Productivity, Matchability and Intermediation in Production Networks

Kalina Manova
UCL, CEPR, CEP

Andreas Moxnes
BI Norwegian Business School, CEPR

Oscar Perelló
UCL, Inter-American Development Bank

March 2026

Abstract

This paper examines trade intermediation to unpack the firm attributes and matching costs that govern firm-to-firm production networks. Exploiting rich customs data for Chile, we show that exporters of all sizes (i) sell direct, through intermediaries or both; (ii) mix trade modes across buyers; and (iii) set lower prices on intermediated flows. We rationalize these facts in a model of network formation with suppliers of heterogeneous productivity and matchability, buyers of heterogeneous productivity, and intermediaries that reduce matching costs for a brokerage fee. Empirical evidence on trade activity across firms and countries corroborates the model, and informs how logistics, customs efficiency, and formal and informal contracting shape network costs. Model estimation reveals that intermediaries lower matching costs by 26% on average, and ignoring buyer heterogeneity would bias this estimate upwards by 60%. Moreover, sellers' attributes are negatively correlated. This amplifies the welfare gains from intermediation, since intermediaries widen and deepen production networks primarily by linking highly productive sellers with low matchability to smaller buyers.

Contact: Kalina Manova (k.manova@ucl.ac.uk), Andreas Moxnes (andreas.moxnes@bi.no), Oscar Perelló (oscar.perello.19@ucl.ac.uk). This project has received funding from the European Research Council (ERC) under the European Union's Horizon 2020 research and innovation programme (grant agreement No 101141494) and from the UK Research and Innovation (UKRI) under the UK's Horizon Europe ERC Funding Guarantee (grant No EPZ5333971).

1. Introduction

Firm production networks have transformed global economic activity, and become focal to policy objectives of growth and stability. Despite dramatic declines in transportation and communication costs in recent decades, driven by both policy advancements and technological innovations, buyer-supplier networks remain sparse and dominated by few, highly connected large firms. These patterns suggest that significant barriers to network formation persist, limiting firms' potential to benefit from globalization. Of special interest is whether network connectivity is subject to market frictions that warrant policy intervention. This underpins the active arena of trade promotion and facilitation, especially in developing countries that are highly reliant on international trade but burdened by poor infrastructure.

Key to these questions are the costs of firm network formation and operation, and the market solutions that emerge to facilitate buyer-supplier interactions. The nature of search, match and transaction costs matters for how firms and countries participate in production networks, how this impacts firm profits and consumer welfare, and how firms prepare for and respond to shocks or policy reforms. By easing firm transactions, specialized intermediaries can importantly reshape these network patterns and consequences. Indeed, wholesalers mediate a significant share of global trade, accounting for example for 50% of imports and 14% of exports in Chile. Yet little is known about the essence of firm network costs and the role of intermediaries in buyer-supplier links.

This paper examines trade intermediation to unpack the firm attributes and matching costs that govern firm-to-firm production networks. Exploiting rich customs data for Chile, we show that exporters of all sizes (i) sell direct, through intermediaries, or both; (ii) mix trade modes across buyers; and (iii) set lower prices on intermediated flows. We rationalize these facts in a model of network formation with suppliers of heterogeneous productivity and matchability, buyers of heterogeneous productivity, and intermediaries that reduce matching costs for a brokerage fee. Empirical evidence on trade activity across firms and countries corroborates the model, and informs how logistics, customs efficiency, and formal and informal contracting shape network costs. Model estimation reveals that intermediaries lower matching costs by 26% on average. Ignoring buyer heterogeneity would bias this estimate upwards by 60%, while ignoring seller matchability would counterfactually imply that all suppliers use intermediation and equally-sized suppliers adopt the same sales strategy. Moreover, sellers' attributes are negatively correlated, such that intermediaries primarily link highly productive sellers with low matchability to smaller buyers. This amplifies the welfare gains from intermediation from 0.4% without heterogeneous matchability to 3.3% with.

Our first contribution is to unveil empirical facts about direct and intermediated trade in firm networks. We exploit comprehensive Chilean data on the universe of firm-to-firm import transactions, matched to tax records that report business activity. This allows us to identify foreign exporters, domestic producers, and import intermediaries.[1] We also classify foreign suppliers according to their trade strategy: purely direct exporters that sell only directly to manufacturers, purely indirect exporters that transact only with wholesalers, and mixed exporters that pursue both trade modes.

We document three stylized facts. First, exporters across the size distribution use all three trading strategies, with bigger exporters less likely to trade purely directly, more likely to mix trade modes, and similarly likely to trade purely indirectly. This sharply contrasts with existing intermediation models, in which all sellers above (below) a productivity cutoff sort into direct (indirect) trade, and points to the need to consider supplier heterogeneity along two, imperfectly correlated dimensions. Second, exporters frequently mix trade modes within narrow products and regardless of product rank. Mixed suppliers split product-level exports evenly between direct and intermediated sales, with negligible variation across their core and peripheral products. This suggests that buyer heterogeneity is also needed to rationalize intermediation patterns. Third, exporters charge wholesalers lower prices than producer buyers. Purely indirect suppliers set lower prices than purely direct and mixed suppliers, and mixed suppliers set lower prices on their indirect transactions. This result informs rent sharing with wholesalers, and the trade-off exporters face when choosing their sales strategy.

Our second contribution is to develop a general-equilibrium model of network formation with trade intermediation that is motivated by the empirical facts. In the model, upstream suppliers choose their optimal set of downstream buyers, trade mode with each buyer, and sales value, price and quantity in each match. Upstream suppliers are heterogeneous along two dimensions: productivity, which pins down their marginal production cost, and matchability, which determines their fixed cost of searching, matching and transacting directly with a buyer. Downstream firms are heterogeneously productive in assembling inputs into final goods. Finally, specialized wholesalers facilitate buyer-supplier transactions at a lower match-specific fixed cost, and charge a fee for their services by capturing a share of the trade surplus from each match under Nash bargaining with the supplier. The general equilibrium is characterized by a fixed point for link functions that describe all direct and indirect matches.

This model illustrates novel economic mechanisms, and delivers rich predictions for the pattern of global production networks. Along the extensive margin, the set of ultimate

[1] We use "wholesaler" and "intermediary" interchangeably. The data distinguishes between wholesalers that conduct firm-to-firm transactions and retailers that mediate firm-to-consumer sales. We restrict our analysis to wholesalers to study intermediation in production networks as distinct from intermediation chains to consumers. We capture the vast majority of cross-border flows, as retailers account for less than 10% of total imports in Chile.

customers widens with a seller's productivity and matchability, where these attributes jointly determine the profitability of each potential buyer under direct and indirect trade and thereby the seller's total sales. There can thus be purely direct, purely indirect, and mixed sellers along the entire seller size distribution. Given productivity (matchability), suppliers with higher matchability (productivity) are less likely to sell exclusively indirectly and more likely to sell exclusively directly. Moreover, mixed suppliers optimally serve buyers above (below) a cutoff productivity directly (indirectly). Along the intensive margin, bilateral sales conditional on a match increase with both seller and buyer productivity, because buyer's input demand is higher when inputs are cheaper and when final demand is greater due to cheaper output. The trade mode also matters, as a seller's price and revenue are lower when serving a buyer through an intermediary.

Intermediaries thus widen production networks by enabling more firm links, especially for smaller buyers and for productive suppliers with low matchability. Intermediaries also deepen production networks, as higher buyer connectivity endogenously increases input purchases through lower input costs and higher final demand.

Our third contribution is to provide empirical evidence that corroborates the model and informs the nature of network transaction costs. At the micro level, we show that the median number of direct buyer links varies little across supplier size bins, while the link distribution overlaps greatly across bins. This is in line with two-dimensional seller heterogeneity in the model, and inconsistent with strict monotonicity predicted by frameworks with a single seller attribute. We also confirm that direct buyer-seller matches exhibit negative degree assortativity such that more connected buyers (suppliers) on average trade with less connected suppliers (buyers). While negative degree assortativity has previously been reported in firm networks, we document it specifically for direct links that differ conceptually from intermediated links.

We then examine the variation in trade intermediation across countries exporting to Chile at the sector level. Using GDP per capita as a proxy for average productivity, we document that the shares of intermediated trade and of indirect suppliers fall with origin income, consistent with model implications for the seller productivity distribution. We also analyze a series of country characteristics that capture three types of matching and transaction costs: shipping and logistics; customs and red tape; and contracting frictions. This informs what barriers challenge buyer-supplier link formation, but are possible for specialized wholesalers to alleviate. Our results suggest that intermediaries primarily help producers in arranging shipping logistics and transacting with customers when informal contracting institutions are weak: they mediate a greater share of trade flows emanating from distant countries with unreliable shipping arrivals, low trust in foreigners, and limited religious similarity. By contrast, trade intermediation varies little with customs efficiency or the quality of formal contracting institutions.

Our final contribution is to quantify the welfare effects of trade intermediation and the role of firm heterogeneity. We estimate the model using the simulated method of moments. Three main results emerge from the quantification exercise. First, we find a negative correlation between supplier productivity and matchability, i.e. highly productive suppliers have higher direct matching costs on average. While we do not investigate the origins of this correlation, it could arise, for example, due to imperfect labor markets or incomplete contracting, such as information frictions in the market for production and sales managers; CEO span of control or attention issues inside the firm; or imperfect incentives with multitasking managers.[2] Second, intermediation reduces matching costs by 26% relative to average direct matching costs. Third, modeling both buyer heterogeneity and two-dimensional seller heterogeneity is essential for matching key data features and quantifying intermediation costs. Ignoring buyer heterogeneity would bias intermediation cost estimates upwards by roughly 60%, while ignoring seller matchability would counterfactually imply that all suppliers use intermediation services (as indirect or mixed sellers) and that there is no variation in sales strategy across suppliers within a size bin.

We conclude with three counterfactual exercises. First, shutting down intermediation raises the consumer final-goods price index (CPI) by 3.3%, implying that the welfare gains from intermediation are around 3%. Intuitively, many firm-to-firm links are broken, with small, less productive buyers and high-productivity, low-matchability sellers affected the most. This speaks to policies that improve access to intermediation services, such as competition policy in the services sector. Second, the welfare gains from intermediation drop to 0.4% when sellers vary only in their productivity but not in their matchability. This suggests that intermediation services are a more valuable market solution to firms' networking problem in environments with inefficiently dispersed matching costs. Finally, maintaining access to intermediation but moving from negatively correlated to uncorrelated seller attributes decreases the CPI by 3.4%. Intuitively, highly productive firms are no longer hindered by high direct matching costs on average, almost never sell purely indirectly, and their inputs are more likely to reach final producers. These counterfactual exercises suggest large gains from trade promotion and facilitation that lowers firm-to-firm matching costs or deep integration that spans goods and services trade.

This paper bridges and advances two parallel literatures on buyer-supplier networks and

[2]There are well-established literatures in economics on limited managerial attention or span of control when supervising multiple activities (Bolton and Dewatripont, 1994; Aghion and Tirole, 1997), and on the behavior of multi-task agents when tasks differ in observability and contractual incentives (Holmstrom and Milgrom, 1991). We elaborate on these potential micro-foundations for the empirical correlation of productivity and matchability in Section 5.2.

on trade intermediation. On the one hand, research on global value chains and production networks has made important advances in documenting and understanding their complexity (Baldwin (2015), Bernard and Moxnes (2018), Antras and Chor (2022)). This literature has examined the role of global input sourcing and roundabout production for firms' productivity, quality, innovation and profitability, and thereby for the gains from trade (Goldberg et al. (2010), Manova and Zhang (2012), Gopinath and Neiman (2014), Caliendo and Parro (2015), Antras et al. (2017), Amiti and Konings (2007), Halpern et al. (2015), Bøler et al. (2015), Blaum et al. (2018), Boehm and Oberfield (2020), Bloom et al. (2021)). Frontier work highlights the roles of two-sided buyer- and seller heterogeneity and imperfect competition for endogenous network formation, performance across the firm size distribution, and the gains from trade (Chaney (2014), Carballo et al. (2018), Bernard et al. (2018), Bernard et al. (2019), Huang et al. (2021), Eaton et al. (2022), Bernard et al. (2022), Fontaine et al. (2023)). While this literature is interested in how firms match and how idiosyncratic shocks propagate to shape aggregate fluctuations, it typically treats network formation and operation costs as a black box, and abstracts away from trade intermediation (Acemoglu et al. (2012), Baqaee and Farhi (2019), Carvalho et al. (2021), Elliott et al. (2022), Lim (2018)).

A separate strand of research has explored the role of intermediaries in facilitating commerce. Intermediaries are believed to reduce the fixed costs of trade (Ahn et al. (2011), Bernard et al. (2015), Blum et al. (2009)), although their market power can diminish the gains from intermediation (Dhingra and Tenreyro (2020), Ganapati (2018), Grant and Startz (2022)). Early theoretical work examined the choice of direct vs. indirect exports of heterogeneous final producers (Antras and Costinot (2011), Ahn et al. (2011)), which counterfactually predicts that sellers above (below) a productivity threshold sort strictly into direct (indirect) sales. Data limitations also restricted early empirical analysis to comparing the exports of manufacturers and intermediaries (Bernard et al. (2010), Bernard et al. (2015)), rather than the direct and indirect exports of manufacturers as dictated by theory.

Frontier analysis highlights the role of transaction costs and intermediation in firm production networks. For example, Cai et al. (2024) find that firm referrals facilitate the formation of buyer-supplier links and benefit both parties' performance in a randomized control trial in China. In another randomized intervention in Egypt, Atkin et al. (2017) show that securing export orders through intermediaries (via trade fairs and direct marketing) likewise improve firm performance. Bekes et al. (2025) observe that specialized intermediary-integrators can also enable both the purchase and adoption of new robot technology in Hungary. In related concurrent work, Blum et al. (2025) allow for both seller and buyer productivity heterogeneity to predict the sorting of low-productivity suppliers into purely indirect sales, mid-productivity suppliers into mixed-mode sales, and high-productivity suppliers into purely direct sales, and study the implications for aggregate productivity. However, this approach cannot rationalize the prominence of purely direct small sellers, purely indirect large sellers, and mixed sales modes across the seller size distribution. We demonstrate theoretically and empirically that this can be attributed to two-dimensional seller heterogeneity (productivity and matchability), and that this feature is critical for quantifying the welfare gains from intermediation. Moreover, while Blum et al. (2025) employ data on Chilean trade with Argentina, we study the heterogeneous use of trade intermediation across all origin countries to inform the nature of network transaction costs.

More generally, our research speaks to the interdependence of manufacturing and services sectors, in that wholesale services directly shape production networks. While we focus on the use of intermediation by suppliers seeking to broaden their sales network, in complementary work Perello (2025) explores how downstream producers choose to source inputs through intermediaries to guard against supply network disruptions. Implicitly, this body of evidence indicates to what extent the market for intermediation services has responded to meet the needs of manufacturing firms. This informs thinking about trade promotion and facilitation that many developing-country governments undertake and international organizations support, as well as discussions of geopolitical reorganization of production networks.

The rest of the paper is organized as follows. Section 2 introduces the data and stylized facts. Section 3 develops the general equilibrium model of trade intermediation in production networks. Section 4 presents empirical evidence for trade patterns across firms and origin countries, and unpacks drivers of network costs. Section 5 provides model quantification and welfare counterfactuals. The last section concludes.

2. Data and Stylized Facts

2.1. Data

We exploit rich data for Chile that allows us to examine the universe of firm-to-firm import transactions and detailed characteristics of domestic firms. We obtain the value, quantity, and unit value for all import flows from the Chilean Customs Service for the 2005-2019 period. These records identify the origin country, HS 6-digit product, foreign seller, and domestic buyer for each transaction. We also collect information on firm size and primary industry of activity from the Business Statistics maintained by the Chilean Tax Authority for the same period. We match these datasets based on a unique firm tax identifier. Below we report results for the most recent cross-section in the data, year 2019; all patterns hold in the cross-section for other years and in the pooled panel with year fixed effects.

We classify Chilean firms into three types based on their main business activity: producers, wholesalers, and retailers. 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". Wholesale operations can include services incidental to trade, 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 intermediate firm-to-firm transactions, while retailers focus on firm-to-consumer transactions.

Table 1 provides summary statistics for the activity of these three types of Chilean firms. Overall, there are 13,524 producer-importers, who represent 45% of all importers and capture 46% of imports by value. Wholesaler-importers number 8,980 (30%) and account for a disproportionately large share of imports (44%). Retailer-importers are likewise numerous at 7,851 (25%), but contribute only 10% of imports. Given our interest in firm-to-firm production networks, we focus exclusively on Chilean producers and wholesalers, and omit retailers from the analysis. For convenience, we will use "wholesaler" and "intermediary" synonymously.

Table 1: Summary statistics by firm type

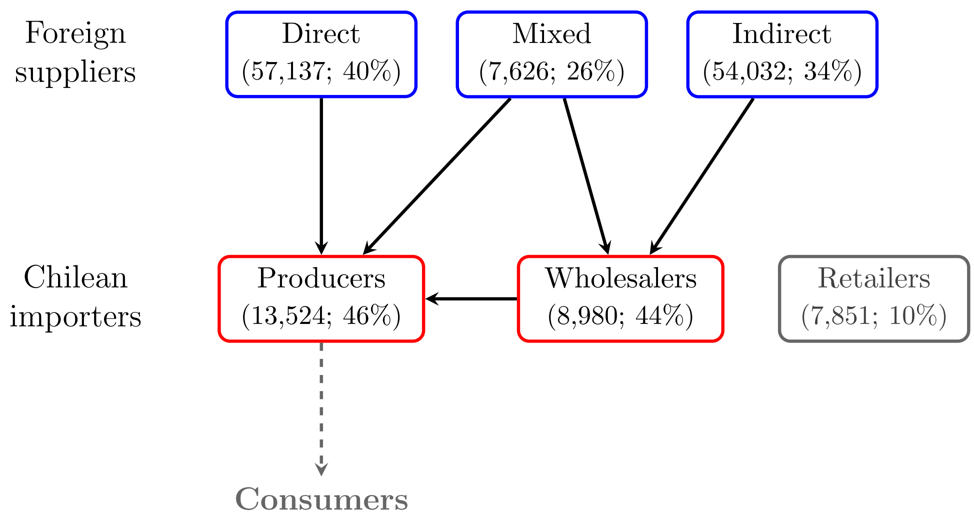
	N	%	trade value	% trade value
Chilean importers				
Producers	13,524	0.45	28,105,142	0.46
Wholesalers	8,980	0.30	26,866,504	0.44
Retailers	7,851	0.25	6,540,562	0.10
Foreign suppliers				
Direct suppliers	57,137	0.48	20,226,218	0.40
Indirect suppliers	54,032	0.45	16,858,178	0.34
Mixed suppliers	7,626	0.07	13,167,955	0.26

Note: Summary statistics are reported for the universe of Chilean importers, and for the subset of foreign suppliers trading with producers and wholesalers. Foreign suppliers transacting with retailers are excluded from the analysis. The table displays cross-sectional data for 2019.

We distinguish between three types of foreign firms exporting to Chile based on their trade strategy: Direct suppliers sell exclusively to producers, indirect suppliers transact only with wholesalers, and mixed suppliers sell both to producers and to wholesalers. In some empirical exercises, we also consider suppliers' trade mode within a particular product, in recognition of the large role of multi-product exporters in the data.

We display summary statistics for foreign suppliers in the bottom half of Table 1, and visualize the relationship between foreign suppliers and domestic buyers in Figure 1. Chile receives imports from 57,137 purely direct foreign suppliers from 141 countries of origin, 54,032 purely indirect suppliers from 148 origins, and 7,626 mixed suppliers from 78 countries. Direct and indirect exporters represent respectively 48% and 45% by count, but are responsible for only 40% and 34% of total trade value (approximately 20% less than their weight in the pool of exporters). Instead, the 7% suppliers with a mixed sales strategy conduct 26% of all exports to Chile, which is almost 4 times their weight by number.

Figure 1: Bi-partite network of foreign suppliers and Chilean importers



Note: Numbers in parenthesis correspond to the count of firms, while percentages indicate trade shares and add up to 1 in each row. The figure displays cross-sectional data for 2019.

