Beefing Up the Service Sector: Commodity Exports to China and Production Network Spillovers*

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Abstract

The rise in commodity exports to China is a worldwide phenomenon affecting most countries in the Global South. We examine the rapid surge of Uruguayan beef exports to China in the 2010s and its impact on the domestic economy. By integrating customs data, administrative tax records of domestic transactions, matched employer-employee data, and firm balance sheets, we analyze how increased beef exports affect domestic firms through the production network. We find that suppliers to beef exporters experience significant sales growth, with the largest effects in the service sector, leading to increased employment, wages, and sales per worker. These impacts extend beyond direct suppliers, amplifying economic activity in the services further up the value chain. Using a network-based accounting framework, we estimate that beef exports to China increased Uruguayan aggregate sales by 1.79%, with one-third of the effect being accounted for by indirect linkages. We also show that over time, the service sector became more tightly integrated with beef exporters, enhancing its ability to benefit from rising trade with China.

Keywords: China shock, commodity exports, production network, services.

JEL Codes: F14, L14, O14, O54.

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1 Introduction

Of all the countries in the world that have experienced sustained economic growth and poverty reduction, the vast majority achieved this by shifting economic activity and employment from agriculture to manufacturing and services. The most recent example is China. Since 1981, China's GDP per capita has increased from 447.1 to 12,174 USD, a 27-fold increase (World Bank, 2023).[1] The share of its population living in extreme poverty—i.e., with less than 2.15 USD per day—was 97% in 1981 and is now below 1% (World Bank, 2022). This rapid growth and decline in absolute poverty are unprecedented in history, surpassed only by the pace of China's rise as the world's manufacturing hub. In 2020, China accounted for 20% of world manufacturing exports, up from 3% in 1995.[2]

China's rise as a manufacturing superpower and its growing per capita income have profoundly reshaped global trade. On one hand, the surge in Chinese imports of manufactured goods has contributed to the decline in manufacturing value added and employment in high-income countries, especially the US (Autor, Dorn and Hanson, 2013; Pierce and Schott, 2016). On the other hand, China's industrial expansion has driven greater demand for raw materials, while rising incomes and a growing middle class have fueled demand for quality food, particularly agri-food and seafood. As a result, over the past two decades, many low- and middle-income countries have experienced a surge in exports to China, spanning both industrial inputs and food products.

Panel a of Figure 1 plots, for selected countries, the change in the Chinese share of exports against the change in the Chinese share of imports over the period 2000 to 2017.[3] In the US, China's share of imports rose by 13 percentage points (pp), while exports to China increased by less than 5pp. Other high-income countries experienced smaller but more balanced shifts, with both imports and exports rising by about 5pp. Some lower-income countries, like Argentina, mirrored the US pattern. Yet, for many others, the increase in China's share of exports was more pronounced. In Uruguay, Brazil, Peru, and Chile, the share of exports going to China grew by 20pp. In the Democratic Republic of the Congo (DRC), exports to China surged by 40pp, compared to a 17pp increase in imports. Panel b of Figure 1 places these figures in a global context, showing changes in Chinese export and import shares across all available countries, categorized by income group. For upper-middle and high-income countries, Chinese imports typically increased more significantly than exports. In contrast, lower-middle and low-income countries experienced notable rises in imports but even larger increases in exports.

Furthermore, an analysis of shifting trade flows by sector reveals that the rise in exports to China is largely concentrated in specific commodity sectors. Appendix Figure A.1 plots, for selected countries, the change in the Chinese share of exports against the change in the Chinese

[1] Values in constant 2015 USD.

[2] VoxEU, https://cepr.org/voxeu/columns/china-worlds-sole-manufacturing-superpower-line-sketch-rise, accessed on July 17, 2024.

[3] That is, from the year prior to China's accession to the WTO until the Trump-era US-China trade war.

share of imports by SITC 2-digit sector. The figures reveal the main drivers of rising exports to China in each country: soy and beef from Uruguay; copper from Peru; cork and wood from Mozambique; cobalt from the DRC. This pattern is distinctive of low and middle-income countries, while high-income countries experienced more granular changes in the Chinese import share across several—typically manufacturing—sectors.

How does the surge in commodity exports to China affect the economies of low and middle-income countries? Commodity exports are typically concentrated among a few large companies in each country, yet these exporters source products and services from numerous domestic producers. What are the indirect effects of rising exports to China on these suppliers? Do these effects spill over to other firms outside the commodity sector through firm-to-firm linkages? Ultimately, do they slow down or accelerate the shift of economic activity toward manufacturing and services? These questions are crucial and pressing because competition from China itself constrains manufacturing export growth, limiting its potential as a pathway to industrialization and sustained economic growth in lower-income countries (Rodrik, 2016; Goldberg and Reed, 2023).

We address these questions in the context of Uruguay and the rapid surge of beef exports to China. Uruguay has been for decades among the largest beef exporters in the world, yet recently, it has experienced a terrific growth of beef exports to China, as summarized in Figure 2. Panel a shows the value of beef exports between 2006 and 2019—before the pandemic—and separately towards China and the rest of the world. While the value of exports to other destinations remained relatively constant over the period, exports to China grew from USD 3.56 million to 1.13 billion, about 1.7% of Uruguay's GDP. As a result, and as shown in panel b of Figure 2, China went from being negligible as a beef export destination to accounting for about 60% of all beef exports in 2019.

We examine the impact of rising beef exports to China on the Uruguayan economy. We integrate customs data with administrative tax records of domestic transactions, matched employer-employee data, and balance sheet data. We analyze firm-to-firm sales records to identify companies linked to beef exporters and compare outcomes between firms with strong versus weak ties as beef exporters increase trade with China. Our main explanatory variable is a Bartik-type instrument. The identifying assumption is that absent the China beef shock, the evolution of firm-level outcomes would have been similar across firms with tighter vs. looser links at baseline with beef exporters that trade more with China over time. The analysis of pre-trends shows that this assumption is plausible.

The reduced-form analysis reveals that suppliers to beef exporters experience significant impacts from the China beef export shock. First, their sales increase significantly. A one standard deviation increase in (indirect) exposure to the China beef export shock increases total sales by about 8%. This effect is more pronounced for initially smaller suppliers and those outside the agricultural sector, reaching up to 14% for service sector firms, especially in information and communication, real estate, retail, and transportation. Second, employment,

wages, and sales per worker also rise significantly, again more so for suppliers in the service sector. Their employment and average wage increase by 3%, and sales per worker by almost 7%. Third, a detailed examination of purchases by sector indicates that the positive effects on service sales extend further up the value chain, affecting the service sector more intensely.

Beyond these firm-level effects, our findings indicate that rising beef exports to China also induced structural changes in the production network. Firms supplying beef exporters expanded their sourcing networks, increasing the number of suppliers and diversifying purchases, as evidenced by a decline in the Herfindahl-Hirschman Index of purchases. At the sector level, exposure to beef trade with China led to higher sales and purchases, yet also resulted in a decline in the number of firms, suggesting sectoral consolidation. Meanwhile, firms with stronger ties to beef exporters were less likely to exit, indicating a reallocation of economic activity toward businesses more deeply integrated into the beef export value chain. These shifts in firm linkages and sectoral composition are crucial for understanding how trade shocks propagate across the economy.

In the last part of the paper, we account for these structural changes in measuring the aggregate effects of the China beef export shock on the Uruguayan economy. We formalize the equilibrium relationship between firm sales based on a standard model of production networks (Acemoglu et al., 2012) and use it to derive counterfactual sales for each firm in the absence of the China beef export shock. Importantly, we evaluate these effects both under the observed production network each year and under a scenario where firm linkages remain constant over time, allowing us to isolate the quantitative role of network adjustments in shaping aggregate outcomes. We find that rising beef exports to China increased Uruguayan aggregate sales by 1.79% over the period 2014 to 2019. The direct value of exports accounts for about two-thirds of this effect, while the remaining one-third stems from indirect effects and propagation through firm linkages. Notably, the service sector absorbs 22% of these network-mediated effects, reinforcing its pivotal role in transmitting the shock throughout the economy.

Our analysis shows that the service sector became more tightly integrated with beef exporters over time. In a counterfactual scenario without beef trade with China, where firm linkages remain fixed at their 2014 structure, the service sector would have had higher aggregate sales than in the actual economy. This suggests that the sector actively repositioned itself to capitalize on rising beef exports, more than offsetting the opportunity cost of restructuring its linkages. In contrast, the agricultural sector, with less scope for diversification, experienced the opposite effect.

Related Literature The key contribution of this paper is to show that rising commodity exports to China affect emerging economies beyond the directly impacted sectors, with particularly strong effects in services. This suggests that growing commodity exports are not necessarily detrimental to structural transformation. These findings thus speak to the literature on premature deindustrialization (Rodrik, 2016), the role of globalization in development (Gold-

berg and Reed, 2023), and the expansion of production services as a development pathway (Fan, Peters and Zilibotti, 2023; Rodrik and Sandhu, 2024).

Our analysis leverages detailed information on firm-to-firm sales that allows us to trace the domestic network of firm-to-firm linkages and pin down the indirect effects of a China commodity export shock on firms and sectors that supply goods and services to beef exporters. As such, we contribute to the literature studying how idiosyncratic shocks propagate and get amplified through the production network (Acemoglu et al., 2012; Boehm, Flaaen and Pandalai-Nayar, 2019; Couttenier, Monnet and Piemontese, 2022; Khanna, Morales and Pandalai-Nayar, 2022; Fujiy, Ghose and Khanna, 2024; Korovkin, Makarin and Miyauchi, 2024). A subset of this literature focuses on international trade (Carvalho et al., 2021; Dhyne et al., 2022) and low and middle-income countries. Using plant-level data from Chile, Linarello (2018) shows that trade liberalization in downstream industries increases the productivity of intermediate input suppliers. Huneeus (2020) uses Chilean firm-to-firm transaction data and a dynamic general equilibrium model to evaluate how international trade shocks during the Great Recession propagated in Chile. Alfaro-Ureña, Manelici and Vasquez (2022) use similar data from Costa Rica to study the effects of becoming a supplier to multinational corporations (MNCs). Alfaro-Ureña, Manelici and Vasquez (2021) also brings in employer-employee matched data to estimate the effects of MNCs on workers. This paper contributes to this literature as we combine customs data with administrative tax records of domestic transactions, matched employer-employee data, and balance sheet data to study the impact of the China beef export shock on the Uruguayan production network, focusing specifically on its indirect effects on beef export suppliers and the network-mediated aggregate impact.

A large literature exists on the effects of trade with China on partner countries. Most contributions focus on the impact of rising import competition from China on high-income countries, particularly the US. The seminal work of Autor, Dorn and Hanson (2013) shows that local labor markets more exposed to manufacturing import competition experienced higher unemployment, lower labor force participation, and reduced wages. Subsequent papers have documented similarly negative effects at the worker level (Autor et al., 2014) as well as sector and plant level (Pierce and Schott, 2016), with total job losses from rising Chinese import competition over 1999-2011 estimated at 2.0-2.4 million in the US only (Acemoglu et al., 2016).[4] Recent evidence shows that countries across Europe experienced similar effects, particularly those that saw a large growth of net imports from China, such as the UK (Dorn and Levell, 2021). Low and middle-income countries were also affected. Using data for Brazil, Costa, Garred and Pessoa (2016) find that local labor markets more affected by Chinese import competition experienced slower growth in manufacturing wages between 2000 and 2010. Medina (2024) shows that following China's accession to the WTO, Peruvian producers lost domestic market share

[4]Recent evidence also shows that US innovation was also negatively impacted by Chinese import competition (Autor et al., 2020), and that a substantial fraction of local labor markets have suffered persistent absolute declines in average real incomes as a result (Autor, Dorn and Hanson, 2021).

and responded by upgrading the quality of their products and exporting the new high-quality products to high-income countries.

There is much less evidence of the impact of rising exports to China on the economies of countries in the Global South. A notable exception is Costa, Garred and Pessoa (2016) on Brazil, who find faster wage growth in locations benefiting from rising Chinese commodity demand. Hansen and Wingender (2023) show that cropland expanded globally to meet Chinese demand for agricultural products, but, at least in the US, this did not translate into agricultural wages. We advance this literature by focusing on the soft commodities and agri-food trade boom with China, particularly the surge in Uruguayan beef exports. We use a rich combination of administrative data and implement a reduced-form firm-level analysis and a counterfactual analysis to examine the impact on the whole economy.

The remainder of the paper is organized as follows. Section 2 provides a brief overview of the Uruguayan economy, its trade profile, the beef sector, and its tax system. Section 3 presents the data sources and their descriptives. Section 4 outlines the reduced-form empirical strategy and presents the main results. Section 5 focuses on aggregate quantifications and counterfactual policy analyses. Finally, Section 6 concludes.

