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How Global Are Local Value Chains?

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How Global Are Local Value Chains?*

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Abstract

This paper examines how international trade shocks transmit through domestic supply chains, shaping local economic vulnerabilities. Using detailed firm-to-firm domestic and foreign transaction data, we quantify the direct and indirect exposure of Italian labor markets to two major sources of external risk: imports from China and exports to the United States. We quantify the importance of firms' domestic and foreign linkages for overall exposure and highlight the critical role of wholesalers and top trading firms within the domestic network in shaping tails risks. Pronounced local disparities in exposure reveal that aggregate trade statistics conceal substantial and uneven regional vulnerabilities.

Keywords: global value chains, local labor markets, trade shocks, firm-to-firm linkages, geopolitical fragmentation, production network.

JEL codes: F14, R12, L14, F61, R15

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1 Introduction

Decades of increasing economic integration have fostered the development of global value chains (GVCs) spanning multiple countries, linking regions, sectors, and firms across borders (World Bank, 2019). However, recent disruptive events—such as the COVID-19 pandemic and the Russian invasion of Ukraine—have highlighted significant vulnerabilities in global production networks, triggering major supply chain disruptions (Gopinath et al., 2025) and widespread economic uncertainty (Baldwin and Freeman, 2022). Amid escalating geopolitical tensions and a renewed wave of protectionism, many governments have raised new trade barriers and tightened foreign investment restrictions.

While the impact of such measures may appear moderate at the aggregate national level, their local effects can be substantial (Magerman and Palazzolo, 2024). This is particularly relevant in regions where economic activity is highly concentrated and specialized in specific sectors or destination markets (Ellison and Glaeser, 1997, 1999). Moreover, domestic supply linkages, both within and across regions, influence how external shocks are distributed geographically, beyond what import and export data suggest (Giroud and Mueller, 2019; Lafrogne-Joussier, Martin and Mejean, 2022). Understanding how domestic economies are integrated into global value chains—especially at a granular, sub-national level—is therefore crucial for assessing vulnerabilities and resilience in an evolving global economy.

In this paper, we analyze the domestic and foreign networks of Italian firms and quantify the direct exposure to international trade and the indirect exposures through domestic linkages of Italian Local Labor Markets (LLMs), focusing on exports to the US and imports from China. To this extent, we leverage detailed Italian firm-level transaction data for 2022, combining domestic and international administrative transaction records. Our approach integrates two unique datasets: mandatory business-to-business (B2B) transaction records covering all domestic trade between VAT-registered firms, and foreign trade records drawn from Intrastat declarations and customs data. This merged dataset, complemented with additional information on firms' balance sheets, employment, and detailed geographic classifications, allows us to map the sub-national structure of production networks and evaluate exposure to external trade shocks of about 1.8 million firms, about four times more than in other papers using similar data (see Bacilieri et al., 2023, for a survey).

While the values of direct exposure to international trade are consistent with aggregate trade data, our analysis reveals levels of total exposure to trade shocks that far exceed those suggested by trade statistics, once we take into account the domestic network

of Italian firms. Moreover, the exposures measured in our analysis are characterized by substantial heterogeneity across both LLMs and economic sectors. In the average LLM, roughly 3.4% of total revenues are linked with exports to the US. More than 50% of such exposure, however, is due to Italian firms' indirect connection to the US market through other national firms. Similarly, we find that 3.6% of costs is connected with imports from China, with about 60% due to the indirect connection to the Chinese market. Hence, domestic firm-to-firm linkages play a crucial role in amplifying the exposure to foreign markets, especially in those LLMs not trading extensively with foreign markets. On average, direct exposure accounts for about 40% of total exposure, but it represents the main driver in the most exposed LLMs.

Direct exposure to exports to the United States and imports from China is concentrated in Italy's northern regions, whereas southern regions are more exposed through indirect channels. In some cases, indirect exposure is so pronounced that local labor markets with limited direct international trade become part of the right tail of the total exposure distribution once domestic inter-firm linkages are accounted for. For this result, domestic supply chains are critical, as they amplify and transmit shocks across space and sectors. Moreover, indirect exposure is not solely driven by first-order channels, i.e., direct transactions with exporters or importers. Higher-order linkages within the network of Italian firms account for a substantial share of the overall exposure, particularly for local labor markets with otherwise limited direct exposure. Our findings are consistent with recent contributions that emphasize the propagation of trade shocks through domestic production networks (Huneus, 2018; Dhyne et al., 2021; Pichler et al., 2023), as well as the importance of regional specialization and limited factor mobility in shaping local adjustment capacity to external shocks (Topalova, 2010; Kovak, 2013; Autor, Dorn and Hanson, 2016; Caliendo, Dvorkin and Parro, 2019).

We explicitly explore two dimensions central to policy discussions: (i) the geographic concentration and clustering of B2B linkages, particularly within local labor markets, and (ii) the extent and role of cross-regional linkages as mechanisms for shock propagation within the country. Localized clusters of interconnected firms can magnify disruptions due to limited factor mobility across sectors and regions, potentially exacerbating the economic impact of external shocks. Conversely, extensive cross-regional linkages may lead to broader geographic diffusion, affecting regions initially considered isolated or resilient to international disturbances (Martin, 2012).

A key novelty of our study is highlighting the role of specific sectors and firms in mediating trade shocks. We do so through two counterfactual exercises. The data reveal that wholesale firms serve as critical nodes within the Italian trading network. In the first

counterfactual, we isolate their role by removing the direct trade connections of wholesale firms with the United States and China and recomputing the resulting trade exposures. In the second counterfactual, we assess the influence of large trading firms on exposure to the US and Chinese markets. To do so, we reallocate the exports to the US and imports from China of Italy’s top-trading firms to the other countries they trade with. This approach preserves firm size while neutralizing direct exposure to the markets of interest.

Our results indicate that excluding wholesale firms would reduce direct and indirect exposure to the US by roughly 10%, direct exposure to China by about 30%, and indirect exposure by up to 40%. Focusing on top traders, we find that removing the top 100 exporters lowers national exposure to the US by approximately 40%, while excluding the top 100 importers reduces national exposure to China by around 25%. In all cases, these findings highlight the granular role of large firms in shaping national exposure to external shocks—albeit differently for exports and imports—and underscore the systemic significance of indirect channels, even when major trading firms are excluded.

We show that among the most trade-exposed LLMs, the share of *total* revenues and costs linked to exports to the US and imports from China is remarkably high, ranging between 10% and 30%. In several of these LLMs, indirect exposure is a first-order driver of vulnerability. These tail risks are largely shaped by the presence of a lead exporter to the US and a lead importer from China within each highly exposed LLM. Importantly, the product categories driving these tail risks only modestly overlap with those responsible for national-level exposure, revealing at least a partial disconnect between aggregate trade patterns and localized vulnerabilities.

Lastly, we find that indirect exposure through domestic supply chains is significantly underestimated by state-of-the-art Inter-Country Regional Input-Output (ICIO) tables. This is due to their reliance on proportionality assumptions, which overlook the fact that import-intensive and export-oriented firms tend to be larger and more central within domestic production networks.

Overall, we provide novel insights into the mechanisms underlying the spatial propagation of potential trade shocks, contributing to a deeper understanding of regional gaps and economic resilience. Our findings offer critical guidance for policymakers aiming to develop targeted, place-based economic strategies to mitigate regional vulnerabilities and enhance resilience against future global disruptions.

Related Literature. This paper provides a granular picture of LLMs exposure to foreign shocks—both directly through international trade and indirectly via domestic supply chains—emphasizing the role of a few large firms in shaping this exposure. It contributes

to four strands of the literature.

First, it contributes to the literature on how international shocks are transmitted within domestic economies. While earlier studies have typically relied on industry- and region-level input-output linkages to measure exposure (Javorcik, 2004; Acemoglu et al., 2012, 2016; Helm, 2020), the growing availability of firm-to-firm transaction data has led to major advances in measuring the transmission of shocks (Huneus, 2018; Alfaro-Urena, Manelici and Vasquez, 2022; Santamaria, Ventura and Yeşilbayraktar, 2023; Demir et al., 2024; Corsetti, Demir and Javorcik, 2025). A key limitation of the input-output approach is the assumption that shocks impact all firms within a sector uniformly (Koopman, Wang and Wei, 2012; Kee and Tang, 2016; De Gortari, 2019; Bems and Kikkawa, 2021). Using administrative data on both domestic and international transactions of Italian firms, this paper measures the exposure of Italian LLMs to international shocks starting from firm-to-firm linkages, without relying on proportionality assumptions. Our results show that a small number of large firms, with multiple linkages across and within LLMs, play a dominant role in driving exposure.

Second, by showing how inter-firm and inter-sectoral linkages shape the heterogeneous exposure of LLMs to foreign shocks, this paper also contributes to the economic geography literature on regional resilience (Martin, 2012; Diodato and Weterings, 2014; Giannakis and Bruggeman, 2017; Giannakis, Bruggeman and Mamuneas, 2024). Specifically, our analysis provides empirical evidence for two key determinants of resilience that the seminal work of Martin and Sunley (2015) discusses from a theoretical perspective: the degree of modularity—i.e., the density of input–output linkages among local firms and industries—and rivet effects, whereby a dominant firm or sector anchors local production through a network of dependent suppliers and subcontractors.

Third, and closely related, this paper contributes to the literature examining the relationship between the spatial concentration of economic activity and exposure to international shocks. This literature documents that economic activity tends to cluster in the most productive regions within countries, largely due to agglomeration externalities and firm selection mechanisms (Combes et al., 2012; Behrens, Duranton and Robert-Nicoud, 2014; Gaubert, 2018; Davis and Dingel, 2020; De la Roca, Ottaviano and Puga, 2023). This spatial concentration not only determines the comparative advantage of dense urban areas but also amplifies their exposure to global economic shocks (Coşar and Fajgelbaum, 2016; Redding, 2022; Bakker et al., 2024). Our findings are consistent with this view and further suggest that foreign shocks diffuse beyond directly exposed locations, propagating across space through firm-level production linkages.

Finally, this paper contributes to the growing literature on the reallocation of economic

activity in response to geoeconomic fragmentation. Most existing studies assess fragmentation shocks at the aggregate level—typically across countries—and find limited direct and indirect exposure risks (see [Baldwin and Freeman, 2022](#), for a survey). Our work contributes to this literature in two ways. First, it documents how fragmentation shocks can propagate within countries through sub-national supply chains—an aspect overlooked in previous studies on geoeconomic fragmentation. Second, by focusing on LLMs rather than national economies, our analysis reveals that indirect linkages generate much higher exposure levels than previously recognized, as well as substantial heterogeneity across regions.

The paper unfolds as follows. Section 2 introduces our data sources, and Section 3 our measures of exposure. Section 4 presents the results, and Section 5 compares exposure based on firm-to-firm transactions with ICIO tables. Section 6 concludes.

2 Data

Our empirical analysis draws on administrative data from Italy for the year 2022, covering domestic and international transactions of Italian firms. Firms are identified via tax identifiers (VAT numbers or fiscal codes), which enable unambiguous merging across multiple sources.¹ The dataset is constructed combining electronic invoicing for domestic transactions, customs declarations for foreign trade, firm registry data, and financial statements.²

The first data source, *FATTEL*, contains information on domestic business-to-business (B2B) transactions via electronic invoices. Since January 1, 2019, e-invoicing is mandatory for all private entities resident or established in Italy, replacing paper invoices.³ Invoices are submitted through the Revenue Agency’s Exchange System, ensuring standardized digital records. The available data are aggregated at the yearly level and include the VAT numbers of both buyers and sellers, along with the corresponding transaction value.

The second source covers foreign trade (exports and imports) of goods and is split into intra-EU and extra-EU components. Intra-EU trade is reported via the Intrastat system, which collects both statistical and VAT compliance data. Monthly declarations include Italian firm’s VAT numbers, partner countries, the classification of the commodity (ac-

¹We discuss how we deal with multiplant firms and VAT groups and issues related to data cleaning and preparation more in detail in Appendix A.

²We use data for 2022 as this is the most recent available year.

³Exemptions apply to entities under special tax regimes and certain small agricultural producers.

ording to the Combined Nomenclature), and transaction values.⁴ Extra-EU trade data are transaction-level and include Italian firm’s VAT numbers, commodity codes, and partner countries. Export and import records are matched to firms using VAT numbers, including adjustments for VAT group identifiers. This allows aggregation of trade flows at the firm level, even when reported under different legal entities.

