S_l^D \tag{29}$$

[47] The transactions between import intermediaries and local producers are observable in the VAT data from the Tax Authority, which has been requested but is not yet operational. Once available, the estimates for the brokerage fee in Chile can be further refined.

[48] This specification allows matching costs to vary across producers, rationalizing deviations from the strict sorting patterns predicted by the model for direct and indirect sourcing. On the other hand, Pareto draws for producers' productivity are taken using stratified random sampling, ensuring that more points are sampled on the right tail of the distribution.

I estimate the vector of 8 parameters $\Omega \equiv \{B, \psi, \beta_0, \beta^{Dist}, \beta^{Lang}, \beta^{Inst}, \beta^{Supp}, \beta^{Disp}\}$ using the Simulated Method of Moments (SMM). For any initial guess, the algorithm solves buyers' optimal sourcing strategy, computes the implied model moments, and iterates until the solution produces moments close to the data. I target a vector M of 8 moments: (1) the overall share of Chilean producers importing directly, (2) - (6) the shares of Chilean producers importing directly from each region, (7) the share of Chilean producers diversifying suppliers, and (8) the share of Chilean producers sourcing indirectly. Intuitively, (1) helps identify the aggregate demand shifter and the baseline matching cost, (2) - (6) account for variation in matching costs across regions, (7) captures how matching costs vary with the number of suppliers, and (8) identifies the relative cost of contracting with intermediaries.[49]

$$\min_{\Omega} Y_t = (M^{Model}(\Omega) - M^{Data}) W (M^{Model}(\Omega) - M^{Data})' \tag{30}$$

Panel C in Table 9 presents the estimates for Ω. As expected, matching costs increase with distance and decrease with common language and institutional quality. Moreover, these costs grow exponentially with the number of suppliers, indicating that diversification is much costlier than simply importing, while contracting with intermediaries is substantially cheaper than direct supplier matching. Table 10 reports the model fit for targeted moments. The model captures the relative importance of different source regions and the shares of producers sourcing directly and indirectly. However, the model overpredicts the share of firms sourcing from multiple suppliers, suggesting additional barriers to diversification. This implies that the role of disruptions and intermediaries is likely greater than indicated by the subsequent counterfactual analysis.

5.3. Counterfactuals

Having estimated the model, I perform counterfactual analysis to quantify the importance of trade intermediation in mitigating disruptions. I first evaluate how supply chain risk affects the performance of heterogeneous producers relative to a scenario without disruptions. I then examine how the intermediation technology reduces the impact of disruptions across the firm size distribution. Finally, I consider changes in intermediation markups, assessing to what extent industrial policies in this sector can enhance producers' resilience in input sourcing.

[49] I use the identity matrix for weights ($W = I$) in the minimization problem, following evidence on a better fit for import shares (Antràs et al. 2017; Huang et al. 2024).

TABLE 10. Empirical and Simulated Moments

Moments	Data	Model
% producers importing directly	0.039	0.057
% producers importing directly per region:		
– Latin America	0.012	0.012
– China	0.020	0.045
– United States	0.014	0.021
– Europe	0.017	0.014
– Rest of the world	0.006	0.004
% producers with multiple suppliers	0.206	0.312
% producers importing indirectly	0.061	0.053

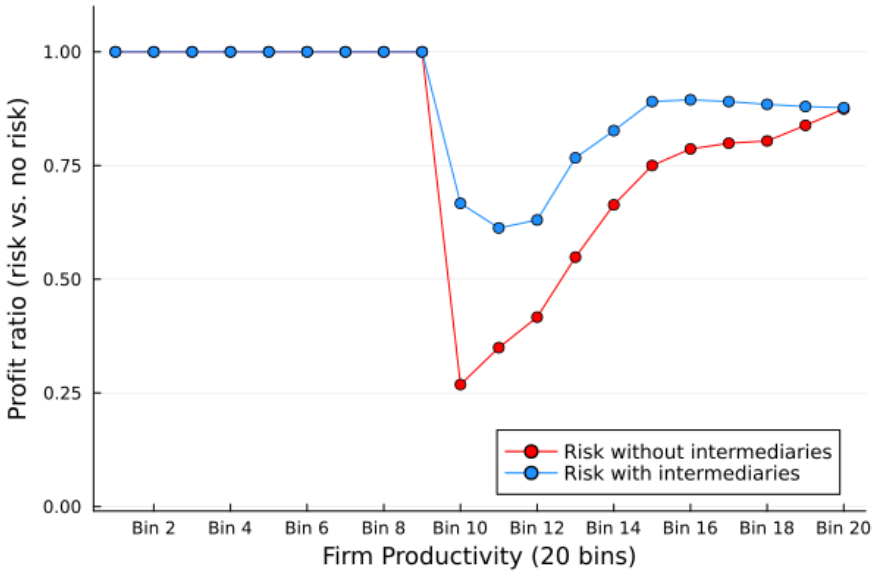
Notes: This table reports the model fit for the eight empirical targets used in the Simulated Method of Moments (SMM). This procedure estimates the vector Ω containing the demand shifter, indirect contracting costs, and the six parameters characterizing direct matching costs.

The Impact of Disruptions. I compute firm profits in the baseline model with the estimated probability of disruptions, and in a counterfactual scenario where these probabilities are set to zero under both sourcing modes. The analysis is conducted for a sample of 1,200 producers, which are then divided into 20 equal-sized bins sorted by productivity. The blue line in Figure 10 plots the ratio of firm profits with and without risk, showing the average value for firms in each bin. The results indicate that supply chain disruptions have a greater impact on mid-size producers, as larger firms source from more locations and suppliers per location, ensuring network operability. In contrast, smaller firms source primarily domestically and are unaffected by foreign disruptions. Table 11 presents the average effect by size group: supply chain disruptions reduce the profits of mid-size producers by nearly 20%, compared to a 16% reduction observed for large firms.[50]

The Role of Intermediaries. I repeat the analysis for scenarios with and without risk, considering a counterfactual where the intermediation technology is not available. This case is represented by the red line in Figure 10. The impact of disruptions increases across the firm distribution, but the effect is more pronounced among mid-size firms. While these producers are large enough for importing, they lack the scale to diversify suppliers

[50] I consider the last two bins (19–20) to be large firms, the remaining importers (10–18) to be mid-size firms, and firms sourcing only domestically (1–9) to be small. Alternative thresholds would alter group effects without changing the overall pattern. Figure 10 helps visualize the effects across the distribution, but the mapping into aggregate measures is not direct. First, producers' Pareto draws are taken using stratified random sampling, ensuring more points in the right tail of the distribution. Additionally, aggregation must consider the relative weight of each bin, with higher bins accounting for a larger share of profits.

FIGURE 10. Supply Chain Disruptions and Trade Intermediaries



and protect from disruptions on their own. In turn, shutting down intermediation is more severe for firms on the lower end of the mid-size spectrum, which typically enter a single import market and supplier, meaning that disruptions could prevent their access to foreign inputs altogether. Table 11 shows that, on average, intermediaries reduce the impact of disruptions for mid-size producers by 20 percentage points, while their contribution is negligible for large producers. These effects are sizable, implying that the profit losses from disruptions would double for this group without access to intermediaries.

Changes in Intermediation Markups. Figure 11 displays the baseline model ($\kappa = 1.2$) alongside counterfactual scenarios with lower ($\kappa = 1.1$) and higher ($\kappa = 1.3$) brokerage fees. The results show that reducing markups improves the disruption buffer for mid-size producers, decreasing the impact of disruptions by 5.4 percentage points, as intermediation becomes more accessible across locations. Conversely, increasing intermediation markups to the levels observed in developed countries (Ganapati 2024; Alexander et al. 2024) detriments mid-size producers, raising the impact of disruptions by 3.2 percentage points. Overall, these results indicate that brokerage fees play a significant role in determining the contribution of intermediaries. This suggests that industrial policies in sectors instrumental to trade, such as wholesaling, could have sizable effects on resilience, given evidence of high intermediation markups.

TABLE 11. Effect of Supply Chain Disruptions

	Baseline (Intermediation)	No Intermediation	Lower Brokerage Fee	Higher Brokerage Fee
Panel A. Profit ratio relative to no-risk scenario				
Mid-size firms	0.799	0.601	0.853	0.768
Large firms	0.836	0.835	0.838	0.835
Panel B. Difference to baseline (pp)				
Mid-size firms	–	-0.199	0.054	-0.032
Large firms	–	-0.001	0.002	-0.001

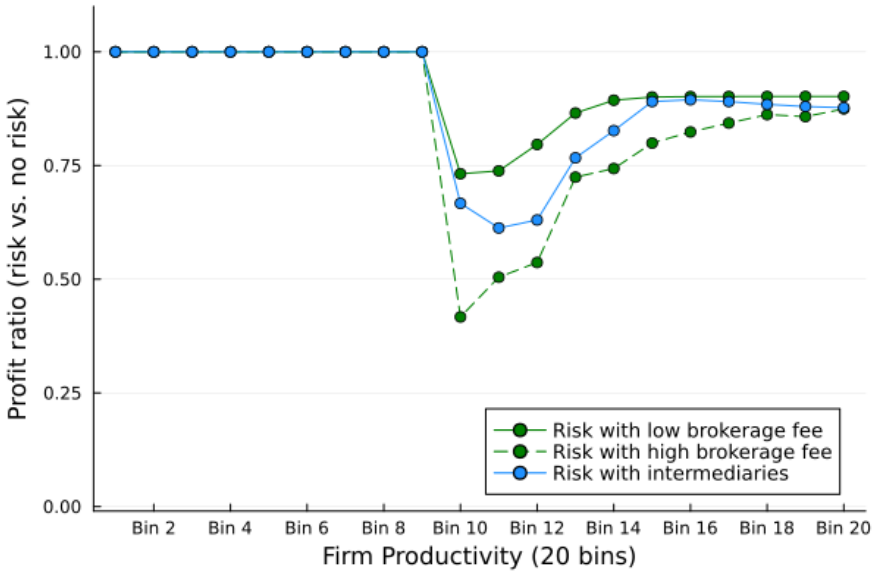
Notes: Panel A reports the ratio of firm profits with and without supply chain risk, considering four scenarios: the baseline model, a model without intermediaries, lower brokerage fees ($\kappa = 1.1$), and higher brokerage fees ($\kappa = 1.3$). Panel B displays percentage point differences relative to the baseline model. Firms are classified as in Figure 10. Among 20 size bins in the baseline distribution, the last two correspond to large firms (19 - 20), the remaining importers are classified as mid-size firms (10 - 18), while small firms source only domestically and are omitted from the table (1 - 9).

