# Trade Intermediation in Global Production Networks

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**Abstract**

This paper examines trade intermediation in global production networks, and unpacks the black box of network formation costs. We establish three new facts in matched data on firm-to-firm import and domestic transactions for Chile: Exporters of all sizes use intermediation services, mix trade modes within products, and set lower prices on intermediated flows. We rationalize these facts in a quantifiable, general-equilibrium model of network formation with suppliers of heterogeneous productivity and matchability, buyers of heterogeneous productivity, and wholesalers that can lower suppliers' relationship-specific costs for a brokerage fee. We present consistent empirical evidence for trade activity across firms and origin countries, and inform how institutions, logistics and customs efficiency, and geographic and cultural-linguistic distance shape network costs. Model quantification reveals that intermediaries widen and deepen global production networks, and thereby induce aggregate welfare gains and heterogeneous effects across firms.

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# 1. Introduction

Firm production networks have transformed global economic activity, and become focal to policy objectives of growth and stability. While access to inputs and markets worldwide can improve firm performance and aggregate growth, buyer-supplier networks remain sparse and dominated by few, highly connected large firms. There have also been growing concerns about shock propagation and supply chain resilience, prompted not least by the global spread of the 2008-2009 financial crisis and supply bottlenecks from COVID disruptions. 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 networks.

This paper examines trade intermediation in global production networks, and unpacks the black box of network formation costs. We establish three new facts in matched data on firm-to-firm import and domestic transactions for Chile: Exporters of all sizes use intermediation services, mix trade modes within products, and set lower prices on intermediated flows. We rationalize these facts in a quantifiable, general-equilibrium model of network formation with suppliers of heterogeneous productivity and matchability, buyers of heterogeneous productivity, and wholesalers that can lower suppliers' relationship-specific costs for a brokerage fee. We present consistent empirical evidence for trade activity across firms and origin countries, and inform how institutions, logistics and customs efficiency, and geographic and cultural-linguistic distance shape network costs. Model quantification reveals that intermediaries widen and deepen global production networks, and thereby induce aggregate welfare gains and heterogeneous effects across firms.

Our first contribution is to unveil new facts about direct and intermediated trade in firm networks. We exploit comprehensive Chilean data on the universe of firm-to-firm import and domestic transactions, matched to tax records that report firm size and 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 uncover three new 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 charge lower prices than purely direct and mixed suppliers, and mixed suppliers charge lower prices on their indirect transactions. This result informs rent sharing with wholesalers, and therefore the trade-off faced by exporters when choosing their optimal sales strategy.

Our second contribution is to develop a general-equilibrium model of trade intermediation in production networks that is motivated by the new 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. Strictly speaking, the data distinguishes between wholesalers that conduct firm-to-firm transactions and retailers that mediate firm-to-consumer sales. We restrict our anaysis 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, as 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 systematic empirical evidence that corroborates the model and informs the nature of network transaction costs. We validate theoretical predictions for the assortativity of producer buyers and suppliers in direct matches, the number and sales share of direct links across suppliers, the number and expenditure share of direct links across buyers, and transaction-level properties across trade modes within suppliers. For instance, we confirm that direct buyer-seller matches exhibit negative degree assortativity such that suppliers with more producer buyers on average sell to producers with fewer suppliers. Analogously, more connected producers on average source from less connected suppliers. 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 also 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.

We also analyze how intermediated trade patterns vary with origin-country characteristics, to unpack the economic forces that drive firm-to-firm matching and transaction costs through the lens of the model. This informs what barriers to buyer-supplier links are most problematic and to what extent wholesalers help overcome them. We consider countries' institutional development, logistics and customs efficiency, and geographic and cultural-linguistic distance to Chile. These can be interpreted as networking costs related to transportation, logistics, red tape, information asymmetry, contracting, and trustworthiness. We find systematically higher shares of intermediated trade and of indi-

rect and mixed suppliers for origin countries that are more distant, have worse logistics, trust foreigners less, and do not share a common religion. By contrast, we find a weaker role for language similarity, legal origins, and border compliance and procedures.

Our final contribution is to quantify the welfare effects of trade intermediation. We first present numerical exercises that illustrate the need for two-sided heterogeneity and two-dimensional supplier heterogeneity for the model to rationalize key patterns in the data. We then calibrate the model to the data to evaluate the gains from intermediation accruing to final consumers, as well as the heterogeneous impact on firm performance across the seller and buyer distributions. We also assess the impact of trade reforms on trade flows and aggregate welfare with and without access to intermediation services.

This paper bridges and advances two parallel literatures on buyer-supplier networks and on trade intermediation. On the one hand, research on global value chains (GVCs) 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 line of research has explored the role of intermediaries in facilitating trade. 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)). This literature has theoretically examined the choice of direct vs. indirect exports of heterogeneous final producers (Antras and Costinot (2011), Ahn et al. (2011)), with data limitations restricting prior empirical analysis to comparing the exports of manufacturers and intermediaries (Bernard et al. (2010), Bernard et al. (2015)). We advance this line of

work by analyzing the role of intermediaries in the endogenous formation of firm-to-firm linkages between heterogeneous sellers and buyers, and the implications for firm performance on both sides of the transaction. We also empirically assess the direct and intermediated exports of manufacturers.

More generally, our work speaks to the interdependence of manufacturing and services sectors, in that wholesale services directly shape seller-buyer production networks. Implicitly, the evidence also indicates to what extent the market for intermediation has responded to meet the needs of manufacturing firms. This helps inform thinking about trade promotion and trade facilitation that many developing-country governments undertake and international organizations support.

The rest of the paper is organized as follows. Section 2 introduces the data and new stylized facts. Section 3 develops the general-equilbrium model of trade intermediation in production networks. Section 4 presents empirical evidence for trade patterns across firms and origin countries, and unpacks drivers of implied 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, the universe of domestic firm-to-firm transactions, and detailed characteristics of domestic firms. First, 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. Second, we access data on transacted values and firm identities for all domestic sales from the VAT records of the Chilean Tax Authority for 2016-2019. As standard with VAT data, the sales quantity, unit price, and product are not reported. Finally, we 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 three 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. Whole-

salers 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% to aggregate 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 |