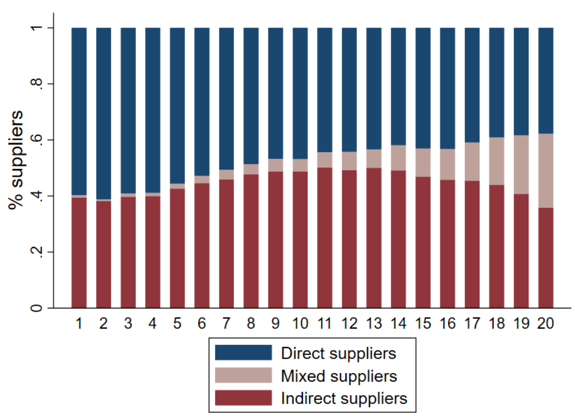
2.2. Stylized Facts

We establish three stylized facts about trade intermediation using the detailed Chilean records. These empirical regularities go against theoretical predictions in the prior literature that have not been confronted with disaggregated data on firm-to-firm transactions, and motivate key ingredients of the novel model we propose in Section 3.

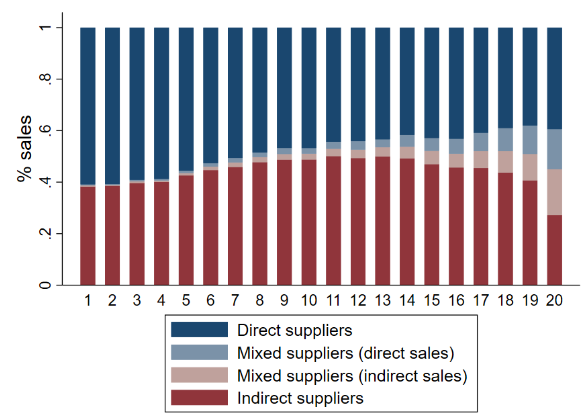
Fact 1. *Exporters across the size distribution use trade intermediation. Bigger exporters are less likely to trade purely directly, more likely to mix trade modes, and similarly likely to trade purely indirectly.*

Figure 2a documents the use of different sales strategies across 20 size bins of exporters to Chile. We measure a seller's size with its total exports to Chile, and summarize trade activity pooling across sellers from all origin countries. The share of suppliers that transact only directly with downstream producers falls systematically with supplier size, from approximately 60% in the bottom 5% to fewer than 40% in the top 5%. The share of suppliers that trade exclusively through wholesalers remains close to 40% across the size distribution, with some indication of an inverse U-shape. Finally, the share of suppliers that pursue both direct and intermediated sales rises monotonically with firm size, from negligible levels among the smallest 5% to about 30% among the biggest 5%.

Figure 2: Trade strategy across the supplier size distribution



(a) Share of suppliers by trade mode



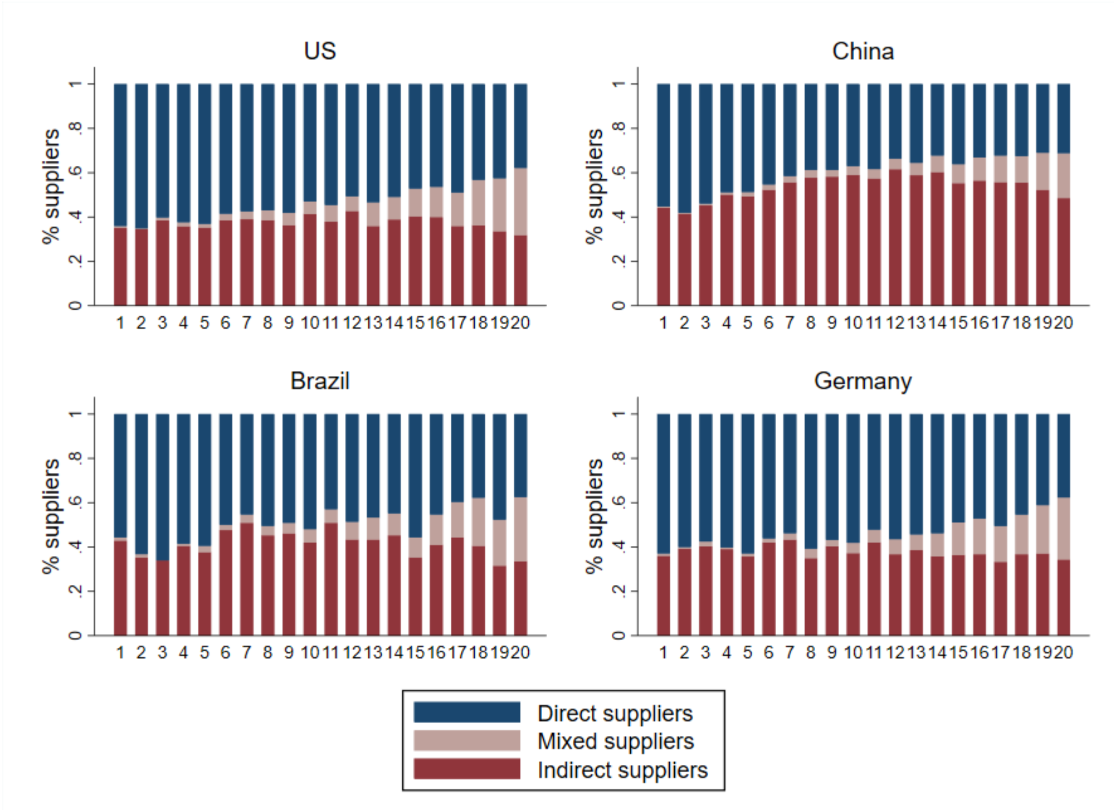
(b) Share of trade value by trade mode

Intermediated trade is not only often used by suppliers big and small, but it also accounts for a large portion of aggregate trade flows. Figure 2b decomposes the value of total exports to Chile in each exporter size bin into direct exports by purely direct suppliers, direct exports by mixed suppliers, indirect exports by mixed suppliers, and indirect exports by purely indirect suppliers. Intermediated trade contributes 40-50% of aggregate exports across the board.

Figure 3 confirms that similar patterns hold when we consider one origin country at a time. We plot the breakdown of export strategies across 20 size bins separately for suppliers from Brazil, China, Germany, and the US. These countries are not only among Chile's most important trade partners, but they also represent a mix of developed and developing economies, near and far. Each sees notable activity under all three trade modes. In Appendix Figure A1, we further confirm that these patterns persist when residualizing by product to account for differences in intermediation across industries, and when restricting the sample to homogeneous goods to account for within-industry differences in product varieties. This suggests that the observed trends are not driven by product heterogeneity.

Fact 1 sharply contrasts key predictions of existing models of trade intermediation.

Figure 3: Suppliers' trade strategy for top origin countries



Frameworks that ignore buyer heterogeneity provide no motive for mixed sales strategies within firms. Conversely, models without seller heterogeneity cannot justify varying sales modes across sellers. Notably, existing models that do feature seller heterogeneity counterfactually imply that all exporters above a productivity cutoff sort exclusively into direct exporting, while all exporters below that cutoff trade only through intermediaries (Ahn et al. (2011), Akerman (2018), Felbermayr and Jung (2011)). The new empirical regularity we uncover points to the need to consider supplier heterogeneity along two, imperfectly correlated dimensions; in our model, these will be seller productivity and matchability.

Fact 2. *Exporters mix trade modes within narrowly defined products, regardless of the exporter's product scope or product rank.*

Table 2 demonstrates that mixed suppliers are not simply multi-product firms that sell each product under a single trade mode but adopt different strategies across products. Instead, mixed suppliers routinely market the same finely disaggregated HS 6-digit product both directly and through wholesalers. Fully 65% of all mixed suppliers mix trade modes within at least one of their products, with the average mixed supplier transacting both directly and indirectly in 31% of their products. Revenues from such mixed-mode products are moreover not trivial, but amount to 45% of total firm sales on average.

Table 2: Trade strategy of mixed suppliers by product scope

Product scope	# Firms	% Firms mixing within product	% Products mixed	% Sales from mixed products
1	1,067	1	1	1
2	1,622	0.5	0.27	0.41
3	1,093	0.53	0.21	0.38
4+	3,844	0.64	0.15	0.35
Total	7,626	0.65	0.31	0.45

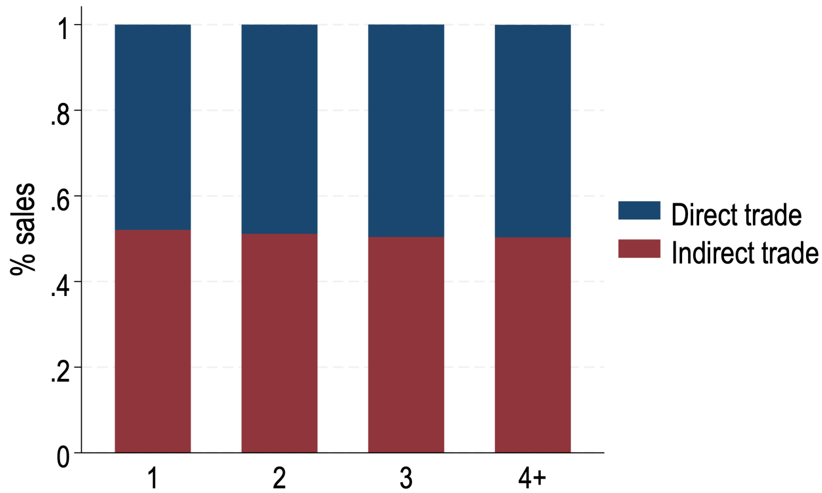
Table 2 also documents that these patterns hold for suppliers of different product scope. We distinguish between mixed exporters with 1, 2, 3, or at least 4 products in their sales portfolio. The share of exporters that mix sales modes within at least one product is always above 50% and generally rises with product scope; this share is definitionally 100% for single-product mixed sellers. Suppliers with a bigger product range tend to mix sales modes for a smaller share of their varieties that in turn generate a smaller share of total revenues, but both shares remain high at 15% and 35% on average, respectively.[3]

Finally, mixed suppliers do not systematically vary their choice of trade mode across products based on the product's sales rank. For each mixed supplier that offers at least n products, we sort their products by export revenue, and assign $rank = 1$ to their core good and $rank = 2, 3, .., n-1, n+$ to their progressively more peripheral goods. We then calculate the share of a product's direct and indirect sales by product rank for each firm, and average these shares across firms. Figure 4 shows that among mixed suppliers of at least 4 products ($n = 4$), intermediated sales account for a remarkably flat 52% regardless of product rank. We have confirmed that the share of indirect sales remains similarly stable across core and peripheral goods when we consider subsamples of mixed suppliers with a more diversified product portfolio, such as $n = 5$ or $n = 10$.

Fact 2 suggests that seller heterogeneity alone is not sufficient to rationalize the incidence of intermediated trade in the data, even when accounting for firms' operations in multiple product markets. Existing models of multi-product firms typically combine heterogeneity in firm-wide efficiency across firms with dispersion in firm-product specific expertise across

[3]We also confirm that, among suppliers that mix within a given HS 6-digit product, more than half do so in goods not classified as differentiated under the Rauch classification, and about a quarter do so in strictly homogeneous goods (primarily commodities). As in Fact 1, this suggests that within-product differences across varieties play little role in the documented patterns.

Figure 4: Trade strategy of multi-product suppliers by product rank



products within firms (Bernard et al. (2011), Manova and Yu (2017)). Incorporating this insight into standard models of trade intermediation with only supply-side heterogeneity would imply that firms choose a single trade mode for each product and are systematically more likely to rely on wholesalers for more peripheral goods. Fact 2 indicates that both of these predictions are counterfactual. Instead, it points to a role for buyer heterogeneity as featured in some prior models of trade intermediation, whereby each exporter supplies a given product directly (indirectly) to buyers above (below) a productivity threshold.

In sum, Facts 1 and 2 together motivate a framework with two-dimensional seller heterogeneity (productivity and matchability) and buyer heterogeneity (productivity). Note that allowing for one-dimensional heterogeneity among both sellers and buyers would fail to explain the incidence of intermediated trade across the seller size distribution or across the product hierarchy within sellers.

Fact 3. *Exporters charge wholesalers lower prices than producer buyers. Purely indirect exporters set lower prices than purely direct and mixed exporters, and mixed exporters set lower prices on their indirect transactions than on their direct transactions.*

Table 3 establishes that trade prices are systematically lower on sales to wholesalers than on sales to producer buyers. This pattern holds both across sellers with different trade strategies and across the buyers of sellers that mix trade modes, even within narrow product categories.

We first compare the prices charged by purely direct, purely indirect and mixed foreign suppliers of the same product.[4] In Column 1 of Table 3, we regress log unit value at the transaction level on dummies for seller type, conditioning on HS 6-digit product fixed effects. Compared to mixed suppliers, purely direct exporters set 50% higher prices on average, while purely indirect exporters receive 15% lower prices on average. These price differentials remain large at roughly 30% in Column 2, when we additionally control for seller, buyer and transaction attributes that may relate to bargaining power or volume discounts and thus capture economic forces other than trade intermediation. In particular, we condition on the size and connectivity of each trade partner, the log transaction value, and the age of the buyer-supplier relationship.[5]

Table 3: Direct and indirect prices

	All suppliers		Mixed suppliers	
	(1) log(Unit Value)	(2) log(Unit Value)	(3) log(Unit Value)	(4) log(Unit Value)
D(Direct Supplier=1)	0.498***	0.326***		
	(0.030)	(0.043)		
D(Indirect Supplier=1)	-0.148***	-0.291***		
	(0.034)	(0.046)		
D(Wholesaler Buyer=1)			-0.100***	-0.090***
			(0.014)	(0.014)
Product FE	Yes	Yes	No	No
Supplier-Product FE	No	No	Yes	Yes
Transacted value	No	Yes	No	Yes
Relationship age	No	Yes	No	Yes
Supplier controls	No	Yes	No	No
Buyer controls	No	Yes	No	Yes
N	469,105	469,105	26,919	26,919

Note: All regressions are at the supplier-HS6 product-buyer level for year 2019. Columns 1-2 compare the prices charged by purely direct and purely indirect suppliers to those of mixed suppliers. Columns 3-4 compare the prices that mixed suppliers charge when exporting to wholesalers and to producer buyers. Buyer and supplier controls include firm size (total trade value) and connectivity (number of trade partners).

We then restrict the analysis to the subsample of mixed suppliers, and evaluate the prices charged by the same supplier across direct and indirect sales transactions for the same product. In Column 3, we now regress log unit values on a dummy for exports to a wholesaler,

[4] Table 3 shows results when mixed suppliers are defined at the firm-product level, such that suppliers are classified as mixed only for their mixed products. As reported in the Appendix, we find similar results when defining mixed suppliers at the firm level.

[5] The size of Chilean buyers is approximated by their total imports, while their connectivity is measured by their total number of international suppliers. The size and connectivity of foreign suppliers is defined analogously, but considering their sales and customers in Chile.

controlling for supplier-product pair fixed effects. In Column 4, we further condition on transaction value, relationship age, buyer size and connectivity. Exporters consistently offer intermediaries 9%-10% lower prices compared to direct producer buyers. In Appendix Table A1, we report additional results using subsamples that either exclude differentiated goods or include only strictly homogeneous goods under the Rauch classification. Despite a substantial reduction in sample size, the results continue to indicate lower prices for indirect transactions.

Fact 3 is informative of price setting in wholesale transactions, and can thus discriminate between different conceptualizations of the seller-wholesaler relationship. This in turn informs the trade-off faced by exporters when choosing their optimal sales strategy. As we show below, the price discount on intermediated sales is consistent with suppliers and wholesalers engaging in Nash bargaining over the associated trade surplus. By contrast, it is inconsistent with the wholesaler applying double marginalization or charging a brokerage fee on the seller's variable profits, as in both cases the supplier would not price discriminate across customers. The evidence also speaks against a brokerage fee on the sales value of the transaction, which would manifest in higher, rather than lower prices on intermediated trade.

3. Theoretical Framework

We develop a quantifiable model of endogenous network formation with trade intermediation. Models of trade and production networks typically abstract from distribution channels, while canonical models of intermediaries ignore their role in shaping firm-to-firm connections. Our framework blends these two approaches in a setting with two-sided firm heterogeneity and heterogeneous relationship capabilities.

3.1. Setup

Consider a world with multiple countries $j \in \mathcal{J}$ and three active sectors in each country: upstream suppliers ($\mathcal{U}$) who use labor to produce differentiated intermediate inputs, downstream producers ($\mathcal{D}$) who assemble intermediates into differentiated final goods, and wholesale intermediaries ($\mathcal{W}$) who can handle transactions between upstream suppliers and downstream producers. The upstream and downstream sectors are populated by a fixed mass of respectively $N_j(\mathcal{U})$ and $N_j(\mathcal{D})$ heterogeneous firms that engage in monopolistic competition. We study homogeneous intermediaries to focus on the sorting of heterogeneous manufacturers into different trade modes. We model intermediaries located in the destination market, as import intermediaries are observationally much more important than export intermediaries in the Chilean context. We use tilde-notation $\widetilde{y}$ to denote variables related to final goods and standard notation y when referring to intermediate inputs, and suppress country subscripts when not of interest.

Upstream suppliers differ along two dimensions: productivity, which pins down their marginal production cost, and relationship capability (also called matchability), which determines their fixed cost of searching, matching and transacting directly with a customer. One can think of productivity and matchability as capturing respectively how efficient a firm is on the production side and how effective it is on the sales side. Downstream producers differ in their productivity in assembling inputs into final goods.[6] Intermediaries offer distribution services that reduce relationship-specific costs in exchange for an implicit brokerage fee that depends on their bargaining power. One can think of them as wholesalers that coordinate transportation, logistics, contracts, insurance, and customer communication. Thus, upstream suppliers choose whether to serve a given downstream producer directly, indirectly by hiring the services of an intermediary, or not at all.

We examine a bi-partite production network in order to characterize the impact of trade intermediation in a transparent and tractable way. In particular, we assume without loss of generality that downstream producers operate domestically, while upstream suppliers can serve both domestic and foreign markets. Incorporating trade in final goods, or the use of final goods in producing intermediates, would add network complexity without qualitatively affecting the novel mechanisms of interest.

3.2. Consumers

Consumers in country j have Cobb-Douglas preferences over homogeneous and differentiated final goods. The homogeneous good $\widetilde{q}_{j\,0}$ is freely traded and produced using labor under constant returns to scale, such that one unit of labor produces w_j units of output. Using the homogeneous good as numeraire sets wages to w_j in country j. Consumers exhibit CES preferences for varieties $\omega \in \Omega_j$ of the non-tradable differentiated good:

$$U_j = \widetilde{q}_{j\,0}^{1-\beta} \left(\int_{\Omega_j} \widetilde{q_j}(\omega)^{\frac{\sigma-1}{\sigma}} d\omega \right)^{\beta\sigma/(\sigma-1)},$$

where $\sigma > 1$ is the elasticity of substitution across varieties. Given aggregate expenditure $\widetilde{E}_j$ and the price index $\widetilde{P}_j \equiv \left(\int_{\Omega_j} \widetilde{p}(\omega)^{1-\sigma} d\omega \right)^{1/(1-\sigma)}$ for differentiated goods, demand for variety ω with price $\widetilde{p}(\omega)$ is:

$$\widetilde{q}_j(\omega) = \widetilde{p}_j(\omega)^{-\sigma} \widetilde{P}_j^{\sigma-1} \left(\beta \widetilde{E}_j \right). \tag{1}$$

[6] We assume that sellers bear all relationship-specific costs in order to understand how upstream suppliers use intermediaries to trade with downstream producers. Section 4 discusses the role of heterogeneous seller matchability in fitting the model to the data.