2 Background

Although much smaller in size than neighboring Argentina and Brazil, Uruguay has a higher GDP per capita, measured at USD 17,000 in 2021. Its population is 3.4 million, half of it living in the capital, Montevideo. The country stands out in Latin America for its stable democracy, the quality of its institutions, and its strong tradition of social welfare and progressive policies.

Uruguay has a highly open economy. The value of exports of goods and services as a percentage of GDP was 30% in 2021 and 24% for imports.[5] Appendix Figure A.2 shows the composition of exports by destination (top) and by category (bottom) and how it changed between 2000 and 2019. While China accounted for just 3.4% of Uruguay's total exports in 2000, it has since become the country's largest export destination, now representing nearly 30% of total exports. This happened while the share of exports going to Brazil and Argentina decreased substantially, from 24 to 13% and from 17 to 4%, respectively.

The sectoral composition of Uruguay's exports has also changed significantly over time. The rise of ICT services exports is noticeable, increasing from 2.5% of total exports in 2000 to 16% in 2019, making Uruguay the second-largest exporter of software per capita in Latin America. This growth is attributable to a combination of factors, including strong government support, tax exemptions for software exports, and the designation of ICT as a sector of national interest. These efforts were bolstered by substantial investments in digital infrastructure and

[5] World Bank World Development Indicators (WDI), https://datacatalog.worldbank.org/search/dataset/0037712, accessed on July 19, 2024.

ICT education, which helped develop a highly skilled, multilingual workforce.

Exports of beef and soy have also undergone important changes. Beef exports, particularly frozen beef, increased from 8% of total exports in 2000 to nearly 12% in 2019, with the growth almost entirely driven by rising demand from China, as shown in Figure 2. Appendix Figure A.4 shows that soy exports also grew substantially but peaked a few years before 2019 and then declined.[6] Meanwhile, pulp exports to China have followed a steady upward trend, driven exclusively by Finnish company UPM, which operates two eucalyptus pulp mills in Uruguay.

These trends raise questions about the presence of Dutch Disease, a phenomenon where a surge in resource-based exports leads to real exchange rate appreciation, undermining the competitiveness of non-resource tradable sectors, potentially causing deindustrialization. The overall evidence for Uruguay is mixed. While indicators such as real exchange rate appreciation suggest potential vulnerabilities, these trends have not significantly impacted the industrial sector's contribution to GDP (Aboal, Lanzilotta and Rego, 2012). Our own analysis, which explores the relationship between economic activity in the beef sector and other sectors, will further contribute to this discussion by examining the extent to which linkages with the beef industry have shaped broader sectoral dynamics.

2.1 Beef Industry

According to the National Meat Institute (*Instituto Nacional de Carnes*, INAC), the Uruguayan beef industry directly employs nearly 90,000 people and generates a direct economic impact of over USD 3.5 billion annually, considering both exports and domestic consumption. It also contributes nearly USD 700 million in taxes annually. The number of cattle is estimated at 12 million, about four times the country's population. Uruguay is consistently among the top 10 beef exporters in the world and the world's top per capita meat exporter, with 134 kg per capita exported in 2023 (INAC, 2024).

Uruguayan beef typically commands higher export prices than its competitors. In the five years from 2018 to 2022, its export prices were 34% higher than Brazil's and 18% higher than Argentina's and Paraguay's.[7] A key determinant of this price premium is Uruguay's fully computerized and mandatory traceability system, which tracks both cattle and beef products. This system, unique in the world, ensures high food safety standards, boosting Uruguay's reputation as a premium supplier (Abraham, Dassatti and Cal, 2014).

The beef sector can be visualized as a value chain that begins in the primary phase of livestock production (which also includes different phases of production and transformation), a second stage of industrial transformation carried out by slaughterhouses, and a final marketing

[6] Between the 2000 and 2010 agricultural censuses, livestock areas shrank due to competition from soybean cultivation, particularly in high-productivity regions. This shift likely intensified livestock production, with greater reliance on grain-fed diets and feedlots, allowing for sustained output despite shrinking pastures.

[7] Australia and the United States compete in the high-value market with grain-fed beef, Brazil is the main exporter of grass-fed beef, while India exports lower-value meat, mainly buffalo meat.

phase, both in the domestic market and through exports. The Uruguayan beef value chain has the "bottleneck" structure that is typical of commodity sectors: a large number of producers or suppliers at the initial stages and a narrow point of concentration at the final stages where few companies dominate the processing and retail phases. Indeed, the 2011 agricultural census counts 36,696 establishments in the sector with any cattle stocks, occupying a total area of 14.8 million hectares and carrying out at least one of the three phases of livestock production: breeding, rearing, and wintering.[8] This contrasts with the small number of slaughterhouses, which also engage in commercialization and exporting. In 2022, 17 of these establishments accounted for 92% of the total volume of processed beef.

2.1.1 Beef Exports to China

In the 2000s, China imposed bans on beef imports from several countries due to concerns over bovine spongiform encephalopathy (BSE), commonly known as "mad cow disease." In 1996, Uruguay was declared free of foot-and-mouth disease (FMD) without vaccination. However, outbreaks in late 2000 and 2001 led to a temporary loss of this status. Following extensive efforts to control and eradicate the disease, Uruguay regained its FMD-free status with vaccination in 2003. Additionally, the country's strict sanitary measures have earned it a negligible risk classification for BSE, ensuring its continued eligibility to export beef to China. Despite this, trade volumes remained modest until 2012 before accelerating sharply in 2013. That year, Uruguay's beef exports to China surged by 455% in volume and 522% in value compared to the previous year.[9] This surge was facilitated by idle capacity in the industry, which INAC estimated to be between 35-45% in the early 2010s (INAC, 2024). By 2019, China had firmly established itself as Uruguay's top beef export market, accounting for USD 1.13 billion and 60% of total beef exports, as shown previously in Figure 2.

The surge in Uruguayan beef exports to China was part of a larger shift in Latin America's trade relationship with China, driven by the country's growing demand for high-quality beef and its rapidly expanding middle class. Uruguay's strict sanitary standards and advanced traceability system helped it gain access to China's market, particularly after 2006, when traceability became mandatory, and 2010, when it was extended to include cattle (Abraham, Dassatti and Cal, 2014). Yet, this boom was not unique to Uruguay. Between 2014 and 2023, beef exports to China from across Latin America have quintupled, with the region now supplying over three-fourths of China's total beef imports (Ray, Albright and Dussel Peters, 2024). Exports expanded dramatically in 2018 when China imposed tariffs on US agricultural imports, redirecting demand to suppliers in Uruguay, Brazil, and Argentina, among others. China's outbreak of African swine fever fueled a sharp rise in meat imports, further accelerating the trend.

[8] In beef production, breeding involves selecting and mating cattle to improve traits like growth and meat quality, while rearing refers to raising calves until they reach a specific age or weight. Wintering ensures cattle health during cold months by providing shelter and supplemental feed when grazing is limited.

[9] MercoPress, https://en.mercopress.com/2013/09/19/china-has-become-uruguay-s-main-market-for-beef-taking-25-of-exports, accessed on November 28, 2024.

Online Appendix Figure A.3 contextualizes Uruguay's experience by plotting the value of beef exports to China over time across several major beef-exporting countries. While Brazil, Argentina, and Australia exhibit higher absolute export values, their economies are significantly larger than Uruguay's. However, when considering beef exports to China as a share of total exports (panel c) and share of GDP (panel d), Uruguay stands out. In 2019, beef exports to China accounted for 1.7% of Uruguay's GDP, far surpassing the figures for other countries, which remained well below 0.5%.

After 2020, the dynamics partially shifted. China lifted restrictions on other beef suppliers, slowed its meat imports due to economic deceleration, and diversified its supply chains. In response, Uruguay, alongside other Latin American countries, began expanding into new markets, particularly North America. By August 2024, the US, Canada, and Mexico collectively accounted for 32% of Uruguay's total beef export revenue, generating USD 390.8 million from 97,375 tonnes, according to INAC. In comparison, China's share dropped to 30%, with USD 371.5 million from 115,324 tonnes.[10]

3 Data

In this section, we introduce the data we use in the analysis. All the data except customs belong to the Uruguayan tax authority (*Dirección General Impositiva*, DGI). All information was anonymized by the DGI and the data merged and processed at their facility.

3.1 Sources

Firm Registry The first source of information is the firm registry, which is a list of all firms that are legally registered in the country. From the registry, we keep the (anonymized) tax ID of the firm as well as the 5-digit sector it belongs to. We use this sector classification to assign firms to sectors and to compute trade flows at the sector level.

VAT Records The bulk of our analysis relies on data from domestic transactions between Uruguayan firms, which we gather from two main sources. The first pertains to the filing of VAT (*Impuesto al Valor Agregado*, IVA), which requires firms to declare all transactions covering at least 90% of the value of their sales and purchases, along with the identity of their trading counterpart.[11] This mandate applies to companies that belong to the group of *Grandes Contribuyentes and CEDE*, meaning large taxpayers and companies subject to enhanced monitoring on behalf of the tax authority, and thus facing stricter reporting procedures. The second

[10] Valor Agro, https://www.valoragro.com.py/ganaderia/carne-vacuna-en-la-busqueda-de-una-menor-dependencia-de-china-uruguay-sale-adelante/, accessed on November 28, 2024.

[11] Compared to the richest countries, lower-income economies typically rely more heavily on indirect taxation, particularly value-added taxes VAT (Bachas, Jensen and Gadenne, 2024). Until recently, this was also the case in Uruguay, where VAT remains the dominant source of tax revenue, accounting for approximately 50% of total tax collection, excluding social security contributions.

source of transaction-level data comes from the filing of the Farming Goods Sale Tax (*Impuesto a la Enajenación de Bienes Agropecuarios*, IMEBA), which is akin to VAT but applies to transactions of agricultural goods, including livestock. These two data sources together detail the universe of all domestic transactions involving medium and large firms, thus also including those between smaller firms and medium and large ones. The electronic filing of VAT and IMEBA was implemented progressively over time. The requirement to declare at least 90% of transaction values was established by the tax authority through Resolution No. 941/013, issued on March 22, 2013, and enforced starting in July 2013. As a result, transaction-level data coverage became near universal and stable by 2014. Given this, and for the purpose of this analysis, we focus on the period from 2014 to 2019.

Income Tax Records To study the evolution of employment-related variables, we gather information on workers and wages from personal income tax (*Impuesto a la Renta de las Personas F'isicas*, IRPF) filings. Using the corresponding forms submitted by employers, we construct an employer-employee matched dataset, which allows us to derive information on the number of employees and their compensation. Since IRPF was introduced in 2007, these data are available starting in 2008.[12]

Customs Records We complement these data with information on all international transactions—imports and exports—made by Uruguayan firms and individuals as recorded by customs. The data is publicly available and provides the tax ID of the company or individual. This publicly available dataset includes the tax ID of the company or individual. The DGI anonymized these tax IDs and merged them with the other data sources to make them available for analysis.

Corporate Tax Records To validate sales data and probe the robustness of our findings, we also use balance sheet information. This comes from the filing of corporate tax (*Impuesto a las Rentas de las Actividades Económicas*, IRAE), which is mandatory for all corporate firms and all firms with sales higher than a given threshold, equal to approximately USD 115,000. While focusing on larger firms only, the balance sheet data cover the universe of this subpopulation, and is available continuously since 2008.

3.2 Descriptives

Our transaction-level data provide a unique opportunity to map the domestic network of firm-to-firm linkages and track its evolution over time. Table 1 presents several summary statistics.

[12] A progressive personal income tax was introduced as part of a broader tax reform aimed at increasing the role of direct taxation. Revenues from IRPF currently represent 12.5% of total tax revenue, making it the second most important source of revenue after VAT (Bergolo et al., 2021).

Across all years from 2014 to 2019, we observe approximately 14 million distinct supplier-buyer relationships, comprising around 250,000 unique sellers and 900,000 unique buyers, spanning 413 and 419 different 4-digit sectors, respectively. The median seller transacts with over 2,000 buyers, while the median buyer sources from 142 sellers. This suggests that, at the aggregate level, the firm network is more concentrated upstream than downstream, with a relatively small number of suppliers serving a much larger pool of buyers.

The second column of Table 1 focuses on transactions where the buyer is a firm in the beef sector (ISIC4 1010 – Processing and Preserving of Meat). Over the six years of data, we identify 94 distinct buyers in the beef sector, each sourcing from a large number of suppliers, with a median of just under 5,000. In total, we count about 110,000 unique buyer-supplier relationships, involving 36,505 different sellers. However, in contrast to the overall economy, where supplier concentration is higher, firms selling to the beef sector serve a median of only five distinct buyers. This highlights a key structural difference: while the broader economy exhibits greater concentration upstream, the beef sector is far more concentrated downstream, a pattern that aligns with the background evidence in Section 2.1.

Table 2 provides several other statistics on the domestic sales to the beef sector. The unit of observation is a buyer in the beef sector in a given year. The top left panel shows that the average number of suppliers across buyers and years is 530, spread across 65 different 4-digit sectors. The purchases of beef sector buyers are on average concentrated, yet this varies substantially across buyer-years (average Herfindahl-Hirschman Index equal to 0.34 with a standard deviation of 0.42). The average total domestic purchases amount to around 9 million Uruguayan Pesos, equal to 232,000 USD.