6. Conclusion

Firms often face disruptions in international supply chains that can significantly affect their operations. While the most common shocks are idiosyncratic and could potentially be mitigated through supplier diversification, the literature on trade and production networks suggests large matching frictions. Thus, maintaining multiple supply relationships can be prohibitive for many producers, but they may be able to protect indirectly by using specialized intermediaries. This paper shows that trade intermediaries effectively reduce the impact of disruptions for mid-size producers, which benefit from foreign inputs but lack the scale to diversify. Intermediation is then instrumental in supporting the expansion of smaller businesses under risky global markets.

Using detailed microdata from Chile, I documented that the use of intermediaries rises with supply chain risk, as they maintain more diversified and robust supply networks. I then developed a theoretical model in which producers trade off input costs and disruption probabilities when choosing source locations, and can directly or indirectly mitigate disruptions at each location. Producers balance intermediation markups against the matching costs of diversification, optimally sorting into different mitigation strategies based on their productivity. Model quantification revealed sizable profit losses from disruptions, with intermediaries substantially reducing their impact for

FIGURE 11. Changes in Intermediation Markups



mid-size producers. Counterfactual analysis also shows that brokerage fees are crucial in determining the contribution of intermediaries to resilience.

From a broader perspective, my findings shed light on market responses to supply chain risk, while also suggesting a role for industrial policy in promoting resilience, particularly in trade-related sectors like wholesaling. The design of such policies would benefit from further research into the business model of intermediaries and the factors behind their market power, considering, for example, the interaction between matching costs and scope economies. Future work could also explore how intermediaries interact with inventory management and transportation logistics, offering a deeper understanding of the role of distribution in resilience. Moreover, the effectiveness of intermediaries and other adaptive responses ultimately depends on the structure of disruptions, where our theoretical and empirical understanding remains preliminary.

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Appendix

A. Anecdotal Evidence on Intermediaries

A.1. Selected Quotes

"Our global supply chain connects thousands of suppliers and vendors with leading brands and retailers, all with the goal of meeting consumer demand. We focus on managing complexity and risk to maximize your profitability."

– Li & Fung, leader intermediary in apparel [link]

"Safety and compliance are the foundation of our supply chain network. We pride ourselves on taking proactive measures to help reduce supplier risk and ensure continual supply of products to our customers."

– Univar Solutions, leader intermediary in chemicals [link]

"Life goes on in these (high-risk) countries despite repeated riots, crises, etc... but we don't establish ourselves there and we remember to put in a buffer on the delivery time."

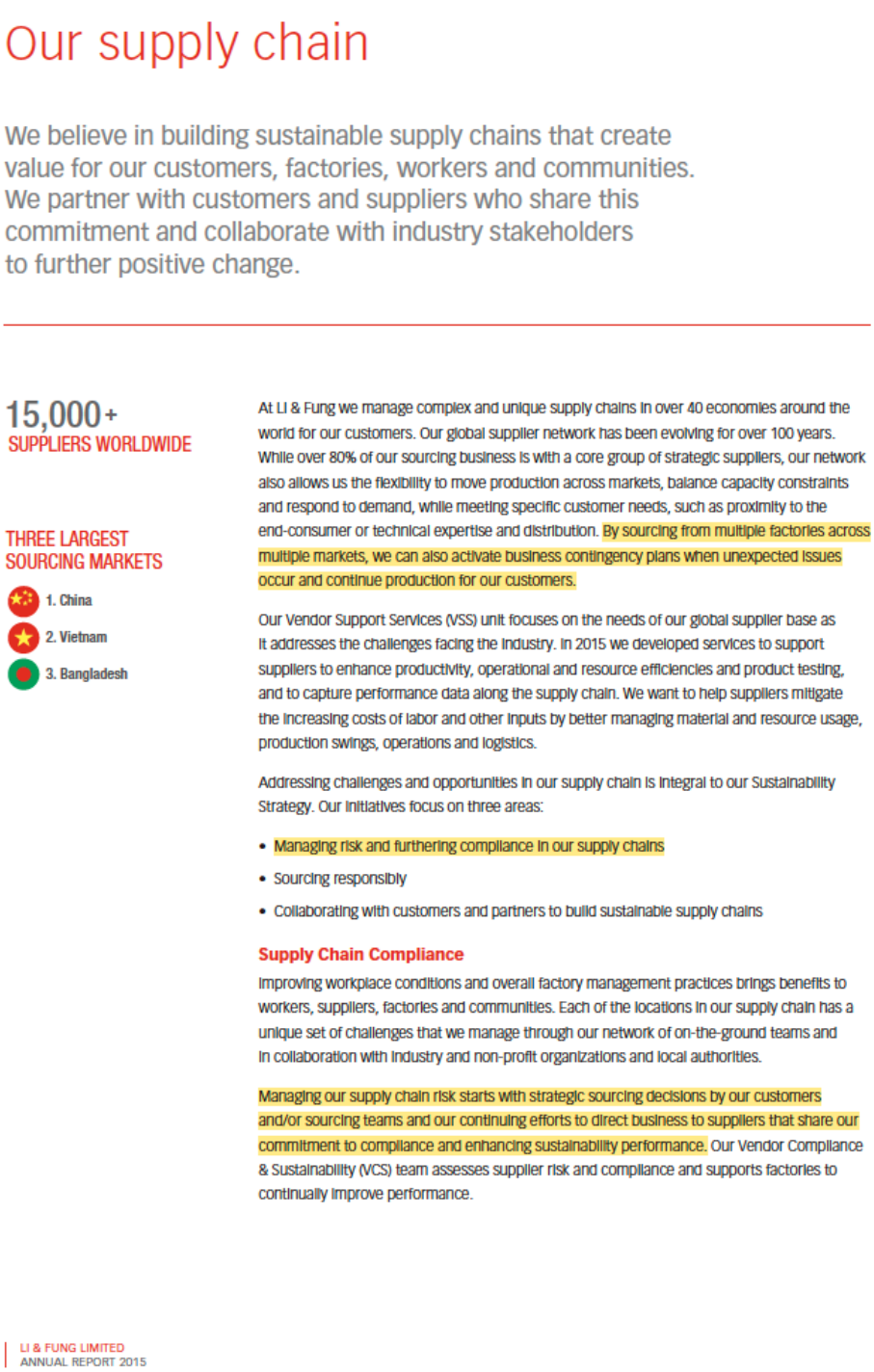
– Interviews with clothing supply chain actors using intermediaries,
Vedel & Ellegaard (2013) [link]

"Distributors play a critical role in the economy, and this role was elevated during recent unpredictable demand fueled by COVID and the subsequent supply-chain disruptions."

– Article on industrial intermediaries, Boston Consulting Group (2023) [link]

A.2. Intermediaries' Annual Reports

FIGURE A1. Li & Fung – Annual Report (2015)



Our supply chain

We believe in building sustainable supply chains that create value for our customers, factories, workers and communities. We partner with customers and suppliers who share this commitment and collaborate with industry stakeholders to further positive change.

15,000+
SUPPLIERS WORLDWIDE

THREE LARGEST SOURCING MARKETS

1. China
2. Vietnam
3. Bangladesh

At LI & Fung we manage complex and unique supply chains in over 40 economies around the world for our customers. Our global supplier network has been evolving for over 100 years. While over 80% of our sourcing business is with a core group of strategic suppliers, our network also allows us the flexibility to move production across markets, balance capacity constraints and respond to demand, while meeting specific customer needs, such as proximity to the end-consumer or technical expertise and distribution. By sourcing from multiple factories across multiple markets, we can also activate business contingency plans when unexpected issues occur and continue production for our customers.

Our Vendor Support Services (VSS) unit focuses on the needs of our global supplier base as it addresses the challenges facing the industry. In 2015 we developed services to support suppliers to enhance productivity, operational and resource efficiencies and product testing, and to capture performance data along the supply chain. We want to help suppliers mitigate the increasing costs of labor and other inputs by better managing material and resource usage, production swings, operations and logistics.

Addressing challenges and opportunities in our supply chain is integral to our Sustainability Strategy. Our initiatives focus on three areas:

- Managing risk and furthering compliance in our supply chains
- Sourcing responsibly
- Collaborating with customers and partners to build sustainable supply chains

Supply Chain Compliance

Improving workplace conditions and overall factory management practices brings benefits to workers, suppliers, factories and communities. Each of the locations in our supply chain has a unique set of challenges that we manage through our network of on-the-ground teams and in collaboration with industry and non-profit organizations and local authorities.

Managing our supply chain risk starts with strategic sourcing decisions by our customers and/or sourcing teams and our continuing efforts to direct business to suppliers that share our commitment to compliance and enhancing sustainability performance. Our Vendor Compliance & Sustainability (VCS) team assesses supplier risk and compliance and supports factories to continually improve performance.

82 | LI & FUNG LIMITED
ANNUAL REPORT 2015

FIGURE A2. Univar Solutions – End of Year Note to Customers (2021)

Managing supply through a resilient and reliable network

Looking ahead to a new year

It's hard to believe another year is coming to an end. While 2021 had more than its share of challenges, the growth in our customer and supplier relationships will serve us all well in the new year. We are hopeful we will put many of the supply challenges behind us in 2022.