3.3. Downstream Producers

Downstream producers sell to local consumers in country j. They own a blueprint for a single variety ω of final goods, and draw productivity $\zeta \in [\underline{\zeta}, \overline{\zeta}]$ from distribution $G(\zeta)$ with density $dG(\zeta)$. The downstream technology transforms intermediate inputs into final goods under constant returns to scale:

$$\widetilde{q}(\zeta) = \zeta Q(\zeta), \qquad Q(\zeta) = \left(\int_{\Omega(\zeta)} q(v,\zeta)^{\frac{\eta-1}{\eta}} dv \right)^{\eta/(\eta-1)},$$

where $\eta > 1$ is the elasticity of substitution across intermediates, and $q(v,\zeta)$ is the quantity purchased of input variety v from the producer's set of upstream suppliers $\Omega(\zeta)$. The marginal cost of downstream producers thus depends on their own productivity and their input cost index $C(\zeta)$, which aggregates input prices $p(v,\zeta)$ across suppliers:

$$\widetilde{c}(\zeta) = \frac{C(\zeta)}{\zeta}, \qquad C(\zeta) = \left(\int_{\Omega(\zeta)} p(v,\zeta)^{1-\eta} dv \right)^{1/(1-\eta)}. \tag{2}$$

Under monopolistic competition and CES final demand, downstream producers charge a constant markup $\widetilde{\mu} = \frac{\sigma}{\sigma-1}$ over their marginal cost, such that $\widetilde{p}(\zeta) = \widetilde{\mu}\,\widetilde{c}(\zeta)$. Thus, quantity sold by producer ζ in country j is given by (1), and its demand for intermediate variety v from country i is:

$$q_{ij}(v,\zeta) = p_{ij}(v,\zeta)^{-\eta} C_j(\zeta)^{\eta-1} X_j(\zeta), \tag{3}$$

where $X_j(\zeta)$ are the total input purchases of producer ζ. Note that the trade mode does not affect input demand beyond any effect it might have on prices. Furthermore, downstream producers incur no matching costs, and the efficiency gains from input variety therefore incentivize them to transact with all interested upstream suppliers $\Omega(\zeta)$.

3.4. Upstream Suppliers

Upstream suppliers sell to downstream producers both at home and abroad. They draw productivity $z \in [\underline{z}, \overline{z}]$ and matchability $f^D \in [\underline{f}^D, \overline{f}^D]$ from joint distribution $G(z, f^D) \equiv G(\lambda)$ with density $dG(\lambda)$, where productivity and matchability may be correlated. They use labor to produce a single variety v of intermediate goods under constant returns to scale, and face iceberg trade costs τ_{ij}. The marginal cost of upstream supplier $\lambda = (z, f^D)$ in country i selling to downstream producers in country j is thus:

$$c_{ij}(\lambda) = \frac{\tau_{ij}\, w_i}{z(\lambda)}. \tag{4}$$

Suppliers face relationship-specific fixed costs f^D (in units of labor) when trading directly with a downstream customer. These fixed costs reflect the costs of searching, matching and transacting with buyers, such as the costs of reaching buyers, contracting, establishing working practices, cultivating and managing the relationship.[7] Alternatively, suppliers can delegate all relationship logistics to an intermediary. They would then incur a fixed cost f^I that does not depend on their matchability, in return for an implicit brokerage fee specified below that reduces their variable profits. One can micro-found this cost structure with intermediaries passing on some of their own fixed costs to the supplier, or as suppliers having to retain some degree of relationship management activities in-house.

Upstream supplier $\lambda = (z, f^D)$ will optimally choose the sets of downstream producers to serve directly $\{\zeta \epsilon D(\lambda)\}$ and indirectly $\{\zeta \epsilon \mathcal{I}(\lambda)\}$ and the price and quantity for each transaction to maximize global profits. The supplier's problem can be expressed as:

$$\max_{\mathcal{D}(\lambda), \mathcal{I}(\lambda), \{p^D(\lambda,\zeta), p^I(\lambda,\zeta), q^D(\lambda,\zeta), q^I(\lambda,\zeta)\}} \pi(\lambda) = \int_{\mathcal{D}(\lambda)} \pi^D(\lambda, \zeta) d\zeta + \int_{\mathcal{I}(\lambda)} \pi^I(\lambda, \zeta) d\zeta, \quad (5)$$

where $\pi^D(\lambda, \zeta)$ and $\pi^I(\lambda, \zeta)$ denote supplier profits when trading with producer ζ under each trade mode, and vector $\left\{ p^D(\lambda, \zeta),\ p^I(\lambda, \zeta), q^D(\lambda, \zeta), q^I(\lambda, \zeta) \right\}$ indicates the bilateral prices and quantities offered in direct and indirect transactions.

3.5. Trade Intermediaries

Intermediaries specialize in operationalizing transactions between foreign suppliers and their matched domestic buyers. We abstract away from intermediaries' matchmaking services, in order to focus on their role specifically in reducing relationship-specific costs associated with logistics, distribution, or communication. We also abstract away from heterogeneiety in intermediaries' own productivity or cost structure. The presence of multiple homogeneous intermediaries could be justified with some degree of horizontal differentiation in intermediation services that is orthogonal to the buyer-supplier production network. For example, intermediaries may operate in different geographic regions that have otherwise identical probabilistic buyer distributions, and suppliers first choose to serve a buyer through an

[7] More precisely, these fixed costs may include investments in market penetration (Arkolakis, 2010), recruiting sales managers to reach customers (Patault and Lenoir, 2024), setting financing terms and learning about buyers' reliability (Antras and Foley, 2015), and designing formal and informal contracts under imperfect enforcement (Baker et al., 2002). At the same time, managerial practices vary widely across firms, and thus their efficiency in performing different tasks (Bloom and Van Reenen, 2007, Bloom et al., 2021). Our notion of seller-specific matchability builds on these insights.

intermediary and then transact with whichever wholesaler covers that buyer's region.[8]

An import intermediary in country j receives and transfers goods from upstream supplier λ in country i intended for downstream producer ζ in j. The wholesaler incurs a fixed cost f^W per relationship, and charges the supplier a brokerage fee. Specifically, the wholesaler and the supplier engage in Nash bargaining over the trade surplus (or variable profits) from the transaction, with bargaining weights ϕ and $1-\phi$ respectively. The wholesaler's profits are thus $\pi^W = \int_{\Omega^W} [B(\phi, \lambda, \zeta) - f^W] d(\lambda, \zeta)$, where Ω^W is its set of intermediated transactions, $p_{ij}^W(\lambda, \zeta)$ is the price it charges the final buyer, and the brokerage fee is $B(\phi, \lambda, \zeta) = \phi \left(p_{ij}^W(\lambda, \zeta) - c_{ij}(\lambda) \right) q_{ij}^I(\lambda, \zeta)$.

We make two assumptions about the market for intermediation services that grant the model transparency and tractability with little loss of generality. These assumptions ensure that the use of wholesale trade is determined solely by the upstream supplier, such that we can cleanly illustrate how access to intermediation reshapes production networks.

First, we take the structure of the intermediation contract and the wholesaler's bargaining power ϕ as exogenous. However, these can be rationalized as equilibrium outcomes of the market for intermediation services, for example under free entry in the wholesale sector or when ϕ reflects a wholesaler's market share of aggregate (intermediated) trade.[9]

Second, we also assume that f^W is sufficiently small to guarantee that intermediaries are willing to carry out any transaction that is deemed profitable by upstream suppliers. Intuitively, this is consistent with specialized intermediaries having high relationship capability due to their established distribution network, streamlined contracting and logistics, and professionalized customer management.[10]

3.6. Firm-to-Firm Sales

Upstream suppliers maximize global profits by making independent sales decisions across buyers.[11] The supplier problem (5) therefore reduces to a two-step optimization: (i) optimal match-specific prices and quantities conditional on a direct or indirect link, and (ii) optimal sets of direct and indirect links. We first characterize the intensive margin of firm-to-firm sales conditional on the network structure; the next section then describes the extensive margin of endogenous network formation.

[8] From the seller's perspective, heterogeneity across intermediaries would only matter qualitatively if the competitiveness of intermediation markets differs across buyer segments. We instead focus on characterizing sellers' decisions when intermediation services are available and quantify their average contribution.

[9] For instance, ϕ would be pinned down by $\pi^W = 0$ under free entry into intermediation.

[10] Alternatively, one can think of intermediaries passing their relationship-specific costs onto suppliers in the form of non-linear pricing. The supplier fixed cost of indirect sales f^I would then encompass f^W.

[11] Interdependence could arise, for example, due to production capacity or credit constraints, or (dis)economies of scale in marketing and distribution.

Conditional on transacting with a given buyer, the supplier will choose the optimal bilateral price and quantity to maximize profits from that relationship, taking into account the chosen trade mode. The profit maximization problem of upstream supplier λ from country i selling directly to downstream producer ζ in market j would be:

$$\max_{p^D(\lambda,\zeta),q^D(\lambda,\zeta)} \pi^D_{ij}(\lambda,\zeta) = \left[p^D_{ij}(\lambda,\zeta) - c_{ij}(\lambda)\right] q^D_{ij}(\lambda,\zeta) - f^D(\lambda).$$

Given downstream input demand (3) and monopolistic competition upstream, suppliers would optimally charge all of their direct customers a constant markup $\mu = \frac{\eta}{\eta-1}$ above their marginal cost of production and delivery, such that $p^D_{ij}(\lambda,\zeta) = \mu c_{ij}(\lambda)$.

On the other hand, the profits of upstream supplier λ when serving the same downstream producer ζ indirectly would be:

$$\pi^I_{ij}(\lambda,\zeta) = (1-\phi)\left[p^W_{ij}(\lambda,\zeta) - c_{ij}(\lambda)\right] q^I_{ij}(\lambda,\zeta) - f^I,$$

where the first term reflects the share $(1-\phi)$ of the variable profits (or trade surplus) $\left(p^W_{ij}(\lambda,\zeta) - c_{ij}(\lambda)\right) q^I_{ij}(\lambda,\zeta)$ generated from an intermediated transaction between λ and ζ.

Given downstream input demand (3) and Nash bargaining between the wholesaler and the supplier, the wholesaler optimally charges the buyer the same price as under a direct transaction, $p^W(\lambda,\zeta) = p^D(\lambda,\zeta) = \mu c_{ij}(\lambda)$, so as to maximize the trade surplus to be shared with supplier λ. Thus, $B(\phi,\lambda,\zeta) = \phi\left(p^D_{ij}(\lambda,\zeta) - c_{ij}(\lambda)\right) q^I_{ij}(\lambda,\zeta)$ is the intermediary's brokerage fee, while $(1-\phi)\left(p^D_{ij}(\lambda,\zeta) - c_{ij}(\lambda)\right) q^I_{ij}(\lambda,\zeta)$ are the seller's variable profits.

The supplier's profit maximization problem under intermediated trade can therefore be expressed in terms of the implied price received on indirect transactions $p^I_{ij}(\lambda,\zeta)$:

$$\max_{p^I(\lambda,\zeta),q^I(\lambda,\zeta)} \pi^I_{ij}(\lambda,\zeta) = \left[p^I_{ij}(\lambda,\zeta) - c_{ij}(\lambda)\right] q^I_{ij}(\lambda,\zeta) - f^I,$$

where $p^I_{ij}(\lambda,\zeta)$ satisfies $\left(p^I_{ij}(\lambda,\zeta) - c_{ij}(\lambda)\right) = (1-\phi)\left(p^D_{ij}(\lambda,\zeta) - c_{ij}(\lambda)\right)$.

Suppliers will therefore price discriminate across customers, and offer intermediaries a lower price than direct producer buyers:

$$p^I_{ij}(\lambda,\zeta) = \left(\frac{\eta-\phi}{\eta}\right) p^D_{ij}(\lambda,\zeta) = \left(\frac{\eta-\phi}{\eta-1}\right) c_{ij}(\lambda). \tag{6}$$

Note that the wedge between the supplier's direct and indirect prices is shaped by the bargaining power of intermediaries: When $\phi \approx 1$, the wholesaler extracts all rents from the transaction and the supplier only covers its marginal costs, while when $\phi \approx 0$, the supplier gives no wholesaler discount. Therefore, upstream prices depend on both seller productivity and trade mode, but not on buyer productivity or any other match characteristic beyond iceberg trade costs. On the other hand, the ultimate buyer faces the same input price regardless of how the input reaches them, since wholesalers' double marginalization implies $p_{ij}^{W}(\lambda, \zeta) = p_{ij}^{D}(\lambda, \zeta)$.[12]

We can characterize seller-buyer trade flows $x_{ij}(\lambda, \zeta) \equiv p_{ij}(\lambda, \zeta) q_{ij}(\lambda, \zeta)$ by replacing optimal prices in the demand for intermediate goods (3):

$$x_{ij}^{D}(\lambda, \zeta) = \mu^{1-\eta} \left(\frac{\tau_{ij}\, w_i}{z(\lambda)} \right)^{1-\eta} C_j(\zeta)^{\eta-1} X_j(\zeta). \tag{7}$$

$$x_{ij}^{I}(\lambda, \zeta) = \left(\frac{\eta - \phi}{\eta} \right) x_{ij}^{D}(\lambda, \zeta). \tag{8}$$

Firm-to-firm sales depend on seller productivity (through marginal cost), buyer productivity (through total input purchases), and trade mode (through transaction price), but are unaffected by seller matchability.

Proposition 1. *(Intensive margin) Conditional on a seller-buyer match, sales from upstream supplier $\lambda = (z, f^{D})$ to downstream producer ζ:*

(a) increase in seller productivity z but are independent of seller matchability f^{D};

(b) increase in buyer productivity ζ;

(c) are lower and cheaper when intermediated.

Proof. See Appendix B. □

Intuitively, more productive upstream suppliers set lower prices due to their lower marginal costs, which in turn increases demand from downstream producers. At the same time, any supplier would earn lower indirect than direct sales revenues because the intermediary holds market power and extracts a share of the supplier's markup on direct sales. Turning to buyer heterogeneity, more productive downstream producers have larger total input purchases, as their lower marginal cost of assembly attracts greater demand from final consumers. This implies larger purchases from each infra-marginal supplier (intensive margin). However, we show below that more productive downstream producers are profitable customers for a larger

[12] Alternative pricing schemes for intermediation services can induce different pricing patterns that contradict Fact 3 that suppliers charge lower prices on indirect transactions (see Appendix C for details). For example, if intermediaries charge sellers an explicit brokerage fee γ as a share of variable profits, sellers would counterfactually charge the same price for direct and indirect transactions. Sellers would instead set higher indirect markups and prices if the wholesale fee is applied on transaction values. Fact 3 aside, one can also always find a level of wholesalers' market power ϕ that is consistent with γ.

set of suppliers. This tends to lower their input cost index, but also raise their consumer appeal and thereby also their total input expenditure, with opposing effects on their input demand from each supplier (extensive margin). The relative strength of these forces depends on supply and demand elasticities.

3.7. Direct and Indirect Links

The second step in the supplier's problem is choosing which downstream producers to serve and via which trade mode. Given optimal firm-to-firm prices, quantities and sales in equations (7) and (8), the supplier's profits from potential match (λ, ζ) become:

$$\pi_{ij}^{D}(\lambda, \zeta) = \frac{x_{ij}^{D}(\lambda, \zeta)}{\eta} - f^{D}(\lambda), \tag{9}$$

$$\pi_{ij}^{I}(\lambda, \zeta) = \left(\frac{\eta - \phi}{\eta}\right) \frac{x_{ij}^{D}(\lambda, \zeta)}{\eta} - f^{I}. \tag{10}$$

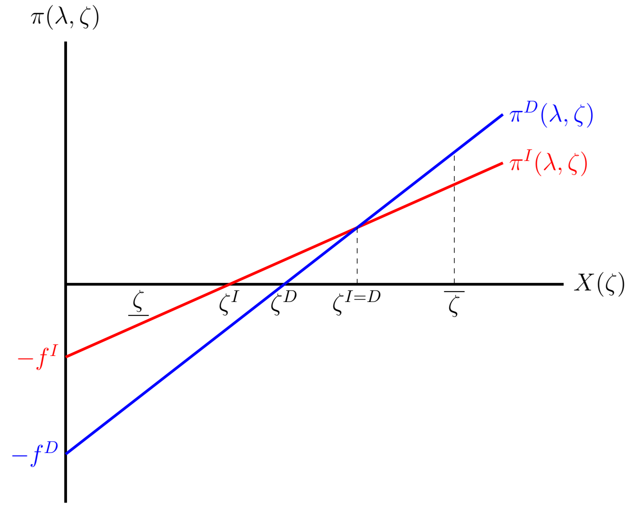
Upstream suppliers will pursue only partnerships that generate non-negative profits, and if both direct and indirect sales are individually profitable, they will pick the more profitable strategy. This gives rise to an endogenous network of direct and indirect links between upstream suppliers and downstream producers.

Figure 5 illustrates the supplier's problem. For a given upstream supplier $\lambda = (z, f^{D})$ in market i, we plot potential direct and indirect profits from transacting with downstream producers ζ in market j. Producers are indexed by their total input purchases $X_j(\zeta)$, so that $X_j(\underline{\zeta})$ and $X_j(\bar{\zeta})$ mark the location of the least and most productive potential customer.[13] We suppress origin and destination subscripts for legibility. Note that supplier productivity z affects the slope of both direct (9) and indirect (10) profits, but not their vertical intercept. By contrast, supplier matchability f^{D} determines the intercept for direct profits, but neither the intercept for indirect profits nor the slope of either profit line.

Upstream supplier λ faces a trade-off when choosing its optimal trade mode: Indirect transactions entail lower fixed costs $f^{I} < f^{D}(\lambda)$, but also lower variable profits as indirect prices are lower. At the same time, both direct and indirect profits increase linearly with the input purchases of downstream producers $X(\zeta)$, which below we establish increase with buyer productivity ζ. This implies that there are downstream productivity thresholds $\zeta^{D}(\lambda)$ and $\zeta^{I}(\lambda)$, above which direct and indirect sales are respectively profitable for upstream supplier λ. There is also a downstream productivity threshold $\zeta^{D=I}(\lambda)$, at which the supplier

[13] Atomistic upstream suppliers take $X_j(\zeta)$ as given: The firm network determines downstream producers' input cost index, and thereby how much final demand they face and their total input purchases.

Figure 5: Direct and indirect supplier profits



is indifferent between trade modes, and above which direct trade is strictly preferred. The following proposition formalizes these properties:

Proposition 2. *(Productivity thresholds) For each upstream supplier $\lambda = (z, f^D)$ in market i selling to downstream producers in market j, there is a set of buyer productivity thresholds $\zeta_{ij}^D(\lambda)$, $\zeta_{ij}^I(\lambda)$ and $\zeta_{ij}^{D=I}(\lambda)$ such that:*

(a) $\pi_{ij}^D(\lambda, \zeta_{ij}^D(\lambda)) = 0$ *and* $\pi_{ij}^D(\lambda, \zeta) > 0$ *for* $\zeta > \zeta_{ij}^D(\lambda)$*;*

(b) $\pi_{ij}^I(\lambda, \zeta_{ij}^I(\lambda)) = 0$ *and* $\pi_{ij}^I(\lambda, \zeta) > 0$ *for* $\zeta > \zeta_{ij}^I(\lambda)$*;*

(c) $\pi_{ij}^D(\lambda, \zeta_{ij}^{D=I}(\lambda)) = \pi_{ij}^I(\lambda, \zeta_{ij}^{D=I}(\lambda))$ *and* $\pi_{ij}^D(\lambda, \zeta) > \pi_{ij}^I(\lambda, \zeta)$ *for* $\zeta > \zeta_{ij}^{D=I}(\lambda)$.

Proof. See Appendix B. □

The optimal trade strategy for upstream suppliers can be fully characterized with these three buyer productivity cutoffs, which are implicit functions of supplier attributes and trade costs. Variation in the distribution of supplier and buyer attributes can thus rationalize heterogeneity in trade mode use across countries and sectors as observed in the data.

The model can accommodate four scenarios. First, the supplier will not trade with any customers when $\zeta^D(\lambda) > \overline{\zeta}$ and $\zeta^I(\lambda) > \overline{\zeta}$, since no buyer is productive enough to incentivize sales by λ. This would be the case if the supplier has both low productivity and low matchability. Second, seller λ will be a purely direct supplier, and transact directly with customers $\zeta \epsilon [max(\underline{\zeta}, \zeta^D(\lambda)), \overline{\zeta}]$ when $\zeta^D(\lambda) < \zeta^I(\lambda)$ and $\zeta^D(\lambda) < \overline{\zeta}$. This would be the case for suppliers with high productivity, high matchability, or both, such that profit curves intersect below the x-axis or not at all.[14] Third, seller λ will be a purely indirect supplier and serve all buyers $\zeta \epsilon [max(\underline{\zeta}, \zeta^I(\lambda)), \overline{\zeta}]$ through an intermediary when $\zeta^I(\lambda) < \overline{\zeta} \leq \zeta^{D=I}(\lambda)$. This might be the case for suppliers with either low productivity or low matchability in a market with few highly productive customers. Lastly, supplier λ will mix trade modes across buyers when $\zeta^I(\lambda) < \zeta^{D=I}(\lambda) < \overline{\zeta}$ and $\underline{\zeta} < \zeta^{D=I}(\lambda)$. Mixed sellers will directly supply sufficiently productive customers $\zeta \epsilon [\zeta^{D=I}(\lambda), \overline{\zeta}]$ that warrant the higher fixed costs, and serve a less productive segment of customers $\zeta \epsilon [max(\underline{\zeta}, \zeta^I(\lambda)), \zeta^{D=I}(\lambda))$ through a wholesaler. This is the case illustrated in Figure 5, and is likely to describe suppliers with intermediate levels of productivity and matchability.