The other five panels in Table 2 report the same statistics but focusing only on purchases from specific sectors. Across buyers and years, the average number of suppliers in the agricultural sector is 490. Purchases from this sector are less concentrated than those from other sectors, where the average number of suppliers per buyer-year is much smaller, down to 39 for suppliers in transportation and six for suppliers in ICT services. Yet, the total purchases from these sectors are still sizeable, almost comparable to those from the agricultural sector.

3.3 Total Sales and Validation

For each firm in the data, we aggregate up all domestic sales from transaction-level data as well as external sales from customs data to derive total sales in each year from 2014 to 2019. For the subset of large firms, we can validate this information using the balance sheet data. Appendix Figure A.5 shows that, on average and for sales exceeding a given threshold, the total sales value derived from transaction-level and customs data aligns closely with the figures reported in corporate tax data.

Appendix Table A.1 confirms this finding by showing the coefficient estimate that we obtain from a simple regression of the (log) sales from corporate tax data over the (log) sales from

domestic transactions and customs data, implemented separately for the years 2014 and 2019. Motivated by the evidence in Figure A.5, we restrict the sample to observations of (log) sales higher than 15. The coefficient estimate is precise, and while we reject the null hypothesis that it equals one, we cannot reject that it is equal to 0.9. This finding is consistent with the VAT reporting mandate, which requires firms to declare at least 90% of their sales and purchases for tax purposes, as discussed earlier. For employment-related outcomes, we perform a similar validation exercise by comparing the total wage bill obtained from personal income tax data with the one recorded in balance sheet data, showing very similar results.

When analyzing the impact on beef exporters' suppliers' sales, we will conduct a robustness exercise using sales information from corporate tax records and balance sheets to impute total sales for all firms, yielding results that closely align with the baseline estimates.

3.4 Sources of Variation

In the first part of the analysis, we achieve identification by leveraging variation across firms in their linkages to beef exporters and the broader beef sector, combined with time variation in exports to China across beef exporters.

We begin by measuring firm linkages to the beef sector in 2014, the year when VAT data coverage stabilized. For each firm in the data, we take the ratio between sales to the beef sector and overall sales (including exports). Panel a of Appendix Figure A.6 shows the overall variation in this beef sector linkage measure across sectors, excluding firms with no linkages with the beef sector, i.e., for which the above ratio is equal to zero. For many firms, the beef sector represents a tiny fraction of their sales, while for many others, it accounts for almost all or all of their sales. Most firms are in between. Panel b of Figure A.6 shows that substantial variation exists even across suppliers within 4-digit sectors.

Tighter links to the beef sector in 2014 predict higher sales growth over the period 2015 to 2019. Figure 3 provides graphical evidence of this by plotting the distribution of sales growth separately for firms with beef sector linkages above and below the median at baseline. The distribution of sales growth for firms with tighter links with the beef sector is shifted towards the right, indicating higher average and median sales growth.

Next, we measure the linkages of each supplier with specific beef exporters. We consider all firms in the beef sector exporting any amount at any point in time between 2015 and 2019 and calculate for each of their suppliers the ratio between sales to beef exporters and overall sales in the baseline year 2014. This means we have several observations per firm, each one corresponding to a different supplier-beef exporter relationship. Panel c of Figure A.6 shows that substantial variation exists within suppliers in their ties to different beef exporters.

In Appendix Figure A.7, we explore the variation among beef exporters in their exports to China vs. the rest of the world over time. The left panel shows the distribution of changes in the China share of exports at the exporter level between the years 2009 and 2019. For some

beef exporters, the China share of exports increased by 80pp while for others the increase was negligible. Interestingly, the modal increase in China's share of exports is 60pp, which exactly matches the aggregate increase shown in panel b of Figure 2. The right panel of Figure A.7 plots instead the change in the (log) value of exports to China against the corresponding change in exports towards the rest of the world. The figure shows how different the changes were in the exporting profile of different beef exporters. Some of them increased exports to China six-fold while keeping exports to the rest of the world essentially unchanged. As mentioned earlier, this is at least partly attributable to the large idle capacity in the industry, estimated at 35-45% in the early 2010s (INAC, 2024). Other beef exporters, instead, substituted exports to the rest of the world with exports to China. Some others experienced almost no change along both dimensions. Overall, evidence shows that there is substantial variation to exploit for identification, both in linkages to beef exporters among suppliers at baseline and in the extent to which these suppliers engaged with the surge of beef exports to China.

Evidence also shows that firm linkages to beef exporters evolved over time. Online Appendix Figure A.8 plots the distribution of changes in the number of suppliers per beef exporter from 2014 to 2019. The distribution is largely skewed toward positive values, indicating that nearly all beef exporters expanded their supplier base and established new connections over this period. However, Online Appendix Figure A.9 reveals that this pattern varies across sectors. On average, beef exporters increased their number of suppliers in the agricultural sector, as well as among retailers, professional service providers, and firms classified under "other services." In contrast, in manufacturing, construction, and information and communication, the distribution of changes is centered around zero, suggesting that while some firms formed new ties, others reduced or discontinued relationships with most of their baseline suppliers. The data thus show that the production network changed during the boom in beef exports to China in a way that was not uniform across sectors.

4 Reduced-Form Analysis

In this section, we estimate the reduced-form impact of rising beef exports to China on the production network. We focus on firms that supplied goods or services to beef exporters in 2014 and compare outcomes between those with strong versus weak ties over time, as beef exporters expanded trade with China. We provide evidence of effects on both first- and second-order links, as well as their heterogeneity across sectors.

4.1 Estimation Samples

Our analysis starts by focusing on all firms that sell any amount of good and services to any beef exporter in 2014. We follow these firms through time from 2015 to 2019. The resulting dataset of supplier-year observations constitute our first estimation sample.

Table 3 shows the distribution of beef exporters' suppliers across sectors. There is 15,208 of them in total, the majority of them (9,594 firms) being in agriculture—which includes livestock, forestry and fishing. Yet, 5,614 of them are outside this sector, and spread among retail (2,509), manufacturing (730), transportation (705), professional (mostly legal) services (624), among others. The services altogether account for about 30% of the sample.

Appendix Table A.2 reports the summary statistics for the estimation sample of all the variables we use in the empirical analysis. We count about 70,000 supplier-year observations in total. Mean total sales equal 11.2 million Uruguayan pesos, circa 280,000 USD. Domestic sales account for the vast majority of total sales. Similarly, domestic purchases account for the vast majority of overall purchases, the mean being close to 100,000 USD. The average firm counts 15 employees. The 15,208 firms in the sample belong to 227 distinct 4-digit sectors.

In a second step, we extend our analysis to second-order links, meaning firms that supply goods and services to the suppliers of beef exporters. We examine these firms primarily by analyzing the purchases made by first-order suppliers but also by directly studying the sample of second-order suppliers. This constitutes our second estimation sample, which includes 46,458 firms, as detailed in Online Appendix Table A.3. Interestingly, though not unexpectedly, firms in this sample are far less concentrated in the agricultural sector (3,589 firms). Instead, they are predominantly found in retail (16,355), professional services (6,606), manufacturing (5,858), and transportation (4,498).

4.2 Empirical Strategy

Our identification strategy combines variation across firms at baseline in their linkages to beef exporters with changes over time in these exporters' trade with China. For each firm i in our sample belonging to sector s, and for each year t, we compute

$$CBE_{ist} = \sum_{m} s_{im}\, x^{c}_{mt} \tag{1}$$

where s_{im} is share of sales of firm i to beef exporter m in the baseline year 2014 and thus fixed at the beginning of the data period, while x^{c}_{mt} is the value of exports to China of exporter m in year t. The CBE variable is a Bartik-type instrument that captures the extent to which suppliers to beef exporters are affected by the surge of exports to China over time. In the language of Borusyak, Hull and Jaravel (2025), x^{c}_{mt} are shifts that are common to all units (firms) while s_{im} are sets of exposure shares that vary across units.

Upon defining this variable, we implement the following main regression specification

$$\ln Y_{ist} = \beta\, CBE_{ist} + \theta_i + \psi_{st} + u_{ist} \tag{2}$$

where Y_{ist} is the outcome of interest of firm i in sector s in year t, and CBE is the (indirect) China beef export shock defined as above. We include the full set of firm fixed effects θ_i as

well as 4-digit sector $\times$ year fixed effects ψ_{st}, which allow for fully flexible differential trends across narrowly defined sectors. This means we compare firms over time within narrowly defined sectors. u_{ist} captures any residual determinants of the outcome of interest. We cluster the standard errors at the 4-digit sector level, thus allowing such residuals to be correlated among observations belonging to the same sector.

Our coefficient of interest is β, which captures the impact of the China beef export shock on the suppliers to beef exporters. Causal identification requires this variable to be as good as randomly assigned to firm-level outcomes, conditional on the included regressors. The identifying assumption is that absent the China beef shock, the evolution of firm-level outcomes would have been similar across firms with tighter vs. looser links at baseline with beef exporters that trade more with China over time. Notice that the specification in equation (2) includes 4-digit sector $\times$ year fixed effects, implying that this assumption must hold when comparing firms within 4-digit sectors.

The identifying assumption is satisfied if the shifts x^c_{mt} are orthogonal to firm (supplier)-level outcomes. This is true even if the shares s_{im} are endogenous, in the sense that firms with strong vs. weak ties to beef exporters may have systematically different unobservables. Note that the inclusion of firm fixed-effects θ_i in equation (2) effectively controls for the sum of shares $\sum_m s_{im}$, which is not equal to one for all firms i in this context (Borusyak, Hull and Jaravel, 2025).

To assess the robustness of the exogenous shifts identification argument, we augment the baseline regression specification with two sets of controls, designed to account for potential shift-level and unit-level confounders. First, we include firm-level control variables that account for direct export and import shocks, which could be correlated with both the residual u_{ist} and the China beef export shock CBE_{ist}. We compute

$$E_{ist} = s_{ie} X_{st} \qquad I_{ist} = s_{im} M_{st} \tag{3}$$

where s_{ie} and s_{im} are, respectively, the ratio between exports and total sales and the ratio between imports and total purchases in the baseline year 2014. X_{st} and M_{st} are the total exports and imports of sector s in year t.

Second, we control for the indirect effect of beef exports to the rest of the world, using the same exposure shares as in the construction of the main regressor. We define

$$ROWBE_{ist} = \sum_m s_{im}\, x^r_{mt} \tag{4}$$

which is similar to the CBE variable but considers now the value of exports to the rest of the world (excluding China) of exporter m in year t. Notice, however, that exports to China and exports to the rest of the world may correlate with each other as exporters make different strategic decisions and assume different trading profiles (see Appendix Figure A.7). The $ROWBE$

variable may therefore be a bad control. Yet, we show that our main results are only marginally affected by the inclusion of this variable as an additional regressor in equation (2).

Before continuing, note that we can also support our empirical strategy with an alternative path to identification based on the exogeneity of shares s_{im} (Goldsmith-Pinkham, Sorkin and Swift, 2020). The key assumption is that the shares satisfy parallel trends. That is, in the absence of the surge of beef trade with China, average changes in outcomes would have been similar across firms regardless of their baseline linkages to beef exporters. Note that exposure shares are "tailored" to the research question and treatment of interest and that the inclusion of firm fixed effects further boosts the plausibility of share exogeneity. In Section 4.3.3, we will empirically assess the overall validity of our research design by analyzing pre-trends.

As discussed earlier, we extend our analysis in a second step to second-order links—firms that supply goods and services to the suppliers of beef exporters. We primarily examine these firms by analyzing the purchases made by first-order suppliers. Additionally, we consider the sample of second-order suppliers and implement a regression specification based on equation (2), incorporating an additional term to capture higher-order effects. We define it as

$$CBE^{(2)}_{ist} = \sum_j s_{ij}\, CBE_{jt} = \sum_j s_{ij} \sum_m s_{jm}\, x^c_{mt} \tag{5}$$

That is, we multiply the is share of sales of firm i to beef exporters' supplier firm j by the value of j's China beef export shock, as defined above. When both variables—CBE_{ist} and $CBE^{(2)}_{ist}$—are included in equation (2), the coefficient on $CBE^{(2)}_{ist}$ captures the second-order impact of beef exports to China, leveraging variation in indirect linkages to beef exporters while controlling for direct linkages and relying on identifying assumptions that mirror those specified above.