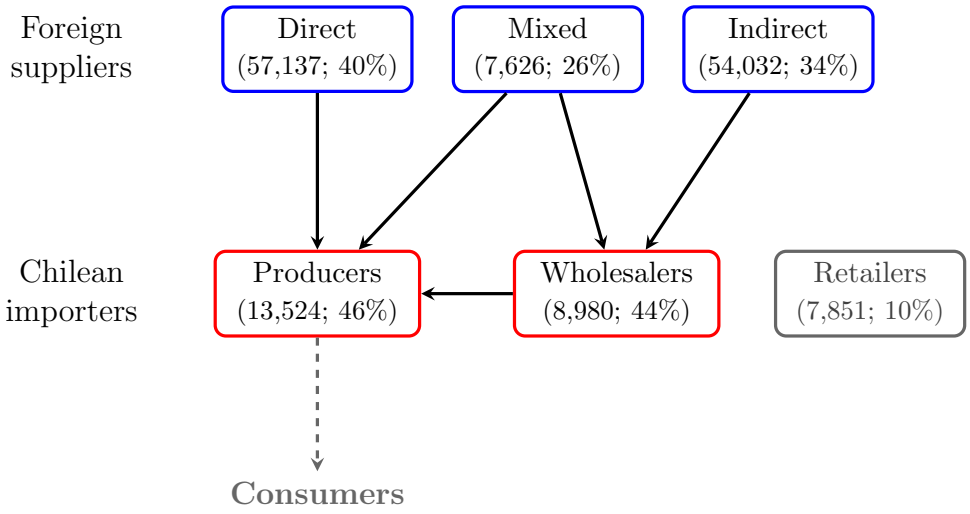
Note: Summary statistics are reported for the universe of Chilean importers, and for the subset of foreign suppliers trading with producers and wholesalers. Foreign suppliers transacting with retailers are excluded from the analysis. The table displays cross-sectional data for 2019.

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 new stylized facts about trade intermediation in the detailed Chilean records. These empirical regularities go against thereotical predictions in the prior literature that have not been confronted with disaggragated 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 2 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%.

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 3b 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.

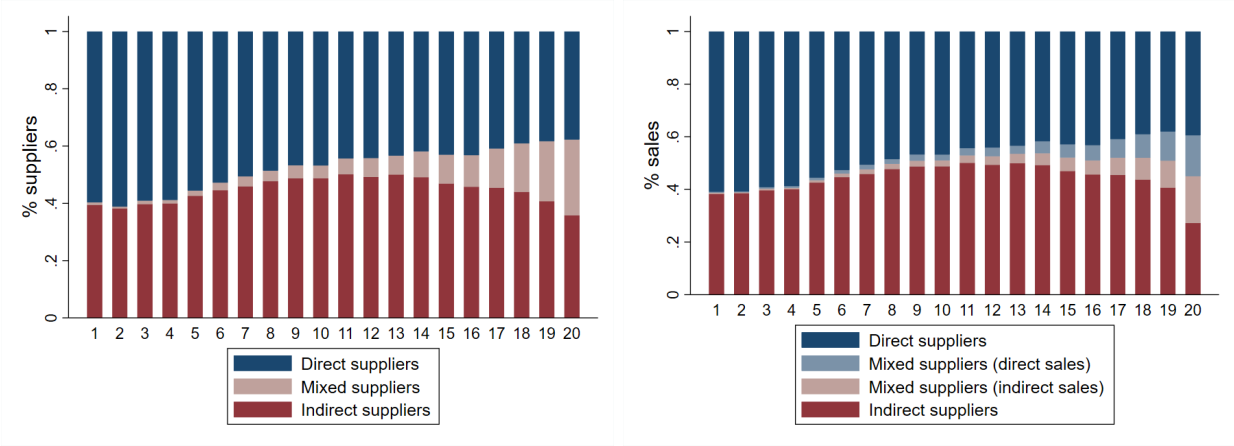
Fact 1 sharply contrasts key predictions of existing models of trade intermediation. Such models feature seller heterogeneity, whereby all exporters above a productivity cutoff sort exclusively into direct exporting, and all exporters below that cutoff trade only through intermediaries (Ahn et al. (2011), 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 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

Figure 2: Trade strategy across the supplier size distribution




(a) Share of suppliers by trade mode

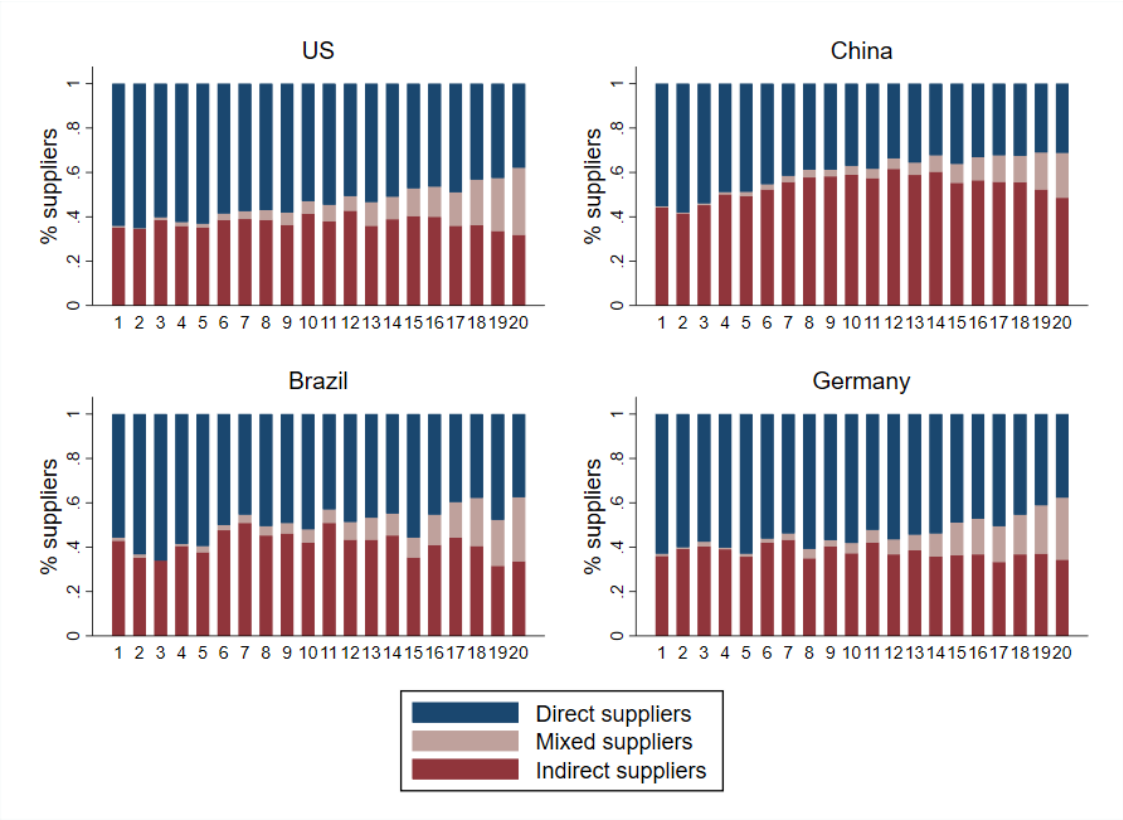
(b) Share of trade value by trade mode

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.

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 is not sufficient to rationalize the incidence of intermediated trade in the data. Existing models of multi-product firms typically combine heterogeneity in firm-wide efficiency across firms with dispersion in firm-product specific expertise across products within firms. 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

Figure 3: Suppliers' trade strategy for top origin countries




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.