The proposition below summarizes suppliers' optimal trade strategy:

Proposition 3. *(Optimal trade strategy) Consider the set of downstream buyers in market j with productivity support $[\underline{\zeta_j}, \overline{\zeta_j}]$. The optimal trade strategy for upstream supplier $\lambda = (z, f^D)$ from market i is:*

(a) No trade if $\zeta_{ij}^D(\lambda) > \overline{\zeta_j}$ and $\zeta_{ij}^I(\lambda) > \overline{\zeta_j}$;

(b) Direct trade with buyers $\zeta \epsilon [max(\underline{\zeta_j}, \zeta_{ij}^D(\lambda)), \overline{\zeta_j}]$ if $\zeta_{ij}^D(\lambda) < \zeta_{ij}^I(\lambda)$ and $\zeta_{ij}^D(\lambda) < \overline{\zeta_j}$;

(c) Indirect trade with buyers $\zeta \epsilon [max(\underline{\zeta_j}, \zeta_{ij}^I(\lambda)), \overline{\zeta_j}]$ if $\zeta_{ij}^I(\lambda) < \overline{\zeta_j} \leq \zeta_{ij}^{D=I}(\lambda)$;

(d) Indirect trade with buyers $\zeta \epsilon [max(\underline{\zeta_j}, \zeta_{ij}^I(\lambda)), \zeta_{ij}^{D=I}(\lambda))$ and direct trade with buyers $\zeta \epsilon [\zeta_{ij}^{D=I}(\lambda), \overline{\zeta_j}]$ if $\zeta_{ij}^I(\lambda) < \zeta_{ij}^{D=I}(\lambda) < \overline{\zeta_j}$ and $\underline{\zeta_j} < \zeta_{ij}^{D=I}(\lambda)$.

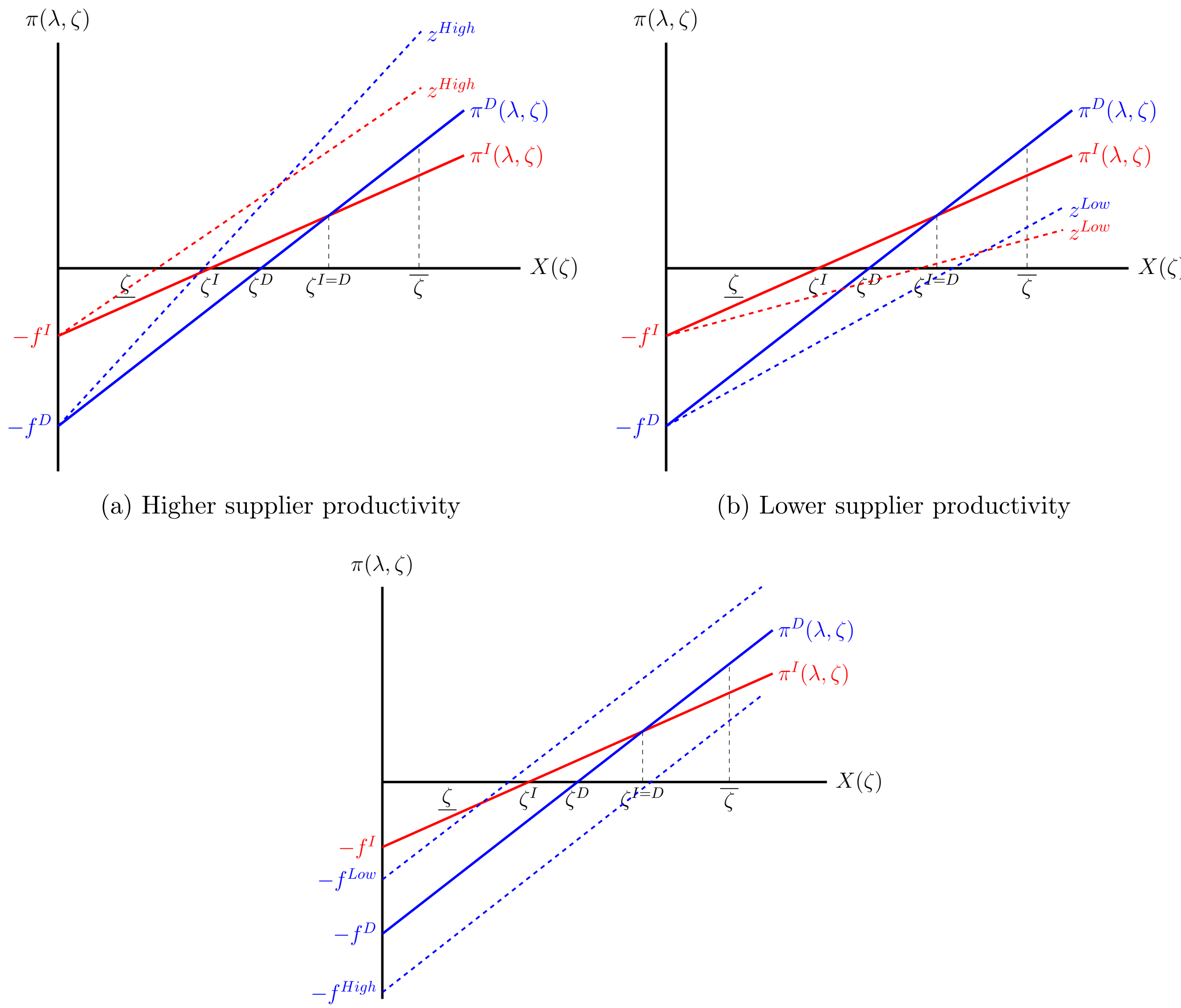
Proof. See Appendix B. □

To build intuition, we analyze the optimal trade mode of upstream suppliers when varying only one of their two dimensions of heterogeneity. Figures 6a and 6b compare suppliers of low, medium and high productivity levels, $z^{Low} < z < z^{High}$, but the same matchability. They all share the same intercepts for direct and indirect profits, but both profit lines are steeper for more productive suppliers. Holding matchability constant, more productive suppliers will thus serve more buyers and be more likely to transact directly. Suppliers with sufficiently high productivity will sell exclusively directly, suppliers with sufficiently low productivity will pursue only indirect trade, and suppliers with intermediate productivity levels will sell directly to their more productive customers and rely on intermediaries for an additional margin of less productive customers.

Figure 6c in turn compares two suppliers of the same production efficiency but different degrees of matchability, $f^{Low} < f^D < f^{High}$. While profits for indirect transactions are

[14] To be precise, there might be a fifth scenario where profit curves intersect above the x-axis, but the supplier still trades only directly (i.e., $\zeta^I(\lambda) < \zeta^D(\lambda)$ and $\zeta^{D=I} < \underline{\zeta}$). We assume that there is always a buyer with sufficiently low productivity to rule this out.

Figure 6: Supplier productivity and matchability



(a) Higher supplier productivity

(b) Lower supplier productivity

(c) Changes in supplier matchability

not affected by matchability, the profit lines for direct sales are parallel to each other at different intercepts, so that they cross the x-axis and π^I at different points. Suppliers with higher matchability will be more likely to have direct customer relationships. Suppliers with sufficiently low relationship costs will sell exclusively directly, and among purely direct sellers, those with higher matchability will have more customers. By contrast, suppliers with sufficiently high relationship costs will sell exclusively through intermediaries. Suppliers with moderate levels of matchability will target more productive buyers directly and reach additional customers through an intermediary. Conditional on productivity, all mixed suppliers will have the same number of ultimate buyers, but those with higher matchability will maintain a bigger share of direct links.

Proposition 4. *(Extensive margin) The set of direct and indirect buyers* $\zeta \in \{\mathcal{D}(\lambda) \cup \mathcal{I}(\lambda)\}$ *of upstream supplier* $\lambda = (z, f^D)$ *is non-contracting in supplier productivity* z *and matchability* f^D.

(i) Given matchability (productivity), suppliers with higher productivity (matchability) are more likely to sell exclusively directly and less likely to sell exclusively indirectly.

(ii) Suppliers with mixed trade strategy serve buyers above (below) a productivity threshold directly (indirectly).

Proof. See Appendix B. □

This endogenous network of direct and indirect buyer-supplier links implies negative degree assortativity along the extensive margin when supplier connectivity captures all ultimate customers. In particular, all upstream suppliers follow the same pecking order of downstream buyers based on buyer productivity, even if some of these transactions are performed indirectly through trade intermediaries. Holding matchability (productivity) constant, a more productive (matchable) supplier would thus serve the same customers as a less productive (matchable) supplier and further add an extra margin of less productive customers. Since buyer size and number of suppliers are monotonic in buyer productivity, the average ultimate customer of a more connected supplier will be smaller and less connected.

However, more connected suppliers need not be more connected in terms of direct links. This occurs because sellers' productivity and matchability jointly determine both the number of their total links and the number of their direct links, but these two numbers need not move proportionately or even in the same direction. This model can therefore rationalize deviations from strict negative degree assortativity in network data that ignores indirect linkages.

3.8. General Equilibrium

The general equilibrium of the model is a bipartite global network of upstream suppliers selling directly and indirectly to downstream producers, who in turn sell to final consumers. We first solve for the equilibrium conditional on a given network of matches, using firms' optimal sales prices and quantities for this network. We then use the formulation for suppliers' optimal direct and indirect matches to characterize the endogenous network as a fixed point that can be solved for numerically.

The network of firm-to-firm linkages can be summarized with two link functions: $l_{ij}^{D}(\lambda, \zeta)$ and $l_{ij}^{I}(\lambda, \zeta)$ for direct and indirect links, respectively. As described below, we follow Bernard et al. (2022) and introduce an idiosyncratic match-specific component to a seller's matching cost in order to estimate the model in Section 5. Thus $l_{ij}^{D}(\lambda, \zeta)$ is the share of seller-buyer pairs (λ, ζ) between i and j that match directly, and $l^{I}_{ij}(\lambda, \zeta)$ is defined analogously for indirect connections. The total share of potential links that are activated is thus $l_{ij}(\lambda, \zeta) = l^{D}_{ij}(\lambda, \zeta) + l^{I}_{ij}(\lambda, \zeta)$. We will establish that the equilibrium is characterized by a single fixed point for $l_{ij}(\lambda, \zeta)$.

We first describe key outcomes for downstream producers. Taking the matching functions as given, and noting that producers perceive the same price under direct and indirect transactions, the input cost index (2) of final producer ζ is:

$$C_j^{1-\eta}(\zeta) = \sum_i \frac{N_i(\mathcal{U})}{\left(\mu w_i \tau_{ij}\right)^{\eta-1}} \left(\int z(\lambda)^{\eta-1} l^{D}_{ij}(\lambda, \zeta) dG(\lambda) + \int z(\lambda)^{\eta-1} l^{I}_{ij}(\lambda, \zeta) dG(\lambda) \right) \tag{11}$$

where $N_i(\mathcal{U})$ is the mass of upstream suppliers in market i. The producer's input cost index depends on the productivity of all its direct and indirect suppliers. It is also implicitly affected by these suppliers' matchability, through the matching process that determines links $l^{D}_{ij}(\lambda, \zeta)$ and $l^{I}_{ij}(\lambda, \zeta)$. Producers' input costs $C_j^{1-\eta}(\zeta)$ in turn pin down their optimal output price $\widetilde{p}_j(\zeta)$ and sales $\widetilde{X}_j(\zeta) \equiv \widetilde{p}_j(\zeta)\widetilde{q}_j(\zeta)$.

We next relate the global sales of upstream suppliers to the equilibrium link functions. Suppliers' total sales are the sum of direct $S_i^D(\lambda)$ and indirect $S_i^I(\lambda)$ sales worldwide, which in turn summate sales $x_{ij}(\lambda, \zeta)$ to individual downstream producers. Aggregating direct (7) and indirect (8) bilateral sales across markets and customers, supplier λ's global sales are:[15]

$$S_i(\lambda) = \sum_j \frac{N_j(\mathcal{D}) B_j\, z(\lambda)^{\eta-1}}{\left(\mu w_i \tau_{ij}\right)^{\eta-1}} \left(\int \frac{\zeta^{\sigma-1}}{C_j(\zeta)^{\sigma-\eta}} l^{D}_{ij}(\lambda, \zeta) dG(\zeta) + \left(\frac{\eta-\phi}{\eta}\right) \int \frac{\zeta^{\sigma-1}}{C_j(\zeta)^{\sigma-\eta}} l^{I}_{ij}(\lambda, \zeta) dG(\zeta) \right) \tag{12}$$

where $N_j(\mathcal{D})$ is the mass of downstream producers in country j, and $B_j = \frac{\beta \widetilde{E}_j \widetilde{P}_j^{\sigma-1}}{\widetilde{\mu}^{\sigma}}$ summarizes aggregate demand for final goods.

Suppliers' global sales depend on their own productivity $z(\lambda)$, as well as the productivity ζ and input costs $C_j(\zeta)$ of all their customers. Suppliers' relationship capability $f^D(\lambda)$ and the option of intermediation affect their sales through the matching functions $l^{D}_{ij}(\lambda, \zeta)$ and $l^{I}_{ij}(\lambda, \zeta)$, which reflect the extensive margins of direct and indirect customers. Access to wholesale services also affects the intensive margin of bilateral sales, since direct and indirect prices differ.

We can express the share of indirect trade for upstream supplier λ globally and within

[15] Producers' total input purchases scale up with their total sales, $X_j(\zeta) = \frac{\widetilde{X}_j(\zeta)}{\widetilde{\mu}}$, where $\widetilde{\mu}$ is the markup for final goods. We use this relationship to express $X_j(\zeta)$ in equation (7) in terms of final demand for good ζ.

market j as:

$$\frac{S_i^I(\lambda)}{S_i(\lambda)} = \frac{\sum_j N_j(\mathcal{D}) B_j \tau_{ij}^{1-\eta} \left(\frac{\eta-\phi}{\eta}\right) \int \frac{\zeta^{\sigma-1}}{C_j^{\sigma-\eta}(\zeta)} l_{ij}^{I}(\lambda,\zeta) dG(\zeta)}{\sum_j N_j(\mathcal{D}) B_j \tau_{ij}^{1-\eta} \left(\int \frac{\zeta^{\sigma-1}}{C_j^{\sigma-\eta}(\zeta)} l_{ij}^{D}(\lambda,\zeta) dG(\zeta) + \left(\frac{\eta-\phi}{\eta}\right) \int \frac{\zeta^{\sigma-1}}{C_j^{\sigma-\eta}(\zeta)} l_{ij}^{I}(\lambda,\zeta) dG(\zeta)\right)}, \tag{13}$$

$$\frac{S_{ij}^I(\lambda)}{S_{ij}(\lambda)} = \frac{\left(\frac{\eta-\phi}{\eta}\right) \int \frac{\zeta^{\sigma-1}}{C_j^{\sigma-\eta}(\zeta)} l_{ij}^{I}(\lambda,\zeta) dG(\zeta)}{\int \frac{\zeta^{\sigma-1}}{C_j^{\sigma-\eta}(\zeta)} l_{ij}^{D}(\lambda,\zeta) dG(\zeta) + \left(\frac{\eta-\phi}{\eta}\right) \int \frac{\zeta^{\sigma-1}}{C_j^{\sigma-\eta}(\zeta)} l_{ij}^{I}(\lambda,\zeta) dG(\zeta)}. \tag{14}$$

Note that these indirect trade shares depend on the supplier's productivity and matchability both through their role in determining equilibrium linkages and through the value of direct vs. indirect bilateral sales conditional on a link. These shares also reflect the relative productivity and input costs of direct and indirect downstream customers, weighted by customers' market size and trade costs when aggregating across destinations.

Firm-to-firm matching in general equilibrium is determined in two steps. In the first step, suppliers determine whether direct or indirect sales dominate to a given seller, i.e. $k^* = \arg\max_{k\in\{D,I\}} \left[\tilde{\pi}_{ij}^{k}(\lambda,\zeta) - f^{k}(\lambda)\right]$, where $\tilde{\pi}_{ij}^{k}(\lambda,\zeta)$ is gross profits for a potential match using mode k. In the second step, we assume that suppliers observe an idiosyncratic multiplicative shock, ϵ, so that their total matching cost becomes $f^{k^*}(\lambda)\,\epsilon$. After observing ϵ, the supplier determines whether to match or not, i.e. whether $\tilde{\pi}_{ij}^{k^*}(\lambda,\zeta) - \epsilon f^{k^*}(\lambda) > 0$. Therefore, the share of seller-buyer pairs (λ,ζ) that trade with each other is:

$$l_{ij}(\lambda,\zeta) = \int I\left[\ln\epsilon < \ln\tilde{\pi}_{ij}^{k^*}(\lambda,\zeta) - \ln f^{k^*}(\lambda)\right] dH(\epsilon), \tag{15}$$

where $I[]$ is the indicator function and $dH(\epsilon)$ denotes the density of ϵ.

The link function is a fixed-point problem, as profits from a potential match determine the link probabilities according to equation (15), and the link probabilities in turn determine profits according to equations (11) and (12).[16] After solving for $l_{ij}(\lambda,\zeta)$, it is straightforward to back out direct $l_{ij}^{D}(\lambda,\zeta)$ and indirect $l_{ij}^{I}(\lambda,\zeta)$ links given the optimal trade strategies described above.

[16] While we do not provide a formal proof for the uniqueness and existence of the unconditional equilibrium, the fixed-point problem is numerically well-behaved and converges to the same solution under different starting values.

3.9. Role of Assumptions

We show numerically that a weakly negative correlation between seller productivity and matchability is necessary to account for the fact that exporters across the size distribution use trade intermediation, with larger suppliers being less likely to trade only directly, more likely to mix trade modes, and similarly likely to trade indirectly. By contrast, the share of purely direct (indirect) suppliers would counterfactually increase (decrease) with supplier size if supplier efficiency and relationship capability were uncorrelated or positively correlated. Reverting to one-dimensional seller heterogeneity in productivity alone would counterfactually imply that sellers sort monotonically into either purely indirect or mixed trade, and are never purely direct. Finally, suppressing productivity differences across buyers would remove suppliers' incentives to mix sales modes, and they would counterfactually sort monotonically into purely indirect or purely direct trade. These simulations are reported in Appendix D.

4. Empirical Evidence

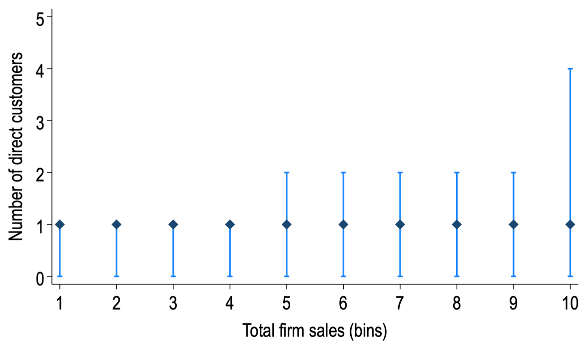
We next provide empirical evidence that corroborates the model and informs the nature of network transaction costs. We first validate theoretical predictions for the number of direct links across suppliers and the assortativity of buyers and suppliers in direct matches. We then show that the shares of intermediated trade and of indirect suppliers fall with origin-country GDP per capita, consistent with model implications for the seller productivity distribution. Lastly, we analyze how trade intermediation varies with different origin-country characteristics, to unpack the economic forces that drive firm-to-firm matching and transaction costs. This informs what barriers to buyer-supplier links are problematic but wholesalers can help overcome.