4.3 Results

4.3.1 Average Effect on Sales

We begin with estimating the impact of rising beef exports to China on suppliers' total sales. Table 4 presents the coefficient estimates obtained from implementing the specification in equation (2) on the sample of beef exporters' suppliers and having the log of total sales as dependent variable $\ln Y$. The first column reports the estimate from the baseline specification. We standardize the (indirect) China beef export shock variable by dividing it by its standard deviation. Column 1 shows that a one standard deviation increase in exposure to the China beef export shock increases total sales by about 8%. The estimate is significant at the 1% level. Including the (direct) export and import shocks as controls in columns 2 and 3 does not change the magnitude of the estimated effect. In columns 4 to 6, we also control for exposure to beef exports towards the rest of the world. The coefficient of the China export shock variable decreases slightly in magnitude to 7% and remains highly significant.

As explained above, firms in our sample are required to report at least 90% of their sales and purchases for tax purposes. The validation exercise in Section 3.3 suggests that this specific requirement is unlikely to introduce bias in our estimates of the China beef export shock's impact on suppliers' sales. We nonetheless explore this further by using the sales information from corporate tax records, thus available for the largest firms only. For each sector, we compute the average discrepancy between our measure of domestic and external sales and the corresponding values from corporate tax records. We then use this discrepancy to impute total sales for all firms in the sample. Online Appendix Table A.4 presents the results obtained when using the log of imputed sales as the dependent variable, which closely align with those in Table 4.

4.3.2 Heterogeneity by Size and Sectors

We then investigate whether the effect is heterogeneous across suppliers. We first consider firm size and split the sample into the four quartiles of the distribution of total sales in the baseline year 2014, then implement the specification in equation (2) separately in each subsample. Figure 4 shows graphically the estimated coefficients of the China beef export shock variable and their 90% confidence intervals. A one standard deviation increase in exposure to the China beef export shock increases sales differentially more for initially smaller suppliers. The effect is 10% and 7.5% respectively for firms in the first and second quartile of the initial sales distribution, significant at the 1% level. It is instead closer to zero and insignificant for firms in the third and fourth quartiles of baseline sales.

Next, we estimate the effect of the China beef export shock separately on suppliers in agriculture, manufacturing, and services. Table 5 shows the corresponding results. The effect on sales is 6.5% and significant at the 1% level for the average supplier in the agricultural sector, which represents more than half of the sample. The magnitude of the effect is more than double for suppliers in manufacturing and services. For manufacturing, the effect is equal to 17% and significant at the 5% level. For suppliers in services, which account for about one-third of the sample, the effect is estimated at 14%, significant at the 1% level. Online Appendix Table A.5 shows that these results are essentially unchanged when using imputed sales instead of the original sales variable as outcome.

To gain more insights into this heterogeneity, we split the sample further and look at a finer sector classification, particularly for services. Figure 5 shows graphically the estimated coefficients of the China beef export shock variable and their 90% confidence intervals that we obtain in each of these more narrowly defined sectors. We find large effects for suppliers in construction (161 firms) and real estate services (183), consistent with beef exporters expanding their facilities to accommodate the increased volume of external sales. The effect is significant at least at the 10% level for several service sectors, from transportation (705 firms) to retail (2,509), professional services (624), and information and communication (92). The effect on financial sector suppliers is also large but estimated with much noise due to the small sample

size (26).

Taken together, evidence shows that sales increase significantly for suppliers more exposed to the China beef export shock. The effect is present across many sectors and is large and significant also outside the agricultural sector and beef value chain, particularly in services.

4.3.3 Pre-Trends and Placebo Estimates

As explained in Section 4.2, identification relies on the assumption that absent the China beef shock, the evolution of firm-level outcomes would have been similar across suppliers with tighter vs. looser links at baseline with beef exporters that trade more with China over time. This assumption must hold when comparing firms within 4-digit sectors since we always obtain our estimates conditioning on 4-digit sector $\times$ year fixed effects.

To assess whether this assumption is plausible, we look at pre-trends in firm-level sales over time. Using data from before 2014, we test whether firms with tighter links at baseline with beef exporters were already on a differential trend prior to the surge of beef exports to China. As we made clear in Section 3.1, the coverage of the transaction-level data that we use to calculate total sales became universal and stable only in 2014. Yet, for the larger firms, we have data on sales from corporate income tax records and balance sheets that go back to 2008. We can, therefore, test for pre-trends at least in this subsample of larger firms.

We begin by showing that the baseline results that we obtain with our measure of domestic plus external sales are unchanged when we use the sales information from balance sheet data. The validation exercise in Section 3.3 suggests that this is the case as it shows that the two sales measures are highly correlated. Appendix Table A.6 makes this explicit by reporting the estimates that we obtain when implementing the same specification over the same sample and using the two different sales measures as dependent variables. Notice that, as anticipated, we can only do this for firms that we can also identify in the corporate tax data. These are the largest firms and, consistent with Figure 4, the average effect of the China beef shock on them is smaller than in the overall sample, equal to 2.5%, but remains significant at the 10% level.

Upon establishing that the results are unchanged when using sales data from balance sheets, we test for pre-trends by looking at sales for these same firms in the years from 2009 to 2013 and attributing to each observation the value of the China export shock variable as measured five years later. If firms with tighter links with beef exporters were already on a differential trend prior to 2014, the coefficient of this *placebo* shock variable would be positive and significant. Appendix Table A.7 shows that this is not the case. Interestingly, columns 4 to 6 show that the coefficient of future exposure to exports to the rest of the world is positive and significant, and close to the one we obtain at baseline and reported in Table 4. This corroborates the notion that the China export shock was indeed exogenous to beef export suppliers, while trends in exports to the rest of the world were not.

Appendix Table A.8 and Table A.9 report the results from this same exercise when focusing

on service sector suppliers. The estimated effect on sales is higher than the one in Table A.6 and highly significant in this case, although still lower than the one in Table 4 as these are the largest companies in the service sector. The placebo estimates in Table A.9 are close to zero, negative, and insignificant.

Overall, the evidence from this subsample of large firms shows that firms with tighter links at baseline with beef exporters were not on a differential sales trend prior to 2014, providing support to our empirical strategy.

4.3.4 Effects on Employment, Wages, and Sales per Worker

After estimating the effect of the China beef export shock on suppliers' sales, we turn to examining its impact on employment-related variables, derived from personal income tax data. We consider three outcomes at the firm level: total employment (number of distinct employee IDs in a given year), average wage (total wage bill divided by employment), and sales per worker (total sales divided by employment).

Table 6 shows the results. We estimate the coefficient separately for each dependent variable and for suppliers in agriculture, manufacturing, and services. We find that a one standard deviation increase in exposure to the China beef export shock increases both employment and average wage by 0.6-0.7% for suppliers in the agricultural sector. Sales per worker also increases by 3.5%, the effect being significant at the 1% level. The estimates for the manufacturing sector are positive for employment and sales per worker, and negative for average wages, but always imprecise and never significant.

For suppliers in the service sector, the effects are large and precisely estimated. A one standard deviation increase in exposure to the China beef export shock increases employment and average wage by 3%, and sales per worker by almost 7%. All the estimates are significant at the 5% level. These findings indicate that the employment, wage, and productivity gains from rising beef exports to China are concentrated among service sector suppliers, underscoring their pivotal role in transmitting the shock throughout the economy.

Figure 6 shows graphically the impact of the China beef export shock on several outcome variables, estimated separately for suppliers grouped into more narrowly defined sectors. In some sectors—such as construction, IT and transportation—the increase in sales per worker is matched by a wage effect of approximately the same magnitude. This is not the case for suppliers in agriculture, suggesting a lower pass-through.

Online Appendix Figure A.10 provides the same information but allows for a direct comparison across sectors. It shows that the effect on wages and sales per worker is the largest for firms in IT. The effect on employment is instead the largest for firms in construction and real estate.

4.3.5 Effects on Purchases and Higher Order Links

Our analysis thus far has focused on first-order linkages with beef exporters, meaning on the impact of the surge of beef exports to China on the suppliers to beef exporters. We now turn to investigate the effect on higher-order links. The simplest way to gain insights is to implement the specification in equation (2) but replacing as dependent variable the log of purchases made by suppliers to beef exporters.

Table 7 reports the corresponding results, once again separately for suppliers in agriculture, manufacturing, and services. A one standard deviation increase in exposure to the China beef export shock increases agricultural suppliers' purchases by almost 5%. The impact on the purchases on manufacturing suppliers is high but insignificant. For suppliers in services, we estimate a 10% increase in purchases following higher exposure to the China beef export shock. These patterns match closely those we observe for sales and reported in Tables 5 and Table 6: suppliers scale up and increase sales, employment, and purchases. We show graphically the impact on purchases in combination with impacts on the other outcomes by more narrowly defined sectors in Figure 6 and Online Appendix Figure A.10.

In addition, we look separately at purchases from specific sectors. That is, we replace as dependent variable the value of purchases from firms in specific sector, and estimate the coefficient of interest accordingly. Figure 7 summarizes the results. Unlike Figure 5, where total sales were always the dependent variable and the specification was estimated separately by supplier sector, here we use a single sample of all suppliers and estimate the effect on different dependent variables capturing purchases from specific sectors. Figure 7 shows large and significant effects on purchases of financial services, information and communication, professional services, retail, transportation, and other services. The estimates on purchases from the agricultural and manufacturing sector are instead insignificant. We interpret this evidence as showing that the service sales effects remain high on higher-order links and thus propagate further up the value chain.

Finally, we directly estimate the second-order impact of beef exports to China. We consider all firms that supply goods and services to the suppliers of beef exporters, i.e., the second estimation sample discussed in Section 4.1, and implement the augmented regression specification discussed in the end of Section 4.2. Online Appendix Figure A.11 and A.12 show graphically the results, showing more evidence of the higher-order effects of beef exports to China on service sector firms.

4.3.6 Changes in the Network and Sectoral Dynamics

Our analysis thus far has examined the impact of rising beef exports to China on the direct and indirect suppliers of beef exporters, using a measure of exposure that held network linkages fixed at their 2014 values. We now turn to investigating whether the China beef export shock led to structural changes in firm linkages themselves.

We begin by focusing on the sample of suppliers to beef exporters and estimate the effect on their number of suppliers, while maintaining the specification in equation (2). Columns 1 to 3 of Table 8 show that, over time, suppliers to beef exporters that are more exposed to the China beef export shock expand their sourcing networks by engaging with a greater number of suppliers. A one standard deviation increase in exposure to the China beef export shock increases the number of suppliers by 2.7%. This leads to diversification in firm purchases, with the corresponding Herfindahl-Hirschman Index (HHI) of purchases decreasing significantly, as shown in columns 4 to 6 of Table 8. As suppliers to beef exporters scale up operations to meet rising demand, they also expand their own suppliers' network.

Next, we examine broader sectoral dynamics. We aggregate our data to the 4-digit sector level, constructing a panel dataset where the unit of observation is the sector over time. We then implement the sector-level counterpart of the regression specification in equation (2), using as the main regressor a new Bartik-type variable that combines variation across sectors in their overall linkages to beef exporters with time variation in these exporters' trade with China. Unlike firm-level specifications, this approach does not permit the inclusion of sector $\times$ year fixed effects. Instead, we include sector and year fixed effects separately as controls. Table 9 presents the corresponding results. Columns 1 to 6 confirm the firm-level findings, showing that sector-level exposure to beef trade with China leads to higher sales and purchases at the sector level. However, Columns 7 to 9 reveal a significant decline in the number of firms in sectors more exposed to the China beef export shock. At the same time, Appendix Table A.10 shows that firm-level exposure is systematically associated with lower exit probabilities. Taken together, these results suggest a reallocation of economic activity within more exposed sectors, favoring firms with tighter links to beef exporters that have expanded trade with China over time.

These sectoral dynamics and shifts in the production network may play a crucial role in shaping the aggregate impact of the China beef export shock on the economy. In Section 5, we explicitly account for these structural changes and quantify their aggregate implications through counterfactual analysis.

4.3.7 Summary

The reduced-form analysis shows that suppliers to beef exporters are significantly impacted by the China beef export shock. Their sales increase significantly, with the effect being larger for initially smaller suppliers, and for those outside of the agricultural sector. Employment, wages, and sales per worker also increase, particularly for service sector suppliers. The same pattern holds when looking at suppliers' purchases. A detailed investigation of higher-order impacts and purchases by sector shows that the service sales effects propagate further up the value chain, impacting the service sector differentially more. We also find evidence that firm linkages themselves change as a result of the shock, with potentially meaningful implications

on its propagation and aggregate impact on the economy.

5 Aggregate Effects

This section quantifies the aggregate impact of rising beef exports to China on the Uruguayan economy. Our objectives are twofold: first, to measure the indirect effect on aggregate firm sales that materializes through the network of firm-to-firm linkages, and second, to assess how changes in the linkages themselves influence these effects. To this end, we use a simple model of production networks and build on its predictions to derive counterfactual sales for each firm in the absence of the China beef export shock.

5.1 Model

Consider a finite number of firms. Each firm i produces output x_i according to the following technology

$$x_i = z_i k_i^{\alpha} l_i^{\beta} m_i^{\gamma} \tag{6}$$

where z_i is firm productivity and k_i, l_i and m_i are the capital, labor, and intermediate inputs. The latter is an aggregator of goods and services produced by other firms j in the economy according to

$$m_i = \prod_j x_{ji}^{\omega_{ij}} \tag{7}$$

where x_{ji} is the amount of good j used by firm i in production.