The third source includes reclassified balance sheet data from Cerved, covering around 700,000 limited companies annually. These are complemented with employment data from INPS and registry data from Infocamere.

The final firm-level dataset includes revenues, employment, assets, legal form, sector classification, location, and trade. Employment figures are harmonized across sources and, where missing, estimated using labor cost data.⁵ Our final dataset includes nearly 1.8 million firms—about four times more than in other papers using similar data (see [Bacilieri et al., 2023](#), for a survey)—and includes 80 million domestic links among them, representing approximately €4 trillion in domestic transactions (Table 1, Panel A). For 2022, we observe approximately 83 thousands exporting firms, accounting for €555 billion in transactions, and 75 thousands importing firms, with total imports amounting to €494 billion. In particular, around 30 thousands firms exported to the United States, generating €60 billion in revenues. At the same time, 30 thousands firms imported goods from China, for a total value of €47 billion. The United States and China consistently represent Italy’s most important extra-EU export and import partners, respectively, accounting for approximately 10% of total external trade. In terms of exports and imports statistics, our coverage relative to official figures is approximately 90% and 75%, respectively. The lower coverage for imports is mostly due to the fact that custom data does not adequately reflect trade in energy commodities and electricity. However, this limitation does not affect our results, as energy imports from China are negligible.⁶

Table 1, Panel B reports descriptive statistics on the structure of the domestic production network among Italian firms. The number of buyers exhibits substantial heterogeneity. While the median firm transacts with 8 buyers, firms in the 95th percentile reach 194 buyers. The distribution of transaction values is even more skewed: the median firm reports €230,000 in sales, but this figure rises to over €5.7 million at the 95th percentile. These patterns highlight the highly unequal structure of the network, with a small subset

⁴Reporting thresholds vary by year and country. For imports, monthly reporting is required if purchases exceed €350,000 in any of the previous four quarters; for exports, the threshold is €50,000.

⁵After the cleaning and matching procedures, we lose about 3% of the transaction value recorded in FATTEL.

⁶Such coverage is in line with that of other works using similar data ([Bems and Kikkawa, 2021](#); [Dhyne et al., 2022](#)).

of firms accounting for a disproportionate share of inter-firm transactions, pointing to the presence of systemic nodes that play a central role in the domestic economy.

Table 1: Descriptive statistics of the final sample

A: Summary of Firm-Level Coverage								
	#	Value (EUR bn)						
Firms	1.8 million	3,941.4						
Exporters	83,190	555.2						
Importers	74,506	493.8						
Exporters to the US	29,585	59.8						
Importers from China	31,041	46.7						

B: Sales and Buyer Distribution								
	Percentile							
	5 th	10 th	25 th	50 th	75 th	90 th	95 th	mean
Number of buyers	1	1	2	8	31	100	194	63
Sales value (th. EUR)	5	15	61	230	822	2,686	5,735	3,122

Notes: Panel A reports the coverage of the dataset across different sources and subsamples. Panel B reports selected percentiles (5th to 95th) and the mean of the firm-level number of buyers and sales value (in thousands of euros).

Firms are geolocated and assigned to a Local Labor Market (*Sistemi Locali del Lavoro*, LLMs) from ISTAT. These zones are defined based on commuting flows from the 2011 Census and represent functional labor market areas. The 2019 classification consists of 610 markets, each mutually exclusive and geographically contiguous.⁷ Figure B.1 shows the median firm-level revenues from FATTEL by LLM across Italy in 2022. As expected, firms located in the northern regions tend to report significantly higher revenues than those in the South, reflecting broader patterns of economic development. However, the geographic gradient is not entirely uniform. Some southern LLMs also exhibit relatively high levels of firm revenue, suggesting the presence of localized industrial clusters or more productive firms in selected areas.

Flows across local labor markets reflect Italy’s North–South divide and a higher degree of integration among more productive areas. Figure B.2 displays a heatmap reporting the percentile rank of trade values between pairs of LLMs. Several patterns emerge. First, a high share of transactions takes place within LLMs, reflecting their role as integrated economic zones. Second, LLMs tend to trade more intensively with geographically prox-

⁷The partition in LLMs does not always fully reflect administrative divisions of Italy: some of them can span over different provinces or even regions as they represent functional areas rather than administrative ones.

imate markets. Third, southern regions of Italy appear to be more internally connected but less integrated with distant parts of the country. This is particularly the case for Sicily and Sardinia, two insular regions. Fourth, major cities (e.g., Turin, Milan, Venice, Trieste, Bologna, Florence, Rome, Naples, and Bari) act as large regional and national hubs (in line with [Di Giacinto et al., 2014](#)).

3 Measures of exposures

Building on [Dhyne et al. \(2021\)](#), this section introduces our measures of firms’ direct and indirect exposure to foreign trade, both for exports and imports.⁸ We also demonstrate how these measures can be decomposed across and within local labor markets and industries.

3.1 Export exposure

We define the total export exposure of firm j to foreign market F as:

$$r_{jF}^T = r_{jF} + \sum_{i \in \mathcal{B}_j} r_{ji} r_{iF}^T. \quad (1)$$

r_{jF}^T is the ratio of firm j ’s export revenues to market F over its total sales. r_{jF} denotes firm j ’s direct export revenue share to market F . r_{ji} is the share of revenues that firm j earns from sales to domestic customer i , and \mathcal{B}_j is the set of j ’s domestic buyers. Therefore, the second component in Equation (1) depends both on the relative importance of customer i in j ’s total revenues and on the total foreign export exposure of firm i itself. When computing each share, the denominator includes total sales to domestic and foreign firms, as well as to final consumers.

The recursive structure of Equation (1) captures both the *direct* export exposure of firm j to market F and the (higher-order) *indirect* export exposure through domestic supply chains, i.e., j ’s transactions with other Italian firms, the transactions that other Italian firms carry out among themselves, and so on. The indirect exposure can be decomposed

⁸For the purpose of this section, we treat all firms as single-plant entities. In the data, however, some firms operate multiple plants, potentially spanning different LLMs and industries. We address this issue empirically in the next section.

to evaluate the relevance of first- and higher-order rounds of export exposures as follows:

$$\begin{aligned}
\sum_{i \in \mathcal{B}_j} r_{ji} r_{iF}^T &= \sum_{i \in \mathcal{B}_j} r_{ji} \left(r_{iF} + \sum_{k \in \mathcal{B}_i} r_{ik} r_{kF}^T \right) \\
&= \sum_{i \in \mathcal{B}_j} r_{ji} \left(r_{iF} + \sum_{k \in \mathcal{B}_i} r_{ik} \left(r_{kF} + \sum_{l \in \mathcal{B}_k} r_{kl} r_{lF}^T \right) \right) \\
&= \dots \\
&= \underbrace{\sum_{i \in \mathcal{B}_j} r_{ji} r_{iF}}_{1^{\text{st}} \text{ indirect}} + \underbrace{\sum_{i \in \mathcal{B}_j} r_{ji} \sum_{k \in \mathcal{B}_i} r_{ik} r_{kF}}_{2^{\text{nd}} \text{ indirect}} + \underbrace{\sum_{i \in \mathcal{B}_j} r_{ji} \sum_{k \in \mathcal{B}_i} r_{ik} \sum_{l \in \mathcal{B}_k} r_{kl} r_{lF}}_{3^{\text{rd}} \text{ indirect}} + \dots \quad (2)
\end{aligned}$$

This decomposition allows us to analyze how each linkage matters for indirect exposure and how quickly indirect export exposure decays, that is, how many linkages are required before it becomes negligible.

Equations (1) and (2) show that firms are exposed to foreign markets directly (through r_{jF}^T), and indirectly (through $\sum_{i \in \mathcal{B}_j} r_{ji} r_{iF}^T$). A shock affecting an export market (e.g., the across-the-board increase in US tariffs) can impact a firm either directly, if it exports to the United States, by changing the revenue share from that market, or indirectly, if it sells to a firm that exports to the US, or to a firm that supplies such an exporter, and so on.

3.2 Import exposure

We define the total import exposure of firm j to market F as:

$$s_{Fj}^T = s_{Fj} + \sum_{i \in \mathcal{S}_j} s_{ij} s_{Fi}^T, \quad (3)$$

s_{Fj}^T is the ratio of firm j 's expenditure on inputs sourced from market F over its total input expenditure. s_{Fj} denotes firm j 's direct import expenditure share from market F . s_{ij} is the share of firm j 's total input expenditure accounted for by purchases from domestic supplier i , and \mathcal{S}_j is the set of j 's domestic suppliers. Therefore, the second component in Equation (3) depends both on the relative importance of supplier i in j 's total expenditure and the total foreign import exposure of firm i . When computing each share, the denominator includes spending on domestic and foreign intermediate inputs, as well as labor costs.

As before, the recursive structure of Equation (3) captures both the *direct* import exposure of firm j to market F and the (higher-order) *indirect* import exposure through domes-

tic supply chains. Indirect exposure can be decomposed as before as:

$$\sum_{i \in \mathcal{S}_j} s_{ij} s_{Fi}^T = \underbrace{\sum_{i \in \mathcal{S}_j} s_{ij} s_{Fi}}_{1^{\text{st}} \text{ indirect}} + \underbrace{\sum_{i \in \mathcal{S}_j} s_{ij} \sum_{k \in \mathcal{S}_i} s_{ki} s_{Fk}}_{2^{\text{nd}} \text{ indirect}} + \underbrace{\sum_{i \in \mathcal{S}_j} s_{ij} \sum_{k \in \mathcal{S}_i} s_{ki} \sum_{l \in \mathcal{S}_k} s_{lk} s_{Fl}}_{3^{\text{rd}} \text{ indirect}} + \dots \quad (4)$$

Analogously to the case of exporters, Equations (3) and (4) show that a firm importing inputs from a foreign market can be affected either by a trade shock (e.g., export controls) directly (through s_{Fj}), or indirectly (through the term $\sum_{i \in \mathcal{S}_j} s_{ij} s_{Fi}^T$). For instance, in the event of an export ban on a specific input, a firm may lose access to that input even if it is not directly part of its production process. This can occur if the firm relies on a domestic supplier that, in turn, depends on the embargoed input from the foreign market. In this way, upstream restrictions propagate through domestic supply chains and disrupt production indirectly.

3.3 Decomposition of indirect exposure

Since our goal is to understand how shocks to foreign markets propagate at the sub-national level through firm-to-firm linkages, we further decompose the indirect exposure terms in Equations (1) and (3) for firm j into within- and between-LLM components.

On the export side, this decomposition can be expressed as:

$$\sum_{i \in \mathcal{B}_j} r_{ji} r_{iF}^T = \sum_{i \in (\mathcal{B}_j \cap \mathcal{L}_j)} r_{ji} r_{iF}^T + \sum_{i \in (\mathcal{B}_j \setminus \mathcal{L}_j)} r_{ji} r_{iF}^T. \quad (5)$$

We denote by \mathcal{L}_j the set of firms active in the same LLMs in which firm j operates. In other words, we distinguish between firm j 's indirect export exposure arising from sales to other firms within the same labor market and sales to firms located in other labor markets.⁹ This decomposition allows us to assess whether firms are more exposed to shocks originating within their own labor market compared to those from other markets. The same decomposition can be applied to the indirect import exposure term in Equation (3).

Following the same logic, firms' indirect export and import exposure can also be decomposed into within- and between-industry components as follows:

$$\sum_{i \in \mathcal{B}_j} r_{ji} r_{iF}^T = \sum_{i \in (\mathcal{B}_j \cap \mathcal{I}_j)} r_{ji} r_{iF}^T + \sum_{i \in (\mathcal{B}_j \setminus \mathcal{I}_j)} r_{ji} r_{iF}^T. \quad (6)$$

⁹In Section 4.2, we further distinguish indirect exposure to firms in other LLMs by separating those located in contiguous versus non-contiguous LLMs.

We denote by \mathcal{I}_j the set of firms active in the same industry in which firm j operates. This decomposition allows us to determine whether firms are more exposed to shocks coming from their own industry or from upstream and downstream sectors. The decomposition can be performed either unconditionally or conditional on firms belonging to the same LLM. As before, this decomposition can also be applied to the indirect import exposure term in Equation (3).