While many factors have created widespread product availability issues in 2021, the situation allowed our team to work with existing suppliers in creative new ways to ensure supply continuity by securing supply routes and finding new sources to keep customers running. Pairing our domestic and global network of manufacturers with our local sales and technical teams proved invaluable to keeping our customers supplied. We plan to keep those communications channels open in the new year and provide our customers with the products and services needed to help keep our communities healthy, fed, clean, operating and safe.

As your partner, we will continue leveraging our extensive geographic footprint and premier producer partners to give our customers an advantage in situations such as supplying materials that require steel drums. We will also remain vigilant in managing supply through reliable freight deliveries, reliable/sustainable packaging, warehousing/inventory, and secure supply routes from our supplier network.

While no one can fully predict what 2022 will bring, Univar Solutions takes pride and is in a position to help our customers operate, overcome and plan for the challenges that remain in place going into 2022, as well as new challenges that arise to minimize disruptions. We are here for our customers, providing continuity to your business with teams of logistics experts, an extensive distribution network comprised of a significant private truck fleet, account managers, product managers, scientists, chemists and technical advisors to find your next solution.

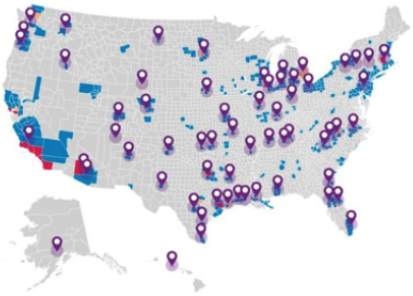
2021 has taught us a lot about the global production base and supply chains. We have been nimble and challenged like most; but we have learned a lot in the process. We are using those learnings and focusing on improving your customer experience.

The new year will start fast as it always does. Your Univar Solutions team will be ready. Please work with your representative early to help you get what you need when you need it.

Thank you for the trust you place in our team every day. We do not take it for granted.

Have a wonderful and safe holiday season!

Largest & Most Local Distribution Network (60 Minutes Away)



Our objectives are focused on customer success and include:

- **Safe handling and on-time delivery**
- **Leverage strong position with local manufacturing and supply chains**
- **Offer technical and application development expertise**
- **Expansion of key supplier relationships**
- **Enabling customers and suppliers ESG objectives**
- **Help customers unlock value using our Solution Centers**
- **Enabling sustainable solutions by offering more sustainably sourced, clean label products**

B. Empirical Appendix

TABLE A1. Number and Concentration of Suppliers (Homogeneous Goods)

	(log) # suppliers		HHI suppliers	
	(1)	(2)	(3)	(4)
Intermediary Dummy	0.044***	0.036***	-0.016***	-0.012***
	(0.007)	(0.008)	(0.002)	(0.003)
Firm size (sales)	Yes	Yes	Yes	Yes
Imported value	Yes	Yes	Yes	Yes
Product - country FE	Yes	Yes	Yes	Yes
Observations	120,930	42,543	120,930	42,543

Notes: This table replicates columns (3) and (6) in Table 3 for subsets of goods that are less differentiated according to the Rauch classification. Columns (1) and (3) exclude products classified as *differentiated* from the sample. Columns (2) and (4) consider only goods classified as *homogeneous* (i.e., goods traded on an organized exchange or where a reference price is available). All regressions are at the firm-HS6 product-origin country level. The independent variable is a dummy indicating whether the buyer is a wholesaler The sample includes all import transactions in Chile in 2019. Standard errors are clustered at the firm level.

TABLE A2. Number of Suppliers and Supply Chain Risk (Producers)

	(log) # suppliers					
	Geopolitical Risk		Economic Uncertainty		Trade Volatility	
	(1)	(2)	(3)	(4)	(5)	(6)
Supply Chain Risk	0.037***	0.043***	0.024***	0.021**	0.046***	0.056***
	(0.005)	(0.009)	(0.007)	(0.009)	(0.002)	(0.002)
Firm size	Yes	Yes	Yes	Yes	Yes	Yes
Imported value	Yes	Yes	Yes	Yes	Yes	Yes
Product FE (HS6)	No	Yes	No	Yes	No	Yes
Origin-country productivity	No	Yes	No	Yes	No	Yes
Origin-country trade costs	No	Yes	No	Yes	No	Yes
Observations	126,671	125,718	108,687	108,088	127,327	125,809

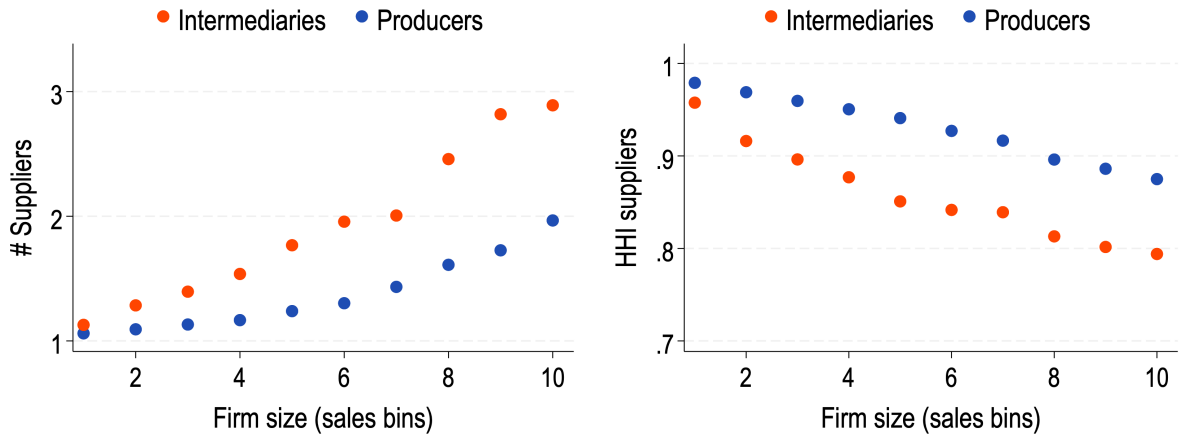
Notes: This table shows how the number of suppliers of producers varies with supply chain risk. All regressions are at the firm-HS6 product-origin country level. Supply chain risk is measured by the Geopolitical Risk index (Caldara & Iacoviello 2022) and the Economic Policy Uncertainty index (Baker, Bloom & Davis 2016) at the origin-country level, and by the volatility of trade flows at the origin country-product level. Controls include the import value of the transaction, and total factor productivity and the number of trade procedures in the origin country. The sample includes all import transactions by Chilean producers in 2019. Standard errors are clustered at the level of the risk measure.

TABLE A3. Number of Suppliers and Supply Chain Risk (Interactions)

	(log) # suppliers					
	Geopolitical Risk		Economic Uncertainty		Trade Volatility	
	(1)	(2)	(3)	(4)	(5)	(6)
Intermediary Dummy	0.049**	0.049***	0.055***	0.054***	0.047***	0.048***
	(0.019)	(0.011)	(0.006)	(0.005)	(0.002)	(0.002)
Intermediary × Supply Chain Risk	0.040***	0.003	0.039***	0.015***	0.057***	0.011***
	(0.014)	(0.004)	(0.006)	(0.004)	(0.002)	(0.002)
Firm size (sales)	Yes	Yes	Yes	Yes	Yes	Yes
Imported value	Yes	Yes	Yes	Yes	Yes	Yes
Product FE (HS6)	Yes	No	Yes	No	Yes	No
Product - Country FE	No	Yes	No	Yes	No	Yes
Observations	317,239	299,476	274,470	264,208	316,783	295,383

Notes: This table shows how the number of suppliers varies with supply chain risk, including interactions for intermediary buyers. All regressions are at the firm-HS6 product-origin country level. Supply chain risk is measured by the Geopolitical Risk index (Caldara & Iacoviello 2022) and the Economic Policy Uncertainty index (Baker, Bloom & Davis 2016) at the origin-country level, and by the volatility of trade flows at the origin country-product level. Controls include firms size (using 10 bins based on total sales) and the import value of the transaction. The sample includes all import transactions by Chilean producers in 2019. Standard errors are clustered at the level of the risk measure.

FIGURE A3. Number and Concentration of Suppliers (Weighted Average)



A. Suppliers per firm-product-origin country

B. Input Concentration across suppliers

Notes: Panel A displays the number of suppliers that a firm has per product (HS 6-digits) and origin country. Panel B computes a Herfindahl-Hirschman index (HHI) across suppliers per product-origin country. Each panel groups firms into 10 bins according to total sales (Tax Authority of Chile, SII). Within each bin, a dot represents the mean value of the variable on the y-axis. Since firms source multiple products from multiple countries, I consider the weighted-average across products and origin countries within a firm. Weights are determined by imported values, which reduces the influence of peripheral inputs and markets.

TABLE A4. Supplier Separation Rates and Supply Chain Risk

	Average Separation Rate					
	Geopolotical Risk		Economic Uncertainty		Trade Volatility	
	(1)	(2)	(3)	(4)	(5)	(6)
Supply Chain Risk	0.055*	0.116***	0.067***	0.116***	0.010***	0.013***
	(0.029)	(0.041)	(0.019)	(0.023)	(0.002)	(0.002)
× Indirect Sourcing		-0.116***		-0.095***		-0.008***
		(0.028)		(0.029)		(0.000)
Product FE (HS6)	Yes	Yes	Yes	Yes	Yes	Yes
Origin-country productivity	Yes	Yes	Yes	Yes	Yes	Yes
Origin-country trade costs	Yes	Yes	Yes	Yes	Yes	Yes
Observations	52,799	52,799	38,801	38,801	54,186	54,186

Notes: This table shows how average separation rates at the origin country-product level vary with supply chain risk. Separation rates are computed as the share of supply links that break from period t to $t+1$. Columns (2), (4), and (6) include interactions to distinguish between links established directly by producers or indirectly through intermediaries. Controls include the origin country's total factor productivity and number of trade procedures. The sample includes all import transactions in 2018 for firms active in both 2018 and 2019. Standard errors are clustered at the level of the risk measure.