Let p_i be the price of the good produced by firm i, which the firm itself and other firms take as given. Firm profit maximization implies

$$\gamma \omega_{ij} = \frac{p_j x_{ji}}{p_i x_i} \tag{8}$$

so that $\gamma \omega_{ij}$ is the value of spending on input j per unit value of production of good i.

Equilibrium market clearing implies that all firm output is either used as input by other firms or consumed by final domestic consumers or foreign firms and consumers whose demand is “external" to the production network. This means that

$$x_i = \sum_{j \neq i} x_{ij} + c_i \tag{9}$$

where c_i is the value of *external demand* for good i. Multiplying both sides by p_i we get

$$p_i x_i = \sum_{j \neq i} p_i x_{ij} + p_i c_i \tag{10}$$

which combined with equation (8) implies

$$p_i x_i = \gamma \sum_{j \neq i} \omega_{ji} p_j x_j + p_i c_i \tag{11}$$

This means we can express each firm sales $s_i = p_i x_i$ as a linear function of all other firms' sales and the value of firm i's external demand $\xi_i = p_i c_i$.

Specifically, let $\mathbf{s}$ be the vector of firm sales, $\boldsymbol{\xi}$ be the vector of external demand, and $\boldsymbol{\Omega}$ be the firm-level input-output matrix with $\gamma\omega_{ij}$ as entries. We can thus rewrite the equilibrium condition in equation (11) as

$$\mathbf{s} = \boldsymbol{\Omega}'\mathbf{s} + \boldsymbol{\xi} \tag{12}$$

While the assumption of perfectly competitive markets can be relaxed, as discussed below, it serves as a useful starting point for mapping the technological parameters $\gamma\omega_{ij}$ to the data as expenditure shares.

5.2 Estimation and Counterfactual Analyses

Equation (12) describes the equilibrium of this economy. Firm sales $\mathbf{s}$ and firm-to-firm transactions and thus $\boldsymbol{\Omega}$ are observable every year from 2014 to 2019. We can obtain the vector of external demand in each year as

$$\left[\mathbf{I} - \boldsymbol{\Omega}_t'\right] \mathbf{s}_t = \boldsymbol{\xi}_t \tag{13}$$

which is equivalent to subtracting sales to other firms from total sales, as per equation (10).

To calculate the aggregate impact of beef exports to China, we can derive counterfactual external demand $\tilde{\boldsymbol{\xi}}_t$ by subtracting the value of exports to China from ξ_{it} for each observation belonging to beef exporters. We can then obtain counterfactual sales $\tilde{s}_{it}$ for each firm in the economy by solving

$$\tilde{\mathbf{s}}_t = \left[\mathbf{I} - \boldsymbol{\Omega}_t'\right]^{-1} \tilde{\boldsymbol{\xi}}_t \tag{14}$$

This means we can compute for each firm and sector the difference between actual sales and counterfactual sales in the absence of the China beef export shock. It is important to note that while this exercise fully accounts for the equilibrium relationship between domestic firms' sales, it does not constitute a fully general equilibrium analysis unless external demand is explicitly modeled as endogenous to domestic consumption. However, if we assume that external demand consists solely of exports and is truly exogenous, then this framework does capture the full general equilibrium effects. This assumption is internally consistent, as firm sales are calculated as the sum of domestic sales to other firms plus exports, with the latter plausibly treated as exogenous.

Combining equations (13) and (14), we can obtain the impact of beef exports to China on

aggregate sales and further disentangle direct effects and network (indirect) effects as follows

$$\underbrace{\boldsymbol{\iota}'(\mathbf{s}_t - \tilde{\mathbf{s}}_t)}_{\text{aggregate effects}} = \underbrace{\boldsymbol{\iota}'\boldsymbol{\Omega}_t'(\mathbf{s}_t - \tilde{\mathbf{s}}_t)}_{\text{network effects}} + \underbrace{\boldsymbol{\iota}'(\boldsymbol{\xi}_t - \tilde{\boldsymbol{\xi}}_t)}_{\text{direct effects}}. \tag{15}$$

5.2.1 Changing Network Effects

The previous effects are measured while keeping the production network fixed to its actual structure in each year t. However, changes in the network structure over time are worth investigating in their own right. These changes are reflected in the data through variations in expenditure shares, which, from the model's perspective, can arise for several reasons.

First, under the assumptions of perfectly competitive markets and no distortions, network changes can result from shifts in technology, as captured by factor shares $\gamma\omega_{ij}$. Second, relaxing the assumption of perfect competition, changes in the network may also be driven by variations in markups or markdowns, which would be reflected in expenditure shares. Third, market distortions can similarly manifest in expenditure share adjustments, as they alter the shadow price of both inputs and output. Finally, changes may materialize along the extensive margin through the formation and disruption of firm linkages, driven, for instance, by variations in bilateral trading fixed costs.

To pin down how these adjustments shape network effects, we can hold the $\boldsymbol{\Omega}$ matrix fixed to its 2014 structure and derive

$$\dot{s}_t = \left[\mathbf{I} - \boldsymbol{\Omega}_{2014}'\right]^{-1} \tilde{\boldsymbol{\xi}}_t \tag{16}$$

which gives the value of counterfactual sales we would have observed had the production network remained unchanged throughout the period. This means we can further decompose network effects as follows

$$\underbrace{\boldsymbol{\iota}'\boldsymbol{\Omega}_t'(\mathbf{s}_t - \tilde{\mathbf{s}}_t)}_{\text{network effects}} = \underbrace{\boldsymbol{\iota}'(\boldsymbol{\Omega}_t'\mathbf{s}_t - \boldsymbol{\Omega}_{2014}'\dot{\mathbf{s}}_t)}_{\text{baseline network effects}} + \underbrace{\boldsymbol{\iota}'(\boldsymbol{\Omega}_{2014}'\dot{\mathbf{s}}_t - \boldsymbol{\Omega}_t'\tilde{\mathbf{s}}_t)}_{\text{changing network effects}} \tag{17}$$

The baseline network effects capture the difference between actual sales and the sales we would have observed in the absence of the China beef export shock, assuming the network remained fixed at its 2014 structure. In contrast, the changing network effects isolate the impact of network evolution by measuring the difference that would have arisen in a scenario without rising exports to China, driven solely by changes in the network structure over time.

5.3 Results

Table 10 presents the results from the main counterfactual analysis. For each year and overall throughout the period, it reports the value of aggregate actual sales and counterfactual sales—i.e., the sales that would have been observed had China beef exports been zero. Additionally, it displays the value and percentage difference between the two, along with the decomposition

into direct and network effects, following equation (15).

The results indicate that beef exports to China increased Uruguayan aggregate sales by 1.79% over the period 2014 to 2019. The direct value of exports accounts for 1.22%, approximately two-thirds of the total effect, while the remaining 0.57% arises from indirect effects and propagation through firm linkages—equivalent to about USD 1.6 billion. These relative proportions remain fairly stable over time. In 2019 alone, the total effect was 3.20%, with 2.19% attributable to direct exports and 1.01% to network-mediated effects.

In Table 11, we further break down aggregate network effects, pooling data across all years. While the majority of these effects are concentrated in the agricultural sector, services account for 22% of the total. We then decompose network effects into baseline and changing network effects, following equation (17). The results reveal a sharp contrast between agriculture and other sectors: baseline network effects are positive for agriculture but negative for other sectors, whereas changing network effects follow the opposite pattern. This means that, in the absence of beef trade with China, and had firm linkages remained fixed at their 2014 structure, the service sector would have generated higher aggregate sales than in the actual economy. In other words, the restructuring of linkages came with an opportunity cost. However, the positive and greater magnitude of changing network effects compared to baseline network effects suggests that the service sector actively restructured its linkages to capitalize on rising beef exports, ultimately more than offsetting this cost. By contrast, with fewer diversification opportunities, the agricultural sector faced the opposite dynamic, benefiting primarily from the initial network structure rather than its evolution over time.

6 Conclusions

The rise in exports of both hard and soft commodities to China is a worldwide phenomenon that affects many countries in the Global South. This paper shows that this commodity export boom can foster production service growth in these countries. Combining customs data from Uruguay with administrative tax records of domestic transactions, matched employer-employee data, and balance sheet data, we show that the rapid surge of Uruguayan beef exports to China has large positive effects on the suppliers of beef exporters, particularly those in services. These indirect effects propagate further up the value chain and have meaningful aggregate implications. Our calculations indicate that beef exports to China increased Uruguayan aggregate sales by 1.79% from 2014 to 2019, with indirect linkages accounting for one-third of this effect and the service sector capturing 22% of these network-mediated gains. Additionally, we show that over time, the service sector actively repositioned itself to capitalize on rising beef exports, strengthening its ability to benefit from expanding trade with China.

As low and middle-income countries struggle to achieve sustained economic growth, rising economic nationalism in high-income nations limits the potential of export manufacturing as a development pathway. As Rodrik and Sandhu (2024) eloquently put it, “the future of develop-

ing countries lies in services." Our findings reveal that commodity exports to China can boost economic activity in production services. The production network mechanisms we identify can be reinforced by income effects that link sectors from the demand side, further enhancing the growth prospects of developing countries. Future research across more countries is needed to determine if this represents a general trend.

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Tables and Figures

Table 1: Firm Linkages

	All Transactions	Sales to Beef Sector
# of Dyads	13,871,164	109,664
# of Sellers	247,963	36,505
# of Sellers' 4d Sectors	413	347
# of Buyers	879,106	94
# of Buyer's 4d Sectors	419	1
# of Buyers per Seller (p50)	2,252	5
# of Sellers per Buyer (p50)	142	4743

Notes. The table reports some summary statistics on the network of firm-to-firm linkages that we trace from administrative transaction-level data.

Table 2: Beef Sector Statistics

	Obs.	Mean	St. Dev.	Min	Max	Obs.	Mean	St. Dev.	Min	Max
	All Sectors					*Transportation*				
# of Suppliers	449	530.49	741.88	1	3220	298	39.33	37.62	1	166
# of Suppliers' 4d Sectors	449	65.03	60.96	1	194	298	6.52	4.26	1	16
HHI of Purchases	449	0.34	0.42	0	1	298	0.37	0.29	0.05	1
Log of Total Purchases (UYP)	446	16.05	5.18	4.65	23.50	298	15.55	3.06	6.70	19.87
	Agriculture, Forestry, Fishing					*ICT Services*				
# of Suppliers	276	490.64	544.56	1	2283	315	6.49	5.54	1	25
# of Suppliers' 4d Sectors	276	9.11	5.05	1	19	315	3.41	2.03	1	8
HHI of Purchases	276	0.15	0.28	0	1	315	0.57	0.29	0.12	1
Log of Total Purchases (UYP)	276	18.38	3.73	1.51	23.40	315	12.75	2.15	6.01	16.75
	Manufacturing					*Professional Services*				
# of Suppliers	313	50.51	43.25	1	164	297	28.61	29.88	1	121
# of Suppliers' 4d Sectors	313	25.80	17.97	1	64	297	5.98	2.97	1	12
HHI of Purchases	313	0.35	0.25	0	1	297	0.33	0.30	0	1
Log of Total Purchases (UYP)	312	16.08	3.24	5.91	21.66	296	15.09	2.59	6.69	19.25

Notes. The table reports some summary statistics on the network of firm-to-firm linkages that we trace from administrative transaction-level data, focusing on the domestic sales to the beef sector. The unit of observation is a buyer in the beef sector in a given year from 2014 to 2019.

Table 3: Estimation Sample: Firms by Sector

	Observations	Frequency (%)
Agriculture, Forestry, and Fishing	9,594	63.09
Construction	161	1.06
Financial Services	26	0.17
Information Communication	92	0.60
Manufacturing	730	4.80
Mining	13	0.09
Other Services	553	3.64
Professional Services	624	4.10
Real Estate Services	183	1.20
Retail	2,509	16.50
Transportation	705	4.64
Utilities	18	0.12
Total	15,208	100.00

Notes. The table shows the distribution of suppliers to beef exporters across sectors. We identify beef exporters as firms in the beef sector exporting any amount at any point in time between 2015 and 2019, and define our estimation sample by identifying the suppliers of these firms in 2014.