4.1. Network Connectivity

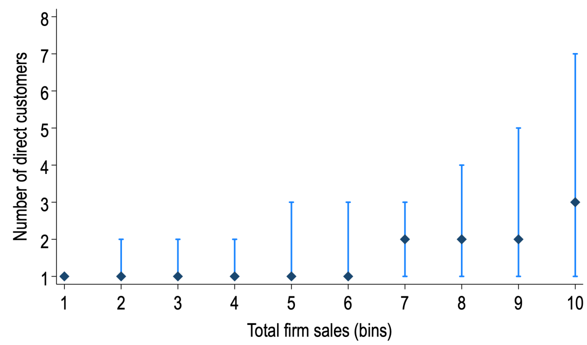
A key feature of the model is sellers' two-dimensional heterogeneity. Since we do not observe seller productivity and matchability in the data, we cannot directly assess their pattern across firms. However, we can evaluate the model's implication that the number of direct matches will generally not vary systematically with total sales across sellers, since neither is a sufficient statistic for sellers' vector of attributes. This contrasts with the prediction of strict monotonicity in standard models with unidimensional firm heterogeneity.

Figure 7 shows that the median number of direct buyer links indeed varies little across suppliers sorted into 10 bins by total sales. This holds not only when we pool all sellers in Panel A, but also when we focus on purely direct sellers in Panel B. Moreover, the distribution of direct connectivity across firms within a size bin overlaps greatly across bins, as illustrated by the 25th-75th interquartile ranges.

Figure 7: Number of direct customers by seller size



(a) All sellers (indirect, mixed, direct)



(b) Purely direct sellers

Since two-dimensional seller heterogeneity breaks the monotonicity of seller size and connectivity, the model implies negative degree assortativity in the production network in terms of firms' number of direct links and buyer size, but not necessarily in terms of seller size. Appendix Figure A2 reveals that, on average, suppliers with more direct connections in Chile sell to producers with fewer direct connections and lower imports. Analogously, more connected Chilean producers on average source directly from suppliers with fewer direct links and lower direct sales, but the latter relationship is significantly flatter as expected.

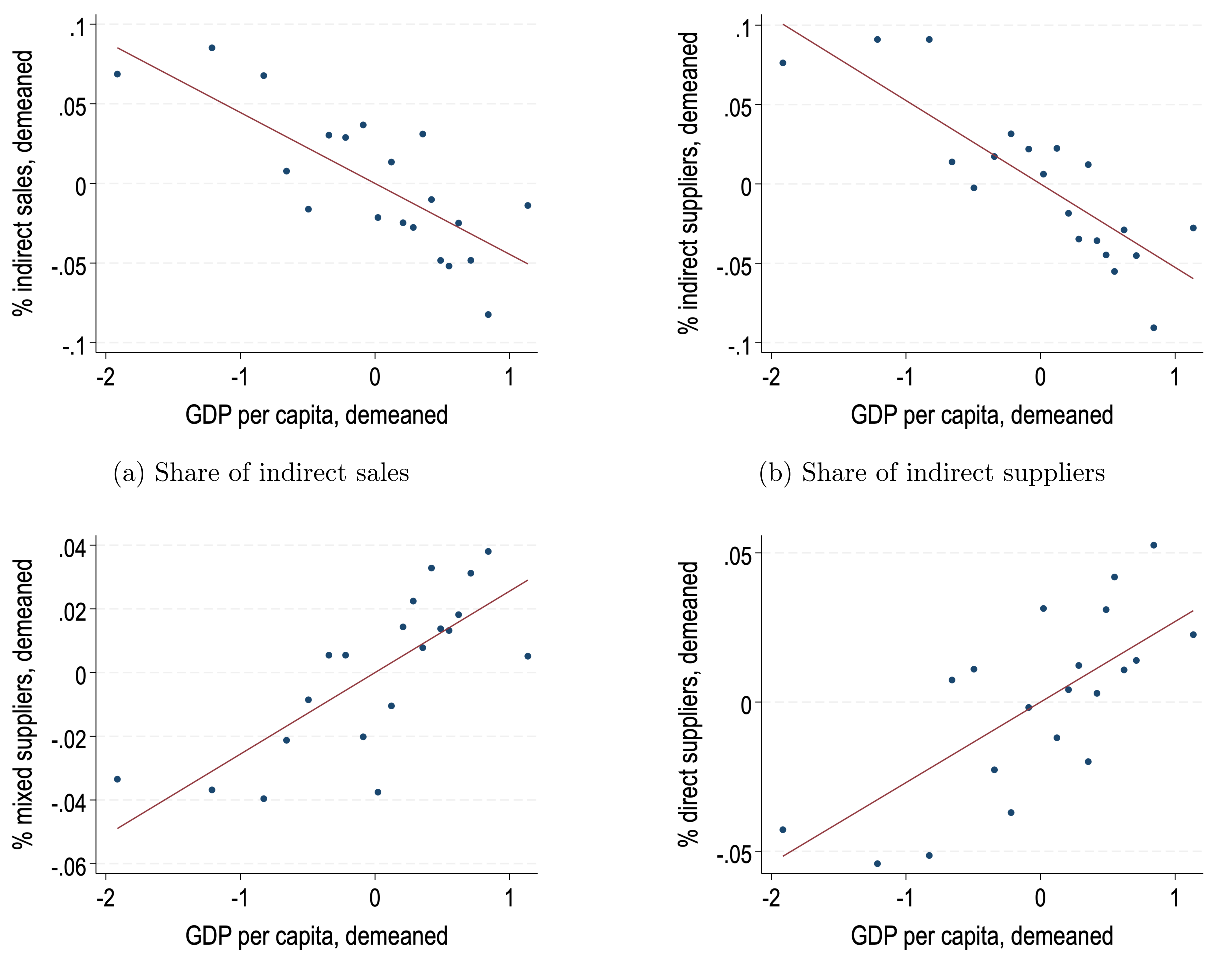
Note that while recent work has analyzed degree assortativity using the universe of transactions across or within countries (Bernard et al. (2018), Bernard et al. (2019), Bernard et al. (2022)), we explicitly exclude intermediated transactions that may be aimed at multiple producers. We thus provide more accurate evidence for negative degree assortativity that in principle need not, but in practice does corroborate conclusions in the prior literature.

4.2. Average Productivity

We next exploit the variation in trade intermediation across origin countries exporting to Chile, in order to inform model predictions for the role of the seller productivity distribution. The model implies that conditional on matchability, more productive suppliers are more likely to sell directly and less likely to trade through intermediaries. We use origin GDP per capita as a proxy for average productivity across suppliers from that origin. Assuming that the shape of the matchability distribution is orthogonal to average productivity across countries (even if average matchability isn't), we can expect less use of intermediation services by exporters from richer origins.

Figure 8 confirms that intermediated exports are indeed more prevalent for origins with lower GDP per capita. We examine aggregate exports to Chile at the country-sector (HS 2-digit) level, demeaned by sector and sorted into 20 bins by origin income. Panel A shows that the share of intermediated sales to Chile systematically decreases with source-country GDP per capita. Panels B-D reveal that this pattern reflects the sorting of foreign suppliers into different trade modes. As origin income rises, there is a smaller share of purely indirect suppliers to Chilean buyers and bigger shares of purely direct and mixed suppliers.

Figure 8: GDP per capita and intermediation shares



(a) Share of indirect sales

(b) Share of indirect suppliers

(c) Share of mixed suppliers

(d) Share of direct suppliers

4.3. Matching Frictions

Finally, we analyze how intermediated trade varies with origin-country characteristics that may plausibly capture economic determinants of network matching and transaction costs. We consider country indicators for three types of potential costs: shipping and logistics, customs procedures, and contracting frictions. We view these country indicators as proxies for average matching costs across suppliers from that origin. Assuming that the shape of the productivity distribution is orthogonal to average matchability across countries (even if average productivity isn't), there is in principle more scope for trade intermediation for origins with higher matching costs. In practice, we can expect more use of intermediation for such origins only to the extent that intermediaries are able to offer specialized services targeted at these frictions.

We measure shipping and logistics costs with the distance between capital cities from CEPII and several indicators from the World Bank's *Logistics Performance Index,* such as the quality of logistic services, track and trace, the ease of arranging shipments, timely shipment arrival, and overall trade infrastructure. For customs procedures, we take the cost and time of border compliance, the cost and time of export documentation, and the number of trade procedures from the World Bank's *Doing Business Report*, as well as the overall customs efficiency component from the *Logistics Performance Index.* Lastly, we distinguish between formal and informal institutions that shape contracting costs. For formal contracting institutions, we study the control of corruption (World Bank's *Worldwide Governance Indicators*), the rule of law (World Bank's *World Development Indicators*), and an indicator for common legal origins with Chile (CEPII). For informal contracting institutions, we exploit measures of trust and cultural affinity. We consider the share of people who report complete trust in foreigners from the *World Values Survey*, and the share of people who share the same religion or language proximity with Chile based on ancestral roots (i.e., language trees) from CEPII.

Armed with these country indicators, we estimate variants of the following specification in the cross-section of origin countries c and sectors s:

$$Y_{cs} = \gamma_1\, Shipping_c + \gamma_2\, Customs_c + \gamma_3\, Formal_c + \gamma_4\, Informal_c + \gamma_5\, Productivity_c + \delta_s + \epsilon_{cs},$$

where the outcome variable is the share of intermediated trade by value or shares of exporters by sales mode. We condition on sector fixed effects δ_s and origin GDP per capita as a proxy for productivity in light of the analysis above. We first run separate horse-race regressions for each cost category that include all cost indicators from that category. Appendix Tables A2, A3 and A4 report these results. We then pool the leading, most significant cost measures across all categories into a holistic regression that we present in Table 4.

Table 4: Matching frictions and intermediation shares

	(1) % Ind Trade	(2) % Ind Sellers	(3) % Mix Sellers	(4) % Dir Sellers
Shipping logistics (distance)	0.041***	0.051***	-0.045***	-0.005
	(0.013)	(0.014)	(0.013)	(0.017)
Customs efficiency (cost in border)	-0.024	-0.044	0.052	-0.008
	(0.088)	(0.092)	(0.073)	(0.109)
Formal contracting (control of corruption)	0.024	0.013	0.006	-0.018
	(0.017)	(0.019)	(0.013)	(0.020)
Informal contracting (trust in foreigners)	-0.432**	-0.420**	-0.014	0.435**
	(0.194)	(0.210)	(0.141)	(0.170)
Average productivity (GDP per capita)	-0.078**	-0.081**	0.034*	0.046
	(0.031)	(0.033)	(0.019)	(0.034)
HS2 sector FE	Yes	Yes	Yes	Yes
N	3,197	3,197	3,197	3,197

Note: All regressions are at the origin country - HS2 sector level for year 2019. The outcome variable is the share of imports intermediated by wholesalers in Column 1, and the shares of purely indirect sellers, mixed sellers, and purely direct sellers in Columns 2-4. Shipping logistics are proxied by the log-distance between the origin country and Chile (CEPII). Customs procedures are measured by the monetary cost at the border (World Bank's Doing Business). The ease of formal contracting is accounted for by the control of corruption (World Bank's Worldwide Governance Indicators). Informal contracting is measured by trust in foreigners (World Values Survey).

The results suggest that intermediaries primarily help producers in arranging shipping logistics and transacting with customers when informal contracting institutions are weak. In particular, intermediaries mediate a greater share of trade flows emanating from distant origins with unreliable shipping arrivals, low trust in foreigners, and limited religious affinity with Chile. A greater share of suppliers from such origin countries are either purely indirect or mixed exporters to Chile. On the other hand, we do not find that trade intermediation varies systematically with customs efficiency or the quality of formal contracting institutions at the source country.

5. Model Estimation and Counterfactuals

We estimate the model by simulated method of moments (SMM). This serves two purposes. First, the estimated parameters are of intrinsic interest, as they inform us about the nature of seller and buyer heterogeneity and about the economic costs and benefits of intermediation. The results reveal that seller productivity and matchability are negatively correlated, which may suggest that there are frictions in the market for managers or span of control issues inside the firm.

Second, using the estimated model parameters, we can perform counterfactual analyses. In particular, we quantify the welfare gains from intermediation by shutting it down and the role of two-dimensional seller heterogeneity by imposing orthogonal productivity and matchability.

5.1. Simulated Method of Moments

Recall that the joint distribution of upstream suppliers' productivity z and matchability f^D is $G\left(z, f^D\right)$. We assume that this distribution is joint log-normal with expectations $\mu_{\ln z} = 0$ and $\mu_{\ln f^D}$, standard deviations $\sigma_{\ln z}$ and $\sigma_{\ln f^D}$, and correlation coefficient ρ. We also assume that the downstream producers' productivity distribution is log-normal with expectation $\mu_{\ln \zeta} = 0$ and standard deviation $\sigma_{\ln \zeta}$.[17] Together with the indirect cost f^I, this yields six unknown parameters to be estimated: $\Upsilon = \left\{\sigma_{\ln z}, \mu_{\ln f^D}, \sigma_{\ln f^D}, \rho, \sigma_{\ln \zeta}, f^I\right\}$.

In addition to these parameters, we need information about the elasticities of substitution σ and η and the bargaining weight ϕ. Since we have no direct evidence on the elasticities, we set $\sigma = \eta = 5$ in the baseline estimation to be consistent with prior estimates of trade elasticities (e.g., Broda and Weinstein (2006)). Recall that ϕ is the share of variable profits generated from an intermediated transaction that accrues to the wholesaler. From the pricing rule in equation (6), the relative price of a direct to an indirect transaction is:

$$\frac{p^D}{p^I} = \frac{\eta}{\eta - \phi}.$$

Rearranging, the bargaining weight is $\phi = \eta\left(1 - p^I / p^D\right)$. From Table 3, the indirect to direct price ratio p^I / p^D is roughly 0.9 in the data, using our preferred estimate with supplier-product fixed effects in Column 3. Inserting $\eta = 5$, the bargaining weight is therefore $\phi = 0.5$.

The idiosyncratic matching cost ϵ is also assumed log-normal, with mean $\mu_{\ln \epsilon} = 0$ and standard deviation $\sigma_{\ln \epsilon}$. Following Bernard et al. (2022), we set the standard deviation to $\sigma_{\ln \epsilon} = 4$.[18] Table 5 summarizes the external parameters of the model.

We choose in total 24 empirical moments to estimate Υ. The first two moments are the variance of log intermediate sales across sellers and the variance of log intermediate purchases across buyers. Intuitively, these moments map to the variance of suppliers' and downstream

[17] The normalizations $\mu_{\ln z} = 0$ and $\mu_{\ln \zeta} = 0$ are innocuous, as a shift in the productivity distribution would not affect firms' market shares or network connections.

[18] The role of ϵ is to make the objective function smooth in the parameters of the model. With a very low $\sigma_{\ln \epsilon}$, the SMM estimation procedure is not well-behaved using standard gradient-based methods.

Table 5: External model parameters

Parameter	Definition	Value	Source
ϕ	Intermediary bargaining weight	.5	$\phi = \eta\left(1-\frac{p^I}{p^D}\right)$, p^I/p^D from Table 3 Column 3
σ	Elasticity of substitution across final goods	5	Broda and Weinstein (2006)
η	Elasticity of substitution across intermediates	5	Assumption: $\eta = \sigma$
$\sigma_{\ln\epsilon}$	Pair matching cost dispersion	4	Bernard et al. (2022)

producers' productivities z and ζ. The third moment is the average share of indirect to total sales across upstream suppliers, S^I/S. Intuitively, this moment relates to the indirect matching cost f^I. The fourth moment is the variance of S^I/S, calculated for each of the 20 sales bins (i.e., the bins from Figure 2), and then averaged across bins. This moment informs us about the variance of the direct matching cost f^D: If $\sigma_{\ln f^D} = 0$, then all firms in a bin would choose the same mode (direct, indirect or mixed), and as such $var\left(S^I/S\right) = 0$. Conversely, if $\sigma_{\ln f^D}$ is very high, we would expect high dispersion in S^I/S.

The last twenty moments are the shares of indirect and mixed firms for each sales decile (again, from Figure 2). These moments reflect $\mu_{\ln f^D}$ relative to indirect costs f^I, as well as the correlation coefficient ρ. With $\rho = 0$ or $\rho < 0$, we expect high-productivity suppliers to choose predominantly direct sales. With $\rho > 0$, however, we expect some high-productivity firms to choose indirect sales, as those firms face high direct matching costs f^D. This is consistent with the evidence in Figure 2: A high proportion of suppliers in the upper sales bins are either indirect or mixed suppliers.

Collecting the empirical moments in vector x and the simulated moments in vector $x^s(\Upsilon)$, the SMM estimates for Υ solve:

$$\arg\min_{\Upsilon}\left(x - x^s(\Upsilon)\right)'\left(x - x^s(\Upsilon)\right).$$

5.2. Estimation Results

The results from the SMM estimation procedure are reported in Column 2 of Table 6. Three take-aways stand out. First, there is a positive correlation between supplier productivity and direct matching costs ($\rho > 0$). In other words, on average highly productive suppliers have lower capabilities of matching with foreign buyers. This is consistent with the conclusion in Bernard et al. (2022) for domestic production networks in Belgium. Interestingly, our identification of ρ is based on a completely different data context and set of moments, but we nevertheless arrive at the same qualitative result.

While we do not examine the origins of $\rho > 0$, a possible explanation may be imperfect labor markets or incomplete contracting, either inside the firm or external to the firm. One possibility is that firms need to hire production and sales managers, whose competence and effort determine respectively how efficiently a firm can manufacture (i.e. its marginal production cost) and how effectively it can match and transact with customers (i.e. its fixed matching cost). One might expect that intrinsically better firms would invest more resources in hiring better managers, leading to $\rho < 0$. However, this relationship may weaken or even flip with information asymmetries in the market for managers, when firms cannot perfectly observe manager talent ex ante, when there are match-specific shocks revealed only after a hire, or when agency problems affect managerial effort.

Another possibility is that firm CEOs have limited span of attention or control when supervising both production and sales managers. This would be consistent with models of information flow and optimal firm organization (Bolton and Dewatripont, 1994, Aghion and Tirole, 1997) and recent evidence on CEO time allocation and the flattening (delegation) in firm hierarchies (Rajan and Wulf, 2006, Bandiera et al., 2012). Even when a firm can attract highly competent managers, it may be difficult for the CEO to monitor that they all perform at their best. This would result in the CEO facing a trade-off between stronger production efficiency and better customer relations, generating $\rho > 0$.

A related third possibility is imperfect incentive systems. Managers (or CEOs) may have to engage in multiple tasks, some of which are more easily observed and therefore contractually rewarded. Holmstrom and Milgrom (1991) show that multi-tasking agents would then optimally focus their efforts on rewarded tasks at the expense of others. If the same manager (or CEO) is responsible for supervising both production and sales but only some dimensions of performance are rewarded (such as finding customers), other dimensions of performance might suffer (such as production efficiency).[19]

Our second take-away is that intermediation indeed lowers matching costs: $f^I/\mu_{FD} = 0.74$, suggesting that using intermediation reduces matching costs by 26% relative to average direct matching costs. However, there is also large dispersion in direct matching costs, so that $f^I > f^D$ for some firms. According to our estimates, the fixed cost of indirect sales exceeds the fixed cost of direct sales for 39% of all firms.

Table 6 also reports targeted and untargeted moments. The SMM procedure is able to fit the first four moments quite well. The simulated share of indirect and mixed firms according to our estimates are shown in Figure 9a. Comparing these shares to the empirical counterpart in Figure 2, we observe that the fit is relatively good.

[19]Empirical evidence on multi-tasking theory is limited. In recent work, Hong et al. (2018) find that workers trade off quality for quantity under a bonus scheme that rewards quantity (but not quality).