TABLE A5. Probability of Supply Link Separations (Demand Controls)

	Firm-product-country			Firm-product-country-supplier		
	(1)	(2)	(3)	(4)	(5)	(6)
Intermediary dummy	-0.078***	-0.063***	-0.061***	-0.060***	-0.048***	-0.046***
	(0.008)	(0.008)	(0.007)	(0.007)	(0.007)	(0.007)
Δ Firm-level imports	Yes	No	Yes	Yes	No	Yes
Δ Firm-level suppliers	No	Yes	Yes	No	Yes	Yes
Firm size (sales)	Yes	Yes	Yes	Yes	Yes	Yes
Imported value	Yes	Yes	Yes	Yes	Yes	Yes
Number of suppliers	Yes	Yes	Yes	No	No	No
Product - country FE	Yes	Yes	Yes	Yes	Yes	Yes
Observations	284,115	284,115	284,115	400,938	400,938	400,938

Notes: This table replicates Table 5 but including controls for changes in demand conditions across buyers: the change in firm-level imports and suppliers. The dependent variable is a dummy indicating whether supply links break from period t to $t+1$. The independent variable is a dummy indicating whether the buyer is a wholesaler. The sample considers all import transactions in 2018 for firms active in both 2018 and 2019. Standard errors are clustered at the firm level.

TABLE A6. Correlation across Supply Link Separations (firm-origin-product)

	Average correlation (ρ)				
	1 supplier	2 suppliers	3 suppliers	4 suppliers	5 suppliers
All firms	–	0.067	0.090	0.092	0.085
Producers	–	0.093	0.094	0.103	0.109
Wholesalers	–	0.051	0.088	0.085	0.071

Notes: This table reports the average correlation across link separations at the buyer-origin country-product (HS6) level. The analysis is conducted separately for observations with $N = \{2, 3, 4, 5\}$ suppliers. The probabilistic event is represented by a binary variable indicating whether a link active in period t will break in $t+1$. Pairwise correlations are computed for each combination of links (i, j) given N, such that ρ reports the average across pairs. The sample includes all producers in 2018 that remain active in 2019.

C. Theory Appendix

C.1. Proof of Proposition 1

Let's first derive the expression for *ex-post* profits conditional on network operability. Recall the *ex-post* maximization problem of producer ω in the single-location case:

$$\max_{p_i(\omega),\, q_i(\omega),\, x_{il}(\omega)} \pi_i^{\text{ex-post}}\left(\omega \,\middle|\, M_l, S_l^D, Z_l\right) = \left[p_i(\omega) - c_i\left(\omega \,\middle|\, M_l, S_l^D, Z_l\right)\right] q_i(\omega)$$

Considering the linear production technology $q_i(\omega) = \varphi(\omega) x_{il}(\omega)$, input purchases are determined by downstream quantities. We then have the standard firm problem with monopolistic competition and CES demand $q_i(\omega) = p_i(\omega)^{-\sigma} P_i^{\sigma-1} E_i$, which can be expressed in terms of downstream prices alone. Omitting indexes, the first-order condition is $q(p) + pq'(p) - cq'(p) = 0$, and producers set a constant markup $p = \frac{\sigma}{\sigma-1} c$ such that:

$$\pi_i^{\text{ex-post}} = c(\omega)^{1-\sigma} \frac{1}{\sigma} \left(\frac{\sigma}{\sigma-1}\right)^{1-\sigma} P_i^{\sigma-1} E_i$$

where the marginal cost is given by input prices in the single location available, $c(\omega) = \frac{p^{x,M}}{\varphi(\omega)}$. Thus, *ex-post* profits under indirect sourcing can be expressed as a fraction of those under direct sourcing:

$$\pi_i^{\text{ex-post}}\left(M_l = I\right) = \varphi(\omega)^{\sigma-1} \left(\kappa p^x\right)^{1-\sigma} \frac{1}{\sigma} \left(\frac{\sigma}{\sigma-1}\right)^{1-\sigma} P_i^{\sigma-1} E_i = \kappa^{1-\sigma} \pi_i^{\text{ex-post}}\left(M_l = D\right)$$

where $\kappa \geq 1$ and $\sigma > 1$.

For the second part, note that $\sigma > 1$ implies that *ex-post* profits are supermodular in

firm productivity $\varphi(\omega)$ and a function $\phi(\kappa) \equiv \frac{1}{\kappa p^x}$, which is analogous to the *sourcing capability* defined in the multi-location case. This implies *negative complementarities* between $\varphi(\omega)$ and κ. Formally, the brokerage fee reduces *ex-post* profits $\left(\frac{\partial \pi_i^{\text{ex-post}}}{\partial \kappa} < 0\right)$, and this effect becomes more negative with higher productivity levels $\left(\frac{\partial^2 \pi_i^{\text{ex-post}}}{\partial \varphi \, \partial \kappa} < 0\right)$.

C.2. Proof of Proposition 2

Part (a). Consider the probability that a supply network in location l is operational, $\Pr\left(S_l^O(\omega) \geq 1\right)$, conditional on a sourcing strategy $\left(M_l(\omega), S_l^D(\omega)\right)$. Under direct sourcing, we need this probability to increase with the number of direct links:

$$\Pr\left(S_l^O(\omega) \geq 1 \middle| D, S+1\right) > \Pr\left(S_l^O(\omega) \geq 1 \middle| D, S\right) \quad \forall S \in \mathcal{N}$$

Since links are disrupted with exogenous probability ζ_l^D, the number of *operational* suppliers $S_l^O(\omega)$ follows a Binomial distribution, such that:

$$\Pr\left(S_l^O(\omega) \geq 1 \middle| D, S\right) = 1 - \Pr\left(S_l^O(\omega) = 0 \middle| D, S\right) = 1 - \binom{S}{0}\left(1-\zeta_l^D\right)^0\left(\zeta_l^D\right)^S = 1 - \left(\zeta_l^D\right)^S$$

and we only need $\left(\zeta_l^D\right)^{S+1} < \left(\zeta_l^D\right)^S$ for all $S \in \mathcal{N}$, which holds trivially for $\zeta_l^D \in (0,1)$.

Analogously, for intermediation to increase operability, we need this probability to increase relative to sourcing directly from one supplier:

$$\Pr\left(S_l^O(\omega) \geq 1 \middle| I\right) > \Pr\left(S_l^O(\omega) \geq 1 \middle| D, 1\right), \text{ where } \Pr\left(S_l^O(\omega) \geq 1 \middle| I\right) = 1 - \left(\zeta_l^I\right)^{S_l^I}$$

Since the intermediation technology exhibits $\left\{S_l^I \geq S_l^D, \zeta_l^I \leq \zeta_l^D\right\}$, it follows $\left(\zeta_l^I\right)^{S_l^I} \leq \left(\zeta_l^D\right)$. Although this analysis considers independent disruptions on supply links, it is possible to incorporate correlated shocks. As discussed in the extensions, producers may face location-level disruptions affecting all l-suppliers with some probability ξ_l.

Part (b). Using the probabilities for network operability derived above, the expected *ex-ante* profits of producer ω under the direct sourcing strategy $\left(D, S^D\right)$ are:

$$\begin{aligned}\mathbb{E}\left[\pi^{\text{ex-ante}}(\omega) \middle| D, S^D\right] &= \left[1 - \left(\zeta^D\right)^{S^D}\right]\pi^{\text{ex-post}}\left(\omega, D\right) - f^D\left(S^D\right) \\ &= \chi(S^D)\,\varphi(\omega)^{\sigma-1}\left(p^x\right)^{1-\sigma}B - f^D\left(S^D\right)\end{aligned}$$

where $\chi(S^D) \equiv \left[1-\left(\zeta^D\right)^{S^D}\right]$ and $B \equiv \frac{1}{\sigma}\left(\frac{\sigma}{\sigma-1}\right)^{1-\sigma} P^{\sigma-1}E$. Consider two firms with productivity levels $\varphi^H > \varphi^L$ that, conditional on direct sourcing, choose to match with $S^{D,H}$ and $S^{D,L}$ suppliers. These choices are optimal if:

$$\text{(A1)} \quad \chi(S^{D,H})\left(\varphi^H\right)^{\sigma-1}\left(p^x\right)^{1-\sigma}B - f^D\left(S^{D,H}\right) \geq \chi(S^{D,L})\left(\varphi^H\right)^{\sigma-1}\left(p^x\right)^{1-\sigma}B - f^D\left(S^{D,L}\right)$$

$$\text{(A2)} \quad \chi(S^{D,H})\left(\varphi^L\right)^{\sigma-1}\left(p^x\right)^{1-\sigma}B - f^D\left(S^{D,H}\right) \leq \chi(S^{D,L})\left(\varphi^L\right)^{\sigma-1}\left(p^x\right)^{1-\sigma}B - f^D\left(S^{D,L}\right)$$

Combining inequalities (A1) and (A2) we get:

$$\text{(A3)} \quad \left[\chi(S^{D,H}) - \chi(S^{D,L})\right]\left[\left(\varphi^H\right)^{\sigma-1} - \left(\varphi^L\right)^{\sigma-1}\right]\left(p^x\right)^{1-\sigma}B \geq 0$$

This implies that if $\varphi^H \geq \varphi^L$, then $\chi(S^{D,H}) \geq \chi(S^{D,L})$ and therefore $S^{D,H} \geq S^{D,L}$. Note that the number of suppliers affects expected profits through $\chi(S^D)$ but not p^x, which relies on perfect supplier substitution within locations. However, this result holds when relaxing this assumption, in which case additional suppliers can reduce input prices (e.g., due to better matches under search frictions or lower markups with imperfect competition) or increase them (e.g., due to less productive suppliers).[51]