Table 4: Effect on Sales

	Log of Total Sales					
	(1)	(2)	(3)	(4)	(5)	(6)
China Beef Export Shock	0.0819***	0.0819***	0.0821***	0.0673***	0.0673***	0.0674***
	(0.0193)	(0.0193)	(0.0193)	(0.0158)	(0.0158)	(0.0159)
Export Shock		-0.0205***	-0.0208***		-0.0206***	-0.0209***
		(0.00472)	(0.00476)		(0.00470)	(0.00474)
Import Shock			0.0417			0.0426
			(0.0325)			(0.0326)
ROW Beef Export Shock				0.0594***	0.0595***	0.0596***
				(0.0153)	(0.0153)	(0.0153)
Firms FE	✓	✓	✓	✓	✓	✓
Sector × Year FE	✓	✓	✓	✓	✓	✓
Observations	69,712	69,712	69,712	69,712	69,712	69,712
R^2	0.871	0.871	0.871	0.871	0.871	0.871

Notes. * p-value< 0.1; ** p-value<0.05; *** p-value<0.01. The unit of observation is a supplier to a beef exporter in a given year. The table reports the coefficient estimates obtained when implementing equation (2) and having as dependent variable the log of total sales, which we calculate from transaction-level and customs data as the sum of domestic and external sales. The independent variables are defined in Section 4.2. Standard errors are clustered at the ISIC 4-digit sector level.

Table 5: Effect on Sales by Industry

	Log of Total Sales								
	Agriculture			*Manufacturing*			*Services*		
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
China Beef Export Shock	0.0653***	0.0651***	0.0651***	0.170**	0.170**	0.169**	0.137***	0.137***	0.138***
	(0.00989)	(0.0101)	(0.0101)	(0.0790)	(0.0791)	(0.0797)	(0.0454)	(0.0454)	(0.0454)
Export Shock		0.361***	0.368***		-0.0278	-0.0187		-0.0232***	-0.0234***
		(0.113)	(0.120)		(0.0620)	(0.0522)		(0.00357)	(0.00362)
Import Shock			0.447			0.592***			0.0277
			(0.843)			(0.114)			(0.0286)
Firms FE	✓	✓	✓	✓	✓	✓	✓	✓	✓
Sector × Year FE	✓	✓	✓	✓	✓	✓	✓	✓	✓
Observations	43,439	43,439	43,439	3,437	3,437	3,437	21,999	21,999	21,999
R^2	0.831	0.831	0.831	0.912	0.912	0.912	0.904	0.904	0.904

Notes. * p-value< 0.1; ** p-value<0.05; *** p-value<0.01. The unit of observation is a supplier to a beef exporter in a given year. The table reports the coefficient estimates obtained when implementing equation (2) and having as dependent variable the log of total sales, which we calculate from transaction-level and customs data as the sum of domestic and external sales. Estimates are obtained separately for the subsamples of suppliers in the agricultural, manufacturing, and service sector. The independent variables are defined in Section 4.2. Standard errors are clustered at the ISIC 4-digit sector level.

Table 6: Effect on Employment, Wages, and Sales per Worker by Industry

	Agriculture			*Manufacturing*			*Services*		
Log of	Employment	Avg. Wage	Sales/Empl.	Employment	Avg. Wage	Sales/Empl.	Employment	Avg. Wage	Sales/Empl.
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
China Beef	0.00708*	0.00614**	0.0356***	0.0722	-0.102	0.0191	0.0321**	0.0340**	0.0679**
	(0.00374)	(0.00218)	(0.00623)	(0.0537)	(0.0719)	(0.0734)	(0.0140)	(0.0160)	(0.0342)
Export Shock	-0.129***	-0.0494	0.544***	-0.0351***	0.0194	-0.0391	0.000671	0.0288***	0.000899
	(0.0271)	(0.108)	(0.158)	(0.00644)	(0.0318)	(0.0768)	(0.00108)	(0.00559)	(0.00152)
Import Shock	-0.110	0.346	0.000272	0.0749	0.0882	0.624***	-0.0138	0.0111	-0.0385
	(0.215)	(0.521)	(0.897)	(0.0475)	(0.0588)	(0.184)	(0.0196)	(0.0354)	(0.0271)
Firms FE	✓	✓	✓	✓	✓	✓	✓	✓	✓
Sector × Year FE	✓	✓	✓	✓	✓	✓	✓	✓	✓
Observations	31,411	31,411	31,411	2,804	2,804	2,804	16,715	16,715	16,718
R^2	0.924	0.761	0.762	0.946	0.881	0.905	0.945	0.850	0.908

Notes. * p-value< 0.1; ** p-value<0.05; *** p-value<0.01. The unit of observation is a supplier to a beef exporter in a given year. The table reports the coefficient estimates obtained when implementing equation (2) and having as dependent variable the log of employment, average wage, and sales per worker. Estimates are obtained separately for the subsamples of suppliers in the agricultural, manufacturing, and service sector. The independent variables are defined in Section 4.2. Standard errors are clustered at the ISIC 4-digit sector level.

Table 7: Effect on Purchases by Industry

	Log of Total Purchases								
	Agriculture			*Manufacturing*			*Services*		
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
China Beef Export Shock	0.0469***	0.0469***	0.0468***	0.145	0.142	0.142	0.0967***	0.0967***	0.0990***
	(0.00848)	(0.00848)	(0.00846)	(0.0873)	(0.0876)	(0.0871)	(0.0341)	(0.0340)	(0.0342)
Export Shock		0.133**	0.161***		-0.315**	-0.328**		-0.0214***	-0.0229***
		(0.0477)	(0.0366)		(0.154)	(0.157)		(0.00660)	(0.00674)
Import Shock			1.863**			0.360*			0.170***
			(0.739)			(0.186)			(0.0554)
Firms FE	✓	✓	✓	✓	✓	✓	✓	✓	✓
Sector × Year FE	✓	✓	✓	✓	✓	✓	✓	✓	✓
Observations	42,421	42,421	42,421	3,407	3,407	3,407	20,762	20,762	20,762
R^2	0.858	0.858	0.858	0.901	0.901	0.901	0.906	0.906	0.906

Notes. * p-value< 0.1; ** p-value<0.05; *** p-value<0.01. The unit of observation is a supplier to a beef exporter in a given year. The table reports the coefficient estimates obtained when implementing equation (2) and having as dependent variable the log of total purchases, which we calculate from transaction-level and customs data as the sum of domestic and external purchases. Estimates are obtained separately for the subsamples of suppliers in the agricultural, manufacturing, and service sector. The independent variables are defined in Section 4.2. Standard errors are clustered at the ISIC 4-digit sector level.

Table 8: Effect on Number of Suppliers and Purchase Concentration

Log of	Number of Suppliers			HHI of Purchases		
	(1)	(2)	(3)	(4)	(5)	(6)
China Beef	0.0266***	0.0266***	0.0268***	-0.00773***	-0.00773***	-0.00765***
	(0.00555)	(0.00554)	(0.00561)	(0.00252)	(0.00252)	(0.00254)
Export Shock		-0.0168***	-0.0174***		-0.00560**	-0.00586**
		(0.00245)	(0.00259)		(0.00279)	(0.00281)
Import Shock			0.0676***			0.0276
			(0.0178)			(0.0205)
Firms FE	✓	✓	✓	✓	✓	✓
Sector × Year FE	✓	✓	✓	✓	✓	✓
Observations	67,478	67,478	67,478	67,478	67,478	67,478
R^2	0.926	0.926	0.926	0.834	0.834	0.834

Notes. * p-value< 0.1; ** p-value<0.05; *** p-value<0.01. The unit of observation is a supplier to a beef exporter in a given year. The table reports the coefficient estimates obtained when implementing equation (2) and having as dependent variable the log of number of suppliers (columns 1 to 3) and the log of HHI of purchases (columns 4 to 6). The independent variables are defined in Section 4.2. Standard errors are clustered at the ISIC 4-digit sector level.

Table 9: Sector-Level Effects on Sales, Purchases and Number of Firms

	Log of Total Sales			Log of Total Purchases			Log of Number of Firms		
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
China Beef Export Shock	0.0411*	0.0402*	0.0404*	0.0291*	0.0281*	0.0292*	-0.0176*	-0.0178*	-0.0187*
	(0.0229)	(0.0229)	(0.0229)	(0.0158)	(0.0158)	(0.0158)	(0.00974)	(0.00971)	(0.00966)
Export Shock		0.0739**	0.0738**		0.0906***	0.0898***		0.0148	0.0154
		(0.0349)	(0.0349)		(0.0274)	(0.0264)		(0.0168)	(0.0174)
Import Shock			0.0179			0.145***			-0.111*
			(0.0288)			(0.0547)			(0.0624)
Firms FE	✓	✓	✓	✓	✓	✓	✓	✓	✓
Sector FE	✓	✓	✓	✓	✓	✓	✓	✓	✓
Observations	1,495	1,495	1,495	1,495	1,495	1,495	1,495	1,495	1,495
R^2	0.977	0.977	0.977	0.966	0.966	0.966	0.990	0.990	0.990

Notes. * p-value< 0.1; ** p-value<0.05; *** p-value<0.01. The unit of observation is an ISIC 4-digit sector. The table reports the coefficient estimates obtained when implementing the sector-level homolog of equation (2), with separate fixed effects for each sector and year. The dependent variables are the log of aggregate total sales (columns 1 to 3), the log of aggregate purchases (columns 4 to 6), and the log of number of firms (columns 7 to 9) in each sector. The independent variables are defined in Section 4.2 but calculated now at the sector level. Standard errors are clustered at the ISIC 4-digit sector level.

Table 10: Aggregate Effects

	2014	2015	2016	2017	2018	2019	Total
Aggregate (Millions UYP)	1,419,782	1,573,081	1,564,832	1,680,643	1,940,057	1,976,130	10,154,525
Aggregate Counterfactual Sales (Millions UYP)	1,408,041	1,552,646	1,542,138	1,653,735	1,904,358	1,914,880	9,975,798
Difference (Millions UYP)	11,741	20,435	22,694	26,908	35,699	61,251	178,728
Direct Effect (Millions UYP)	8,112	13,885	15,559	18,148	24,317	41,978	121,999
Network Effect (Millions UYP)	3,629	6,549	7,135	8,760	11,382	19,273	56,728
Difference (%)	0.83	1.32	1.47	1.63	1.87	3.20	1.79
Direct Effect (%)	0.58	0.89	1.01	1.10	1.28	2.19	1.22
Network Effect (%)	0.26	0.42	0.46	0.53	0.60	1.01	0.57

Notes. The table reports the results from the counterfactual analysis presented in Section 5.2. Aggregate counterfactual sales correspond to those we would have observed had China beef exports been equal to zero in each year. The table reports the value and percentage difference between actual and counterfactual sales, along with the decomposition into direct and network effects, as outlined in equation (15).

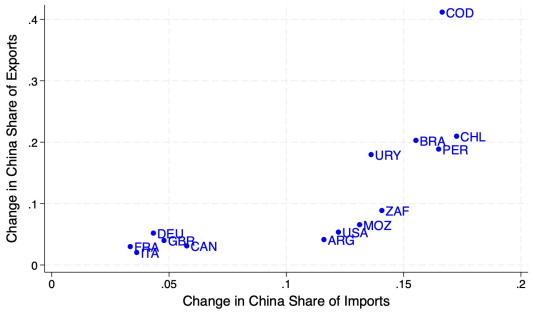
Table 11: Network Effects by Sector

	Millions UYP	%	Baseline	Changing
Agriculture	40,845	72.00	62,638	-21,793
Mining	882	1.55	-2,525	3,407
Manufacturing	2,267	4.00	-19,654	21,921
Services	12,734	22.45	-36,035	48,769
Total	56,728	100.00	4,424	52,304

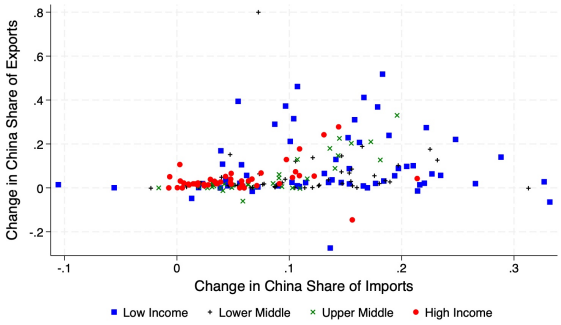
Notes. The table reports the results from the decomposition of network effects into baseline and changing network effects, as discussed in Section 5.2.1. Values are aggregated over the whole period from 2014 to 2019.