3.4 Aggregation of total exposure

Solving Equation (1) for r_{iF}^T and Equation (3) for s_{Fi}^T determines total export and import exposure at the firm level, respectively. Since our primary focus is on the geographical exposure to foreign shocks, we aggregate these firm-level exposures to the level of LLMs. In the aggregation, we account for the relative size of each firm: for export exposure, we weight firms by their total sales, whereas for import exposure, we use total input cost (including labor) as the weighting factor.¹⁰ Therefore, larger firms have a proportionally greater influence on the aggregated exposure measures.

4 Results

We use the measures described in the previous section to quantify the direct and indirect exposure of Italian firms to potential external trade shocks (Equations (1) and (3)).¹¹ On the import side, we focus on purchases from China; on the export side, we analyze sales to the United States. As is standard in the literature, we focus on LLMs as our unit of analysis, given our interest in understanding the agglomeration of economic activities in specific areas and the sources of exposure within and across them (for a review, see [Moretti, 2011](#)).

Strategic dependence on inputs from China has become a central theme in recent policy debates. For Italy, China is a critical sourcing market, particularly in sectors such as electronic appliances and machinery ([Panon et al., 2024](#)).

On the US side, the second term of President Trump, which began in January 2025, has been characterized by escalating trade tensions not only toward China, but also toward traditional allies, including the EU, Canada, and Japan. For the EU, the bilateral agreement reached at the end of July 2025 set US tariffs on most European exports at 15%.

¹⁰We apply similar procedures when aggregating firm-level results across different dimensions, such as by sector.

¹¹As a technical remark, we solve for r_{iF}^T and s_{Fi}^T using fixed-point iteration, since the large size of the problem makes it computationally infeasible to invert the sparse matrix of domestic firm-to-firm linkages.

However, substantially higher rates were imposed on specific sectors, notably aluminum, copper, iron, and steel (Conteduca, Mancini and Borin, 2025). This abrupt increase in trade barriers may significantly constrain the ability of Italian firms to penetrate the US market, which remains Italy’s most important non-EU export destination.

4.1 Direct and indirect exposure

At the national level, about 1.5% of total revenues (Panel A) are generated by goods directly exported to the US, while 1.4% of LLM costs are associated with direct imports from China (Panel B). Yet there is marked heterogeneity across Italian LLMs in their exposure to these international trade shocks, as shown by Figures 1a and 1b, which plot kernel densities of the distribution of average LLM-level exposures to exports to the United States and imports from China, respectively. In each case, we display the direct (green solid line), indirect (purple solid line), and total (pink solid line) components, together with the nationwide averages (vertical dashed lines).

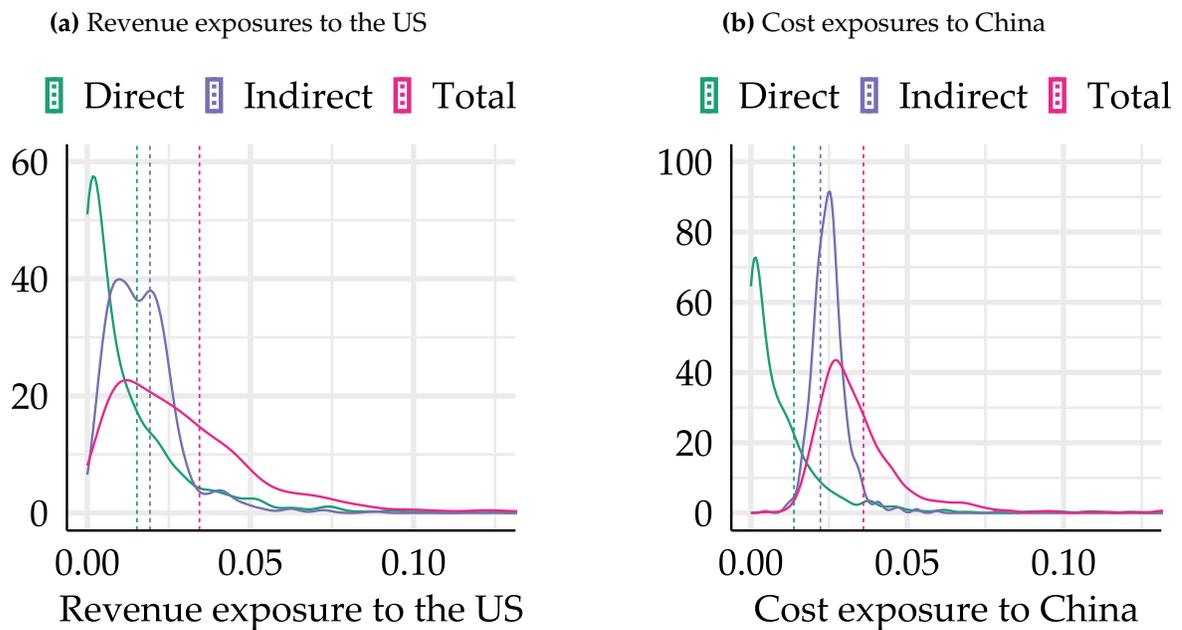
Table 2: Direct and indirect exposures

A: US-export exposure		B: China-import exposure	
	Exposure (%)		Exposure (%)
Direct	1.5	Direct	1.4
Indirect	1.9	Indirect	2.2
<i>of which: first round</i>	0.8	<i>of which: first round</i>	0.7
Total	3.4	Total	3.6

Notes: Panel A and Panel B report national-level exposure to exports to the United States and imports from China, respectively. The *Direct* component corresponds to the weighted average of firms’ exports to the US (imports from China) over total revenues (total costs) in 2022, using revenues (costs) as weights. The *Indirect* component captures all higher-order terms defined in Equations (2) and (4), similarly aggregated using the appropriate firm-level weights. Within this indirect component, we also report the contribution of first-order linkages (*of which: first round*). The *Total* exposure combines both direct and indirect channels, corresponding to the weighted average of the firm-level solutions to systems eqs. (1) and (3), again aggregated using revenue or cost weights as appropriate.

Direct exposures are highly concentrated: most LLMs exhibit very limited direct exposure. For 45% of LLMs, direct exports to the United States account for less than 0.5% of total sales. Similarly, for about half of LLMs, imports from China account for less than 0.5% of total costs. At the same time, a small share of LLMs exhibit very high direct exposure: approximately 1.5% rely on imports from China for more than 10% of their total costs, and about 1% derive over 10% of their revenues from direct shipments to the United States.

Figure 1: Distribution of revenue and cost exposures across Italian Local Labor Markets



Notes: Kernel densities of the average exposures across Italian local labor markets (LLMs). Figure 1a shows revenue exposures to the US in 2022; Figure 1b shows cost exposures to China in 2022. The green solid line represents the direct exposure, the purple solid line the indirect exposure, and the pink solid line the total exposure. Vertical lines correspond to nationwide averages. Averages are obtained by aggregating firm-level exposures using total revenues (Figure 1a) or total costs (Figure 1b) as weights. LLMs classification is from ISTAT.

Although direct foreign transactions are concentrated in a relatively small set of LLMs, domestic firm-to-firm linkages play a critical role in spreading exposure to external trade shocks. For both exports to the United States and imports from China, the total exposure curves (pink, including domestic propagation) lie to the right of the direct exposure curves (green) in Figures 1a and 1b. This visual shift indicates that indirect effects substantially amplify overall exposure. Accounting for these domestic transmission channels raises average exposure from 1.5% to 3.4% for US exports and from 1.4% to 3.6% for Chinese imports—implying that indirect linkages account for roughly 56% and 61% of overall exposure, respectively.¹²

The distribution of exposure across LLMs also becomes wider once indirect effects are accounted for, especially in the case of imports from China. Notably, for most LLMs, indirect exposure exceeds direct exposure. Specifically, 77% of LLMs exhibit higher indirect than direct exposure to the US market, while the corresponding share for China is 91%.

In line with Equations (2) and (4), Figure B.3 presents the decomposition of exposures to US exports and imports from China. First-order indirect exposure is substantial in both cases—US export exposure (Figure B.3a) and Chinese import exposure (Figure B.3b). Notably, also higher-order indirect exposures are far from negligible: they significantly contribute to overall exposure, especially among LLMs with low direct exposure, and are particularly relevant on the import side from China. In general, LLMs with relatively low direct exposure often move into the upper tail of the total exposure distribution once indirect channels are taken into account.

4.2 Geographical aggregation and transmission

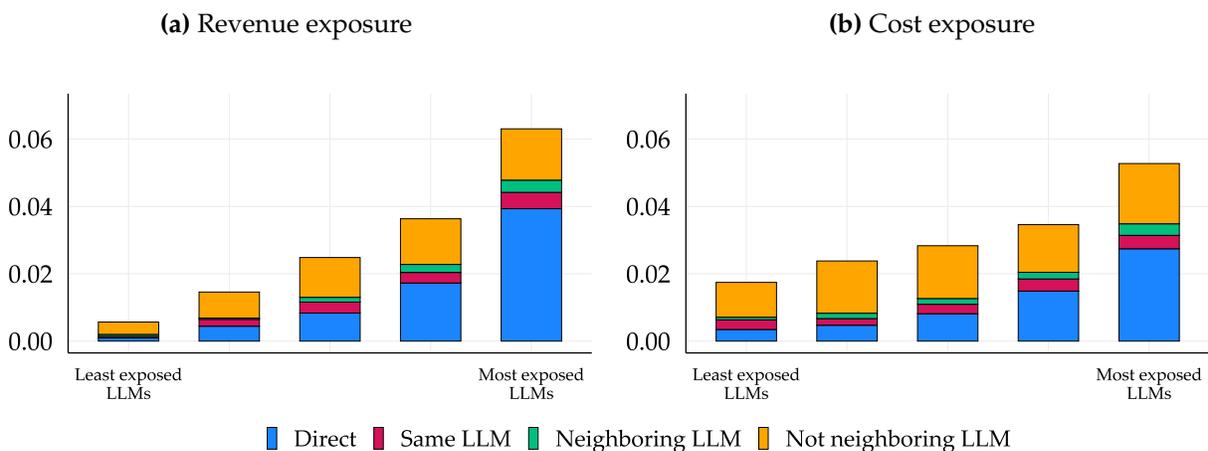
A more detailed picture of the relative role of direct and indirect linkages through space is provided in Figure 2, which decomposes exposures for each quintile of the distribution of LLM total exposure into direct, intra- and neighboring-LLM exposures, and more distant component using Equation (5).¹³ The results show that while local linkages are important, cross-regional supply chains account for a large share of exposure to external shocks. This pattern highlights the extent to which indirect domestic supply chain connections diffuse and amplify exposure, thereby reshaping the geography of vulnerability beyond what is apparent from direct trade flows alone. Indeed, a substantial share of indirect exposure originates from non-contiguous LLMs both for exports to the US (Figure 2a) and imports from China (Figure 2b). For exports to the US, about 70% of indirect expo-

¹²The idea that indirect exposure plays a major role in shock transmission is consistent with a substantial body of existing literature (Baqaee, 2018; Huneeus, 2018; Dhyne et al., 2021, 2022; Ferrari, 2023).

¹³Figure B.4 shows the full distribution for all LLMs.

sure stems from non-neighboring LLMs, with the share particularly high among LLMs with limited direct exposure. By contrast, only 19% of indirect exposure arises within the same LLM—consistent with the structure of integrated local production districts—while neighboring LLMs contribute just 11%.

Figure 2: Decomposition of exposure by proximity of partner LLMs across total exposure quintiles



Notes: Figure 2a shows the decomposition of US revenue exposures across the quintiles of the distribution of LLMs’s total exposure by type of partner LLM in 2022, while Figure 2b reports the corresponding decomposition of Chinese cost exposures. *Same LLM* denotes the contribution to indirect exposure from firms located in the same LLM. *Neighboring LLM* captures the contribution from firms located in contiguous LLMs, whereas *Not neighboring LLM* refers to the contribution from firms in non-contiguous LLMs. Revenue exposures are aggregated using revenues in 2022, while cost exposures are aggregated at the LLM-level using costs in 2022.

A comparable pattern emerges on the import side. For Chinese inputs, 17% of indirect exposure originates within the same LLM, 10% from neighboring LLMs, and 73% from non-contiguous LLMs. Taken together, these figures point to a clear hierarchy in sourcing and selling strategies: Italian firms are most likely to trade with partners located in distant LLMs, followed by those within their own LLM, and least with those in adjacent areas. This organization of domestic production networks implies that geographically localized shocks can travel substantial distances, shaping exposure patterns across regions well beyond their point of origin.