Part (c). Consider again two firms with productivity levels $\varphi^H > \varphi^L$ and sourcing modes M^H and M^L. The proposition states that $M^H = I$ and $M^L = D$ cannot be optimal, which can be shown by contradiction. If $M^H = I$ and $M^L = D$ are optimal, they must satisfy the following conditions:

$$\text{(A4)} \quad \chi(D, S^{D,H})\left(\varphi^H\right)^{\sigma-1}\left(p^x\right)^{1-\sigma}B - f^D\left(S^{D,H}\right) \leq \chi(I)\left(\varphi^H\right)^{\sigma-1}\left(p^x\right)^{1-\sigma}B - f^I$$

$$\text{(A5)} \quad \chi(D, S^{D,L})\left(\varphi^L\right)^{\sigma-1}\left(p^x\right)^{1-\sigma}B - f^D\left(S^{D,L}\right) \geq \chi(I)\left(\varphi^L\right)^{\sigma-1}\left(p^x\right)^{1-\sigma}B - f^I$$

where $\chi(M, S^D) \equiv \left[1-\left(\zeta^D\right)^{S^D}\right]$ under direct sourcing, $\chi(I) \equiv \frac{1}{\kappa^{\sigma-1}}\left[1-\left(\zeta^I\right)^{S^I}\right]$ under indirect sourcing, and $S^{D,H}$ and $S^{D,L}$ are the best direct options for each firm. In the case of φ^H, this implies that $M^H = I$ is also preferred to $S^{D,L}$. Replacing this in (A4) we get:

$$\text{(A6)} \quad \chi(D, S^{D,L})\left(\varphi^H\right)^{\sigma-1}\left(p^x\right)^{1-\sigma}B - f^D\left(S^{D,L}\right) \leq \chi(I)\left(\varphi^H\right)^{\sigma-1}\left(p^x\right)^{1-\sigma}B - f^I$$

[51] In the first case, producers have two reasons to diversify: lower prices and risk mitigation. In the second case, the price effect reduces the incentives to diversify, but it remains true that more productive firms are more likely to afford it.

and combining (A6) with the condition for φ^L to source directly (A5), we obtain:

$$\left[\chi(I) - \chi(D, S^{D,L})\right]\left[\left(\varphi^H\right)^{\sigma-1} - \left(\varphi^L\right)^{\sigma-1}\right]\left(p^x\right)^{1-\sigma} B \geq 0 \tag{A7}$$

The inequality (A7) requires $\chi(I) > \chi(D, S^{D,L})$. However, in that case it would not be optimal for φ^L to source directly in the first place: since $f^I < f^D(S)$, the condition (A5) would not be satisfied, leading to a contradiction.

C.3. Proof of Proposition 3

Part (a). Consider the triplet $\mathcal{I} = \left\{S_l^I \geq 1, \zeta_l^I \leq \zeta_l^D, \kappa \geq 1\right\}$ containing the intermediation technology and brokerage fee to access inputs in location l, and expected input costs $\mathbb{E}\left[\left(p_{il}^x\right)^{1-\sigma} \middle| M_l, S_l^D\right]$ given a sourcing strategy $\{M_l, S_l^D\}$. I define a mapping $\widetilde{S}_l^I$ that transforms $\mathcal{I}$ into an *equivalent* number of direct suppliers:

$$\widetilde{S}_l^I(\mathcal{I}) \equiv \left\{S : \mathbb{E}\left[\left(p_{il}^x\right)^{1-\sigma} \middle| D, S\right] = \mathbb{E}\left[\left(p_{il}^x\right)^{1-\sigma} \middle| I\right]\right\}$$

As shown in Proposition 2, under independent disruptions across links the number of operational suppliers follows a Binomial distribution, such that:

$$\left[1 - \left(\zeta_l^D\right)^{\widetilde{S}_l^I}\right]\left(p_{il}^x\right)^{1-\sigma} = \frac{\left[1 - \left(\zeta_l^I\right)^{S_l^I}\right]}{\kappa^{\sigma-1}}\left(p_{il}^x\right)^{1-\sigma}$$

$$\iff \widetilde{S}_l^I = \frac{\ln\left(1 - \dfrac{1 - \left(\zeta_l^I\right)^{S_l^I}}{\kappa^{\sigma-1}}\right)}{\ln\left(\zeta_l^D\right)} > 0 \tag{A8}$$

For the numerator in (A8) to be well-defined, we need $\left(1 - \dfrac{1 - \left(\zeta_l^I\right)^{S_l^I}}{\kappa^{\sigma-1}}\right) > 0$, which is always satisfied considering that $\kappa^{\sigma-1} \geq 1$ for $\sigma > 1$ and $\left(1 - \left(\zeta_l^I\right)^{S_l^I}\right) \in (0, 1)$. On the other hand, the denominator is well-defined for $\zeta_l^D \in (0, 1)$. Since both the numerator and denominator take negative values, we have $\widetilde{S}_l^I > 0$. Intermediation then reduces (increases) expected input costs for firms that can match fewer (more) than $\widetilde{S}_l^I$ suppliers directly.

Part (b). Consider a set of productivity cutoffs $\left\{\varphi_l^D(S_l^D)\right\}$ such that, under direct sourcing and a particular choice $S_l^D \in \mathcal{S}_l$, expected *ex-ante* profits are zero. Each cutoff is

unique as *ex-ante* expected profits are monotonically increasing in φ.

$$\text{(A9)} \quad \mathbb{E}\left[\pi_i^{\text{ex-ante}} \,\middle|\, D, S_l^D\right] = 0 \iff \varphi_l^D(S_l^D) = \left(\frac{f_l^D(S_l^D)}{\left(1-(\zeta_l^D)^{S_l^D}\right)\left(P_{il}^x\right)^{1-\sigma} B} \right)^{\frac{1}{\sigma-1}} \quad \text{for } S_l^D \in \mathcal{S}_l$$

Analogously, φ_l^I sets expected *ex-ante* profits to zero under indirect sourcing:

$$\text{(A10)} \qquad \mathbb{E}\left[\pi_i^{\text{ex-ante}} \,\middle|\, I\right] = 0 \iff \varphi_l^I = \left(\frac{\kappa^{\sigma-1} f_l^I}{\left(1-(\zeta_l^I)^{S^I}\right)\left(P_{il}^x\right)^{1-\sigma} B} \right)^{\frac{1}{\sigma-1}}$$

For a positive mass of producers to source indirectly, we need both $\mathbb{E}\left[\pi_i^{\text{ex-ante}} \,\middle|\, I\right] > 0$ and $\mathbb{E}\left[\pi_i^{\text{ex-ante}} \,\middle|\, I\right] > \mathbb{E}\left[\pi_i^{\text{ex-ante}} \,\middle|\, D, S_l^D\right]$ for all $S_l^D \in \mathcal{S}_l$ in some productivity range. The monotonicity of expected profits ensures that $\mathbb{E}\left[\pi_i^{\text{ex-ante}} \,\middle|\, I\right]$ and each curve $\mathbb{E}\left[\pi_i^{\text{ex-ante}} \,\middle|\, D, S_l^D\right]$ intersect at most once. Since $f_l^I \geq f_l^D(S_l^D)$ for all $S_l^D \in \mathcal{S}_l$, this can only occur if expected indirect profits reach the zero-profit threshold before all direct curves.[52] From (A9) and (A10) we have:

$$\text{(A11)} \qquad \varphi_l^I < \varphi_l^D(S_l^D) \;\; \forall \; S_l^D \in \mathcal{S}_l \iff \frac{1-(\zeta_l^I)^{S_l^I}}{1-(\zeta_l^D)^{S_l^D}} > \frac{\kappa^{\sigma-1} f_l^I}{f_l^D(S_l^D)} \;\; \forall \; S_l^D \in \mathcal{S}_l$$

This provides a technological condition for intermediation to take place: the resilience of intermediated networks must be high enough to compensate for the brokerage fee, once adjusted for reductions in matching costs.

Part (c). I now derive the productivity threshold φ_l^* where producers switch from indirect to direct sourcing. Given the higher intercept of $\mathbb{E}\left[\pi_i^{\text{ex-ante}} \,\middle|\, I\right]$ and the monotonicity of expected *ex-ante* profits in φ, producers move to direct sourcing after the first direct curve $\mathbb{E}\left[\pi_i^{\text{ex-ante}} \,\middle|\, D, S_l^D\right]$ crosses the indirect curve from below. The intersections for each

[52] If some direct curve reaches zero-profits before, then all producers opt for direct sourcing. The technological condition above guarantees that this is not the case.

$S_l^D \in \mathcal{S}_l$ are:

$$\mathbb{E}\left[\pi_i^{\text{ex-ante}} \,\middle|\, D, S_l^D\right] = \mathbb{E}\left[\pi_i^{\text{ex-ante}} \,\middle|\, I\right]$$

$$\iff \varphi_l^*(S_l^D) = \left(\frac{f_l^D(S_l^D) - f_l^I}{\left(1 - (\zeta_l^D)^{S_l^D} - \frac{1-(\zeta_l^I)^{S^I}}{\kappa^{\sigma-1}}\right)\left(P_{il}^x\right)^{1-\sigma} B} \right)^{\frac{1}{\sigma-1}} \quad \text{for } S_l^D \in \mathcal{S}_l \tag{A12}$$

We can then define the switching threshold as the minimum of the thresholds in (A12):

$$\varphi_l^* = \min_{S_l^D} \varphi_l^*(S_l^D) \text{ for } S_l^D \in |\mathcal{S}_l| \tag{A13}$$

Note that $\varphi_l^* > 0$ if $\frac{1-(\zeta_l^I)^{S^I}}{1-(\zeta_l^D)^{S_l^D}} < \kappa^{\sigma-1}$ for some S_l^D, while all producers would source indirectly otherwise (i.e., indirect *ex-ante* profits do not intersect with any of the direct *ex-ante* profits for positive values of φ). Therefore, combining parts (b) and (c), we have the following condition for both indirect and direct sourcing to take place:

$$\frac{\kappa^{\sigma-1} f_l^I}{f_l^D(S_l^D)} < \frac{1-(\zeta_l^I)^{S^I}}{1-(\zeta_l^D)^{S_l^D}} < \kappa^{\sigma-1} \quad \forall\, S_l^D \in \mathcal{S}_l$$