Figure 1: China Share of Imports and Exports: Changes 2000 to 2017

(a) Selected Countries

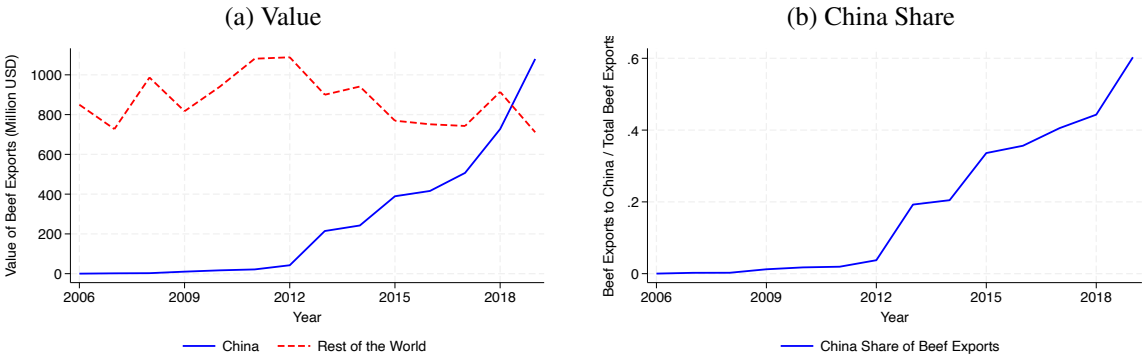


(b) All Countries



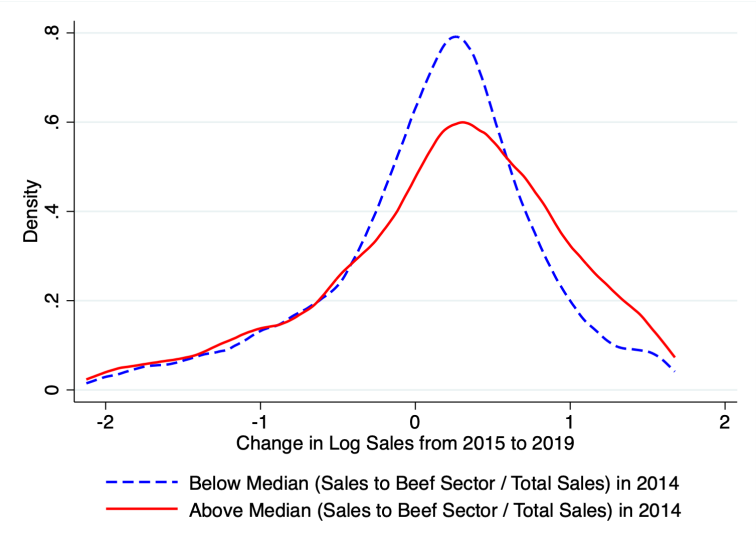
Notes. The left panel plots, for selected countries, the change in the Chinese share of exports against the change in the Chinese share of imports over the period 2000 to 2017. The right panel plots the same changes in Chinese export and import shares for all countries for which data are available, split by income group. Data from COMTRADE via The Growth Lab at Harvard University (2019).

Figure 2: Uruguay Exports of Beef



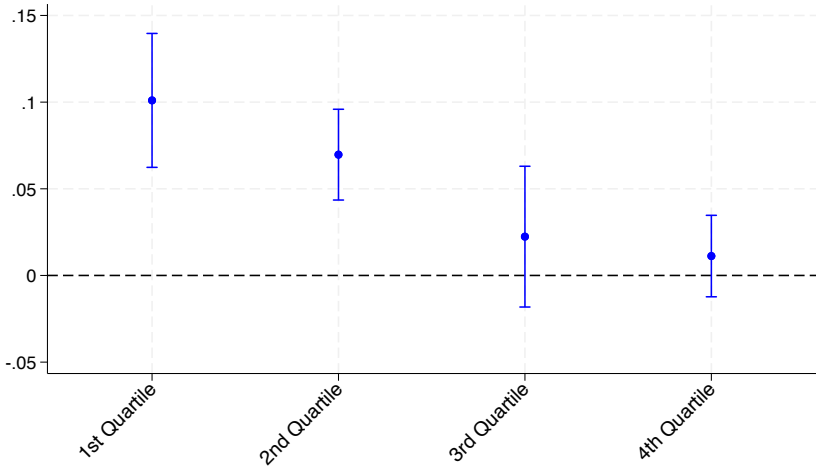
Notes. The left panel shows the value of beef exports over time and separately towards China and the rest of the world. The right panel shows beef exports to China as a share of all beef exports over the same period.

Figure 3: Linkages to the Beef Sector and Sales Growth



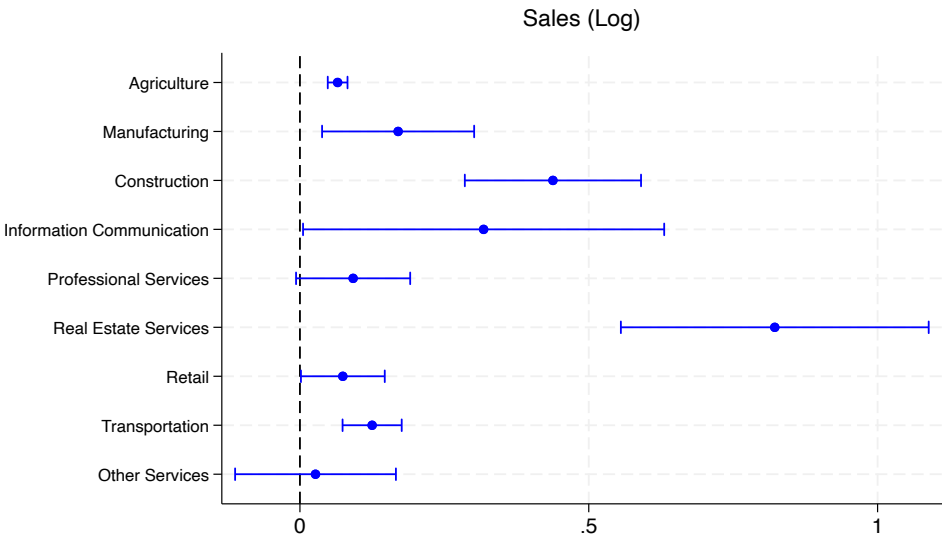
Notes. The figure plots the distribution of sales growth from 2015 to 2019 separately for firms with beef sector linkages above and below the median in the baseline year 2014.

Figure 4: Sales Effect Heterogeneity by Initial Size



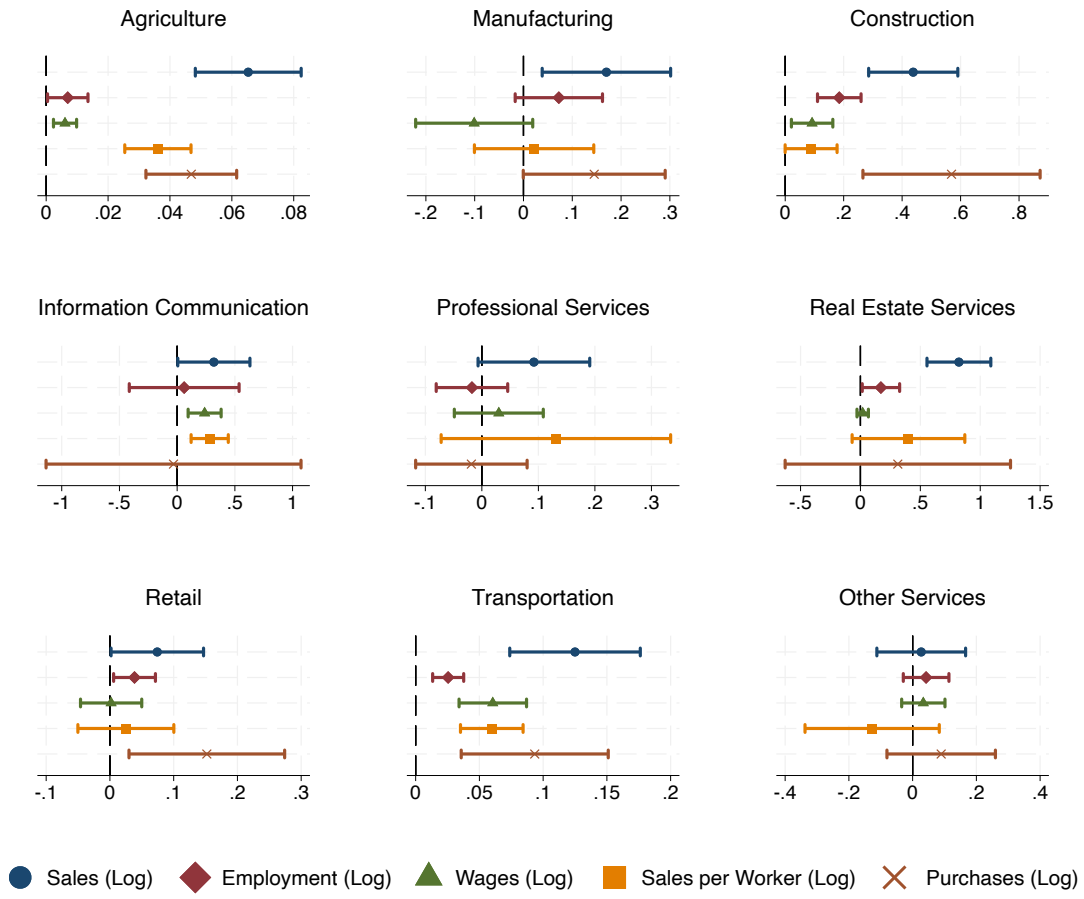
Notes. The figure shows graphically the estimated coefficients of the China beef export shock variable and their 90% confidence intervals, obtained when implementing the specification in equation (2) separately in each quartiles of the distribution of suppliers' total sales in the baseline year 2014.

Figure 5: Sales Effect Heterogeneity by Sector



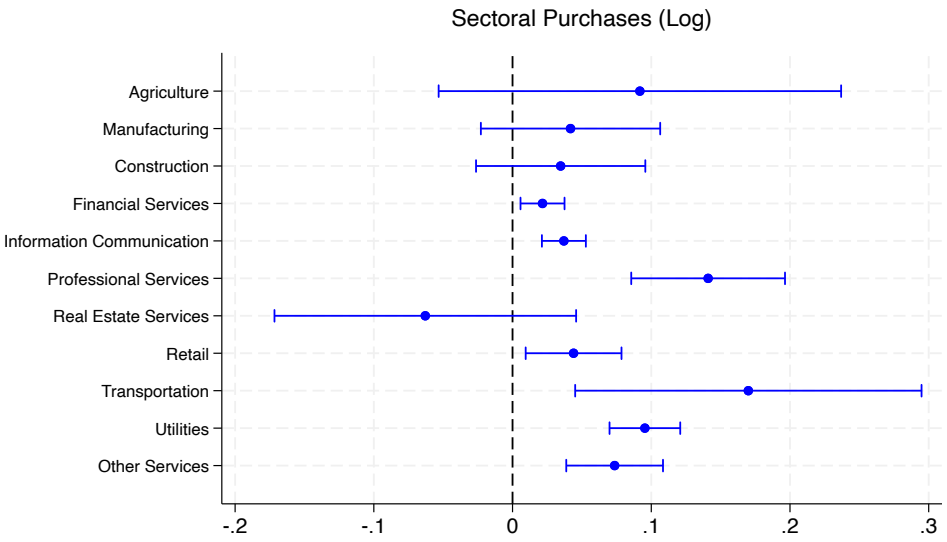
Notes. The figure shows graphically the estimated coefficients of the China beef export shock variable and their 90% confidence intervals, obtained when implementing the specification in equation (2) separately for suppliers grouped into specific sectors, which we construct by aggregating ISIC 4-digit classifications.

Figure 6: Effect Heterogeneity by Sector and Outcome



Notes. The figure shows graphically the estimated coefficients of the China beef export shock variable and their 90% confidence intervals, obtained when implementing the specification in equation (2) separately for suppliers grouped into specific sectors—which we construct by aggregating ISIC 4-digit classifications—and having as dependent variables the log of sales, log of employment, log of wages, log of sales per worker, and log of total purchases.

Figure 7: Effect on Sectoral Purchases



Notes. The figure shows graphically the estimated coefficients of the China beef export shock variable and their 90% confidence intervals, obtained when implementing the specification in equation (2) over the entire sample but considering separately as dependent variable all purchases from specific sectors, which we construct by aggregating buyers according to their ISIC 4-digit classifications.

ONLINE APPENDIX

Beefing Up the Service Sector: Commodity Exports to China and Production Network Spillovers

Francesco Amodio, Giorgio Chiovelli and Serafín Frache*

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Table A.1: Validation of Total Sales

	Log of Sales (IRAE)	
	2014	2019
Log of Sales (Domestic + Exports)	0.913***	0.903***
	(0.005)	(0.005)
Observations	15,423	19,243

Notes. * p-value< 0.1; ** p-value<0.05; *** p-value<0.01. The table reports the coefficient estimates that we obtain from a simple regression of the (log) sales from corporate tax data over the (log) sales from domestic transactions and customs data, implemented separately for the years 2014 and 2019. Motivated by the evidence in Figure A.5, we restrict the sample to observations of (log) sales higher than 15.