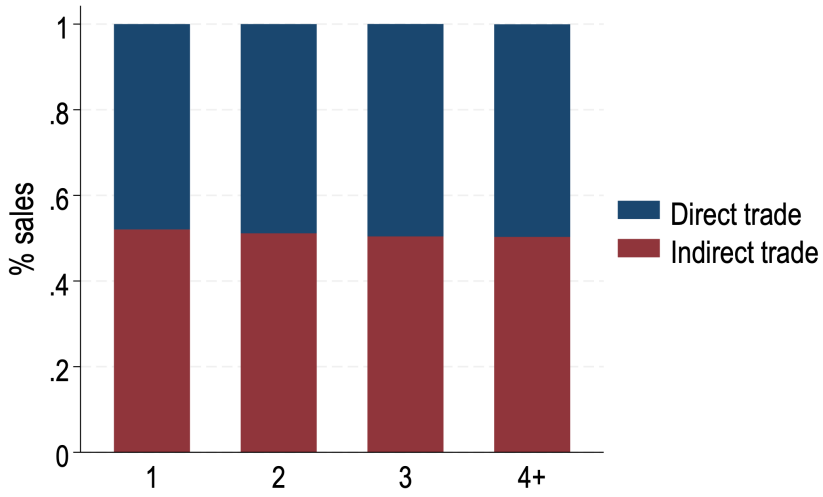
**Fact 3.** *Exporters charge wholesalers lower prices than producer buyers. Purely indirect exporters set lower prices than purely direct and mixed exporters, and mixed exporters set lower prices on their indirect transactions than on their direct transactions.*

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.

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 |

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




We first compare the prices charged by purely direct, purely indirect and mixed foreign suppliers of the same product.[2] In Column 1 of Table 3, we regress log unit value at the transaction level on dummies for seller type, conditioning on a full set of HS 6-digit product fixed effects. Compared to mixed suppliers, purely direct exporters set 50% higher prices on average, while purely indirect exporters receive 14% lower prices on average. These price differentials remain large at 28.5% and 25% respectively 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, as well as the

[2]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.

log transaction value.[3]

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, controlling for supplier-product pair fixed effects. In Column 4, we further condition on transaction value, buyer size and connectivity. Exporters consistently offer intermediaries 8.3%-9.6% lower prices compared to direct producer buyers.

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) | 0.496*** | 0.285*** | | |
| | (0.030) | (0.042) | | |
| D(Indirect Supplier=1) | -0.141*** | -0.251*** | | |
| | (0.033) | (0.044) | | |
| D(Wholesaler Buyer=1) | | | -0.096*** | -0.083*** |
| | | | (0.014) | (0.015) |
| Product FE | Yes | Yes | No | No |
| Supplier-Product FE | No | No | Yes | Yes |
| Transacted value | No | Yes | No | Yes |
| Supplier controls | No | Yes | No | No |
| Buyer controls | No | Yes | No | Yes |
| N | 471,730 | 471,730 | 27,296 | 27,296 |

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

Fact 3 is informative of price setting in wholesale transactions, and can thus discriminate between different conceptualizations of the seller-wholesaler relationship in the prior literature. This in turn informs the trade-off faced by exporters when choosing their optimal sales strategy. The price discount on intermediated sales is inconsistent with the wholesaler engaging in 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

[3]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.

transaction, which would manifest in higher, rather than lower prices on intermediated trade. Instead, the new fact we document sugggests that suppliers and wholesalers may engage in Nash bargaining, whereby the fee for intermediation services depends on the wholesalers' relative market power.

## 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 trade intermediaries ($\mathcal{W}$) who 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 specifically 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 $y$ for those 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. Downstream producers differ in their productivity in assembling inputs into final goods.[4] 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,

[4]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.

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 $\widetilde{q}_{j0}$ 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:

$$U_j = \widetilde{q}_{j0}^{1-\beta} \left( \int_{\Omega_j} \widetilde{q}_j(\omega)^{\frac{\sigma-1}{\sigma}} d\omega \right)^{\beta\sigma/(\sigma-1)},$$

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 $\omega$ with price $\widetilde{p}(\omega)$ is:

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

### 3.3. Downstream Producers

Downstream producers sell to local consumers in country $j$. They own a blueprint for a single variety $\omega$ 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:

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

where $\eta > 1$ is the elasticity of substitution across intermediates, and $q(\nu, \zeta)$ is the quantity purchased of input variety $\nu$ 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 $p(\nu, \zeta)$ across suppliers:

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

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 $\zeta$ in country $j$ is given by (1), and its demand for intermediate variety $\nu$ from country $i$ is:

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

where $X_j(\zeta)$ are the total input purchases of producer $\zeta$. 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 $\nu$ of intermediate goods under constant returns to scale, and face iceberg trade costs $\tau_{ij}$. 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. Alternatively, they 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 $\{\zeta \in D(\lambda)\}$ and indirectly $\{\zeta \in \mathcal{I}(\lambda)\}$ and the price and quantity for each transaction to maximize global profits. The supplier's problem can be expressed as:

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

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

### 3.5. Trade Intermediaries

Import intermediaries specialize in operationalizing transactions between foreign suppliers and their matched domestic buyers. We abstract away from intermediary heterogeneity and matchmaking services, and focus on the role of homogeneous intermediaries in reducing relationship-specific costs associated for example with logistics, distribution, or communication.[5]

An import intermediary in country $j$ receives and transfers goods from upstream supplier $\lambda$ in country $i$ intended for downstream producer $\zeta$ 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 $\phi$ 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 $\Omega^W$ 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. We are able to characterize rich and empirically relevant sorting patterns, without having to consider an exhaustive taxonomy of cases.

First, we take the structure of the intermediation contract and the wholesaler's bargaining power $\phi$ as exogenous. However, these can be rationalized as equilibrium outcomes of the market for intermediation services, for example under free entry in the wholesale

[5]The presence of multiple homogeneous intermediaries that offer identical service contracts 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 specialize in different geographic regions that have otherwise identical probabilistic buyer distributions, such that suppliers first choose intermediated buyer links and then transact with whichever wholesaler covers that buyer's region.

sector or when $\phi$ reflects a wholesaler's market share of aggregate (intermediated) trade.[6]

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.[7]

### 3.6. Firm-to-Firm Sales

Upstream suppliers maximize global profits by making independent sales decisions across buyers.[8] 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.

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 $\lambda$ from country $i$ selling directly to downstream producer $\zeta$ in market $j$ would be:

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

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 $p_{ij}^D(\lambda,\zeta) = \mu c_{ij}(\lambda)$.

On the other hand, the profits of upstream supplier $\lambda$ when serving the same downstream producer $\zeta$ indirectly would be:

$$\pi_{ij}^I(\lambda,\zeta) = (1-\phi) \left[ p_{ij}^W(\lambda,\zeta) - c_{ij}(\lambda) \right] q_{ij}^I(\lambda,\zeta) - f^I,$$

where the first term reflects the share $(1-\phi)$ of the variable profits (or trade surplus) $\left( p_{ij}^W(\lambda,\zeta) - c_{ij}(\lambda) \right) q_{ij}^I(\lambda,\zeta)$ generated from an intermediated transaction between $\lambda$ and $\zeta$.