Zooming in on the link between direct and indirect exposure reveals distinct patterns across exposure types. For exports to the United States, direct and indirect exposure are positively and statistically significantly correlated ($\rho = 0.39$; Table 3, Panel A). The association strengthens when we restrict attention to exposure originating within the same LLM ($\rho = 0.51$), whereas exposure from other LLMs is only weakly related to an LLM’s own direct exposure. By contrast, for imports from China the correlation is weaker ($\rho = 0.30$),

and, crucially, the link between direct exposure and within-LLM spillovers is far less important than in the case of US exports (Table 3, Panel B).

Table 3: Correlation matrices by type of LLM, revenue and cost exposures

A: Revenue exposure to the US					
	Direct	Total indirect	Same LLM	Neighboring LLM	Non-neighboring LLM
Direct	1.00				
Total indirect	0.39	1.00			
Same LLM	0.51	0.63	1.00		
Neighboring LLM	0.27	0.56	0.42	1.00	
Non-neighboring LLM	0.29	0.95	0.44	0.33	1.00
B: Cost exposure to China					
	Direct	Total indirect	Same LLM	Neighboring LLM	Non-neighboring LLM
Direct	1.00				
Indirect	0.30	1.00			
Same LLM	0.28	0.71	1.00		
Neighboring LLM	0.17	0.25	0.03	1.00	
Non-neighboring LLM	0.18	0.67	0.03	0.06	1.00

Notes: Panel A reports the correlation matrix for revenue exposures to the US in 2022. Panel B reports the correlation matrix for cost exposures to China in 2022. Correlations are computed across Italian local labor markets (LLMs).

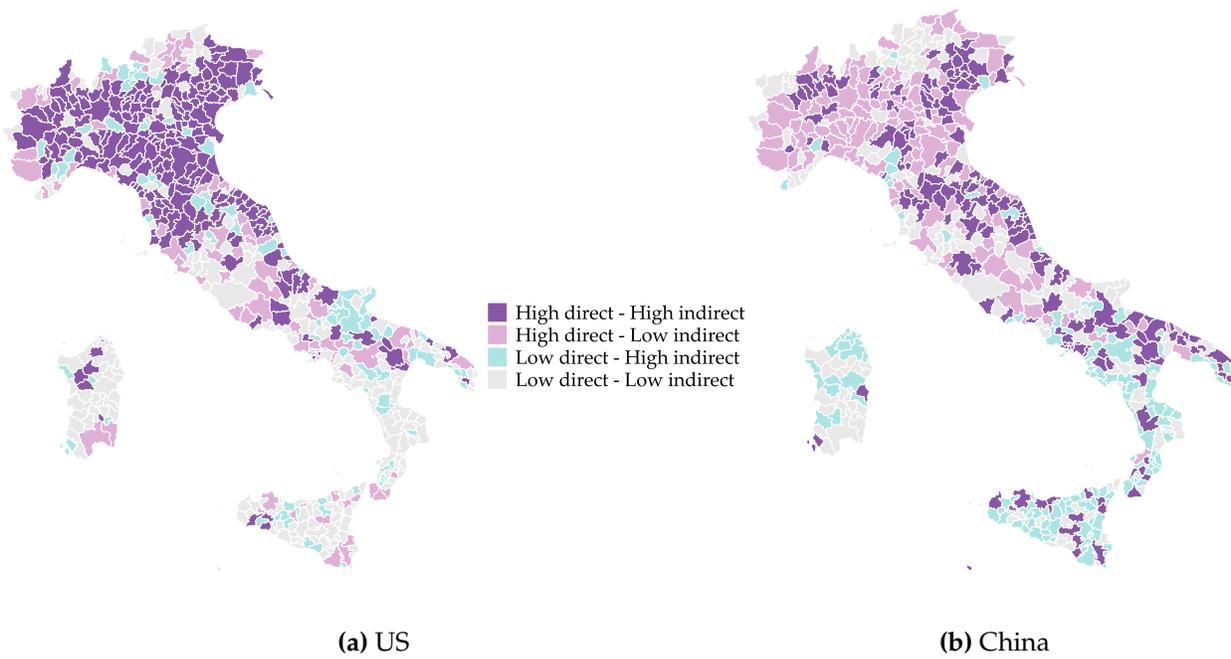
The importance of local concentration of direct and indirect connections for exports to the US is confirmed by looking at the geographical distribution of exposures reported in the map in Figure 3a. A large number of LLMs in the Center-North register exposure levels above the median in both direct and indirect terms. Conversely, in the Center-South, LLMs with exposure below the median for both indicators prevail. On the import side, the picture is quite different. Figure 3b shows that only direct exposure is concentrated in the Center-North LLMs, whereas high indirect exposure displays a much more uniform distribution across different areas, with many districts in the Center-South showing indicator values above the median.

4.3 Sectoral aggregation and transmission

Figures 4a and 4b report the sectoral decomposition of exposures to exports to the US and imports from China across the quintiles of the distribution of LLMs' total exposures.¹⁴

¹⁴Figures B.5a and B.5b report the decomposition of exposures across LLMs.

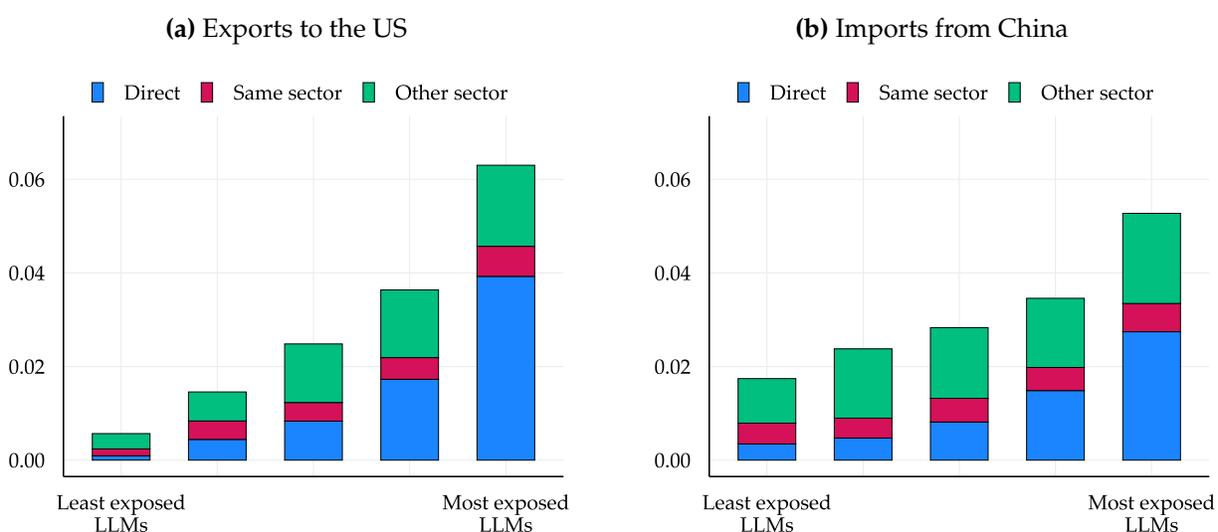
Figure 3: Direct vs. indirect exposure by LLM



Notes: Figure 3a shows the distribution of local labor markets (LLMs) by the combination of direct and indirect revenue exposures to the US in 2022. Figure 3b shows the corresponding distribution for cost exposures to China in 2022. Revenue exposures are aggregated using revenues in 2022, while cost exposures are aggregated using costs in 2022. We classify exposure in each LLM as high or low based on whether its exposure value is above or below the national median.

Grouping LLMs by exposure intensity, we find that cross-sector indirect linkages constitute more than half of overall exposure among LLMs with exposure at or below the median (Figures 4a and 4b). For these LLMs, within-sector exposure is also relatively important, whereas direct revenue and cost exposures primarily drive the highest exposure levels. Overall, the cross-sector channel accounts for about two-third of the total indirect exposure, both for exports to the US and for imports from China. The within-sector indirect channel accounts for about 24% of the overall indirect exposure of local revenues to exports to the United States, and it represents 23% of the indirect exposure associated with purchases from China.

Figure 4: Decomposition of exposure by type of sectoral links across exposure quintiles



Notes: Figure 4a shows the decomposition of exposure to US exports to the US by type of sectoral links across quintiles of the exposure distribution; Figure 4b shows the corresponding decomposition for exposure to imports from China. Revenue exposures are aggregated at the LLM and quintile level using revenues in 2022, while cost exposures are aggregated using costs in 2022. Quintiles are computed over LLM-level exposure.

Table 4 shows how total exposure to US exports and Chinese imports is distributed across broad sectoral groups and different types of exposures. For US exports (Panel A), the manufacturing sector dominates, accounting for 61.8% of total exposure—mostly due to its overwhelming contribution to direct exposure (84.2%). Indirect exposure is more evenly spread across sectors: manufacturing share accounts for 45.3% of the total, while trading activities and energy represent 19.8% and 11.9%, respectively. Transport also accounts for a non-negligible share of indirect exposure (6.2%). For exposure to Chinese imports, the distribution is less concentrated. Manufacturing and trade each contribute roughly equally to total exposure (40.7% and 36.8%, respectively), although manufacturing is more prominent on the direct side (49.7%) and trade on the indirect side (35.6%).

Within manufacturing, machinery and fabricated metals are the most prominent sectors in terms of contribution to the total exposure: for the exposure to the US market, they account for more than 16% of total exposure whereas for the exposure to the Chinese market, they account for 10.5%.

Table 4: Sectoral shares of exposure to the US and China (percent of column total)

Sector	A: US exposure			B: China exposure		
	Direct (%)	Indirect (%)	Total (%)	Direct (%)	Indirect (%)	Total (%)
Manufacturing	84.2	45.3	61.8	49.7	35.2	40.7
<i>Machinery</i>	16.0	4.0	10.1	9.0	5.5	6.8
<i>Fabricated Metals</i>	4.4	7.8	6.3	3.3	4.0	3.7
Trade	11.4	19.8	16.0	38.6	35.6	36.8
Other Services	3.4	15.3	9.9	4.6	19.2	13.6
Energy	0.0	11.9	6.6	7.0	3.2	4.6
Transport	0.3	6.2	3.6	0.1	5.6	3.5
Primary	0.7	1.4	1.1	0.0	1.2	0.7

Notes: Panel A reports sectoral contributions to US-export exposure. Panel B reports sectoral contributions to China-import exposure. Revenue exposures are aggregated at the national level using 2022 revenues; cost exposures use 2022 costs. *Manufacturing* includes NACE 10–33; *Trade* 45–47; *Energy* 35; *Transport* 49–53; *Primary* agriculture/primary sectors; *Other Services* remaining services.

4.4 Counterfactual exposures

In this subsection, we conduct two counterfactual exercises. The first isolates the role of wholesale and retail trade in shaping international supply and sales networks. Specifically, we remove, in turn, the direct trade connections of wholesale and retail firms with the United States and China, and then recompute counterfactual trade exposures. Comparing these counterfactual exposures with the baseline ones obtained from the actual data provides evidence on the extent to which the two sectors act as sources and intermediaries of external shocks to the domestic economy.

The second counterfactual exercise examines the role of large trading firms in shaping exposure to the US and Chinese markets. We focus, in turn, on the top- k exporters and importers, and reallocate their exports to the United States and imports from China to the other countries they trade with. This procedure preserves firm size while neutralizing their direct exposure to the markets of interest.