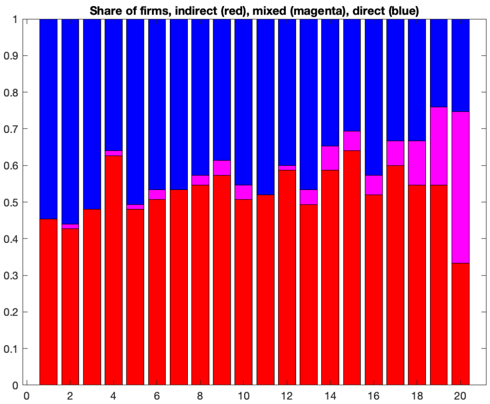
Table 6: SMM model fit

	Data (1)	Estimated model (2) Baseline
Estimated parameters:		
$\mu_{\ln F^D}$		1.48
$\sigma_{\ln z}$		0.44
$\sigma_{\ln F^D}$		1.49
ρ		0.32
$\sigma_{\ln \zeta}$		0.48
f^I/μ_{F^D}		0.74
Targeted moments:		
$var\,(\ln Sales)$	4.86	4.86
$var\,(\ln Purchases)$	6.01	6.01
mean (indirect sales / total sales)	0.48	0.56
$var\,(S^I/S)$, average across bins	.24	.23
Share indirect firms, by sales decile (10 moments)	Figure 2a	Figure 9a
Share mixed firms, by sales decile (10 moments)	Figure 2a	Figure 9a
Non-targeted moments:		
Share intermediated trade value	.48	.54
Share intermediated trade value, by sales decile	Figure 2b	Figure 9b
Share sellers using intermediation	.52	.59
Share of intermediate trade, top 5% sellers	.82	.65
Share of final goods trade, top 5% buyers		.67

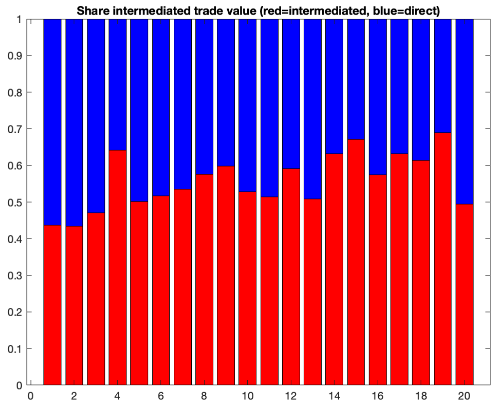
Turning to untargeted moments, Figure 9b reports the share of intermediated trade value to total trade for each sales bin according to the model. This is the model counterpart to the empirical patterns in Figure 2b. The model matches the data relatively well. Table 6 also reports three additional untargeted moments. On average, the share of intermediated trade value is slightly over-predicted. Dispersion in suppliers' sales, as indicated by the share of intermediate trade by the top 5% suppliers is also somewhat under-predicted. While not observed in the data, the simulated distribution of final good sales by downstream buyers seems comparable to that of intermediate sales by upstream suppliers, as reflected in the market share of the top 5% of final producers.

Our third take-away is that correctly specifying the network model with both buyer heterogeneity and two-dimensional seller heterogeneity is essential both for matching key data features and for accurately estimating the costs of intermediation. We draw this conclusion by estimating two restricted versions of the model:

Figure 9: Estimated model: Trade strategy across the supplier size distribution



(a) Share of suppliers by trade mode



(b) Share intermediate/direct trade value

Restricted model: No buyer heterogeneity

Throughout this paper, we have emphasized that we need heterogeneity among both buyers and suppliers to explain and understand our empirical findings. We now consider how sensitive the estimated cost of intermediation is to estimating a counterfactually restricted model without buyer heterogeneity, by imposing $\sigma_{\ln \zeta} = 0$.

We report the results in Column 2 of Table 7. We target the same moments as above, except the variance of input purchases across buyers and the share of mixed sellers are now both zero by definition. Intermediation costs are now estimated to be roughly 60% higher than in the baseline, and moreover 17% higher than the average cost of direct sales f^D. The reason is straightforward: With no buyer heterogeneity, suppliers always choose a single sales mode. As a result, highly productive suppliers with low matchability would be more likely to sell exclusively indirectly, instead of mixing sales strategies. The implied cost of intermediation must then be sufficiently high to ensure the use of intermediation does not exceed that in the data.

In sum, a counterfactual model without buyer heterogeneity would bias intermediation cost estimates upwards. This exercise shows that specifying a data-consistent model with two-sided heterogeneity is crucial for accurately estimating intermediation costs.

Restricted model: One-dimensional seller heterogeneity

Throughout the paper, we have also argued that we need two-dimensional seller heterogeneity in both productivity and matchability to rationalize key empirical facts. We now illustrate the role of this property by estimating a counterfactually restricted model without seller heterogeneity in matchability, by setting $\sigma_{\ln f^D} = 0$ and $\rho = 0$.

We present the results in Column 3 of Table 7, where we once again target the baseline empirical moments. As discussed above, a model without heterogeneity in matchability cannot account for the variation in sales modes across suppliers within a size bin. Indeed, the implied variance of S^I/S is now counterfactually zero. Moreover, in the restricted model, all suppliers use intermediation services, either as purely indirect or mixed suppliers, which is at odds with the data. The share of indirect sellers and the average share of indirect sales are also almost twice as high as in the data.

In sum, our findings confirm that heterogeneity in matchability is a key model ingredient in order to match our empirical facts.

Table 7: SMM model fit : Restricted models

	Data	Estimated model	
	(1)	(2) $\sigma_{\ln \zeta} = 0$	(3) $\sigma_{\ln f^D} = 0$
Estimated parameters:			
$\mu_{\ln F^D}$		1.50	1.47
$\sigma_{\ln z}$		0.40	0.42
$\sigma_{\ln F^D}$		1.24	0.00
ρ		0.12	0.00
$\sigma_{\ln \zeta}$		0.00	0.48
f^I/μ_{F^D}		1.17	0.61
Targeted moments:			
var $(\ln Sales)$	4.86	4.86	4.86
mean (indirect sales / total sales)	0.48	0.45	0.95
var $\left(S^I/S\right)$, average across bins	.24	.25	.00
Share indirect firms, by sales decile (10 moments)	.46 (average)	0.45 (average)	0.85 (average)
Non-targeted moments:			
Share intermediated trade value	.48	.41	.49
Share sellers using intermediation	.52	.45	1.00

5.3. Counterfactual Analysis

We end this section by performing three informative counterfactuals. The first counterfactual is to shut down intermediation completely, by setting $f^I = \infty$. Column 2 of Table 8 summarizes the results. With no access to wholesale services, the final-goods price index increases by 3.3%, implying that the welfare gains from intermediation are around 3%. This occurs because many connections are broken in the absence of intermediation: The total number of buyer-seller links declines by more than 15%. This provides some indication of the relevance of policies that improve access to cross-border intermediation services, such as domestic competition policy in the services sector or multilateral deep integration that spans goods and services trade liberalization.

Table 8: Counterfactuals I & II: No intermediation

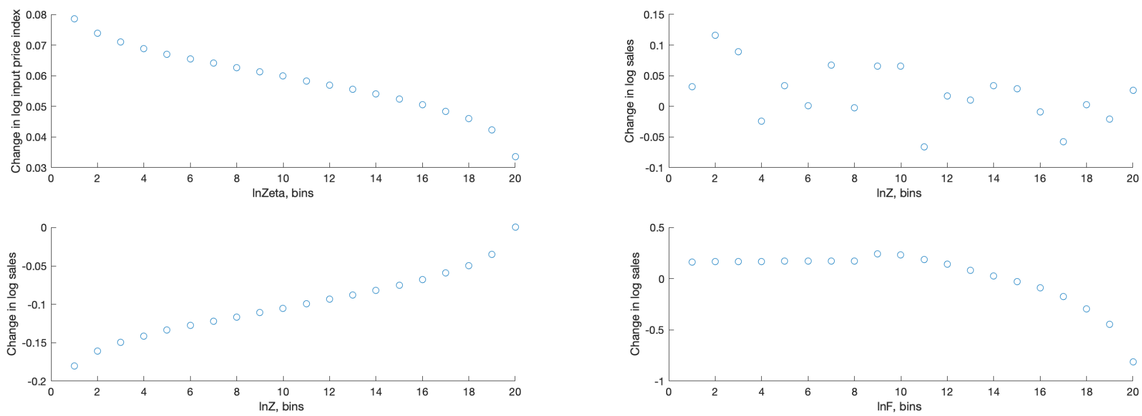
	Baseline (1)	No Intermediation (2)	No Intermediation, Identical Matchability (3)
Change in consumer price index		3.3%	0.4%
Change in number of firm links		-15.3%	-6.3%
Share intermediated trade value	.54	0	0
Share sellers using intermediation	.59	0	0
Share of intermediate trade, top 5% sellers	.65	.66	.70
Share of final goods trade, top 5% buyers	.67	.69	.68

Figure 10a reports the change in the input price index $C(\zeta)$ and final-goods sales across 20 bins of the final-goods seller productivity distribution ζ. Small, low-productivity final-goods firms are most affected, with their input prices increasing by as much as 8% and sales declining by almost 20%. Intuitively, these producers rely heavily on intermediated trade, which is no longer available. Figure 10b reports changes in suppliers' sales across 20 bins of the productivity, z, and direct matching cost, f^D, distributions. Our results indicate that both low- and high-productivity suppliers are affected by intermediation, possibly because of the positive estimate for ρ. In addition, low-matchability sellers see the largest reduction in sales, as these use intermediation intensively in the baseline scenario.

The second counterfactual we consider is eliminating access to intermediation services when there is no heterogeneity in matchability among sellers to begin with, i.e. $\sigma_{\ln f^D} = 0$ and $\rho = 0$. As Column 3 of Table 8 shows, the welfare gains from intermediation are now much smaller at 0.4%. This occurs because now all productive suppliers rely less on intermediation, since they all have the same degree of matchability, and no disproportionate benefits accrue to highly productive firms with low matchability as in the baseline. This suggests that intermediation services are a more valuable market solution to firms' networking problem in environments with inefficiently dispersed matching costs.

In our final counterfactual, we maintain access to intermediation to explore the role of the correlation between seller productivity and matchability, by setting $\rho = 0$. Table

Figure 10: Counterfactual I (no intermediation): Seller and buyer outcomes



(a) Buyer outcomes

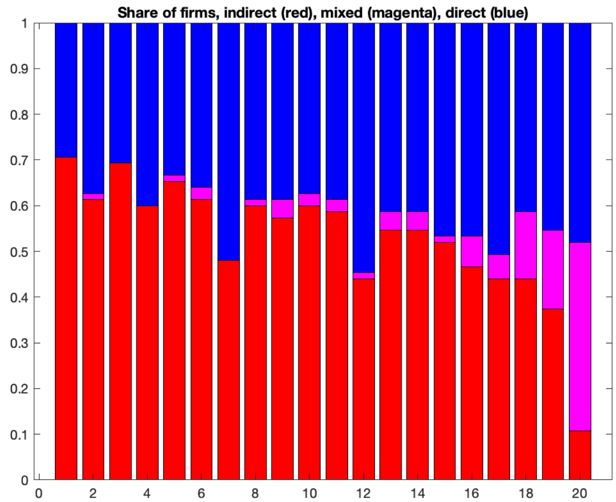
(b) Seller outcomes

9 summarizes our findings. In this case, the consumer price index decreases by 3.4%, as highly productive suppliers are no longer penalized by having high direct matching costs on average. Interestingly, the total number of buyer-seller connections declines by 1.3%. Figure 11 reports the shares of direct, indirect and mixed suppliers in the counterfactual scenario. The largest suppliers are now almost completely absent among indirect firms. The reason is straightforward: Highly productive firms are now no longer burdened by low matchability, and therefore almost always sell directly to at least one customer. Nevertheless, we still observe many large mixed suppliers, as intermediation may still be the most profitable option when selling to small customers. This exercise signals the scope for larger gains from trade liberalization when it is accompanied by trade promotion and facilitation that lowers firm-to-firm matching costs, particularly for productive sellers.

Table 9: Counterfactual III: Orthogonal seller attributes

	Baseline (1)	Orthogonal Seller Productivity & Matchability (2)
Change in consumer price index		-3.4%
Change in number of firm links		-1.3%
Share intermediated trade value	.54	.34
Share sellers using intermediation	.59	.59
Share of intermediate trade, top 5% sellers	.65	.69
Share of final goods trade, top 5% buyers	.67	.66

Figure 11: Counterfactual II (orthogonal seller attributes): Share of suppliers by trade mode



6. Conclusion

This paper examines the role of trade intermediaries in buyer-supplier networks and the implications for international trade and aggregate welfare. Using uniquely rich data for Chile, we establish novel stylized facts about seller-buyer interactions when suppliers can access wholesale services. We develop a general-equilibrium model of production networks with suppliers of heterogeneous productivity and relationship capability, buyers of heterogeneous productivity, and intermediaries that reduce relationship-specific costs in exchange for an implicit brokerage fee related to their bargaining power. This model with two-sided heterogeneity and two sources of supplier heterogeneity can rationalize how exporters optimally sort into different sales strategies. Intermediaries widen production networks by enabling more firm-to-firm links, especially for smaller buyers and for productive suppliers with low matchability. Intermediaries also deepen production networks, as higher buyer connectivity endogenously increases their input purchases through lower input costs and higher final demand. The presence of specialized intermediaries thus induces welfare gains and heterogeneous effects across firms.

Our work begins to unpack the nature of search, match and transaction costs that shape global value chains. This opens promising avenues for future research at the intersection of production networks and trade intermediation. Micro-foundations for the market power of wholesalers can provide additional insights on rent sharing, and inform policies aiming at a more competitive intermediation sector or denser production networks. The role of intermediaries in buyer-supplier links may also have important implications for shock transmission and the adjustment of firms' sourcing and sales decisions in response to trade reforms or macroeconomic movements. Further analysis can illuminate to what extent the market for intermediation services has responded to meet the needs of manufacturing firms, whether its market structure warrants policy intervention, and how trade promotion and facilitation policies implemented in developing countries can be most effective.

References

Acemoglu, Daron, Vasco M Carvalho, Asuman Ozdaglar, and Alireza Tahbaz-Salehi, "The network origins of aggregate fluctuations," *Econometrica*, 2012, *80* (5), 1977–2016.

Aghion, Philippe and Jean Tirole, "Formal and real authority in organizations," *Journal of political economy*, 1997, *105* (1), 1–29.

Ahn, JaeBin, Amit K Khandelwal, and Shang-Jin Wei, "The role of intermediaries in facilitating trade," *Journal of International Economics*, 2011, *84* (1), 73–85.

Akerman, Anders, "A theory on the role of wholesalers in international trade based on economies of scope," *Canadian Journal of Economics/Revue canadienne d'économique*, 2018, *51* (1), 156–185.

Amiti, Mary and Jozef Konings, "Trade liberalization, intermediate inputs, and productivity: Evidence from Indonesia," *American Economic Review*, 2007, *97* (5), 1611–1638.

Antras, Pol and Arnaud Costinot, "Intermediated trade," *The Quarterly Journal of Economics*, 2011, *126* (3), 1319–1374.

_ **and C. Fritz Foley**, "Poultry in Motion: A Study of International Trade Finance Practices," *Journal of Political Economy*, 2015, *123* (4), 853–901.

_ **and Davin Chor**, "Global Value Chains," in "Handbook of International Economics," Vol. 5 2022.

_ **, Teresa Fort, and Felix Tintelnot**, "The Margins of Global Sourcing: Theory and Evidence from US Firms," *American Economic Review*, 2017, *107* (9), 2514–2564.

Arkolakis, Costas, "Market Penetration Costs and the New Consumers Margin in International Trade," *Journal of Political Economy*, 2010, *118* (6), 1151–1199.

Atkin, David, Amit K Khandelwal, and Adam Osman, "Exporting and firm performance: Evidence from a randomized experiment," *The Quarterly Journal of Economics*, 2017, *132* (2), 551–615.

Baker, George, Robert Gibbons, and Kevin J. Murphy, "Relational Contracts and the Theory of the Firm," *Quarterly Journal of Economics*, 2002, *117* (1), 39–84.

Baldwin, Richard, *The Great Convergence: Information Technology and the New Globalization*, Harvard University Press, 2015.

Bandiera, Oriana, Luigi Guiso, Andrea Prat, and Raffaella Sadun, "What do CEOs do?," 2012.

Baqaee, David Rezza and Emmanuel Farhi, "The macroeconomic impact of microeconomic shocks: Beyond Hulten's theorem," *Econometrica*, 2019, *87* (4), 1155–1203.

Bekes, Gabor, Rosario Crino, Alessandra Bonfiglioli, and Gino Gancia, "The Diffusion of Robotics in Hungary: A Firm-Level View," *Mimeo*, 2025.

Bernard, Andrew B and Andreas Moxnes, "Networks and trade," *Annual Review of Economics*, 2018, *10*, 65–85.

_ , _ , and Karen Helene Ulltveit-Moe, "Two-sided heterogeneity and trade," *Review of Economics and Statistics*, 2018, *100* (3), 424–439.

_ , _ , and Yukiko U Saito, "Production networks, geography, and firm performance," *Journal of Political Economy*, 2019, *127* (2), 639–688.

_ , Emmanuel Dhyne, Glenn Magerman, Kalina Manova, and Andreas Moxnes, "The origins of firm heterogeneity: A production network approach," *Journal of Political Economy*, 2022, *130* (7), 1765–1804.

_ , J Bradford Jensen, Stephen J Redding, and Peter K Schott, "Wholesalers and retailers in US trade," *American Economic Review*, 2010, *100* (2), 408–13.

_ , Marco Grazzi, and Chiara Tomasi, "Intermediaries in international trade: Products and destinations," *Review of Economics and Statistics*, 2015, *97* (4), 916–920.

_ , Stephen J Redding, and Peter K Schott, "Multiproduct firms and trade liberalization," *The Quarterly journal of economics*, 2011, *126* (3), 1271–1318.

Blaum, Joaquin, Claire Lelarge, and Michael Peters, “The gains from input trade with heterogeneous importers,” *American Economic Journal: Macroeconomics*, 2018, *10* (4), 77–127.

Bloom, Nicholas and John Van Reenen, “Measuring and Explaining Management Practices Across Firms and Countries,” *Quarterly Journal of Economics*, 2007, *122* (4), 1351–1408.

Bloom, Nick, Kalina Manova, John Van Reenen, Stephen Sun, and Zhihong Yu, “Trade and Management,” *Review of Economics and Statistics*, 2021, *103*, 1–18.

Blum, Bernardo S, Sebastian Claro, and Ignatius Horstmann, “Intermediation and the nature of trade costs: Theory and evidence,” *University of Toronto, mimeograph*, 2009.

Blum, Bernardo, Sebastian Claro, Kunal Dasgupta, Ignatius Horstmann, and Marcos Rangel, “Wholesalers in International Production Networks,” 2025.

Boehm, Johannes and Ezra Oberfield, “Misallocation in the Market for Inputs: Enforcement and the Organization of Production,” *The Quarterly Journal of Economics*, 2020, *135* (4), 2007–2058.

Bøler, Esther Ann, Andreas Moxnes, and Karen Helene Ulltveit-Moe, “R&D, international sourcing, and the joint impact on firm performance,” *American Economic Review*, 2015, *105* (12), 3704–3739.

Bolton, Patrick and Mathias Dewatripont, “The firm as a communication network,” *The Quarterly Journal of Economics*, 1994, *109* (4), 809–839.

Broda, Christian and David E Weinstein, “Globalization and the Gains from Variety,” *The Quarterly journal of economics*, 2006, *121* (2), 541–585.

Cai, Jing, Wei Lin, and Adam Szeidl, “Firm-to-Firm Referrals,” *National Bureau of Economic Research*, 2024, *No. w33082.*

Caliendo, Lorenzo and Fernando Parro, “Estimates of the Trade and Welfare Effects of NAFTA,” *Review of Economic Studies*, 2015, *82* (1), 1–44.

Carballo, Jerónimo, Gianmarco IP Ottaviano, and Christian Volpe Martincus, “The buyer margins of firms’ exports,” *Journal of International Economics*, 2018, *112*, 33–49.

Carvalho, Vasco M, Makoto Nirei, Yukiko U Saito, and Alireza Tahbaz-Salehi, "Supply chain disruptions: Evidence from the great east japan earthquake," *The Quarterly Journal of Economics*, 2021, *136* (2), 1255–1321.

Chaney, Thomas, "The network structure of international trade," *American Economic Review*, 2014, *104* (11), 3600–3634.

Dhingra, Swati and Silvana Tenreyro, "The rise of agribusiness and the distributional consequences of policies on intermediated trade," 2020.

Eaton, Jonathan, David Jinkins, James R Tybout, and Daniel Xu, "Two-sided search in international markets," Technical Report, National Bureau of Economic Research 2022.

Elliott, Matthew, Benjamin Golub, and Matthew V Leduc, "Supply network formation and fragility," *American Economic Review*, 2022, *112* (8), 2701–2747.