Given downstream input demand (3) and Nash bargaining between the wholesaler

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

[7] 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 $f^W$.

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

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 $\lambda$. The intermediary's brokerage fee is thus $B(\phi,\lambda,\zeta) = \phi\left(p^D_{ij}(\lambda,\zeta) - c_{ij}(\lambda)\right) q^I_{ij}(\lambda,\zeta)$, while the seller's variable profits are $(1-\phi)\left(p^D_{ij}(\lambda,\zeta) - c_{ij}(\lambda)\right) q^I_{ij}(\lambda,\zeta)$.

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 $p^W_{ij}(\lambda,\zeta) = p^D_{ij}(\lambda,\zeta)$.[9]

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):

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

$$x^I_{ij}(\lambda,\zeta) = \left(\frac{\eta-\phi}{\eta}\right) x^D_{ij}(\lambda,\zeta). \tag{8}$$

[9]Alternative pricing schemes for intermediation services can induce different pricing patterns across trade strategies that contradict Fact 2. For example, if intermediaries charge sellers an explicit brokerage fee $\gamma$ as a share of variable profits, sellers would optimally charge the same price for direct and indirect transactions, while they would set higher markups and indirect prices if the fee is applied on transaction values. Moreover, one can always find a level of wholesalers' market power $\phi$ that is consistent with $\gamma$. However, these alternative pricing schemes fail to accomodate Fact 2 that suppliers charge lower prices on indirect transactions.

Firm-to-firm sales depend on seller productivity (through marginal cost and trade mode), 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* $\zeta$*:*

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

*(b) increase in buyer productivity* $\zeta$*;*

*(c) are lower and cheaper when intermediated.*

*Proof.* See Appendix. □

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, on the one hand 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 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.

We consider the segment of the parameter space that is consistent with positive assortativity along the intensive margin in terms of firm productivity: more productive sellers transact larger values with more productive buyers. In particular, we assume as standard that final goods are closer substitutes in consumption than intermediate inputs in production, $\sigma > \eta$, which is a sufficient condition given CES technology, CES preferences, and $\eta > 1$. As we discuss next, however, the extensive margin of firm links will depend on both seller matchability and productivity, giving rise to ambiguous intensive-margin assortativity in terms of total firm sales. This model can therefore account for deviations from strict positive assortativity in network data on firm-to-firm sales.

### 3.7. Direct and Indirect Links

The second step in the supplier's problem is choosing which downstream producers to serve and which trade mode to employ in each transaction. Given optimal firm-to-firm prices, quantities and sales in (7) and (8), the supplier's profits from any potential match $(\lambda, \zeta)$ 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 undertake whichever strategy generates higher profits. This gives rise to an endogenous network of direct and indirect links between upstream suppliers and downstream producers.

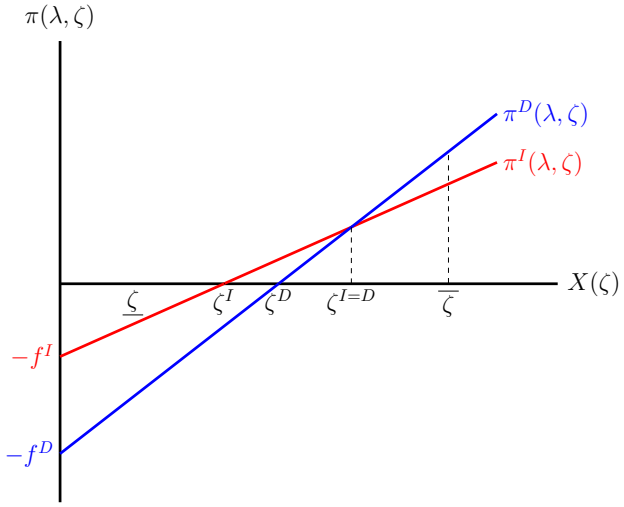
Figure 5 illustrates the supplier's problem. For a given upstream supplier $\lambda = (z, f^{D})$ in market $i$, we plot potential direct and indirect profits from transacting with downstream producers $\zeta$ in market $j$. Producers are indexed by their total input purchases $X_j(\zeta)$, so that $X_j(\underline{\zeta})$ and $X_j(\bar{\zeta})$ mark the location of the least and most productive potential customer.[10] 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 $\lambda$ 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 $\zeta$. 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 $\lambda$. There is also a downstream productivity threshold $\zeta^{D=I}(\lambda)$, at which the supplier is indifferent between trade modes, and above which a direct transaction is strictly preferred. The following proposition formalizes these properties:

**Proposition 2.** *(Productivity thresholds) For each upstream supplier* $\lambda = (z, f^{D})$ *in market* $i$

[10] Atomistic upstream suppliers take $X_j(\zeta)$ as given: The network of firm-to-firm linkages 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




*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. □

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. In particular, the optimal set of direct and indirect customers in market $j$ for supplier $\lambda$ from country $i$ depends on where the profit lines $\pi^D(\lambda, \zeta)$ and $\pi^I(\lambda, \zeta)$ cross the x-axis and where they intersect each other. Variation in the distribution of supplier and buyer attributes can thus rationalize heterogeneity in trade mode use across origins, destinations, 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 $\lambda$. This would be the case if the supplier has both low productivity and low matchability. Second, seller $\lambda$ 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.[11]

Third, seller $\lambda$ 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 $\lambda$ 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 $\zeta^D_{ij}(\lambda) > \overline{\zeta}_j$ and $\zeta^I_{ij}(\lambda) > \overline{\zeta}_j$;*

*(b) Direct trade with buyers $\zeta \epsilon [max(\underline{\zeta_j}, \zeta^D_{ij}(\lambda)), \overline{\zeta}_j]$ if $\zeta^D_{ij}(\lambda) < \zeta^I_{ij}(\lambda)$ and $\zeta^D_{ij}(\lambda) < \overline{\zeta}_j$;*