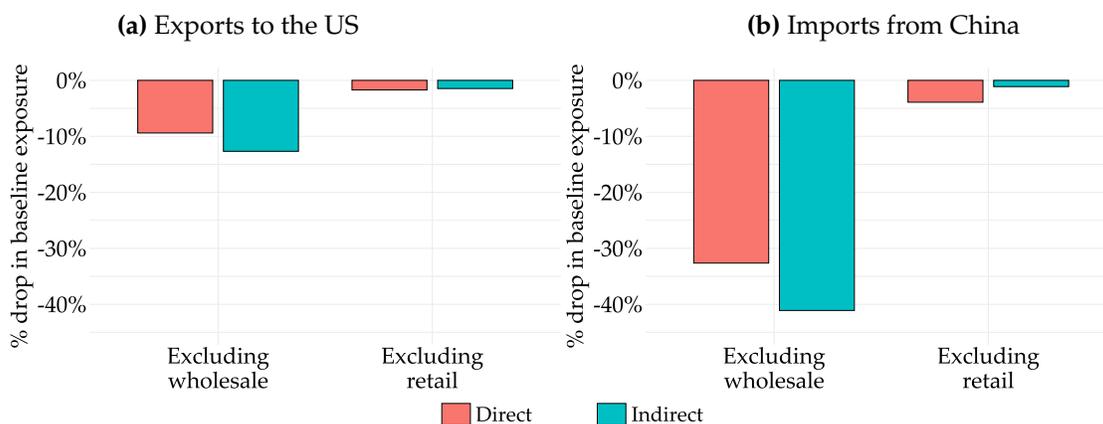
4.4.1 The role of wholesalers

Trading, logistics, and distribution sectors often account for a significant share of direct export and import activities, serving as intermediaries that connect domestic producers and consumers with foreign markets (Bernard et al., 2007; Crozet, Lalanne and Poncet, 2013; Ganapati, 2025).

Consistent with prior evidence, Table 4 shows that wholesale trade conveys substantial trade volumes on the import side, while playing a more limited role on the export side. In particular, wholesale trade accounts for less than 10% of Italy’s direct exports to the United States. However, it contributes indirectly through upstream domestic linkages: approximately 12% of overall indirect revenue exposure is mediated by wholesale firms (Figure 5a). On the import side, wholesale trade is significantly more prominent, representing roughly one-third of total direct exposure to imports from China. It also drives a large portion of the domestic propagation of shocks: over 40% of indirect cost exposure is attributable to linkages involving wholesalers (Figure 5b). The prominent role of wholesale intermediaries in imports from China may mitigate the risk of supply disruptions associated with geopolitical tensions. Evidence from Perello (2025) indicates that intermediaries tend to maintain more diversified and resilient supply networks than direct manufacturing importers, thereby enhancing overall supply chain stability.

In contrast, the role of retail trade in mediating international exposure—whether direct or indirect—is negligible in both export and import channels.

Figure 5: Drop in exposure after excluding wholesale and retail firms



Notes: Figure 5a shows the drop in exposure to exports to the US when excluding wholesale and retail firms. Figure 5b shows the drop in exposure to imports from China when excluding wholesale and retail firms. Revenue exposures are aggregated at the national level using revenues in 2022, while cost exposures are aggregated using costs in 2022.

4.4.2 The role of top trading firms

Table 5 reports the national-level direct, indirect, and total exposure to US export exports and Chinese imports, after sequentially excluding the top traders in each transaction. The results reveal the disproportionate role of a relatively small number of firms in shaping aggregate exposures.

Panel A shows that the top 10 exporters to the US account for nearly 14% of total exposure, with the average total exposure falling from 3.4% in the baseline to 3.2% (when only the top exporter is excluded), and further to 2.8% after excluding the top 10 firms. Excluding the top 100 exporters reduces national exposure substantially, by about 40%, highlighting a high degree of concentration.

Panel B presents the results for imports from China. Removing the top 10 importers delivers a smaller change in exposure relative to exports. Similarly, excluding the top 100 importing firms would lead to a drop in exposure by about 25%. Interestingly, the indirect component remains substantial even after removing top direct importers, suggesting that inter-firm linkages continue to propagate exposure through the domestic supply network.

These findings emphasize the granular role of large firms in driving national exposure to external shocks—albeit differently on the export and import sides—and underscore the systemic importance of indirect channels, even when major trading firms are excluded.

Table 5: Direct and indirect exposures after excluding top traders

A: US-export exposure				B: China-import exposure		
Top- k excluded	Direct (%)	Indirect (%)	Total (%)	Direct (%)	Indirect (%)	Total (%)
<i>Baseline</i>	1.5	1.9	3.4	1.4	2.2	3.6
1	1.4	1.8	3.2	1.4	2.2	3.5
3	1.4	1.7	3.1	1.3	2.2	3.5
5	1.3	1.7	3.0	1.3	2.1	3.5
10	1.2	1.6	2.8	1.3	2.1	3.3
50	1.0	1.3	2.3	1.1	1.8	3.0
100	0.8	1.2	2.0	1.0	1.7	2.7
500	0.5	0.7	1.2	0.7	1.2	1.9
1,000	0.4	0.5	0.9	0.5	0.9	1.5

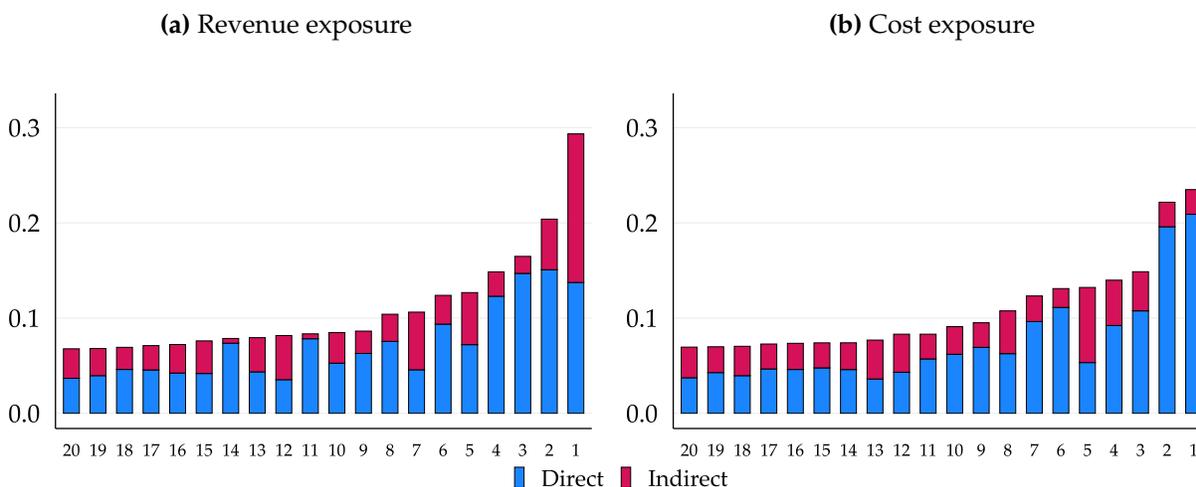
Notes: Panel A excludes the top k exporters to the US in terms of value (US-export exposure). Panel B excludes the top k importers (China-import exposure). Revenue exposures are aggregated at the national level using revenues in 2022, while cost exposures are aggregated using costs in 2022. In *Baseline*, we report the exposure without excluding any exporters and importers.

4.5 Highly exposed local labor markets

Since factor mobility across sectors and places is limited, geographically concentrated risks can translate into sizable local losses even when the average national shock is small (Caliendo, Dvorkin and Parro, 2019). Understanding how domestic economies are embedded in global value chains at a granular, sub-national scale is therefore essential to assess vulnerabilities and resilience. With our data we can focus on LLMs most exposed to the considered external risks. Previous research has shown the importance of the spatial agglomeration of Italian firms for their productivity and resilience to shocks (Di Giacinto et al., 2014). In this section, we highlight that many of the most exposed LLMs are also highly specialized in a narrow set of production activities. This specialization can magnify their vulnerability with repercussions potentially extending to the whole LLM.

Figures 6a and 6b rank the twenty LLMs most exposed to exports to the United States and to imports from China, respectively. Among the top exporters, the share of revenues exposed to the US market ranges from just under 10% to almost 30%; a similar range holds for the cost share associated with purchases of Chinese goods among the most exposed importers.

Figure 6: Decomposition of exposure by type across the top-20 most exposed LLMs

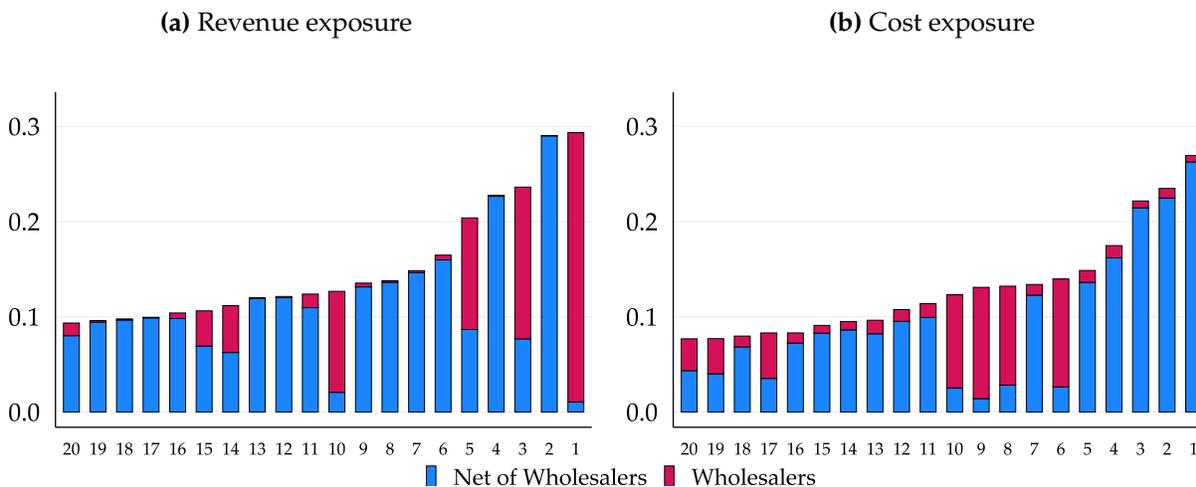


Notes: Figure 6a shows the decomposition of exposure to US exports to the US by type in the top-20 most exposed LLMs; Figure 6b shows the corresponding decomposition for exposure to imports from China. Revenue exposures are aggregated at the LLM and quintile level using revenues in 2022, while cost exposures are aggregated using costs in 2022. Quintiles are computed over LLM-level exposure.

While direct exports/imports constitute the larger component in most cases, indirect exposure—arising from domestic firm-to-firm propagation—is a first-order driver in several right-tail LLMs. In many of the most exposed areas, total exposure sits well above

direct exposure. Notably, for a number of LLMs highly exposed to Chinese imports, domestic propagation pushes total exposure into the upper tail despite relatively modest direct importing activity within the LLM itself. This highlights how upstream input dependencies located elsewhere in the country transmit exposure to local buyers, widening the geography of vulnerability beyond direct imports.

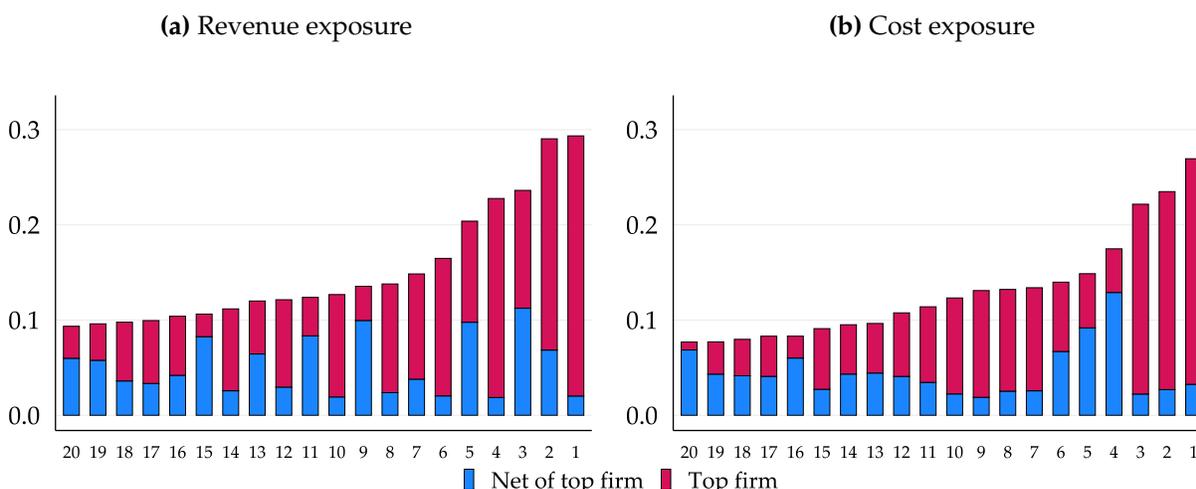
Figure 7: Decomposition of total exposure by sector (wholesalers vs. others) across the top-20 most exposed LLMs



Notes: Figure 7a shows the decomposition of total exposure to exports to the US by sector (wholesalers vs. other sectors) in the top-20 most exposed LLMs; Figure 7b shows the corresponding decomposition for exposure to imports from China. Revenue exposures are aggregated at the LLM level using revenues in 2022, while cost exposures are aggregated using costs in 2022.