C.4. Proof of Proposition 4

Part (a). From Proposition 3, the productivity cutoff φ_l^I above which indirect sourcing generates positive expected *ex-ante* profits is given by (A10), which is a function of the indirect disruption probability ζ_l^I:

$$\varphi_l^I(\zeta_l^I) = \left(\frac{\kappa^{\sigma-1} f_l^I}{\left(1 - (\zeta_l^I)^{S^I}\right)\left(p_{il}^x\right)^{1-\sigma} B} \right)^{\frac{1}{\sigma-1}}$$

Assuming that the technological condition for intermediation (A11) is satisfied, there is a positive mass of firms sourcing indirectly starting from this cutoff. Given final demand

B, the change in φ_l^I with respect to small changes in ζ_l^I is:

$$\frac{\partial \varphi_l^I(\zeta_l^I)}{\partial \zeta_l^I} = \frac{1}{\sigma-1}\left(\frac{\kappa^{\sigma-1} f_l^I}{\left(1-(\zeta_l^I)^{S^I}\right)\left(p_{il}^x\right)^{1-\sigma} B}\right)^{\frac{1}{\sigma-1}-1} \frac{\partial\left(1-(\zeta_l^I)^{S^I}\right)^{-1}}{\partial \zeta_l^I} \frac{\kappa^{\sigma-1} f_l^I}{\left(p_{il}^x\right)^{1-\sigma} B}$$

$$= \frac{1}{\sigma-1}\,\varphi_l^I(\zeta_l^I)\,\frac{S^I(\zeta_l^I)^{S^I-1}}{1-(\zeta_l^I)^{S^I}} \quad > 0$$

This expression is positive given that $\sigma > 1$, $\zeta_l^I \in (0,1)$, $S^I \in \mathbb{N}^+$, and $\varphi_l^I(\zeta_l^I) > 0$. Thus, the threshold $\varphi_l^I(\zeta_l^I)$ increases and some indirect buyers stop sourcing indirectly.

Part (b). Consider now the productivity threshold where firms switch from indirect to direct sourcing, φ_l^*, as defined in (A12). This is a function of direct ζ_l^D and indirect ζ_l^I disruption probabilities:

$$\varphi_l^*(\zeta_l^D, \zeta_l^I) = \min_{S_l^D}\left[\frac{f_l^D(S_l^D) - f_l^I}{\left(1-(\zeta_l^D)^{S_l^D} - \frac{1-(\zeta_l^I)^{S^I}}{\kappa^{\sigma-1}}\right)\left(P_{il}^x\right)^{1-\sigma} B}\right]^{\frac{1}{\sigma-1}} \quad \text{for } S_l^D \in |\mathcal{S}_l|$$

As before, I assume that the technological condition for intermediation (A11) is satisfied, ensuring that a positive mass of firms sources indirectly. Similarly, I assume $\kappa^{\sigma-1} > \frac{1-(\zeta_l^I)^{S^I}}{1-(\zeta_l^D)^{S_l^D}}$, which ensures $\varphi^*(\zeta_l^D, \zeta_l^I) > 0$ and therefore a positive mass of direct buyers. Since ζ_l^D and ζ_l^I vary in the same proportion, we can write $\zeta \equiv \zeta_l^D$ and $\zeta_l^I = \mu\zeta$ for some factor $\mu \in (0,1)$. Considering $\tilde{S}_l^D$ as the number of direct suppliers that defines the cutoff $\varphi_l^*(\zeta_l)$ and differentiating with respect to ζ we get:

$$\frac{\partial \varphi_l^*(\zeta_l)}{\partial \zeta_l} = \frac{1}{\sigma-1}\left[\frac{f_l^D(\tilde{S}_l^D) - f_l^I}{A(\zeta_l)\left(P_{il}^x\right)^{1-\sigma} B}\right]^{\frac{1}{\sigma-1}-1} \frac{\partial A^{-1}(\zeta_l)}{\partial \zeta_l} \frac{\left(f_l^D(\tilde{S}_l^D) - f_l^I\right)}{\left(P_{il}^x\right)^{1-\sigma} B}$$

where the auxiliary mapping is $A(\zeta_l) \equiv \left(1 - (\zeta_l)^{\tilde{S}_l^D} - \frac{1-(\mu\,\zeta_l)^{S_l^I}}{\kappa^{\sigma-1}}\right)$, such that:

$$\frac{\partial A(\zeta_l)}{\partial \zeta_l} = -\left(A(\zeta_l)\right)^{-2}\left(\frac{S_l^I\left(\zeta_l\right)^{S_l^I-1}\mu^{S_l^I}}{\kappa^{\sigma-1}} - \tilde{S}_l^D\left(\zeta_l\right)^{\tilde{S}_l^D-1}\right)$$

Since $\sigma > 1$, $f_l^D(S) > f_l^I$, and $A(\zeta_l) > 0$ under the condition for direct sourcing, we have that $\frac{\partial \varphi_l^*(\zeta)}{\partial \zeta_l} > 0$ when $\frac{\partial A(\zeta_l)}{\partial \zeta} > 0$. This requires the following condition to hold:

$$\left(\zeta_l\right)^{S_l^I-\tilde{S}_l^D}\left(\frac{S_l^I}{\tilde{S}_l^D}\right) < \left(\frac{\kappa^{\sigma-1}}{\mu^{S_l^I}}\right)$$

This is satisfied as long as the probability of disruptions ζ_L is not particularly high. In fact, noting that the RHS is always greater than one and defining $d \equiv S_l^I - \tilde{S}_l^D \geq 1$, a sufficient condition is $\zeta < \left(\frac{\tilde{S}_l^D}{\tilde{S}_l^D+d}\right)^{1/d}$. Since the upper bound increases with $\tilde{S}_l^D$ and d, we can set $\tilde{S}_l^D = d = 1$ to show that $\zeta_l < 0.5$ is sufficient (though not necessary) for $\frac{\partial A(\zeta)}{\partial \zeta} > 0$, in which case firms switch from direct to indirect sourcing in response to risk.

Part (c). Consider an arbitrary number of direct suppliers $S \in \mathcal{S}_l$ and define the productivity cutoff φ_{S+1}^D, which equalizes expected *ex-ante* profits for S and $S+1$ suppliers:

$$\varphi_{S+1}^D(\zeta_l^D) = \left(\frac{f_l^D\left(S+1\right) - f_l^D\left(S\right)}{\left(1-(\zeta_l^D)^{S+1} - \left(1-(\zeta_l^D)^S\right)\right)\left(p_{il}^x\right)^{1-\sigma}B}\right)^{\frac{1}{\sigma-1}} \tag{A14}$$

Following Proposition 2(b), producers with productivity above this cutoff prefer to source from $S+1$ rather than S direct suppliers, while the opposite is true for those below. Differentiating with respect to ζ_l^D we obtain:

$$\frac{\partial \varphi_{S+1}^D(\zeta_l^D)}{\partial \zeta_l^D} = \frac{1}{\sigma-1}\left[\frac{f_l^D\left(S+1\right) - f_l^D\left(S\right)}{A(\zeta_l^D)\left(P_{il}^x\right)^{1-\sigma}B}\right]^{\frac{1}{\sigma-1}-1}\frac{\partial A^{-1}(\zeta_l^D)}{\partial \zeta_l^D}\frac{\left(f_l^D\left(S+1\right) - f_l^D\left(S\right)\right)}{\left(P_{il}^x\right)^{1-\sigma}B}$$

where the auxiliary mapping is now $A(\zeta_l^D) \equiv (\zeta_l^D)^S \left(1 - \zeta_l^D\right) > 0$ and:

$$\frac{\partial A(\zeta_l^D)}{\partial \zeta_l^D} = -\left(A(\zeta)\right)^{-2} \left(S(\zeta_l^D)^S - (S+1)(\zeta_l^D)^{S+1}\right) < 0 \quad \text{for} \;\; \zeta_l^D < \frac{S}{S+1}$$

Given that $\sigma > 1$ and $f_l^D(S+1) > f_l^D(S)$, we have that $\frac{\partial \varphi_{S+1}^D(\zeta_l^D)}{\partial \zeta_l^D} < 0$ if the probability of disruptions ζ_l^D is not particularly high. This implies that some producers sourcing directly expand their supply sets. In turn, this condition always holds if $\zeta_l^D < 0.5$, and it becomes more flexible as the number of suppliers increases.

C.5. Proof of Proposition 5

Part (a). The expected *ex-ante* profits of producer ω given a sourcing strategy $\vartheta(\omega) \equiv \left\{L(\omega), M_l(\omega), S_l^D(\omega)\right\}$ are:

$$\mathbb{E}\left[\pi^{\text{ex-ante}}(\omega) \,\middle|\, \vartheta(\omega)\right] = \varphi(\omega)^{\sigma-1} \mathbb{E}\left[\Theta^{\frac{\sigma-1}{\eta-1}} \,\middle|\, \vartheta(\omega)\right] B - \sum_{L(\omega)} \mathbb{I}_{\{M_l(\omega)=D\}} f_l^D\left(S_l^D(\omega)\right) - \sum_{L(\omega)} \mathbb{I}_{\{M_l(\omega)=I\}} f_l^I$$

Consider two firms with productivity levels $\varphi^H > \varphi^L$. For readability, denote their sourcing strategies as ϑ^H and ϑ^L, and the associated fixed sourcing costs as $F(\vartheta^H)$ and $F(\vartheta^L)$. For these choices to be optimal, we require:

$$\left(\varphi^H\right)^{(\sigma-1)} \mathbb{E}\left[\Theta^{\frac{\sigma-1}{\eta-1}} \,\middle|\, \vartheta^H\right] B - F(\vartheta^H) \geq \left(\varphi^H\right)^{(\sigma-1)} \mathbb{E}\left[\Theta^{\frac{\sigma-1}{\eta-1}} \,\middle|\, \vartheta^L\right] B - F(\vartheta^L) \tag{A15}$$

$$\left(\varphi^L\right)^{(\sigma-1)} \mathbb{E}\left[\Theta^{\frac{\sigma-1}{\eta-1}} \,\middle|\, \vartheta^H\right] B - F(\vartheta^H) \leq \left(\varphi^L\right)^{(\sigma-1)} \mathbb{E}\left[\Theta^{\frac{\sigma-1}{\eta-1}} \,\middle|\, \vartheta^L\right] B - F(\vartheta^L) \tag{A16}$$

Combining both inequalities, we obtain:

$$\left[\mathbb{E}\left[\Theta^{\frac{\sigma-1}{\eta-1}} \,\middle|\, \vartheta^H\right] - \mathbb{E}\left[\Theta^{\frac{\sigma-1}{\eta-1}} \,\middle|\, \vartheta^L\right]\right]\left[\left(\varphi^H\right)^{\sigma-1} - \left(\varphi^L\right)^{\sigma-1}\right] B \geq 0 \tag{A17}$$

Since $\sigma > 1$, this implies that $\mathbb{E}\left[\Theta^{\frac{\sigma-1}{\eta-1}} \,\middle|\, \vartheta^H\right] \geq \mathbb{E}\left[\Theta^{\frac{\sigma-1}{\eta-1}} \,\middle|\, \vartheta^L\right]$ for $\varphi^H \geq \varphi^L$. Note that this result does not depend on the specific pattern of disruptions assumed.