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

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

*Proof.* See Appendix. □

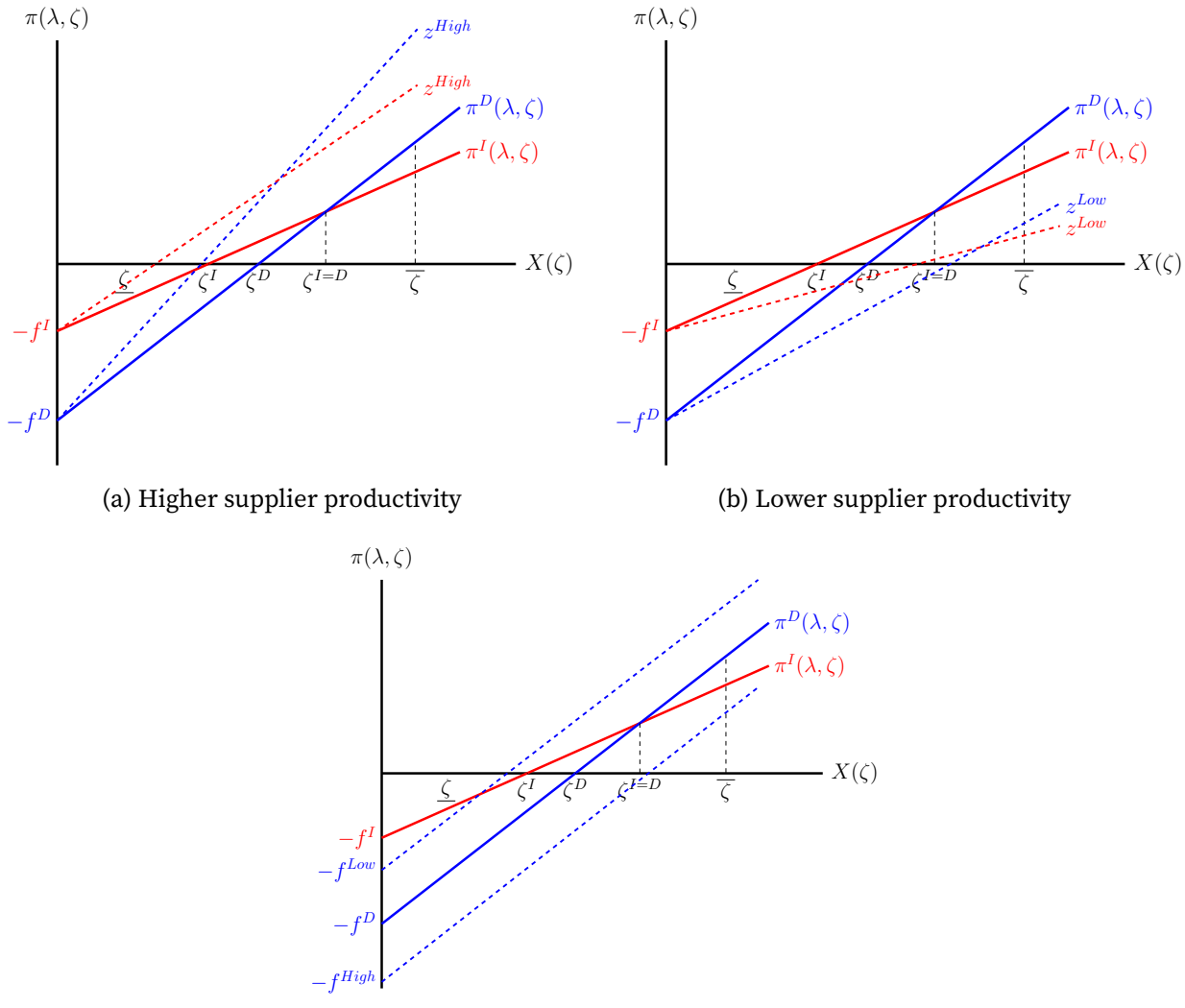
To build intuition, we analyze the optimal trade mode of upstream suppliers when varying only one of their two dimensions of heterogeneity. Figures (6a) and (6b) compare suppliers of low, medium and high productivity levels, $z^{Low} < z < z^{High}$, but the same matchability. They all share the same 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

[11] 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.

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 $\pi^I$ 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. These mixed suppliers will have the same number of ultimate buyers, but those with higher matchability will maintain a bigger share of direct links.

Figure 6: Supplier productivity and matchability




(a) Higher supplier productivity

(b) Lower supplier productivity

(c) Changes in supplier matchability

**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. □

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 may 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.

Propositions 1 and 4 together imply that across suppliers, the dispersion of sales across buyers can widen with the number of buyers both from above and from below. At the top end, more connected suppliers may sell more to any buyer, including their largest, most connected buyer (who is also the largest, most connected customer for less connected suppliers). This results from more productive suppliers having more buyers (holding matchability constant) and higher sales per buyer. At the bottom end, more connected suppliers may sell more or less to their smallest, least connected buyer depending on the relative elasticity of firm-to-firm sales with respect to seller and buyer attributes.

### 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: $l_{ij}^{D}(\lambda, \zeta) = \{0, 1\}$ and $l_{ij}^{I}(\lambda, \zeta) = \{0, 1\}$ for direct and indirect links, respectively. More precisely, $l_{ij}^{D}(\lambda, \zeta)$ indicates whether upstream supplier $\lambda = (z, f^{D})$ in market $i$ sells directly to downstream producer $\zeta$ in market $j$, and $l_{ij}^{I}(\lambda, \zeta)$ is defined analogously for indirect connections. The set of all firm-to-firm links is thus $l_{ij}(\lambda, \zeta) = l_{ij}^{D}(\lambda, \zeta) + l_{ij}^{I}(\lambda, \zeta)$. Below we 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 $\zeta$ is:

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

where $N_i(\mathcal{U})$ is the mass of upstream suppliers in market $i$. Note that 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 and trade mode, through the matching process that determines links $l_{ij}^{D}(\lambda, \zeta)$ and $l_{ij}^{I}(\lambda, \zeta)$. 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 are in turn the sum of bilateral sales $x_{ij}(\lambda, \zeta)$ to each downstream producer they transact with. Aggregating direct (7) and indirect (8) bilateral sales across markets and customers, supplier $\lambda$'s global sales are:[12]

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

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

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.[13]

Suppliers' global sales depend on their own productivity $z(\lambda)$, as well as the productivity $\zeta$ and input costs $C_j(\zeta)$ of all their customers. Suppliers' relationship capability $f^D(\lambda)$ and the possibility of trade intermediation affect their sales through the matching functions $l_{ij}^D(\lambda, \zeta)$ and $l_{ij}^I(\lambda, \zeta)$, 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 $\lambda$ globally and within market $j$ as:

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

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

Note that these indirect trade shares depend on the supplier's productivity and matchability only through their role in determining equilibrium linkages, and not through the intensive margin of 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.

Finally, we characterize the general equilibrium of the global economy in two steps. We first establish the existence and uniqueness of the equilibrium conditional on the link functions; we present the formal proof in the Appendix following Allen et al. (2020).

The unconditional equilibrium is then given by a fixed point for the endogenous network. Consider the generalized matching function $l_{ij}(\lambda, \zeta)$ that comprises all equilbrium linkages regardless of trade mode. 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. Using the buyer productivity thresholds $\zeta_{ij}^D(\lambda)$ and $\zeta_{ij}^I(\lambda)$, we define the generalized matching function as:

[13] Recall that we assume $\sigma \geq \eta$, such that final goods are closer substitutes in consumption than intermediate inputs are in production.

$$l_{ij}(\lambda, \zeta) = \begin{cases} 1 & \zeta \geq \min\left[\zeta_{ij}^{D}(\lambda), \zeta_{ij}^{I}(\lambda)\right] \\ 0 & \zeta < \min\left[\zeta_{ij}^{D}(\lambda), \zeta_{ij}^{I}(\lambda)\right] \end{cases}. \tag{15}$$

The matching function affects the profitability of firm-to-firm transactions through its impact on downstream producers' input costs, which in turn determine the matching cutoffs on the right-hand side of (15). This constitutes a fixed-point problem that can be solved numerically starting with a guess for $l_{ij}(\lambda, \zeta)$.[14] Furthermore, the choice of trade mode influences supplier-level outcomes but does not interact with the generalized link function. The threshold $\zeta_{ij}^{D=I}(\lambda)$ determines which profitable matches will be performed directly and indirectly, but not whether a match is profitable or not, and it is thus used to find the set of direct and indirect matches in equilibrium.