Felbermayr, Gabriel and Benjamin Jung, "Trade intermediation and the organization of exporters," *Review of International Economics*, 2011, *19* (4), 634–648.

Fontaine, FranÃ§ois, Julien Martin, and Isabelle Mejean, "Frictions and Adjustments in Firm-to-Firm Trade," *CEPR Discussion Paper No. 18110*, 2023.

Ganapati, Sharat, "The Modern Wholesaler: Global Sourcing, Domestic Distribution, and Scale Economies," 2018.

Goldberg, Pinelopi K., Amit K. Khandelwal, Nina Pavcnik, and Petia Topalova, "Imported Intermediate Inputs and Domestic Product Growth: Evidence from India," *Quarterly Journal of Economics*, 2010, *125* (4), 1727–1767.

Gopinath, Gita and Brent Neiman, "Trade adjustment and productivity in large crises," *American Economic Review*, 2014, *104* (3), 793–831.

Grant, Matthew and Meredith Startz, "Cutting out the middleman: The structure of chains of intermediation," 2022.

Halpern, László, Miklós Koren, and Adam Szeidl, "Imported inputs and productivity," *American Economic Review*, 2015, *105* (12), 3660–3703.

Holmstrom, Bengt and Paul Milgrom, "Multitask principal–agent analyses: Incentive contracts, asset ownership, and job design," *The Journal of Law, Economics, and Organization*, 1991, *7* (special_issue), 24–52.

Hong, Fuhai, Tanjim Hossain, John A List, and Migiwa Tanaka, "Testing the theory of multitasking: Evidence from a natural field experiment in Chinese factories," *International Economic Review*, 2018, *59* (2), 511–536.

Huang, Hanwei, Kalina Manova, Oscar Perello, and Frank Pisch, "Firm Heterogeneity and Imperfect Competition in Global Production Networks," 2021. UCL mimeo.

Lim, Kevin, "Endogenous production networks and the business cycle," *Work. Pap*, 2018.

Manova, Kalina and Zhihong Yu, "Multi-Product Firms and Product Quality," *Journal of International Economics*, 2017, *109*, 116–137.

_ **and Zhihong Zhang**, "Export Prices Across Firms and Destinations," *Quarterly Journal of Economics*, 2012, *127*, 379–436.

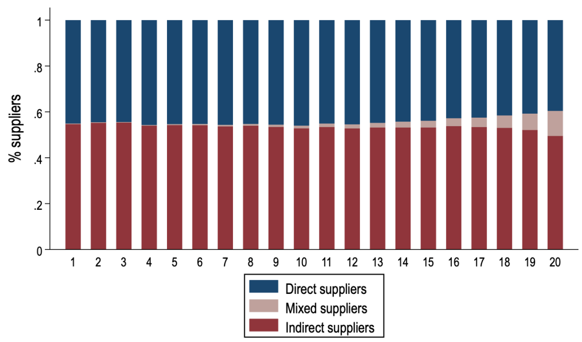
Pataault, BÃ©rengÃšre and ClÃ©mence Lenoir, "Recruiting Sales Managers to Reach Customers," 2024. Working paper.

Perello, Oscar, "Trade Intermediation and Resilience in Global Sourcing," 2025.

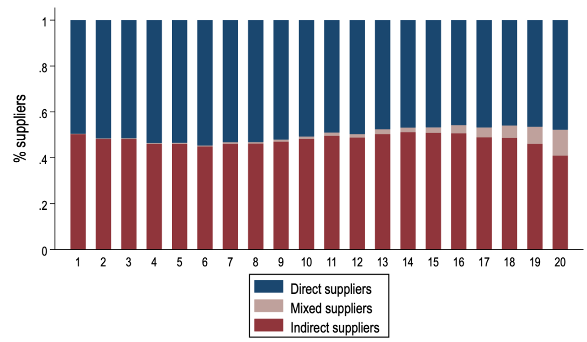
Rajan, Raghuram G and Julie Wulf, "The flattening firm: Evidence from panel data on the changing nature of corporate hierarchies," *The Review of Economics and Statistics*, 2006, *88* (4), 759–773.

Appendix A. Additional Empirical Results

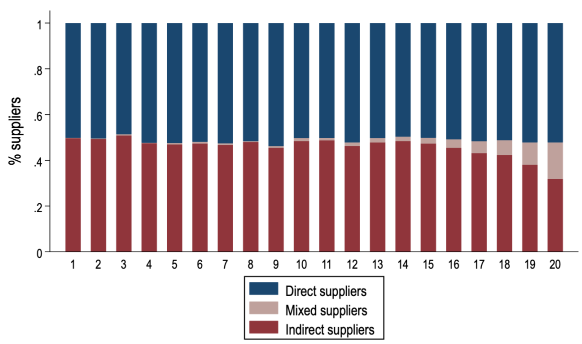
Figure A1: Trade strategy across the supplier size distribution



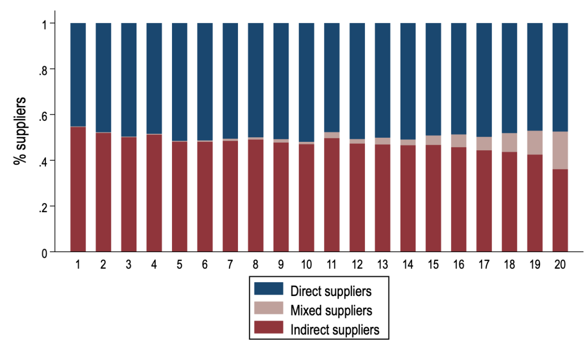
(a) Residualized by product (HS6)



(b) Excluding differentiated goods



(c) Including only homogenous goods



(d) Homogeneous goods and product residualization

Note: These figures replicate supplier sorting into trading modes (Fact 1) at the supplier-product level (HS 6-digit) to account for variation in the use of intermediation across industries. Panel (a) residualizes suppliers total exports to Chile at the product level before sorting them into 20 bins. Panel (b) excludes goods classified as differentiated under the Rauch classification, while Panel (c) includes only goods classified as homogeneous. Panel (d) restricts the sample to homogeneous goods and residualizes exports at the product level.

Table A1: Direct and indirect prices by product type

	Non-differentiated goods		Homogeneous goods	
	(1) log(Unit Value)	(2) log(Unit Value)	(3) log(Unit Value)	(4) log(Unit Value)
D(Direct Supplier=1)	0.302***		0.171***	
	(0.043)		(0.049)	
D(Indirect Supplier=1)	-0.181***		-0.146**	
	(0.045)		(0.058)	
D(Wholesaler Buyer=1)		-0.039**		-0.030
		(0.018)		(0.022)
Product FE	Yes	No	Yes	No
Supplier-Product FE	No	Yes	No	Yes
Transacted value	Yes	Yes	Yes	Yes
Relationship age	Yes	Yes	Yes	Yes
Supplier controls	Yes	No	Yes	No
Buyer controls	Yes	Yes	Yes	Yes
N	168,534	12,149	58,787	5,120

Note: This table replicates the results of Table 3 for (i) a subsample excluding goods classified as differentiated, and (ii) goods classified as homogeneous under the Rauch classification. All regressions are at the supplier-HS6 product-buyer level for 2019. Columns 1 and 3 compare prices charged by purely direct and purely indirect suppliers to those of mixed suppliers. Columns 2 and 4 compare prices charged by mixed suppliers when exporting to wholesalers versus producer buyers. Buyer and supplier controls include firm size (total trade value) and connectivity (number of trade partners).

Table A2: Shipping logistics

	(1) % Ind Trade	(2) % Ind Sellers	(3) % Mix Sellers	(4) % Dir Sellers
(log) Distance	0.050***	0.062***	-0.057***	-0.006
	(0.013)	(0.012)	(0.007)	(0.014)
Logistic services	-0.059	0.061	-0.153	0.092
	(0.263)	(0.255)	(0.142)	(0.260)
Track and trace	0.298	0.143	0.123	-0.266
	(0.185)	(0.195)	(0.089)	(0.189)
Ease of arranging shipments	0.273	0.260	-0.040	-0.221
	(0.165)	(0.160)	(0.083)	(0.153)
Shipment arrivals (within time)	-0.613***	-0.578***	0.164	0.414*
	(0.187)	(0.176)	(0.124)	(0.218)
Trade infrastructure	-0.144	-0.208	0.191**	0.017
	(0.148)	(0.157)	(0.082)	(0.149)
(log) GDP per capita	-0.008	-0.002	-0.021*	0.023
	(0.023)	(0.023)	(0.012)	(0.024)
HS2 sector FE	Yes	Yes	Yes	Yes
N	4,008	4,008	4,008	4,008

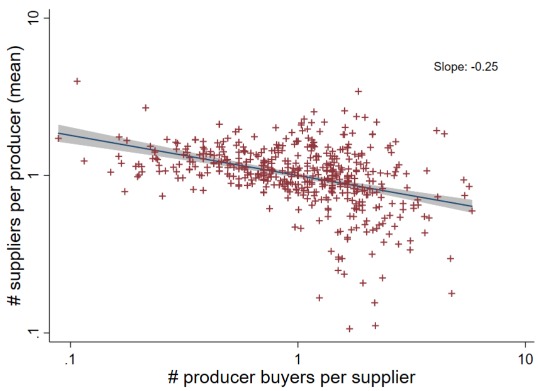
Table A3: Customs procedures

	(1) % Ind Trade	(2) % Ind Sellers	(3) % Mix Sellers	(4) % Dir Sellers
Border compliance: USD (0-1)	-0.035	-0.027	0.087	-0.060
	(0.119)	(0.112)	(0.097)	(0.130)
Border compliance: hours (0-1)	0.005	-0.054	0.011	0.043
	(0.198)	(0.190)	(0.093)	(0.177)
Export documentation: USD (0-1)	0.008	0.073	-0.161	0.088
	(0.297)	(0.324)	(0.223)	(0.299)
Export documentation: hours (0-1)	-0.117	-0.015	-0.213	0.228
	(0.253)	(0.261)	(0.140)	(0.238)
(log) # procedures	-0.051	-0.072	0.053	0.019
	(0.049)	(0.053)	(0.036)	(0.049)
Customs efficiency	-0.005	-0.052	0.072	-0.021
	(0.092)	(0.096)	(0.073)	(0.094)
(log) GDP per capita	-0.059**	-0.063**	0.017	0.046**
	(0.025)	(0.027)	(0.017)	(0.023)
HS2 sector FE	Yes	Yes	Yes	Yes
N	3,955	3,955	3,955	3,955

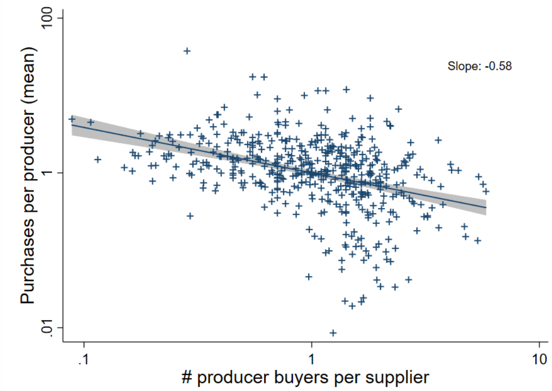
Table A4: Formal and informal contracting institutions

	(1) % Ind Trade	(2) % Ind Sellers	(3) % Mix Sellers	(4) % Dir Sellers
Control of corruption	0.016	-0.000	0.022	-0.022
	(0.017)	(0.019)	(0.015)	(0.020)
Rule of law	-0.000	0.008	-0.026**	0.018*
	(0.012)	(0.014)	(0.012)	(0.010)
Common legal origins (=1)	0.023	0.015	0.022	-0.037
	(0.027)	(0.024)	(0.017)	(0.024)
Trust in foreigners (%)	-0.625***	-0.617***	0.089	0.528***
	(0.180)	(0.203)	(0.154)	(0.171)
Common religion (%)	-0.108***	-0.117***	0.047*	0.070**
	(0.040)	(0.040)	(0.028)	(0.034)
Language proximity (tree index)	0.032	0.043	-0.045	0.002
	(0.039)	(0.046)	(0.042)	(0.033)
(log) GDP per capita	-0.042	-0.045	0.026	0.019
	(0.030)	(0.033)	(0.024)	(0.033)
HS2 sector FE	Yes	Yes	Yes	Yes
N	3,104	3,104	3,104	3,104

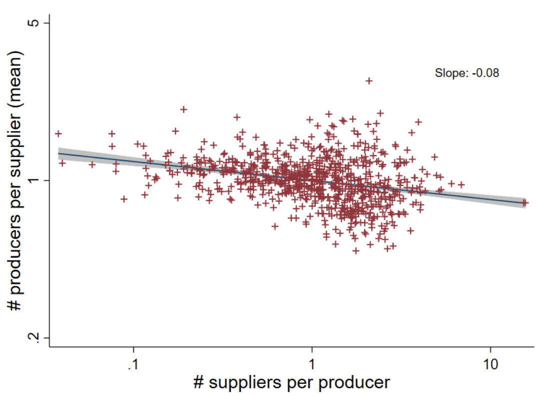
Figure A2: Degree assortativity in direct transactions



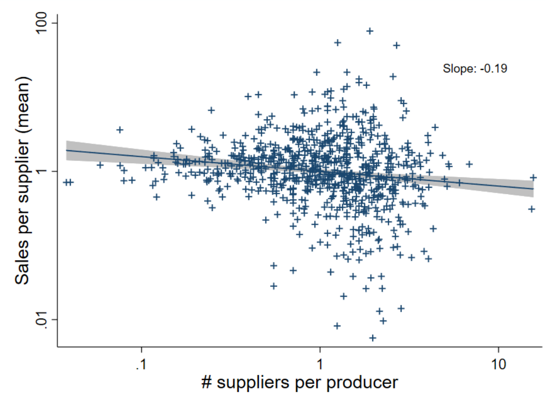
(a) Average connectivity of buyers



(b) Average size of buyers



(c) Average connectivity of suppliers



(d) Average size of suppliers

Appendix B. Proofs

B.1. Proposition 1

Part (a)

Consider a supplier $\lambda = (z, f^D)$ in market i selling to downstream producer ζ in market j. According to Equation (7), firm-to-firm sales conditional on a direct match are $x_{ij}^D(\lambda,\zeta) = \mu^{1-\eta}\left(\frac{\tau_{ij}\,w_i}{z(\lambda)}\right)^{1-\eta} C_j(\zeta)^{\eta-1} X_j(\zeta)$, where $\mu \equiv \frac{\eta}{\eta-1}$. Differentiating with respect to seller productivity we obtain $\frac{\partial x_{ij}^D(\lambda,\zeta)}{\partial z(\lambda)} = (\eta-1)^{\eta}\eta^{1-\eta} z(\lambda)^{\eta-2}\left(\tau_{ij}\,w_i\right)^{1-\eta} C_j(\zeta)^{\eta-1} X_j(\zeta)$, which is positive since $\eta > 1$ by assumption and all other terms are positive by definition. Under an indirect match, Equation (8) states that firm-to-firm sales are proportional to direct sales, $x_{ij}^I(\lambda,\zeta) = \left(\frac{\eta-\phi}{\eta}\right) x_{ij}^D(\lambda,\zeta)$, and considering that $\phi \in [0,1]$ we have that $\frac{\partial x_{ij}^I(\lambda,\zeta)}{\partial z(\lambda)} = \left(\frac{\eta-\phi}{\eta}\right)\frac{\partial x_{ij}^D(\lambda,\zeta)}{\partial z(\lambda)}$ is also positive. Finally, note that neither $x_{ij}^D(\lambda,\zeta)$ or $x_{ij}^I(\lambda,\zeta)$ depend on seller matchability f^D.

Part (b)

Considering again Equation (7) for firm-to-firm sales under direct trade. Differentiating with respect to buyer productivity ζ we obtain $\frac{\partial x_{ij}^D(\lambda,\zeta)}{\partial \zeta} = \mu^{1-\eta}\left(\frac{\tau_{ij}\,w_i}{z(\lambda)}\right)^{1-\eta}\frac{\partial}{\partial \zeta}\left(C_j(\zeta)^{\eta-1} X_j(\zeta)\right)$, where total input purchases can be expressed as $X_j(\zeta) = \tilde{c}(\zeta)\tilde{q}(\zeta) = \zeta^{\sigma-1} C_j(\zeta)^{1-\sigma}\tilde{\mu}\tilde{P}_j^{\sigma-1}\beta\tilde{E}_j$ after replacing downstream demand (1) and the marginal cost (2). We then have that $\frac{\partial x_{ij}^D(\lambda,\zeta)}{\partial \zeta} = \left[(\sigma-1)\zeta^{\sigma-2} C_j(\zeta)^{\eta-\sigma} + (\eta-\sigma)\zeta^{\sigma-1} C_j(\zeta)^{\eta-\sigma-1}\frac{\partial C_j(\zeta)}{\partial \zeta}\right]\bar{K}_j$ where the last element is $\bar{K}_j \equiv \mu^{1-\eta}\left(\frac{\tau_{ij}\,w_i}{z(\lambda)}\right)^{1-\eta}\tilde{\mu}^{-\sigma}\tilde{P}_j^{\sigma-1}\beta\tilde{E}_j > 0$. For the case where elasticities are identical across final and intermediate goods ($\sigma = \eta$), this expression is always positive since $\sigma > 1$ and the second term cancels out, such that firm-to-firm sales increase with buyer productivity. The demonstration is analogous for the case of indirect trade using equation (8). For the case where $\sigma > \eta$, a sufficient condition is that the buyer's input cost index $C(\zeta)$ is decreasing in buyer productivity ζ, which ultimately depends on seller's endogenous matching decisions.

Part (c)

Conditional on a match (λ,ζ),the fact that firm-to-firm sales are lower under indirect mode is evident from Equation (8), where $x_{ij}^I(\lambda,\zeta) = \left(\frac{\eta-\phi}{\eta}\right) x_{ij}^D(\lambda,\zeta)$, $\eta > 1$ and $\phi \in [0,1]$. The fact that sales are cheaper follows from Equation (6), where $p_{ij}^I(\lambda,\zeta) = \frac{\eta-\phi}{\eta}\, p_{ij}^D(\lambda,\zeta)$.

B.2. Proposition 2

Part (a)

From Equation (9) we have that direct profits from upstream supplier $\lambda = (z, f^D)$ in market i selling in market j are $\pi_{ij}^D(\lambda, \zeta) = \frac{x_{ij}^D(\lambda,\zeta)}{\eta} - f^D(\lambda)$ for each potential buyer with productivity ζ. As shown in Proposition 1, $x_{ij}^D(\lambda, \zeta)$ is continuous and monotonically increasing in ζ. Also note that $x_{ij}^D(\lambda, \zeta) = 0$ when $\zeta = 0$, such that $\pi_{ij}^D(\lambda, \zeta) < 0$. Thus, there exists a unique threshold $\zeta_{ij}^D(\lambda)$ where the direct profits curve of supplier λ equals zero and $\pi_{ij}^D(\lambda, \zeta) > 0$ for $\zeta > \zeta_{ij}^D(\lambda)$.

Part (b)

From Equation (10) we can have that indirect profits of upstream supplier $\lambda = (z, f^D)$ in market i selling in market j are $\pi_{ij}^I(\lambda, \zeta) = \left(\frac{\eta-\phi}{\eta}\right)\frac{x_{ij}^D(\lambda,\zeta)}{\eta} - f^I$. Since $\eta > 1$ and $\phi \in [0, 1]$, the analysis is analogous to that of part (a) for direct profits: $x_{ij}^D(\lambda, \zeta)$ is continuous and monotonically increasing in ζ, so there exists a unique threshold $\zeta_{ij}^I(\lambda)$ where the indirect profits curve of supplier λ equals zero and $\pi_{ij}^I(\lambda, \zeta) > 0$ for $\zeta > \zeta_{ij}^I(\lambda)$.