Those extreme exposures are not systematically explained by wholesale intermediaries, which play a relevant role only in few top-exposed LLMs (Figures 7a and 7b). Conversely, the right tail of LLMs risk exposure is more often associated with few large manufacturing firms and a narrow set of (HS4) product lines, both on the export and import. For most LLMs in this tails, the leading exporter to the US and the main importer from China account for approximately two-thirds of total exposure (Figures 8a and 8b). These firms often specialize in a single HS4 product category, which alone is responsible for over 80% of exposure in the right tail (Figures B.6a and B.6b). This result aligns with the rivet effect proposed by Martin and Sunley (2015), whereby dominant firms within LLMs serve as anchors for regional production systems through networks of suppliers. The failure or decline of such firms in response to trade shocks can trigger cascading disruptions, potentially leading to the collapse or significant contraction of the entire LLM economy.

Figure 8: Decomposition of total exposure by firm size (top exporter/importer vs. others) across the top-20 most exposed LLMs



Notes: Figure 8a shows the decomposition of total exposure to exports to the US between the top exporter and the other firms within each of the top-20 most exposed LLMs; Figure 8b shows the decomposition of total exposure to imports from China between the top importer and the other firms within the top-20 most exposed LLMs. Revenue exposures are aggregated at the LLM level using revenues in 2022, while cost exposures are aggregated using costs in 2022.

The evidence presented in this section reveals a clear distinction between the drivers of exposure in the most vulnerable LLMs and those that dominate national average. While wholesale intermediaries play an important role in aggregate transmission—especially for Chinese inputs—the most exposed LLMs are typically those that host a dominant trader or exhibit a tightly focused product mix, which in turn propagates risk through local and extra-local supplier networks.

Lastly, the overlap between the list of product more exposed at the national level and those that drives the exposure of top-exposed LLMs is only partial. In the case of exports to the US, four HS4 product categories simultaneously drive both aggregate and local exposure. However, six of the most exported products at the national level do not contribute to tail risks at the LLM level (Table B.1). A similar pattern emerges on the import side: only three products appear in both the top 10 list of aggregate imports and the top 10 list of products driving the highest exposure across LLMs (Table B.2). This finding highlights a disconnect between national trade patterns and localized vulnerabilities.

5 Comparing indirect exposure: Firm-Level vs. Input–Output

In this last section, we show that indirect exposure obtained from firm-to-firm transactions data is substantially higher than that derived from inter-country input–output (ICIO) tables. The core limitation of ICIO tables lies in their proportionality assumption (Koopman, Wang and Wei, 2012; Kee and Tang, 2016; De Gortari, 2019; Bems and Kikkawa, 2021). By construction, ICIO tables treat all firms within a sector and geographic unit as if they used the same mix of inputs, regardless of whether these inputs are destined for the domestic market or for exports. This assumption overlooks the well-documented heterogeneity in both sourcing and selling strategies.¹⁵

The proportionality assumption can also bias the estimation of indirect exposure to foreign shocks. In particular, when more import-intensive or export-oriented firms are also larger and more central in the domestic production network, maintaining numerous buyer and supplier relationships—as is typically the case (Bernard et al., 2022)—ICIO-based exposure measures systematically underestimate true indirect exposures. Firm-level data allow us to directly observe supply relationships between firms and to measure the extent to which import or export dependence spills over onto domestic suppliers. This approach relaxes the proportionality assumption by exploiting actual variation in import and export intensity across firms and their role in the production network.

To illustrate the systematic bias in ICIO-based estimates of indirect exposure, we compute indirect exposure at the regional-sector level for Italy using both ICIO data and firm-to-firm transactions data.¹⁶ For the ICIO-based measure, we rely on FIGARO-REG, Eurostat’s state-of-the-art inter-country and inter-regional input–output database (Lopez Alvarez, Galiano Bastarrica and Rueda-Cantucho, 2025). FIGARO-REG covers 288 EU regions at the NUTS2 level, plus 16 major non-EU trading partners, providing a 10-sector breakdown for each geographic unit.¹⁷ For the firm-level measure, we aggregate our indirect exposure measures to the same sector-region level to ensure comparability with FIGARO-REG.¹⁸

¹⁵Bems and Kikkawa (2021) shows that ICIO tables typically underestimate a country’s participation in GVCs, measured as the import content of exports, because more import-intensive firms are often also more export-oriented, and the proportionality assumption dilutes this feature. Conversely, ICIO tables can overestimate GVCs involvement if less import-intensive firms dominate exports—a situation that is rare, occurring, for example, in commodity exporters like Chile, whose exports require minimal foreign inputs.

¹⁶The literature does not provide a measure of indirect exposure through domestic supply chains based on ICIO data. In Appendix C, we outline how we construct such a measure using FIGARO-REG data.

¹⁷The dataset was released in February 2025 and accessed in May 2025. The last available data is for 2017.

¹⁸While the rest of the analysis relies on LLMs, this section hinges on regional aggregation due to the available level of aggregation of FIGARO-REG.

5.1 Results

Table 6 compares the ICIO-based measures with those based on firm-to-firm transactions data. Across Italian regions, indirect exposures derived from firm-level data (FATTEL) are consistently higher than those from FIGARO.¹⁹ This holds both for exposures to Chinese imports and to US exports. The gap is often large, suggesting—as expected—ICIO-based measures substantially understate the strength of domestic supply chain linkages compared to what granular data reveal. On the import side, FATTEL estimates cluster around 2–2.7 for most regions, whereas FIGARO values are typically below 1. The largest discrepancy is found in Molise, with an exceptionally high FATTEL value (5.89) against only 0.72 in FIGARO. On the export side, FATTEL exposures are again higher than FIGARO, generally ranging between 1.5 and 2.3 versus 0.6–1.2 in FIGARO. The strongest differences are visible in Friuli-Venezia Giulia (2.77 vs 0.88) and Basilicata (2.20 vs 0.63). By contrast, some central regions (Lazio, Emilia-Romagna, Tuscany) show relatively smaller gaps, indicating that in some regions FIGARO aggregation may approximate granular linkages more closely.

Lastly, Figure B.7 compares the two measures at the region-sector level. Again, the contrast is striking: indirect exposure based on ICIO tables is consistently lower than the one obtained from granular firm-to-firm data.

The FIGARO dataset also lets us quantify indirect exposure through *non-domestic* supply chains—an aspect that cannot be captured using firm-level data from the domestic economy alone.²⁰ At the regional level, estimated exposures range approximately from 0.7 to 1.1 on the import side and from 0.5 to 1.1 on the export side. Although these figures may still underestimate the true extent of cross-border exposure, they reflect the current state of the art, given the limited availability of cross-country firm-level transaction data due to confidentiality constraints. Therefore, to achieve the most accurate assessment of *total* indirect exposure, we recommend integrating advanced regional ICIO data with firm-to-firm transaction data wherever such information is accessible.

¹⁹It is important to acknowledge certain systematic differences between firm-level data and the FIGARO dataset. First, while our analysis benefits from access to firm-level data for the year 2022, the most recent figures available from FIGARO-REG date back to 2017. Second, FIGARO-REG does not include labor cost information, which we incorporate in the denominator of our import exposure measure. Thus, this omission works to our disadvantage. Third, in ICIO tables investments are found in final demand, while in our firm-level data they are found as domestic transactions between firms.

²⁰The algebraic derivation of this exposure is available upon request.

Table 6: Indirect exposure by region: FATTEL vs. FIGARO, China vs. US

Region	China		US	
	FATTEL	FIGARO	FATTEL	FIGARO
Piedmont	2.22	0.84	2.03	0.92
Aosta Valley	2.03	0.62	1.03	0.66
Lombardy	2.07	0.65	2.13	0.84
Trento	2.08	0.54	1.71	0.60
Bolzano	1.76	0.53	1.20	0.74
Veneto	2.54	0.76	2.25	1.19
Friuli-Venezia Giulia	2.26	0.87	2.77	0.88
Liguria	1.74	0.95	2.11	0.70
Emilia-Romagna	2.41	0.93	2.05	1.20
Tuscany	2.48	0.69	2.25	1.12
Umbria	2.55	0.79	1.74	0.77
Marche	2.63	0.71	2.17	0.93
Lazio	1.70	0.71	1.39	1.19
Abruzzo	2.51	1.04	1.78	0.58
Molise	5.89	0.72	1.44	0.40
Campania	2.67	0.87	1.50	0.81
Apulia	2.51	0.90	1.76	0.85
Basilicata	2.67	0.85	2.20	0.63
Calabria	2.72	0.81	1.05	0.74
Sicily	2.30	0.76	1.11	0.67
Sardinia	2.05	0.86	0.97	0.60

Notes: The table reports average indirect exposure computed from FATTEL and FIGARO data, by Italian region. Columns 2–3 refer to exposure to China; columns 4–5 refer to exposure to the United States.

6 Conclusions

This paper investigates how domestic production networks shape exposure to foreign trade shocks, highlighting heterogeneity across geography and sectors. Using firm-to-firm transaction data for Italy in 2022, we construct measures of direct and indirect exposure to Chinese imports and US exports at the firm, local labor market and national levels. Our findings emphasize the role of domestic linkages in determining external exposure, beyond what suggested by firms’ direct exporting and importing activities.

We show that indirect channels arising from firm-to-firm linkages contribute substantially to overall exposure. In many cases, LLMs with low direct exposure emerge in the upper tail of the distribution once indirect effects are accounted for. The propagation of exposures often occurs across long distances: more than 60% of indirect exposure to US exports and Chinese imports originates from non-contiguous LLMs, highlighting the national scope of domestic supply chains.

Sectoral decomposition further reveals that while manufacturing plays a central role in driving direct exposure, wholesale and trade intermediaries are key channels for indirect propagation, especially on the import side. Counterfactual exercises confirm the mediating role of wholesale trade in transmitting exposure across firms and regions. Moreover, granularity matters as large exporting and importing firms account for a substantial share of exposures to foreign trade.

Our findings suggest that assessments of trade vulnerability based solely on direct exposure and aggregate outcomes can be misleading. Policymakers must account for the geography of domestic production networks when evaluating risks from external shocks—such as trade tensions, tariffs, or input supply disruptions—, as economic resilience depends not only on a region’s direct trade, but also on its embeddedness within national supply chains. While aggregate risks may appear moderate, exposure to international trade disruptions can be disproportionately high for certain LLMs, and affect a significant share of their economic activity. Effective policy design should therefore consider both national-level risk drivers and local-level exposures. This perspective enables more targeted interventions accounting for region-specific vulnerabilities.

Enabling such assessments requires access to highly detailed firm-level data, such as those used in this work. It is therefore crucial to collect and make such microdata available for research purposes. Looking ahead, matching granular firm-level data *across* countries will be essential to accurately measure indirect exposures through international supply chains. In this context, we support the call by [Pichler et al. \(2023\)](#) for an “alliance to map global supply networks”, and leave this important challenge for future research.

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A Data Appendix

We construct the analytical dataset by integrating the following sources:

- **FATTEL (Electronic Invoicing Data):** Data are provided by SOGEI S.p.A. and they cover all the domestic B2B and transactions and the B2C transactions that require the emission of an electronic invoice. The dataset contains the total taxable amount of invoices issued in each quarter, broken down by seller and buyer. For confidentiality, the transactions that involve sole proprietorships or consumers are aggregated. However, for sole proprietorships, we also have information on the sector (NACE 2-digit). Outliers are identified and flagged by the data provider.
- **Dogane (Customs Transactions):** Includes export and import flows of physical goods, matched to firms via VAT numbers. The dataset excludes natural gas in gaseous form and electricity. Overall, these products account for 0.4% of the Italian export and 9.8% of the import as of 2022.
- **Cerved (Balance Sheet Data):** Provides reclassified financial statements of Italian corporations, partnerships are excluded from the dataset.
- **Infocamere (Firm Registry):** Supplies legal form, sector classification (NACE), firm age, and location. Used to fill missing identifiers and validate firm-level information.
- **INPS and Auxiliary Employment Data:** Reports for each firm the number of employees and their spatial distribution, detailed at the municipal level.
- **ISTAT (Local Labor Markets):** Maps municipalities into local labor markets identified by the national institute of statistics.