## 4. Empirical Evidence

We provide systematic empirical evidence that corroborates the model and informs the nature of network transaction costs. We first validate theoretical predictions for the assortativity of producer buyers and suppliers in direct matches, the number and sales share of direct links across suppliers, the number and expenditure share of direct links across buyers, and transaction-level properties across trade modes within suppliers. Moreover, we 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. We then analyze how intermediated trade patterns vary with origin-country characteristics, to unpack the economic forces that drive firm-to-firm matching and transaction costs through the lens of the model. This informs what barriers to buyer-supplier links are most problematic and to what extent wholesalers help overcome them.

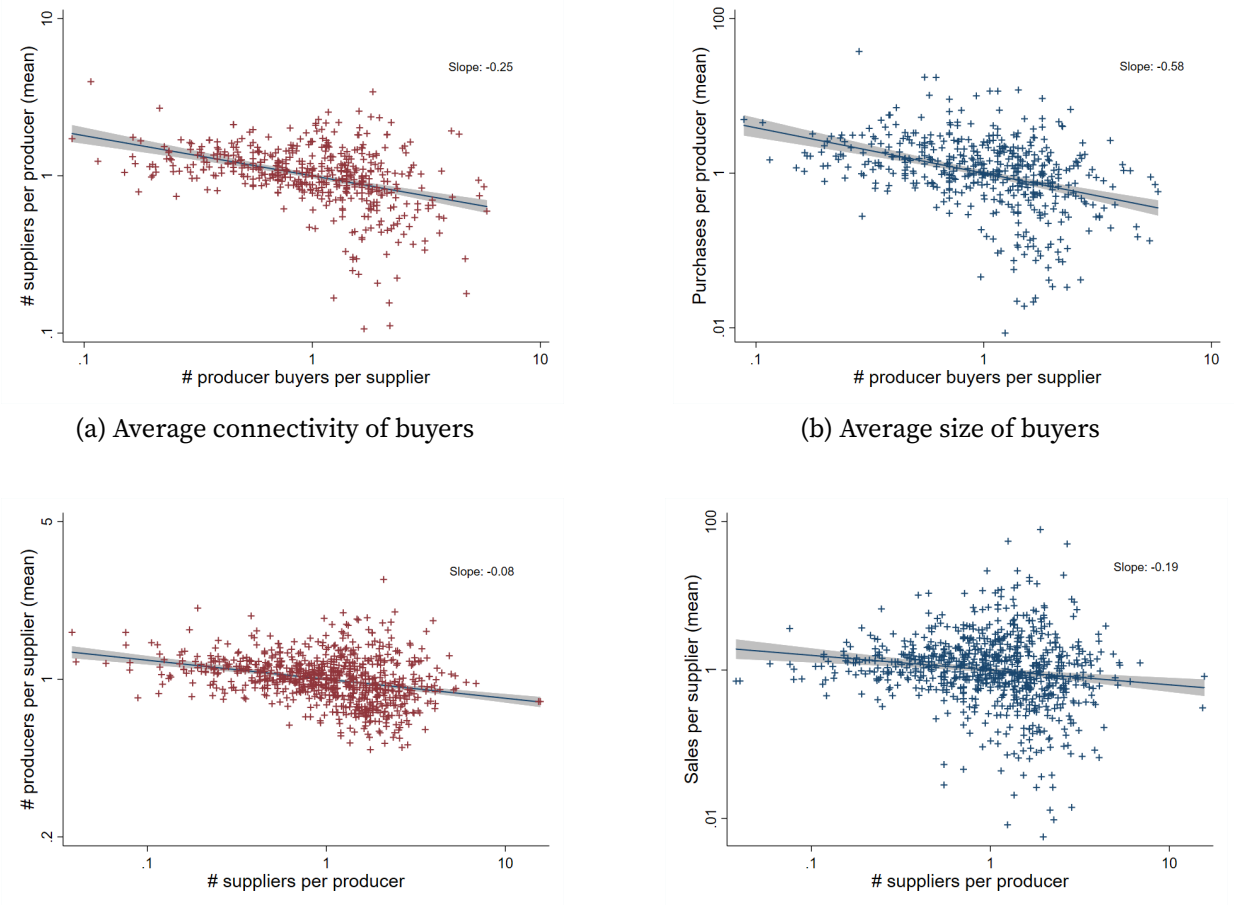
### 4.1. Network Patterns

Figure 7 plots degree assortativity measures for suppliers and producers in direct transactions. Panels A and B sort suppliers by their number of Chilean producer buyers on the x-axis, and display the average number of direct suppliers and direct input purchases among those producers on the y-axis. The axes scales are in logs and both variables are demeaned at the origin-country level. The data reveals that, on average, suppliers with more

[14] 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.

direct connections in Chile sell to producers with fewer direct connections and imports. Analogously, Panels C and D demonstrate that more connected Chilean producers source directly from suppliers that have less direct links and lower direct sales. These patterns are consistent with negative degree assortativity as predicted by the model. Furthermore, this evidence confirms and expands upon previous findings reported in firm networks. While recent works have 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 distinguish between direct and intermediated transactions since the latter can be aimed at multiple producers.

Figure 7: Degree assortativity in direct transactions




(a) Average connectivity of buyers

(b) Average size of buyers

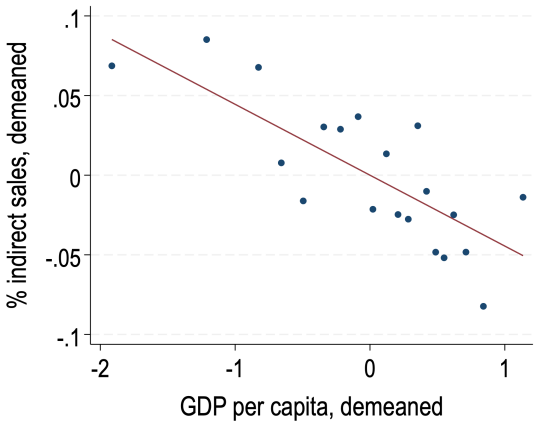
(c) Average connectivity of suppliers

(d) Average size of suppliers

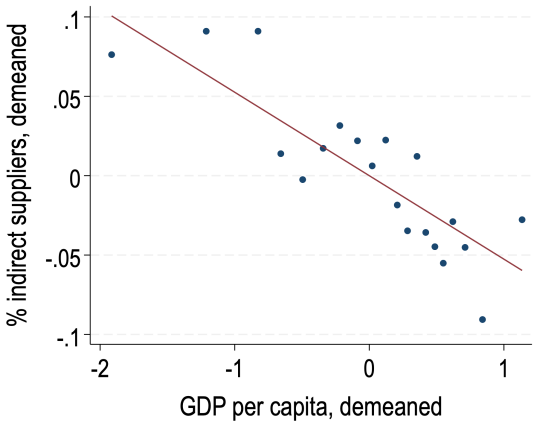
Figure 8 illustrates how the relevance of intermediated trade varies across origin countries with different income levels. We examine all exports to Chile at the country-sector (HS 2-digit) level, demeaned by sector and sorted into 20 equally-sized bins by