Part (b). I first show that expected *ex-ante* profits satisfy increasing differences in the choice of source locations $(\mathbb{I}_l, \mathbb{I}_{l'})$, where $\mathbb{I}_l$ and $\mathbb{I}_{l'}$ are indicator variables for whether l

and l' are included in the sourcing strategy. In the case without risk and parameter space $\sigma > \eta$, this holds trivially in the profit function $\pi(\mathbb{I}_l, \mathbb{I}_{l'}) = \varphi^{\sigma-1}\big(\Theta(\mathbb{I}_l, \mathbb{I}_{l'})\big)^{\frac{\sigma-1}{\eta-1}} B - F(\mathbb{I}_l, \mathbb{I}_{l'})$, which implies:

$$\pi(1,1) - \pi(0,1) \geq \pi(1,0) - \pi(0,0) \iff$$

$$\Theta(1,1)^{\frac{\sigma-1}{\eta-1}} - \Theta(0,1)^{\frac{\sigma-1}{\eta-1}} \geq \Theta(1,0)^{\frac{\sigma-1}{\eta-1}} - \Theta(0,0)^{\frac{\sigma-1}{\eta-1}}$$

To extend this result to the case with independent disruptions, consider χ_l and χ'_l as the probabilities that each location is operational. Expected profits satisfy increasing differences if:

$$\mathbb{E}\Big[\pi^{\text{ex-ante}}(1,1)\Big] - \mathbb{E}\Big[\pi^{\text{ex-ante}}(0,1)\Big] \geq \mathbb{E}\Big[\pi^{\text{ex-ante}}(1,0)\Big] - \mathbb{E}\Big[\pi^{\text{ex-ante}}(0,0)\Big] \iff$$

$$\chi_{l'}\chi_l\Theta(1,1)^{\frac{\sigma-1}{\eta-1}} + \chi_{l'}\big(1-\chi_l\big)\Theta(1,0)^{\frac{\sigma-1}{\eta-1}} + \big(1-\chi_{l'}\big)\chi_l\Theta(0,1)^{\frac{\sigma-1}{\eta-1}} + \big(1-\chi_{l'}\big)\big(1-\chi_l\big)\Theta(0,0)^{\frac{\sigma-1}{\eta-1}}$$

$$-\left\{\chi_l\Theta(0,1)^{\frac{\sigma-1}{\eta-1}} + \big(1-\chi_l\big)\Theta(0,0)^{\frac{\sigma-1}{\eta-1}}\right\} \geq \chi_{l'}\Theta(1,0)^{\frac{\sigma-1}{\eta-1}} + \big(1-\chi_{l'}\big)\Theta(0,0)^{\frac{\sigma-1}{\eta-1}} \iff$$

$$\chi_{l'}\chi_l\left[\Theta(1,1)^{\frac{\sigma-1}{\eta-1}} - \Theta(0,1)^{\frac{\sigma-1}{\eta-1}} - \Theta(1,0)^{\frac{\sigma-1}{\eta-1}} + \Theta(0,0)^{\frac{\sigma-1}{\eta-1}}\right] \geq 0$$

where $\chi_{l'}\chi_l > 0$ and the term in brackets is positive under increasing differences without risk, which is satisfied for $\sigma > \eta$. Note that, for simplicity but without loss of generality, I have abstracted from risk in locations other than l and l'.[53]

I next show that expected *ex-ante* profits satisfy increasing differences in the choice of direct suppliers $(S_l^D, S_{l'}^D)$. To ease notation, consider the following mapping:

$$\begin{aligned}\mathrm{K}(S', S) \equiv{}& \chi_{l'}(S')\chi_l(S)\big(\Theta(1,1)\big)^{\frac{\sigma-1}{\eta-1}} + \chi_{l'}(S')\big(1-\chi_l(S)\big)\big(\Theta(1,0)\big)^{\frac{\sigma-1}{\eta-1}} + \\ &\big(1-\chi_{l'}(S')\big)\chi_l(S)\big(\Theta(0,1)\big)^{\frac{\sigma-1}{\eta-1}} + \big(1-\chi_{l'}(S')\big)\big(1-\chi_l(S)\big)\big(\Theta(0,0)\big)^{\frac{\sigma-1}{\eta-1}}\end{aligned} \tag{A18}$$

where $\chi_{l'}(S')$ and $\chi_l(S)$ are the probabilities that locations l' and l are operational given

[53] The assumption of independent disruptions adds tractability but is not necessary for this result. Intuitively, increasing differences in location choices without risk extend to the risk case as long as the contribution of additional locations does not reduce the contribution of current locations. This may not hold if sourcing from l' increases the probability of disruptions in l, but can accommodate global shocks to all locations. However, if shocks are more correlated, the benefits of diversification diminish.

choices S' and S.[54] For increasing differences to hold, we need:

$$\mathbb{E}\Big[\pi^{\text{ex-ante}}(S'+1,S+1)\Big]-\mathbb{E}\Big[\pi^{\text{ex-ante}}(S',S+1)\Big]\geq\mathbb{E}\Big[\pi^{\text{ex-ante}}(S'+1,S)\Big]-\mathbb{E}\Big[\pi^{\text{ex-ante}}(S',S)\Big]$$

$$\iff \mathsf{K}(S'+1,S+1)-\mathsf{K}(S',S+1)\geq\mathsf{K}(S'+1,S)-\mathsf{K}(S',S)$$

$$\iff \Big(\chi_{l'}(S'+1)-\chi_{l'}(S')\Big)\Big(\chi_{l}(S+1)-\chi_{l}(S)\Big)\ *$$

$$\Big[\big(\Theta(1,1)\big)^{\frac{\sigma-1}{\eta-1}}-\big(\Theta(0,1)\big)^{\frac{\sigma-1}{\eta-1}}-\big(\Theta(1,0)\big)^{\frac{\sigma-1}{\eta-1}}+\big(\Theta(0,0)\big)^{\frac{\sigma-1}{\eta-1}}\Big]\geq 0$$

The first two terms are positive as the probability that a location is operational increases with the number of suppliers, while the square brackets contain the condition for increasing differences without risk, which holds for $\sigma>\eta$.

I have shown that expected *ex-ante* profits satisfy increasing differences in $(\mathbb{I}_l,\mathbb{I}_{l'})$ and $(S^D_{l'},S^D_l)$, while increasing differences in $(\mathbb{I}_l,S^D_l)$ follow trivially. Given that for any choice $(\mathbb{I}_l,S^D_{l'},\cdot)$ we have $\mathbb{E}\Big[\pi^{\text{ex-ante}}(\mathbb{I}_l,S^D_l,\cdot)\Big]=\varphi^{\sigma-1}\mathsf{K}(\mathbb{I}_l,S^D_l,\cdot)\,B-F(\mathbb{I}_l,S^D_l,\cdot)$, this function also satisfies increasing differences in $(\mathbb{I}_l,\varphi)$ and (S^D_l,φ) for $\sigma>\eta>1$. Applying Topkis's monotonicity theorem, we have that $\mathbb{I}_l(\varphi^H)\geq\mathbb{I}_l(\varphi^L)$ and $S^D_l(\varphi^H)\geq S^D_l(\varphi^L)$ for $\varphi^H\geq\varphi^L$.

Part (c). From Proposition 3, we know that at any location l', there exists an equivalent number of direct suppliers $\widetilde{S}_{l'}$ for the intermediation technology (A8). Only firms that can match with $S^D_{l'}>\widetilde{S}_{l'}$ suppliers consider sourcing directly in l', and $S^D_{l'}$ is an increasing function of firm productivity φ. In the single-location case, this guarantees that a high-productivity firm φ^H would not resort to indirect sourcing if a low-productivity firm φ^L sources directly. With multiple locations, sourcing decisions in l' are affected by decisions in all locations through the expected sourcing capability, $\mathbb{E}\Big[\Theta(\varphi)^{\frac{\sigma-1}{\eta-1}}\Big]$. Parts (a) and (b) demonstrated that this object is an increasing function of φ and, if $\sigma>\eta$, this increases the optimal number of direct suppliers at any location. This monotonic relationship extends the result to the multi-location context.