Data Processing Steps Firm identifiers are harmonized across datasets, including corrections for sole proprietorships and VAT groups.²¹ In the case of multiplant firms, characterized by a single VAT identifier and multiple plants, we impute transactions to each plant proportionally to the number of employees at the municipality level. Based on 2022 balance sheet data, Italian corporations belonging to VAT groups account for approximately 6% of total revenues. In our exercise, we consolidate all transactions at the group level for VAT groups.

²¹A VAT group is a fiscal arrangement that allows multiple entities — closely linked financially, economically, and organizationally — to be treated as a single taxable person for VAT purposes. This means that intra-group transactions are not subject to VAT, and the group submits a single VAT return.

We merge registry and financial data, then match transaction records (FATTEL, Dogane) to firms. Transactions are aggregated at the firm-pair level for the entire year 2022. For firms in VAT groups, transactions are consolidated at the group level. By combining these datasets, we compute total revenues and total costs for each enterprise. Total revenues are calculated as the sum of the total taxable amount of invoices issued by the firm and its exports. Total costs are calculated as the sum of the total taxable amount of invoices received by the enterprise, total imports, and labor costs.

A few caveats are in order. Revenues from the export of services are not accounted for due to the lack of granular data. For 2022, the export of services from Italy, excluding travel, financial, and insurance services, is around €70 billion, whereas for imports is €90 billion. Moreover, the data do not allow us to distinguish between revenues from ordinary business activities and those resulting from disinvestment. At the same time, total costs include also investments, which cannot be separated from expenditures on intermediate goods and services. Hence, the total costs may be inflated for firms undergoing an expansion of their investments. Finally, when the balance sheet is not available, labor costs are estimated based on the firm's sector of activity and number of employees.

To remove outliers from the data, we compare total revenues from our integrated dataset with the sum of turnover and disinvestment reported in the balance sheet. This helps to determine whether to retain or exclude flagged observations. VAT groups and enterprises are excluded from this comparison as well as with IAS financial statements, as their turnover is calculated using different criteria. In cases where the financial statement is unavailable (including VAT groups and IAS financial statements), we apply the most frequently adopted decision: retaining the outliers.

Correcting Turnover and Costs Due to the data limitations described above, our estimates of turnover and costs may be subject to downward bias. This bias could artificially amplify the direct and indirect exposure calculated in our exercise. To address this issue, we compare our estimates with financial statement data for firms with available balance sheets. We detect significant underestimation in several sectors, particularly in transportation and trade. In retail trade, transactions with consumers are generally not subject to electronic invoicing requirements. Similarly, air and maritime transport often operate internationally, with a substantial portion of sales excluded from our dataset. For these reasons, we correct our dataset by adding residual sales to an unknown counterpart whenever our turnover estimates for a specific firm fall below the official figures from the financial statement.

The underestimation of supply costs is less likely for trading sectors, thus we apply a

similar adjustment only to the transportation sector, where deviations from balance sheet data are more pronounced, probably due to purchases of fuel and supplies abroad.

In some cases, especially for small firms in the retail trade sector, financial statements are not available. In such instances, we compare estimated costs with estimated turnover and adjust turnover whenever it is lower than the estimated costs.

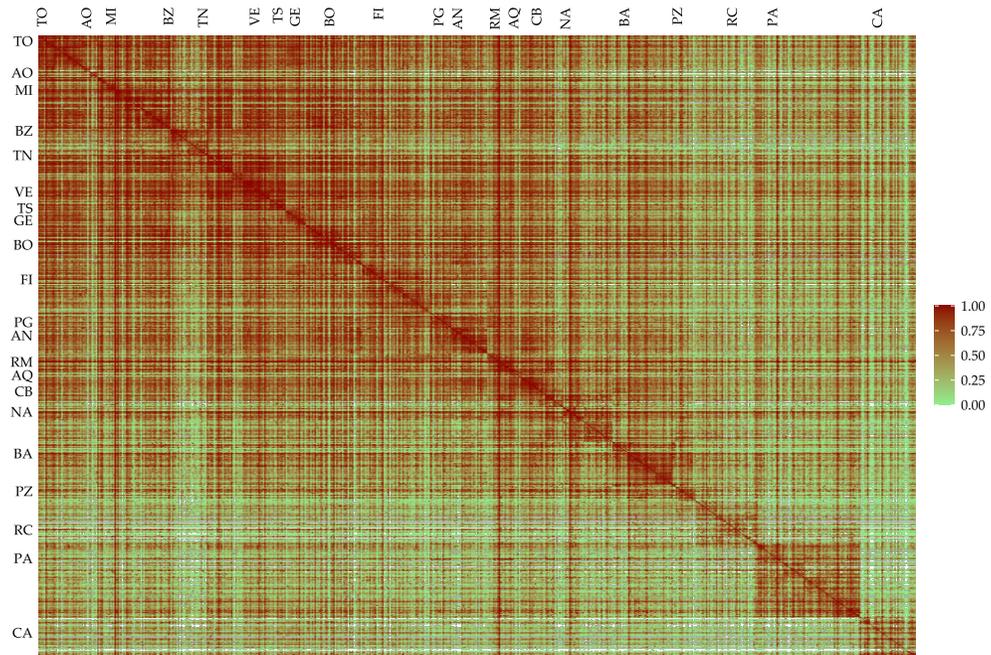
B Additional Figures and Tables

Figure B.1: Median firm's sales across Local Labor Markets



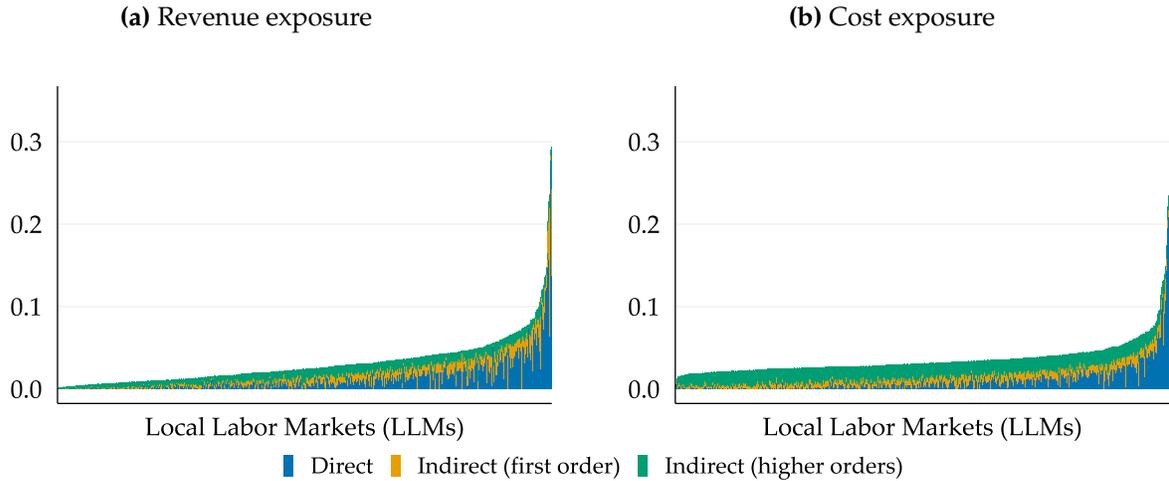
Notes: Median firms' sales across Italian Local Labor Markets (LLMs) in 2022. LLMs as defined by ISTAT in the 2019 revision.

Figure B.2: Heatmap of transaction flows between LLMs



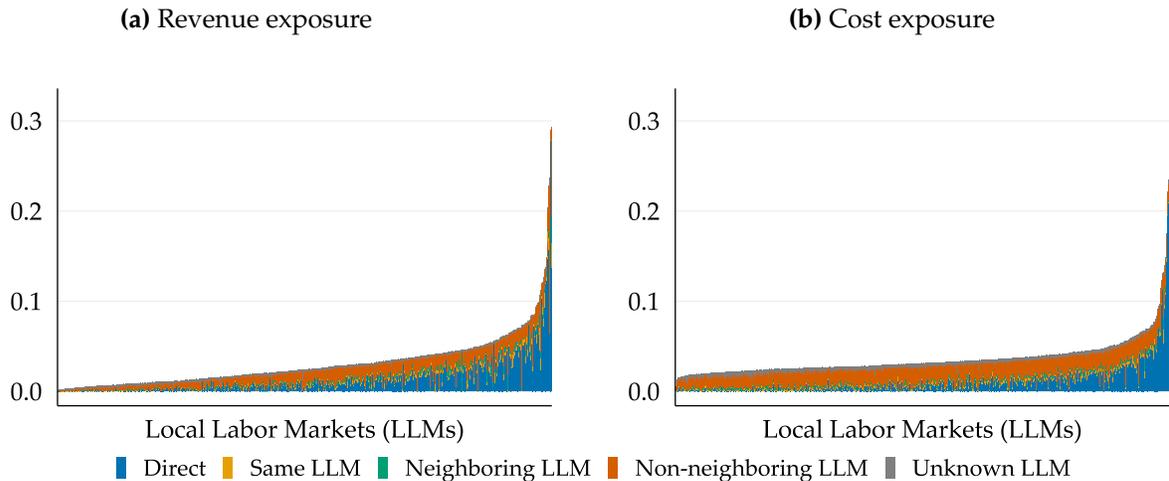
Notes: Heatmap of transaction flows between local labor markets (LLMs) in 2022. Rows correspond to origin LLMs, columns to destination LLMs. Labels indicate the capital cities of Italy's 19 regions and two autonomous provinces. Each square represents the percentile of the trade flow value between two LLMs within the nationwide distribution.

Figure B.3: Exposures across LLM, direct vs. indirect



Notes: Figure B.3a presents the decomposition of revenue exposures to US exports across LLMs by type of exposure (direct, first-order indirect, and higher-order indirect) in 2022, while Figure B.3b reports the corresponding decomposition for cost exposures to Chinese imports. *Indirect (first order)* refers to the contribution from firms that are either a buyer’s buyer or a supplier’s supplier. *Indirect (higher orders)* captures the contribution from firms that are farther along the domestic supply chain. Revenue exposures are aggregated using firm-level revenues in 2022, while cost exposures are aggregated at the LLM level using firm-level cost data from the same year.

Figure B.4: Decomposition of exposure by proximity of partner LLMs



Notes: Figure B.4a shows the decomposition of US revenue exposures across LLMs by type of partner LLM in 2022, while Figure B.4b reports the corresponding decomposition of Chinese cost exposures. *Same LLM* denotes the contribution to indirect exposure from firms located in the same LLM. *Neighboring LLM* captures the contribution from firms located in contiguous LLMs, whereas *Non-neighboring LLM* refers to the contribution from firms in non-contiguous LLMs. *Unknown LLM* is a residual category comprising the contribution of firms operating in an unknown LLMs. Revenue exposures are aggregated using revenues in 2022, while cost exposures are aggregated at the LLM-level using costs in 2022.