origin-country GDP per capita. We interpret GDP per capita as a proxy for average firm productivity within countries. Panel A shows that the share of intermediated sales to Chile systematically decreases with GDP per capita in the source country. Panels B-D reveal that this pattern responds to the endogenous sorting of foreign suppliers into different trade modes. As GDP per capita increases in the origin country, there is a smaller share of suppliers selling purely indirect to Chilean buyers, while the shares of purely direct and mixed suppliers increase. These patterns are consistent with model implications for the seller productivity distribution. In particular, more productive suppliers are less likely to engage in indirect trade for any given level of matchability.

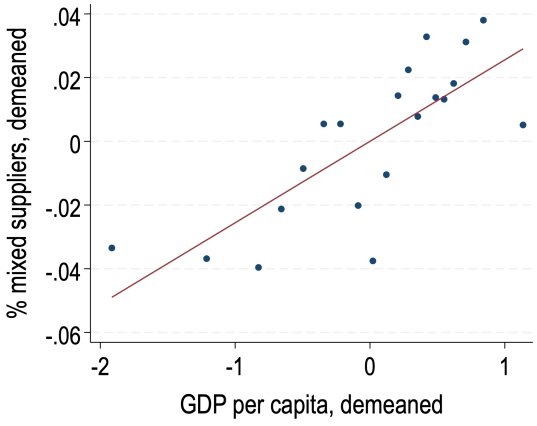
Figure 8: GDP per capita and intermediation shares



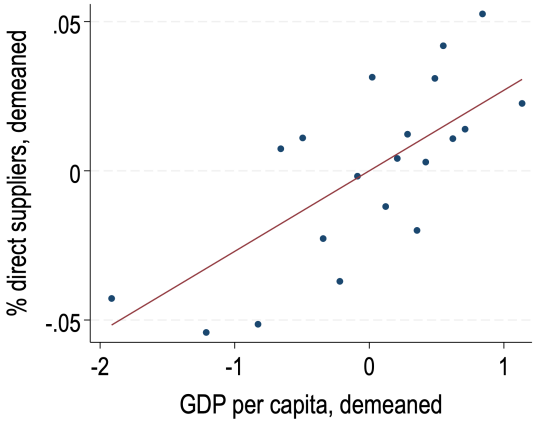

(a) Share of indirect sales




(b) Share of indirect suppliers




(c) Share of mixed suppliers




(d) Share of direct suppliers

### 4.2. Network Transaction Costs

We analyze how intermediated trade varies with origin-country characteristics, which informs the economic factors behind network transaction costs. More precisely, we focus on potential costs related to transportation, logistics, red tape, contracting, and information asymmetry or trustworthiness.

Table 4 examines countries' geographic and cultural-linguistic distance to Chile. We consider the distance between capital cities, the share of people with the same religion, language proximity using ancestral roots (i.e., language trees), and a dummy indicating common legal origins. All these variables are collected from the *CEPII gravity database*. Moreover, our trust measure is based on the *World Values Survey* and considers the share of people that report "complete trust" in foreigners in each origin country. We find systematically higher shares of intermediated trade and of indirect suppliers for origin countries that are more distant, trust foreigners less, and do not share a common religion. By contrast, the effects of language similarity and legal origins are not significant. Our results are robust to using alternative measures for these variables. For instance, the conclusions are analogous when using the distance between the largest cities or a weighted average by population, when expanding our trust measure to the share of people that declare "some trust" in foreigners, or when considering lexical similarity of languages, a dummy for common official languages, or the share of people that speak the same language.

Table 5 considers countries' logistics and customs efficiency. We evaluate the World Bank's *Logistics Performance Index* and multiple variables related to border compliance and procedures from the *Doing Business* report. We find higher shares of intermediated trade and of indirect suppliers for origin countries that have weaker overall logistics performance. On the other hand, the monetary and time cost of border compliance and export documentation does not significantly affect intermediation shares. This evidence suggests that the availability of logistic services is more important than customs procedures for exporters' trade mode, and therefore in explaining network transactions costs.

## 5. Quantitative Analysis

### 5.1. Simulation

We first simulate a simplified version of the model with two countries, in order to illustrate the numerical solution and inform the role played by different assumptions. This requires us to specify the parameters that govern the distribution of firm attributes, the market structure, and the rent sharing between wholesalers and suppliers.

Table 4: Matching costs and intermediation shares

| | Sales to Chile | Firms selling to Chile | | |
|---|---|---|---|---|
| | (1) | (2) | (3) | (4) |
| | % Indirect | % Indirect | % Mixed | % Direct |
| (log) Distance | 0.031* | 0.043** | -0.052*** | 0.009 |
| | (0.018) | (0.021) | (0.012) | (0.019) |
| Trust in foreigners (%) | -0.462** | -0.484** | 0.007 | 0.477*** |
| | (0.186) | (0.193) | (0.116) | (0.168) |
| Common religion (%) | -0.075* | -0.067 | -0.019 | 0.086** |
| | (0.042) | (0.042) | (0.024) | (0.040) |
| Language proximity (tree index) | 0.015 | 0.017 | -0.016 | -0.001 |
| | (0.028) | (0.033) | (0.034) | (0.034) |
| Common legal origins (=1) | 0.032 | 0.025 | 0.016 | -0.040* |
| | (0.028) | (0.024) | (0.014) | (0.023) |
| HS2 sector FE | Yes | Yes | Yes | Yes |
| N | 3,152 | 3,152 | 3,152 | 3,152 |

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 $\rho = -0.2$. As discussed below, a negative correlation between suppliers' productivity and matchability is important for rationalizing the observed sorting of suppliers into different sales strategies through the lens of the model. It is also consistent with previous results in the literature (Bernard et al. (2022)). 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 $\sigma = 4$. For simplicity, we use the same value for the elasticity of substitution across intermediate inputs $\eta$ in this simulation.

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. It proves convenient for the solution algorithm to characterize the seller-wholesaler contract with an implicit brokerage fee $\gamma = 0.1$ on the seller's variable profits from the transaction; as discussed in Footnote 9 , this is a dual formulation of the Nash bargaining problem specified in the baseline model in terms of the wholesaler's bargaining weight $\phi$.