Part (c)

Combining equations (9) and (10), we can define the curve $\pi_{ij}^*(\lambda, \zeta) = \pi_{ij}^D(\lambda, \zeta) - \pi_{ij}^I(\lambda, \zeta) = \left(\frac{\phi}{\eta}\right)\frac{x_{ij}^D(\lambda,\zeta)}{\eta} - \left(f^D(\lambda) - f^I\right)$, where $\frac{\phi}{\eta} \in [0, 1]$ since $\eta > 1$ and $\phi \in [0, 1]$. If direct matching costs are higher than contracting with intermediaries ($f^D(\lambda) - f^I > 0$), then the analysis is analogous to that of parts (a) and (b): $x_{ij}^D(\lambda, \zeta)$ is continuous and monotonically increasing in ζ, so there exists a unique threshold $\zeta_{ij}^{D=I}(\lambda)$ where $\pi_{ij}^*(\lambda, \zeta) = 0$ and $\pi_{ij}^D(\lambda, \zeta) = \pi_{ij}^I(\lambda, \zeta)$, such that $\pi_{ij}^*(\lambda, \zeta) > 0$ and $\pi_{ij}^D(\lambda, \zeta) > \pi_{ij}^I(\lambda, \zeta)$ for $\zeta > \zeta_{ij}^{D=I}(\lambda)$. For suppliers with high matchability ($f^D(\lambda) - f^I < 0$), then $\pi_{ij}^*(\lambda, \zeta) > 0$ and $\pi_{ij}^D(\lambda, \zeta) > \pi_{ij}^I(\lambda, \zeta)$ for any $\zeta > 0$.

B.3. Proposition 3

Part (a)

From Proposition 2a we know that $\pi_{ij}^D(\lambda, \zeta) < 0$ for $\zeta < \zeta_{ij}^D(\lambda)$, such that all potential direct matches in market j are unprofitable for seller λ when the highest-productivity buyer is $\overline{\zeta}_j < \zeta_{ij}^D(\lambda)$. Analogously, from Proposition 2b, $\pi_{ij}^I(\lambda, \zeta) < 0$ for $\zeta < \zeta_{ij}^I(\lambda)$, and all potential indirect matches are unprofitable for $\overline{\zeta}_j < \zeta_{ij}^I(\lambda)$. Thus, no-trade is the optimal strategy for seller λ.

Part (b)

Since $\zeta_{ij}^{D}(\lambda) < \overline{\zeta}_j$, there exists a set of potential buyers $[max(\underline{\zeta_j}, \zeta_{ij}^{D}(\lambda)), \overline{\zeta_j}]$ in market j that generates positive profits for seller λ under direct trade. If $\zeta_{ij}^{D}(\lambda) < \zeta_{ij}^{I}(\lambda)$ then it must be the case that $\zeta_{ij}^{D=I}(\lambda) < \left\{\zeta_{ij}^{D}(\lambda), \zeta_{ij}^{I}(\lambda)\right\}$, because $f^D(\lambda) < f^I$ and both direct and indirect profit curves are monotonically increasing in buyer productivity (Propositions 2a and 2b), so direct profits can only reach zero from below before indirect profits if these curves already crossed each other. This implies that $\pi_{ij}^{D}(\lambda, \zeta) > \pi_{ij}^{I}(\lambda, \zeta)$ for all potential buyers that generate positive profits for seller λ, since direct and indirect profits cross only once (Proposition 2c). The optimal trade strategy is then to sell only directly to all potential buyers $\zeta \epsilon [max(\underline{\zeta_j}, \zeta_{ij}^{D}(\lambda)), \overline{\zeta}_j]$.

Part (c)

Considering $\zeta_{ij}^{I}(\lambda) < \overline{\zeta}_j$, there exists a set of potential buyers $[max(\underline{\zeta_j}, \zeta_{ij}^{I}(\lambda)), \overline{\zeta}_j]$ in market j that generates positive profits for seller λ under indirect trade. Analogous to part (b), the fact that $f^D(\lambda) < f^I$ and that both profits curves are monotonically increasing implies that, if $\zeta_{ij}^{I}(\lambda) < \zeta_{ij}^{D}(\lambda)$, then it must be the case that $\zeta_{ij}^{D=I}(\lambda) > \left\{\zeta_{ij}^{D}(\lambda), \zeta_{ij}^{I}(\lambda)\right\}$ (i.e., if indirect profits reach zero from below before direct profits, then these curves must cross each other afterwards both curves generate positive profits). This implies that $\pi_{ij}^{I}(\lambda, \zeta) > 0$ and $\pi_{ij}^{I}(\lambda, \zeta) > \pi_{ij}^{D}(\lambda, \zeta)$ for buyers with productivity $[\zeta_{ij}^{I}(\lambda), \zeta_{ij}^{D=I}(\lambda)]$, while $\pi_{ij}^{I}(\lambda, \zeta) < \pi_{ij}^{D}(\lambda, \zeta)$ for buyers above $\zeta_{ij}^{D=I}(\lambda)$. In the case where $\zeta_{ij}^{D=I}(\lambda) > \overline{\zeta}_j$, there is no buyer in market j with a productivity large enough to induce seller λ to prefer direct over indirect trade. The optimal trade strategy is then to sell only indirectly to all potential buyers $\zeta \epsilon [max(\underline{\zeta_j}, \zeta_{ij}^{I}(\lambda)), \overline{\zeta}_j]$.

Part (d)

Starting from part (c), we now consider the case where $\zeta_{ij}^{I}(\lambda) < \overline{\zeta}_j$ and $\zeta_{ij}^{D=I}(\lambda) < \overline{\zeta}_j$. Analogously, this implies that $\zeta_{ij}^{D=I}(\lambda) > \left\{\zeta_{ij}^{D}(\lambda), \zeta_{ij}^{I}(\lambda)\right\}$ and $\pi_{ij}^{I}(\lambda, \zeta) > 0$ and $\pi_{ij}^{I}(\lambda, \zeta) > \pi_{ij}^{D}(\lambda, \zeta)$ for buyers with productivity $[\zeta_{ij}^{I}(\lambda), \zeta_{ij}^{D=I}(\lambda)]$, while $\pi_{ij}^{I}(\lambda, \zeta) < \pi_{ij}^{D}(\lambda, \zeta)$ for buyers above $\zeta_{ij}^{D=I}(\lambda)$. As long as $\zeta_{ij}^{D=I}(\lambda) > \underline{\zeta_j}$, the optimal trade strategy for seller λ is to mix trade modes, selling indirectly to buyers $\zeta \epsilon [max(\underline{\zeta_j}, \zeta_{ij}^{I}(\lambda)), \zeta_{ij}^{D=I}(\lambda)]$ and directly to buyers $\zeta \epsilon [\zeta_{ij}^{D=I}(\lambda), \overline{\zeta}_j]$. Note that the case where $\zeta_{ij}^{D=I}(\lambda) < \underline{\zeta_j}$ is analogous to part (b), and seller λ would sell directly to all potential buyers in market j, $\zeta \epsilon [\underline{\zeta_j}, \overline{\zeta}_j]$.

B.4. Proposition 4

Part (a)

From equation (9) and (10), we know that upstream supplier $\lambda = (z, f^D)$ in market i selling in market j obtains direct profits $\pi_{ij}^D(\lambda, \zeta) = \frac{x_{ij}^D(\lambda,\zeta)}{\eta} - f^D(\lambda)$ and indirect profits $\pi_{ij}^I(\lambda, \zeta) = \left(\frac{\eta-\phi}{\eta}\right)\frac{x_{ij}^D(\lambda,\zeta)}{\eta} - f^I$ when transacting with a buyer with productivity ζ. An increase in seller productivity z increases firm-to-firm sales under both trade modes as shown in Proposition 1a, and we have that $\frac{\partial x_{ij}^I(\lambda,\zeta)}{\partial z(\lambda)} = \left(\frac{\eta-\phi}{\eta}\right)\frac{\partial x_{ij}^D(\lambda,\zeta)}{\partial z(\lambda)}$ where $\left(\frac{\eta-\phi}{\eta}\right) < 1$ since $\eta > 1$ and $\phi \in [0, 1]$, such there is a greater increase in direct profits. Thus, given a matchability level $\bar{f}^D$, more productive sellers are more likely to trade directly. On the other hand, given a productivity level $\bar{z}$, a higher matchability level (i.e., lower f^D) increase direct profits $\pi_{ij}^D(\lambda, \zeta)$ without affecting indirect profits $\pi_{ij}^I(\lambda, \zeta)$, such that sellers are more likely to trade directly.

Part (b)

The fact that mixed suppliers serve buyers above (below) a productivity threshold directly (indirectly) follows directly from Proposition 3d.

Appendix C. Alternative Pricing Schemes

Consider the following prices in each potential firm-to-firm transaction: (i) supplier λ charges $P^D(\lambda,\zeta)$ to buyer ζ under direct trade, supplier λ charges $P^I(\lambda,\zeta)$ to the wholesaler under indirect trade, and (iii) the wholesaler charges $P^W(\lambda,\zeta)$ to buyer ζ. Below we explore alternative pricing schemes for intermediaries, relative to the one presented in Section 3: Nash bargaining over the trade surplus (or variable profits) from the firm-to-firm transaction, with bargaining weights ϕ and 1 - ϕ, respectively.

C.1. Brokerage fee on variable profits

Consider that the intermediary takes a share $\gamma \in (0,1)$ of supplier variable profits. The demand faced by supplier λ when selling indirectly to buyer ζ is $q^I(\lambda,\zeta) = \left(p^W(\lambda,\zeta)\right)^{-\eta} B$, and in the absence of double marginalization $p^W(\lambda,\zeta) = p^I(\lambda,\zeta)$

$$\begin{aligned}
\max_{p^I} \pi^I &= (1-\gamma)\left(p^I - c\right) q^I - f^I \\
&= (1-\gamma)\left(\left(p^I\right)^{1-\eta} B - c\left(p^I\right)^{-\eta} B\right) - f^I \\
FOC:\ (1-\eta)\left(p^I\right)^{-\eta} &+ \eta c \left(p^I\right)^{-\eta-1} = 0 \quad \Rightarrow p^I = \left(\frac{\eta}{\eta-1}\right) c
\end{aligned}$$

Note that firm-to-firm sales are independent of the trade mode: $x^I(\lambda,\zeta) = p^I(\lambda,\zeta) q^I(\lambda,\zeta) = x^D(\lambda,\zeta)$. The supplier charges the same price $p^I(\lambda,\zeta) = p^D(\lambda,\zeta)$, while $q^I(\lambda,\zeta) = q^D(\lambda,\zeta)$ because the buyer perceives the same price $p^W(\lambda,\zeta) = p^D(\lambda,\zeta)$

C.2. Brokerage fee on sales

Consider that the intermediary takes a share $\gamma \in (0,1)$ of the supplier sales. As before, buyer demand is $q^I(\lambda,\zeta) = \left(p^I(\lambda,\zeta)\right)^{-\eta} B$ when the supplier sells indirectly because $p^W(\lambda,\zeta) = p^I(\lambda,\zeta)$ without double marginalization. The supplier's optimal indirect prices are then:

$$\begin{aligned}
\max_{p^I} \pi^I &= (1-\gamma)\, p^I q^I - c q^I - f^I \\
&= (1-\gamma)\left(p^I\right)^{1-\eta} B - c\left(p^I\right)^{-\eta} B - f^I \\
FOC:\ (1-\gamma)(1-\eta)\left(p^I\right)^{-\eta} &+ \eta c \left(p^I\right)^{-\eta-1} = 0 \quad \Rightarrow p^I = \left(\frac{1}{1-\gamma}\right)\left(\frac{\eta}{\eta-1}\right) c
\end{aligned}$$

Indirect firm-to-firm sales are $x^I(\lambda,\zeta) = (1-\gamma)^{\eta-1} x^D(\lambda,\zeta) \quad \Rightarrow \quad x^I(\lambda,\zeta) < x^D(\lambda,\zeta)$.

The supplier receives $p^I(\lambda,\zeta) > p^D(\lambda,\zeta)$, while $q^I(\lambda,\zeta) < q^D(\lambda,\zeta)$ because the buyer perceives $p^W(\lambda,\zeta) > p^D(\lambda,\zeta)$, and the reduction in buyer demand dominates. The intuition for this result is that the suppliers has a lower marginal revenue, similar to monopolist facing a less elastic demand.

C.3. Double marginalization

In thie case, the intermediary charges a markup $\mu^W > 1$ over the supplier price. The demand faced by supplier λ when selling indirectly is now $q^I(\lambda,\zeta) = \left(\mu^W p^I(\lambda,\zeta)\right)^{-\eta} B$, because the price perceived by the buyer is $p^W(\lambda,\zeta) = \mu^W p^I(\lambda,\zeta)$. The supplier's optimal indirect prices are then:

$$\begin{aligned}
\max_{p^I} \pi^I &= p^I q^I - cq^I - f^I \\
&= \left(\mu^W\right)^{-\eta}\left(p^I\right)^{1-\eta} B - c\left(\mu^W p^I\right)^{-\eta} B - f^I \\
FOC:\ (1-\eta)\left(p^I\right)^{-\eta} &+ \eta c\left(p^I\right)^{-\eta-1} = 0 \quad \Rightarrow p^I = \left(\frac{\eta}{\eta-1}\right) c
\end{aligned}$$

Indirect firm-to-firm sales are $x^I(\lambda,\zeta) = \left(\mu^W\right)^{-\eta} x^D(\lambda,\zeta) \;\; \Rightarrow \;\; x^I(\lambda,\zeta) < x^D(\lambda,\zeta)$. The supplier charges same price for indirect and direct transactions $p^I(\lambda,\zeta) = p^D(\lambda,\zeta)$, but $q^I(\lambda,\zeta) < q^D(\lambda,\zeta)$ because the buyer perceives a higher price $p^W(\lambda,\zeta) > p^D(\lambda,\zeta)$.

C.4. Implications for Prices and Sales

The following table summarizes the implications for prices and sales under each pricing scheme, including the case with Nash bargaining considered in the model.

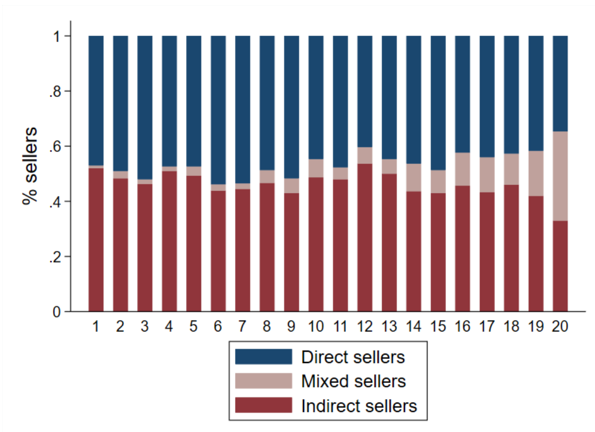
	p^D	p^I	p^W	Pricing	Sales
Fee on variable profits	$\left(\frac{\eta}{\eta-1}\right) c$	$\left(\frac{\eta}{\eta-1}\right) c$	$\left(\frac{\eta}{\eta-1}\right) c$	$p^D = p^I = p^W$	$x^I = x^D$
Fee on sales	$\left(\frac{\eta}{\eta-1}\right) c$	$\left(\frac{1}{1-\gamma}\right)\left(\frac{\eta}{\eta-1}\right) c$	$\left(\frac{1}{1-\gamma}\right)\left(\frac{\eta}{\eta-1}\right) c$	$p^I > p^D,\ p^W > p^D$	$x^I < x^D$
Double marginalization	$\left(\frac{\eta}{\eta-1}\right) c$	$\left(\frac{\eta}{\eta-1}\right) c$	$\mu^W\left(\frac{\eta}{\eta-1}\right) c$	$p^I = p^D,\ p^W > p^D$	$x^I < x^D$
Nash bargaining	$\left(\frac{\eta}{\eta-1}\right) c$	$\left(\frac{\eta-\phi}{\eta-1}\right) c$	$\left(\frac{\eta}{\eta-1}\right) c$	$p^I < p^D,\ p^W = p^D$	$x^I < x^D$

Appendix D. Role of Model Assumptions

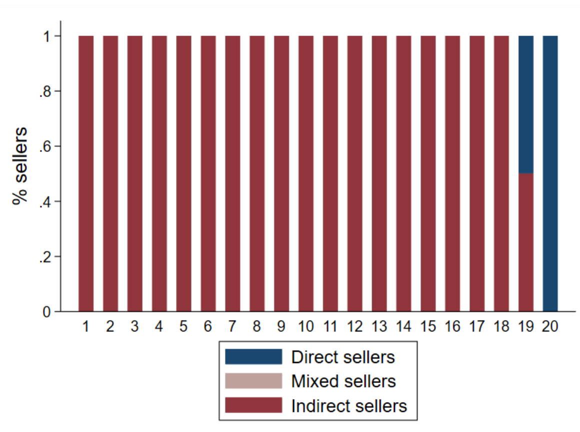
We simulate a simplified version of the model to inform the role played by different assumptions in matching the sorting of sellers into different trade modes. For this exercise, we assume that the productivity and matchability of upstream suppliers $\lambda = (z, f^D)$ are distributed joint log-normal with expectations $\mu_{ln\,z} = 0$ and $\mu_{ln\,f^D} = 1$, standard deviations $sd_{ln\,z} = 0.25$ and $sd_{ln\,f^D} = 1$, and a correlation coefficient of $\rho = -0.2$. We likewise assume that the productivity of downstream producers is log-normally distributed with parameters $\mu_{ln\,\zeta} = 0$ and $sd_{ln\,\zeta} = 0.25$. As standard in the trade literature, we set the elasticity of substitution for final goods to $\sigma = 5$, and we also use this value for the elasticity of substitution across intermediate inputs, η. Lastly, we let the fixed cost of trading indirectly f^I be 10% lower than the average relationship-specific cost f^D for direct transactions.

Figure A3 illustrates how the model is able to accommodate the sorting of exporters into different sales strategies. Panel A demonstrates that the model can reproduce Fact 1 under the assumed weakly negative correlation between seller productivity and matchability: Exporters across the size distribution use trade intermediation, with larger suppliers being less likely to trade only directly, more likely to mix trade modes, and similarly likely to trade indirectly. By contrast, Panel D indicates that the share of purely direct (indirect) suppliers would counterfactually increase (decrease) with supplier size if supplier efficiency and relationship capability were uncorrelated (or positively correlated). Panels B and C in turn show that alternative frameworks with no buyer heterogeneity or with one-dimensional seller heterogeneity cannot replicate Fact 1. Without productivity differences across buyers, there is no incentive for exporters to mix sales modes, and they sort monotonically into purely indirect or purely direct trade according to size. When suppliers instead differ only in productivity but not in matchability, they sort monotonically into purely indirect or mixed trade, with no purely direct sellers.

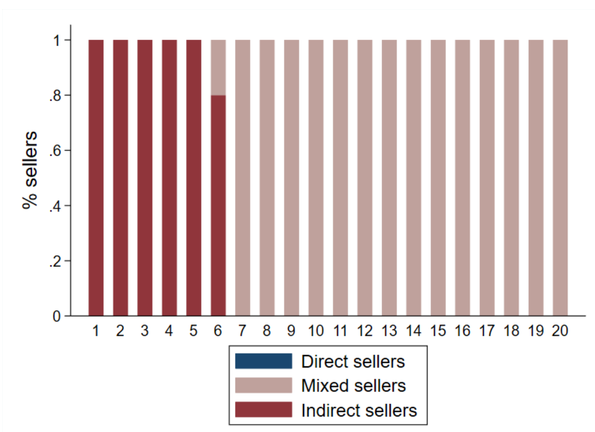
Figure A3: Direct and indirect sellers



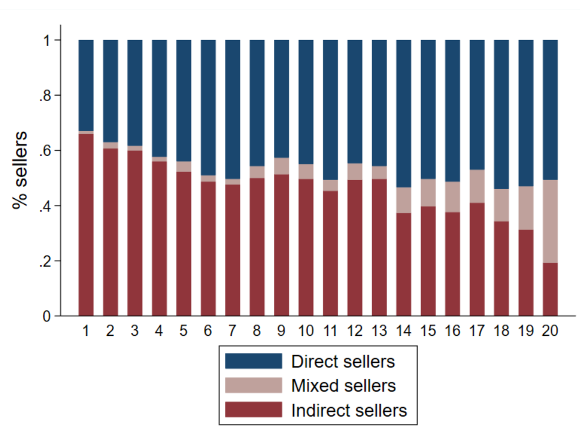
(a) Model simulation



(b) Homogeneous buyer productivity



(c) Homogeneous seller matchability



(d) Uncorrelated productivity and matchability