Table B.1: Top-10 HS4 codes for exposure to exports to the US at the national and LLM level

Code	Product	Aggregate	Most exposed LLMs	Both
8703	Motor vehicles for people	X		
2710	Petroleum-based oils	X		
3004	Packaged medicaments	X		
7113	Jewellery of precious metals	X		
9403	Furniture and parts	X		
6403	Leather footwear	X		
0406	Cheese and curd		X	
9303	Firearms and devices		X	
8431	Machinery components		X	
2206	Other fermented drinks		X	
2201	Mineral and aerated water		X	
9003	Frames for spectacles		X	
9004	Spectacles and goggles			X
8901	Ships and cargo vessels			X
3002	Vaccines and blood products			X
2204	Wine from fresh grapes			X

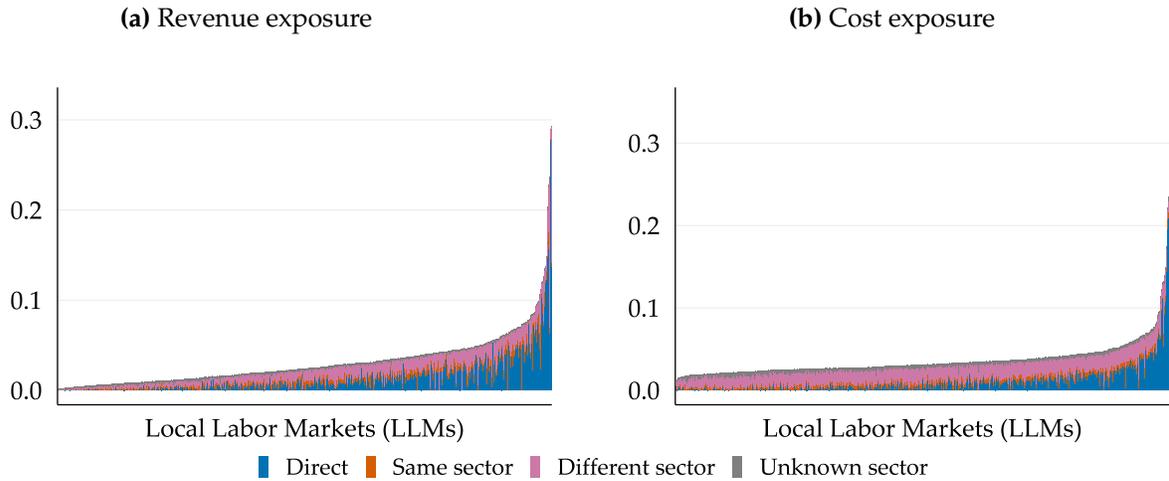
Notes: In each panel, we focus on 10 products identified at the 4-digit level of the *Harmonized System*. The *National level* panel reports the 10 products with the highest total export value to the US in 2022. In the *LLM level* panel, we consider the LLMs with the highest total exposure to exports to the US and, for each, select the product with the highest import value. From this list, ordered by total exposure, we extract the first 10 unique products. The *Both* category includes products that appear in both the *National level* and *LLM level* lists.

Table B.2: Top-10 HS4 codes for exposure to imports from China at the national and LLM level

Code	Product	Aggregate	Most exposed LLMs	Both
8517	Telephones and communication devices	X		
4202	Bags, cases and containers	X		
8708	Motor vehicle parts	X		
8501	Electric motors and generators	X		
7219	Stainless steel flat products	X		
9405	Lamps and light fittings	X		
2933	Heterocyclic compounds	X		
8703	Motor vehicles for people		X	
5102	Animal hair		X	
8431	Machinery parts		X	
9003	Frames for spectacles		X	
9505	Festive articles and decorations		X	
8418	Refrigerators and freezers		X	
1518	Animal or vegetable oils (inedible, modified)		X	
8507	Electric accumulators			X
8504	Transformers and converters			X
8415	Air conditioning machines			X

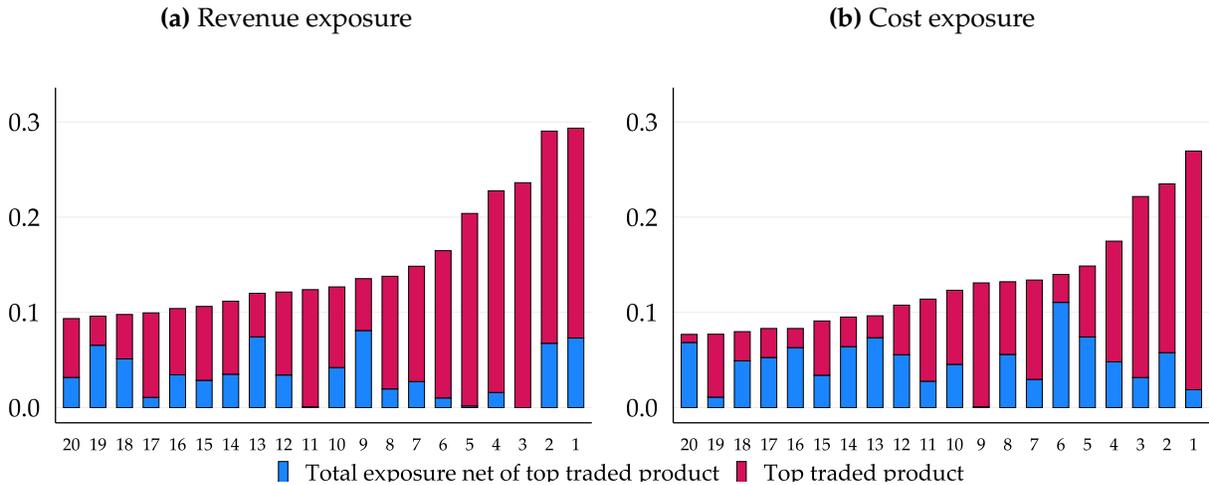
Notes: In each panel, we focus on 10 products identified at the 4-digit level of the *Harmonized System*. The *National level* panel reports the 10 products with the highest total import value from China in 2022. In the *LLM level* panel, we consider the LLMs with the highest total exposure to imports from China and, for each, select the product with the highest import value. From this list, ordered by total exposure, we extract the first 10 unique products. The *Both* category includes products that appear in both the *National level* and *LLM level* lists.

Figure B.5: Exposures across LLMs by partner sector



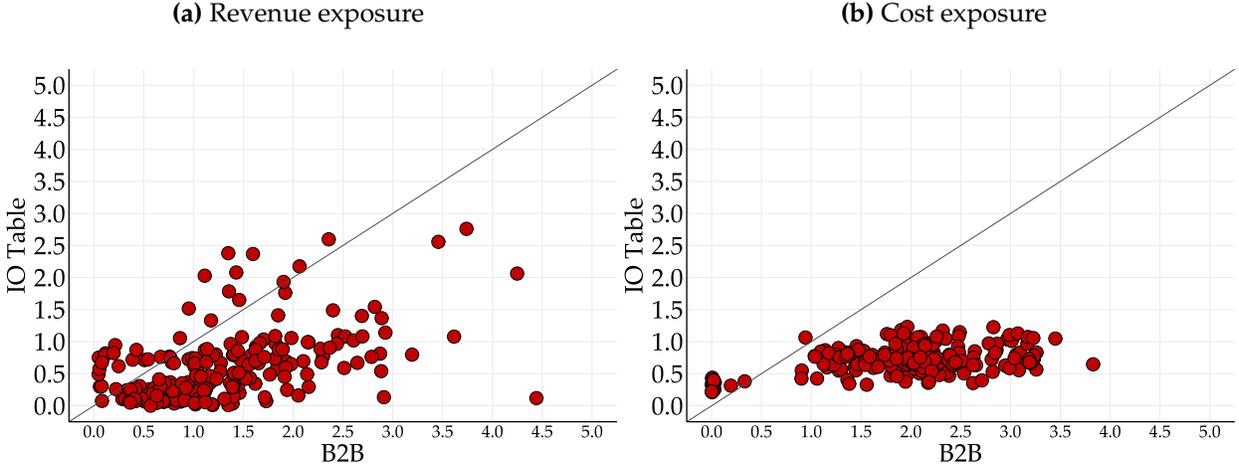
Notes: Figure B.4a shows the decomposition of US revenue exposures across LLMs by type of partner sector in 2022, while Figure B.4b reports the corresponding decomposition of Chinese cost exposures. Sectors defined as the first 2-digit of the NACE code. *Same sector* denotes the contribution to indirect exposure from firms operating in the same sector. *Different sector* captures the contribution from firms operating in a different sector. *Unknown sector* is a residual category comprising the contribution of firms operating in an unknown sector. Revenue exposures are aggregated at the LLM-level using revenues in 2022, while cost exposures are aggregated using costs in 2022.

Figure B.6: Decomposition of total exposure by firm size (top exporter/importer vs. others) across the top-20 most exposed LLMs



Notes: Figure B.6a shows the decomposition of total exposure to exports to the US between the top exported product (at the HS 4-digit level) and the other products within each of the top-20 most exposed LLMs; Figure B.6b shows the decomposition of total exposure to imports from China between the top imported product and the other products within the top-20 most exposed LLMs. Revenue exposures are aggregated at the LLM level using revenues in 2022, while cost exposures are aggregated using costs in 2022.

Figure B.7: Scatter plot of indirect exposure across Italian regions and sectors, B2B data vs. Fattel



Notes: Figure B.7a shows indirect exposures measured through B2B data (from FATEL) and IO table data (from Figaro) across Italian regions and available sectors; Figure B.7b shows the analogous scatter for indirect exposure to imports from China. Revenue exposures are aggregated at the LLM using revenues in 2022, while cost exposures are aggregated using costs in 2022. Figure B.7b omits the data point for Molise – Wholesale and Retail Trade for graphical clarity: the B2B-based indirect exposure is 15, while the IO table-based exposure is only 0.6.

C Computing Indirect Exposure through Domestic Supply Chains with ICIO Data

Looking at the export side, consider a standard Inter-Country Input–Output (ICIO) framework with G countries and N sectors. Let $\mathbf{E}_{j,US}^G$ denote the $N \times 1$ vector of goods exported from Italian region j to the US. Then, the indirect exposure of an Italian region s through domestic supply chains to exports to the US ($\mathbf{IE}_{s,exp}^{US}$) can be expressed as:

$$\mathbf{IE}_{s,exp}^{US} = \left(\sum_{k \neq s, s, k \in ITA}^K \sum_{j \in ITA}^J \mathbf{A}_{s,k} \mathbf{L}_{k,j}^{ITA,ITA} \mathbf{E}_{j,US}^G \right) \oslash \mathbf{X}_s \mathbf{u}_N, \quad (\text{C.1})$$

where $\mathbf{L}_{k,j}$ is the $N \times N$ local Leontief inverse taking into account only the domestic chains, i.e. $(\mathbf{I} - \mathbf{A}_{ITA,ITA})^{-1}$, with $\mathbf{A}_{ITA,ITA}$ the direct requirements matrix of Italian regions' inputs in Italian regions' production. The matrix $\mathbf{A}_{s,k}$ instead captures the direct requirements of inputs from region s used in production in region k . To obtain relative rather than absolute measures, the numerator is normalized by total sales of the corresponding region–sector, where \mathbf{X}_s is an $N \times N$ diagonal matrix with region s 's total output on the main diagonal, and \mathbf{u}_N is an $N \times 1$ vector of ones.

The intuition is as follows. Indirect exposure reflects the sales of inputs (goods or services) by region s to another Italian region k , which then employs them—either directly or through multiple stages of domestic production through the Italian supply chains—to generate exports to the US. This can occur in three ways: (i) when $k = j$, region k uses inputs from s directly in its exports to the US; (ii) when $k \neq j$, region k uses inputs from s in the production of intermediate goods that are subsequently sold to another Italian region j , which in turn exports to the US; (iii) when $s = j$, region k uses inputs from s in the production of intermediate goods that are subsequently sold to the original Italian region s , which exports to the US (as k must be different from s).

On the import side, the indirect exposure of an Italian region s to imports from China through domestic supply chains ($\mathbf{IE}_{s,imp}^{CHN}$) can be expressed as

$$\mathbf{IE}_{s,imp}^{CHN} = \left(\sum_{k \neq s, s, k \in ITA}^K \mathbf{A}_{CHN,k}^G \mathbf{L}_{k,s}^{ITA,ITA} \mathbf{X}_s \mathbf{u}_N \right) \oslash \sum_t^T \mathbf{A}_{t,s} \mathbf{X}_s \mathbf{u}_N, \quad (\text{C.2})$$

where $\mathbf{A}_{CHN,k}^G$ is the $N \times N$ matrix of direct requirements of Chinese products used in production in region k . To obtain a relative measure, the numerator is normalized by total purchases of inputs of the corresponding region–sector, as $\mathbf{A}_{t,s}$ is the $N \times N$ matrix of direct requirements of inputs from any country or region t used in production in re-

gion s to produce its own output. The intuition is the following. Indirect exposure arises when region s employs goods originally imported from China by region k —possibly after multiple rounds of processing within the domestic supply chain—to produce either intermediate or final goods.

For each Italian region s , this procedure yields two vectors of indirect exposures—one for exports to US and one for imports from China—each with N elements corresponding to the different sectors. For each firm in our granular dataset, we assign the corresponding region–sector indirect exposure derived from ICIO data and then recompute overall indirect exposure at the region–sector level. This procedure ensures that the composition of the firm-level dataset does not introduce systematic differences relative to the ICIO-based measures.