Figure 9 illustrates how the model is able to accommodate the sorting of exporters into

Table 5: Logistics, customs efficiency and intermediation shares

| | Exports to Chile | Sellers to Chile | | |
|---|---|---|---|---|
| | (1) | (2) | (3) | (4) |
| | % Indirect | % Indirect | % Mixed | % Direct |
| (log) Logistic performance index | -0.186* | -0.222** | 0.104* | 0.119 |
| | (0.096) | (0.099) | (0.055) | (0.093) |
| Export documentation: (log) hours | -0.012 | -0.003 | -0.008 | 0.011 |
| | (0.012) | (0.014) | (0.009) | (0.012) |
| Export documentation: (log) USD | -0.002 | -0.004 | -0.008 | 0.012 |
| | (0.017) | (0.019) | (0.012) | (0.017) |
| Border compliance: (log) hours | 0.015 | 0.002 | 0.003 | -0.004 |
| | (0.012) | (0.014) | (0.010) | (0.011) |
| Border compliance (log) USD | -0.004 | 0.001 | 0.015 | -0.016 |
| | (0.021) | (0.023) | (0.016) | (0.018) |
| HS2 sector FE | Yes | Yes | Yes | Yes |
| N | 3,267 | 3,267 | 3,267 | 3,267 |

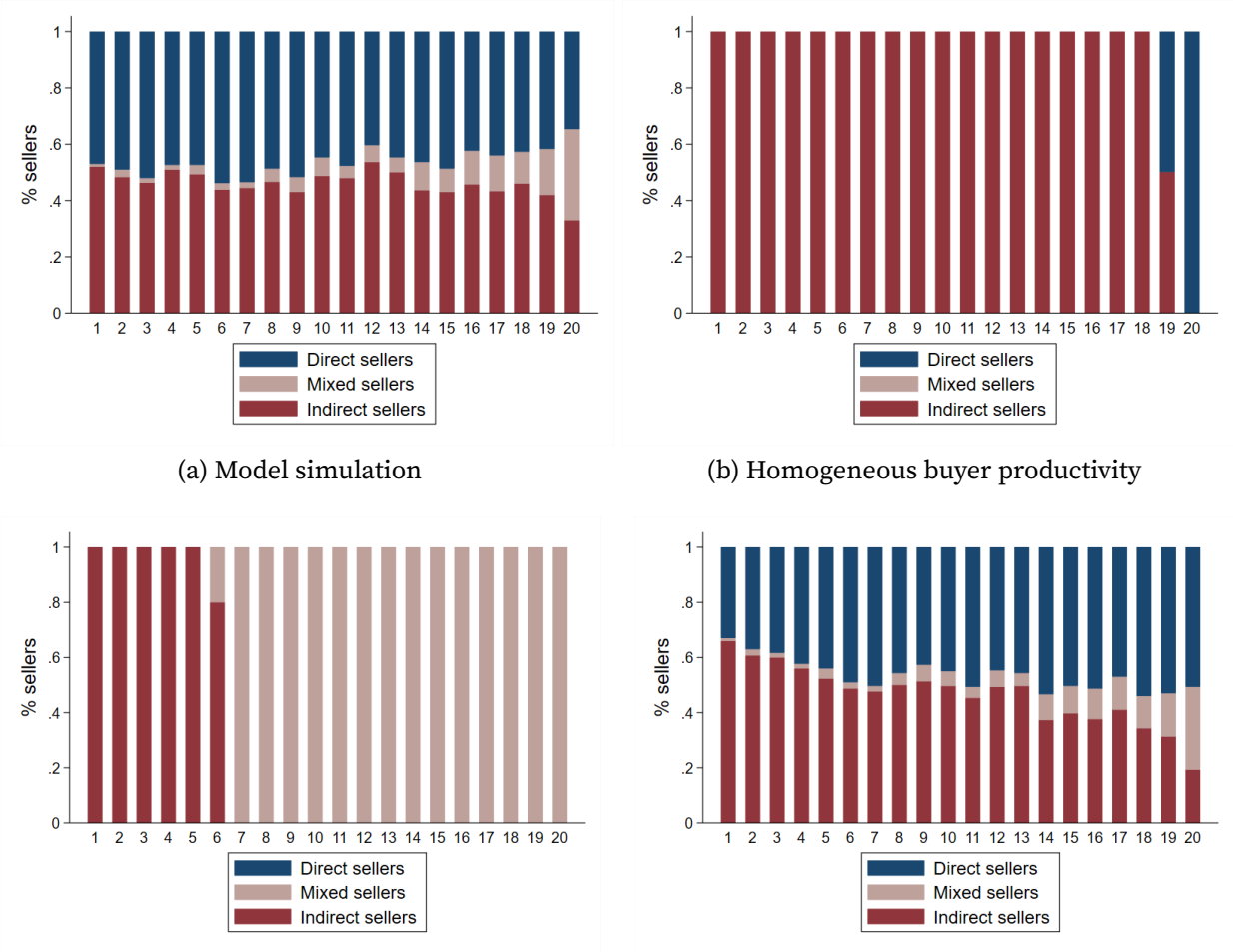
different sales strategies. In particular, the numerical exercises suggest that the modeling assumptions of two-sided heterogeneity and two-dimensional supplier heterogeneity are necessary to rationalize key empirical patterns in the data.

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.

Finally, Figure 10 uses the simulated model to compare the input costs of downstream producers with and without access to intermediation services. Producers across the pro-

ductivity distribution enjoy lower marginal costs when suppliers can transact through wholesalers. Moreover, smaller, less efficient producers have greater gains from intermediation. As predicted by the model, these buyers are not productive enough to generate profitable direct matches for many upstream suppliers, and therefore benefit more from network expansion through indirect linkages.

Figure 9: Direct and indirect sellers



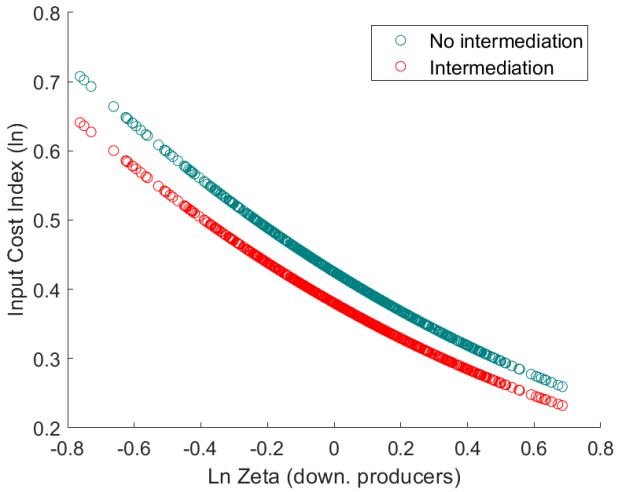

(a) Model simulation

(b) Homogeneous buyer productivity

(c) Homogeneous seller matchability

(d) Uncorrelated productivity and matchability

Figure 10: Producers' input cost with and without intermediation




### 5.2. Estimation (in progress)

### 5.3. Counterfactuals (in progress)

## 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. Microfoundations 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.

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