I prove this by contradiction for the case with two locations, l' and l. To ease notation, I use the mapping $\mathsf{K}(S',S)$ defined in (A18) for choices S' and S in locations l' and l. If φ^H sources indirectly from l', and S^H_l is the corresponding choice in l, the following

[54] The number of suppliers enters only the probabilities and not the sourcing capability under perfect supplier substitution. However, it is straightforward to extend this result under imperfect supplier substitution as modelled in Section 3.6.

condition would be satisfied:

$$\left(\varphi^H\right)^{\sigma-1}\mathrm{K}\left(\widetilde{S}_{l'}, S_l^H\right)B - f_{l'}^I - f_l^D(S_l^H) \geq \left(\varphi^H\right)^{\sigma-1}\mathrm{K}\left(S_{l'}, S_l\right)B - f_{l'}^D(S_{l'}) - f_l^D(S_l) \quad \forall S_{l'} \in \mathcal{S}_{l'}, S_l \in \mathcal{S}_l$$

where indirect sourcing in l' is *equivalent* to access $S' = \widetilde{S}_{l'}$ direct suppliers. This implies:

$$\left(\varphi^H\right)^{\sigma-1}\mathrm{K}\left(\widetilde{S}_{l'}, S_l^H\right)B - f_{l'}^I \geq \left(\varphi^H\right)^{\sigma-1}\mathrm{K}\left(S_{l'}^H, S_l^H\right)B - f_{l'}^D(S_{l'}^H) \tag{A19}$$

where $S_{l'}^H$ is the best direct alternative in l' given a choice S_l^H in l, and the fixed costs $f_l^D(S_l^H)$ offset each other. Analogously, if φ^L sources directly from $S_{l'}^L$ suppliers in l', and the corresponding choice in l is S_l^L, we have:

$$\left(\varphi^L\right)^{\sigma-1}\mathrm{K}\left(S_{l'}^L, S_l^L\right)B - f_{l'}^D(S_{l'}^L) - f_l^D(S_l^L) \geq \left(\varphi^L\right)^{\sigma-1}\mathrm{K}\left(\widetilde{S}_{l'}, S_l\right)B - f_{l'}^I - f_l^D(S_l) \quad \forall S_{l'} \in S_l \in \mathcal{S}_l$$

which implies that:

$$\left(\varphi^L\right)^{\sigma-1}\mathrm{K}\left(S_{l'}^L, S_l^L\right)B - f_{l'}^D(S_{l'}^L) \geq \left(\varphi^L\right)^{\sigma-1}\mathrm{K}\left(\widetilde{S}_{l'}, S_l^L\right)B - f_{l'}^I \tag{A20}$$

Combining inequalities (A19) and (A20) we get:

$$\begin{aligned} f_{l'}^D(S_{l'}^H) - f_{l'}^D(S_{l'}^L) \;\geq\; & \left(\varphi^H\right)^{\sigma-1}\Big(\mathrm{K}\left(S_{l'}^H, S_l^H\right) - \mathrm{K}\left(\widetilde{S}_{l'}, S_l^H\right)\Big)B \\ & - \left(\varphi^L\right)^{\sigma-1}\Big(\mathrm{K}\left(S_{l'}^L, S_l^L\right) - \mathrm{K}\left(\widetilde{S}_{l'}, S_l^L\right)\Big)B \end{aligned} \tag{A21}$$

However, if $S_{l'}^H$ is the best direct alternative in l' given a choice S_l^H in l, then we also have:

$$\left(\varphi^H\right)^{\sigma-1}\Big(\mathrm{K}\left(S_{l'}^H, S_l^H\right) - \mathrm{K}\left(S_{l'}^L, S_l^H\right)\Big)B \;\geq\; f_{l'}^D(S_{l'}^H) - f_{l'}^D(S_{l'}^L) \tag{A22}$$

which combined with inequality (A21) implies:

$$\left(\varphi^L\right)^{\sigma-1}\Big(\mathrm{K}\left(S_{l'}^L, S_l^L\right) - \mathrm{K}\left(\widetilde{S}_{l'}, S_l^L\right)\Big)B \;\geq\; \left(\varphi^H\right)^{\sigma-1}\Big(\mathrm{K}\left(S_{l'}^L, S_l^H\right) - \mathrm{K}\left(\widetilde{S}_{l'}, S_l^H\right)\Big)B \tag{A23}$$

We know that $\mathrm{K}\left(S_{l'}^L, S_l^L\right) - \mathrm{K}\left(\widetilde{S}_{l'}, S_l^L\right) \geq 0$ since $f_{l'}^D(S_{l'}^L) \geq f_{l'}^I$ in (A20). However, $\mathrm{K}\left(S_{l'}^L, S_l^H\right) - \mathrm{K}\left(\widetilde{S}_{l'}, S_l^H\right)$ is also positive and larger in magnitude since $S_l^H \geq S_l^L$ for $\varphi^H > \varphi^L$, which is driven by the increasing differences established in part (b). This leads to a contradiction.

D. Estimation Appendix

TABLE A7. Elasticity of Substitution across Input Locations

	(log) Input purchases					1rst Stage	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
(log) Input prices	-0.248***	-0.224***	-0.251***	-0.404***	-0.378***		
	(0.002)	(0.002)	(0.008)	(0.082)	(0.074)		
(log) Distance						0.302***	0.338***
						(0.025)	(0.025)
Firm-Year FE	Yes	Yes	No	No	No	No	No
Firm FE	No	No	Yes	Yes	Yes	Yes	Yes
Country-Year FE	No	Yes	No	No	No	No	No
Country productivity	No	No	No	No	Yes	No	Yes
IV	No	No	No	Yes	Yes	Yes	Yes
Sample	2005-19	2005-19	2019	2019	2019	2019	2019
Observations	365,505	365,104	22,176	21,955	21,805	21,955	21,805

Notes: This table uses an empirical counterpart of equation (18) to estimate the elasticity of substitution across input locations (η). The dependent variable is the (log) of input purchases for a given buyer-origin country-year, the key regressor is the (log) of input prices, and the estimated coefficients correspond to $1 - \eta$. All regressions include firm (firm-year) fixed effects, capturing variation for the same buyer across origins. Columns (1) and (2) use the full panel of years (2005–2019), column (3) considers the last year in the sample (2019), columns (4) and (5) instrument input prices with geographic distance from Chile, while columns (6) and (7) present first stages. The table reports robust standard errors.

TABLE A8. Elasticity of Substitution across Suppliers

	(log) Input prices			
	(1)	(2)	(3)	(4)
(log) # Suppliers	-0.256***	-0.279***	-0.266***	-0.295***
	(0.003)	(0.003)	(0.011)	(0.012)
Country-Product FE	No	No	Yes	Yes
Country-Product-Year FE	Yes	Yes	No	No
Firm FE	No	No	No	Yes
Firm-Year FE	No	Yes	No	No
Sample	2005-19	2005-19	2019	2019
Observations	1,954,843	1,917,790	115,483	112,903

Notes: This table uses an empirical counterpart of equation (21) to estimate the elasticity of substitution across suppliers within locations (θ). The dependent variable is (log) input prices for a given location (country - HS6 product) and year, the key regressor is the (log) number of suppliers, and the estimated coefficients correspond to $-1/\theta$. All regressions include location (location-year) fixed effects, capturing variation across buyers sourcing from the same market. Columns (1) and (2) consider the full sample of years, while columns (3) and (4) use the last year available (2019). The table reports robust standard errors.

TABLE A9. Location-Specific Trade and Production Unit Costs

	Raw estimates (USD)		Normalized (Chile=1)	
Region	All years (2005-19)	Only 2019	All years (2005-19)	Only 2019
CHN	12.67	17.31	1.93	3.12
EU	74.92	91.03	11.42	16.42
LAT	17.72	14.97	2.70	2.70
ROW	109.46	56.34	16.68	10.16
US	84.74	88.99	12.92	16.05

Notes: This table presents estimates for trade and production costs ($\tau_l \alpha_l$) across source regions. The raw estimates are in USD, and the normalized version is defined relative to input costs in Chile. Since domestic sourcing is not directly observed, I assume similar production costs in Chile and Latin America, attributing all differences to iceberg trade costs, which are estimated to be around a factor of 2.7 (Anderson and Van Wincoop 2004). Thus, by construction, Latin America has an input cost of 2.7 in the last two columns.

TABLE A10. Estimated Parameters for Link Separation Probabilities

Dep. Variable: $\mathbb{D}(separation)_{bsl}$					
Location factors (Z_l)				Demand factors (D_b)	
Geopolitical risk	0.328***	Low-income dummy	-1.817***	Δ firm imports	-0.254***
	(0.033)		(0.066)		(0.066)
Economic uncertainty	0.180***	Mid-income dummy	-1.993***	Δ firm suppliers	-1.057***
	(0.027)		(0.063)		(0.018)
Trade volatility	0.052***	High-income dummy	-2.385***		
	(0.007)		(0.011)		

Notes: This table presents the estimates for vectors Z_l and D_b in the logit model (27) estimating the probability of link separations. The regressions are at the buyer-supplier-location level, where locations are defined at the origin country-HS6 product level. The dependent variable is a dummy that equals 1 when a buyer-supplier link in period t will be inactive in $t+1$. The demand factors are excluded from the projected disruption probabilities. The sample considers all import transactions in 2018 for firms active in 2018 and 2019. The table reports robust standard errors clustered at the location level.

TABLE A11. Differences in Separation Rates by Region (Indirect vs. Direct)

	LAT	CHN	USA	EUR	ROW
	(1)	(2)	(3)	(4)	(5)
Intermediary dummy	-0.060***	-0.055***	-0.070***	-0.050***	-0.064***
	(0.015)	(0.012)	(0.013)	(0.012)	(0.018)
Firm size (sales)	Yes	Yes	Yes	Yes	Yes
Imported value	Yes	Yes	Yes	Yes	Yes
Number of suppliers	Yes	Yes	Yes	Yes	Yes
Product - country FE	Yes	Yes	Yes	Yes	Yes
Δ Firm-level imports	Yes	Yes	Yes	Yes	Yes
Δ Firm-level suppliers	Yes	Yes	Yes	Yes	Yes
Observations	29,694	72,881	49,715	87,922	43,868

Notes: This table compares supplier separation rates for producers and intermediaries in each source region: Latin America, China, the United States, Europe, and Rest of the World. For each group, the regressions are at the buyer-origin country-HS6 product level. The dependent variable is a dummy that equals 1 when the buyer has a separation from period t to $t+1$. The independent variable is a dummy indicating whether the buyer is an intermediary. Controls for changes in demand conditions across buyers are included (firm-level imports and suppliers). The sample includes all import transactions in 2018 for firms active in both 2018 and 2019. Standard errors are clustered at the firm level.