Table A.2: Summary Statistics

	Obs.	Mean	St. Dev.	Min	Max
Sales (Millions UYP)	69,712	11,200,000	20,400,000	77.27	141,000,000
Log of Sales	69,712	14.844	1.976	4.347	18.767
Domestic Sales (Millions UYP)	69,569	10,800,000	19,500,000	77.27	132,000,000
Log of Domestic Sales	69,569	14.834	1.969	4.347	18.698
Exports	69,569	65,564.51	1,690,940	0	120,000,000
Log of Exports	69,569	0.168	1.504	0	18.603
Purchases	67,478	3,908,745	9,448,054	160	63,600,000
Log of Purchases	67,478	12.722	2.579	5.075	17.968
Domestic Purchases	67,185	3,148,550	7,450,233	160	52,700,000
Log of Domestic Purchases	67,185	12.653	2.510	5.075	17.780
Imports	67,185	523,254.2	3,169,247	0	58,100,000
Log of Imports	67,185	1.093	3.876	0	17.877
Employment	54,518	14.968	86.465	1	5,584
Log of Employment	54,518	1.761	1.178	0	8.628
Average Wage	52,239	2,129,666	3,296,343	1	20,100,000
Log Average Wage	52,239	13.619	1.481	0	16.818
Firms	15,208				
4d Sectors	227				

Notes. The table reports the summary statistics for the estimation sample of all the variables we use in the empirical analysis. The unit of observation is a supplier-year in the period from 2015 to 2019. Values in Uruguayan Pesos (1 USD equals 25 UYP in 2014; 1 USD equals 38 UYP in 2019).

Table A.3: Second-Order Effect Estimation Sample: Firms by Sector

	Observations	Frequency (%)
Agriculture, Forestry, and Fishing	3,589	7.73
Construction	1,886	4.06
Financial Services	337	0.73
Information Communication	1,340	2.88
Manufacturing	5,858	12.61
Mining	83	0.18
Other Services	4,958	10.67
Professional Services	6,606	14.22
Real Estate Services	815	1.75
Retail	16,355	35.20
Transportation	4,498	9.68
Utilities	133	0.29
Total	46,458	100.00

Notes. The table shows the distribution of second-order links (suppliers of suppliers to beef exporters) across sectors.

Table A.4: Robustness: Effect on Sales Including Imputed Final Consumer Sales

	Log of Total Sales					
	(1)	(2)	(3)	(4)	(5)	(6)
China Beef Export Shock	0.0754***	0.0754***	0.0755***	0.0617***	0.0617***	0.0618***
	(0.0151)	(0.0151)	(0.0151)	(0.0112)	(0.0112)	(0.0112)
Export Shock		-0.00309	-0.00328		-0.00312	-0.00331
		(0.00691)	(0.00705)		(0.00692)	(0.00706)
Import Shock			0.0655*			0.0657*
			(0.0394)			(0.0393)
ROW Beef Export Shock				0.0559***	0.0559***	0.0559***
				(0.0148)	(0.0148)	(0.0148)
Firms FE	✓	✓	✓	✓	✓	✓
Sector × Year FE	✓	✓	✓	✓	✓	✓
Observations	70,221	70,221	70,221	70,221	70,221	70,221
R^2	0.885	0.885	0.885	0.885	0.885	0.885

Notes. * p-value< 0.1; ** p-value<0.05; *** p-value<0.01. The unit of observation is a supplier to a beef exporter in a given year. The table reports the coefficient estimates obtained when implementing equation (2) and having as dependent variable the log of predicted total sales obtained as the sum of domestic and external sales and imputed final consumer sales. The independent variables are defined in Section 4.2 where shares of sales are calculated using predicted total sales that include imputed final consumer sales. Standard errors are clustered at the ISIC 4-digit sector level.

Table A.5: Robustness: Effect on Sales by Industry Including Imputed Final Consumer Sales

	Log of Total Sales								
	Agriculture			*Manufacturing*			*Services*		
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
China Beef	0.0639***	0.0637***	0.0637***	0.196**	0.196**	0.191**	0.133***	0.133***	0.134***
	(0.00827)	(0.00844)	(0.00843)	(0.0866)	(0.0866)	(0.0877)	(0.0424)	(0.0424)	(0.0424)
Export Shock		0.672**	0.683**		0.00266	0.00198		-0.103***	-0.104***
		(0.313)	(0.322)		(0.00286)	(0.00253)		(0.0214)	(0.0216)
Import Shock			0.416			0.650***			0.0292
			(0.898)			(0.146)			(0.0333)
Firms FE	✓	✓	✓	✓	✓	✓	✓	✓	✓
Sector × Year FE	✓	✓	✓	✓	✓	✓	✓	✓	✓
Observations	43,767	43,767	43,767	3,691	3,691	3,691	21,881	21,881	21,881
R^2	0.840	0.840	0.840	0.923	0.923	0.923	0.910	0.910	0.910

Notes. * p-value< 0.1; ** p-value<0.05; *** p-value<0.01. The unit of observation is a supplier to a beef exporter in a given year. The table reports the coefficient estimates obtained when implementing equation (2) and having as dependent variable the log of predicted total sales obtained as the sum of domestic and external sales and imputed final consumer sales. Estimates are obtained separately for the subsamples of suppliers in the agricultural, manufacturing, and service sector. The independent variables are defined in Section 4.2 where shares of sales are calculated using predicted total sales that include imputed final consumer sales. Standard errors are clustered at the ISIC 4-digit sector level.

Table A.6: Effect on Sales: IRAE Firms

	Log of Sales (Domestic + Exports)			Log of Sales (IRAE)		
	(1)	(2)	(3)	(4)	(5)	(6)
China Beef Export Shock	0.0262*	0.0262*	0.0262*	0.0253*	0.0253*	0.0253*
	(0.0157)	(0.0157)	(0.0157)	(0.0131)	(0.0132)	(0.0132)
Export Shock		0.0565*	0.0563*		0.0915*	0.0915*
		(0.0305)	(0.0305)		(0.0490)	(0.0490)
Import Shock			-0.00602			0.00117
			(0.0186)			(0.0155)
Firms FE	✓	✓	✓	✓	✓	✓
Sector × Year FE	✓	✓	✓	✓	✓	✓
Observations	14,077	14,077	14,077	14,077	14,077	14,077
R^2	0.929	0.929	0.929	0.952	0.953	0.953

Notes. * p-value< 0.1; ** p-value<0.05; *** p-value<0.01. The unit of observation is a supplier to a beef exporter in a given year. The table reports the coefficient estimates obtained when implementing equation (2) and having as dependent variable the log of sales from domestic transaction-level and customs data (columns 1 to 3) and the log of sales from corporate tax data (columns 4 to 6). The sample is restricted to those firm-year observations that appear in the two datasets. The independent variables are defined in Section 4.2. Standard errors are clustered at the ISIC 4-digit sector level.

Table A.7: Placebo Estimates: IRAE Firms

	Log of Total Sales (2009-2013)					
	(1)	(2)	(3)	(4)	(5)	(6)
China Beef Export Shock $t+5$	-0.00824	-0.00824	-0.00829	-0.0263	-0.0263	-0.0264
	(0.0121)	(0.0121)	(0.0122)	(0.0175)	(0.0175)	(0.0175)
Export Shock $t+5$		0.0109	0.0106		0.0109	0.0106
		(0.0510)	(0.0510)		(0.0514)	(0.0513)
Import Shock $t+5$			-0.0106			-0.0104
			(0.0288)			(0.0289)
ROW Beef Export Shock $t+5$				0.0599*	0.0599*	0.0598*
				(0.0343)	(0.0343)	(0.0343)
Firms FE	✓	✓	✓	✓	✓	✓
Sector × Year FE	✓	✓	✓	✓	✓	✓
Observations	14,077	14,077	14,077	14,077	14,077	14,077
R^2	0.923	0.923	0.923	0.923	0.923	0.923

Notes. * p-value< 0.1; ** p-value<0.05; *** p-value<0.01. The unit of observation is a supplier to a beef exporter in a given year. The table reports the coefficient estimates obtained when implementing equation (2) and having as dependent variable the log of sales from domestic transaction-level and customs data (columns 1 to 3) and the log of sales from corporate tax data (columns 4 to 6) looking at the period 2009 to 2013. The sample is restricted to those firm-year observations that appear in the two datasets. The independent variables are defined in Section 4.2, and take their value in year $t+5$. Standard errors are clustered at the ISIC 4-digit sector level.

Table A.8: Effect on Sales: IRAE Service Firms

	Log of Sales (Domestic + Exports)			Log of Sales (IRAE)		
	(1)	(2)	(3)	(4)	(5)	(6)
China Beef Export Shock	0.0624**	0.0623**	0.0623**	0.0631***	0.0630***	0.0631***
	(0.0257)	(0.0258)	(0.0257)	(0.0203)	(0.0203)	(0.0204)
Export Shock		0.0941**	0.0940**		0.151	0.151
		(0.0358)	(0.0358)		(0.103)	(0.103)
Import Shock			-0.000404			0.00808
			(0.0178)			(0.0157)
Firms FE	✓	✓	✓	✓	✓	✓
Sector × Year FE	✓	✓	✓	✓	✓	✓
Observations	7,922	7,922	7,922	7,922	7,922	7,922
R^2	0.937	0.937	0.937	0.965	0.965	0.965

Notes. * p-value< 0.1; ** p-value<0.05; *** p-value<0.01. The unit of observation is a supplier to a beef exporter in a given year. The table reports the coefficient estimates obtained when implementing equation (2) and having as dependent variable the log of sales from domestic transaction-level and customs data (columns 1 to 3) and the log of sales from corporate tax data (columns 4 to 6). The sample is restricted to the service sector and to those firm-year observations that appear in the two datasets. The independent variables are defined in Section 4.2. Standard errors are clustered at the ISIC 4-digit sector level.

Table A.9: Placebo Estimates: IRAE Service Firms

	Log of Total Sales (2009-2013)					
	(1)	(2)	(3)	(4)	(5)	(6)
China Beef Export Shock $t+5$	-0.0148	-0.0147	-0.0149	-0.0298	-0.0298	-0.0299
	(0.0256)	(0.0256)	(0.0257)	(0.0328)	(0.0328)	(0.0327)
Export Shock $t+5$		-0.0348	-0.0355		-0.0352	-0.0359
		(0.0598)	(0.0591)		(0.0597)	(0.0590)
Import Shock $t+5$			-0.0117			-0.0116
			(0.0297)			(0.0298)
ROW Beef Export Shock $t+5$				0.0415	0.0416	0.0414
				(0.0628)	(0.0626)	(0.0628)
Firms FE	✓	✓	✓	✓	✓	✓
Sector $\times$ Year FE	✓	✓	✓	✓	✓	✓
Observations	7,922	7,922	7,922	7,922	7,922	7,922
R^2	0.934	0.934	0.934	0.934	0.934	0.934

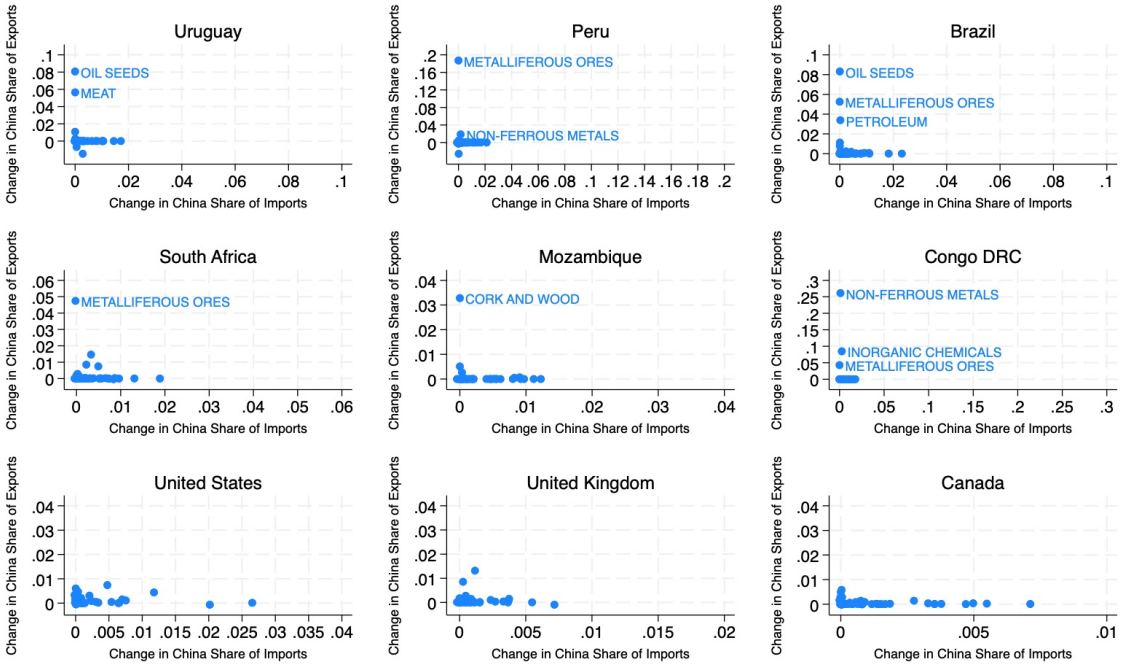
Notes. * p-value< 0.1; ** p-value<0.05; *** p-value<0.01. The unit of observation is a supplier to a beef exporter in a given year. The table reports the coefficient estimates obtained when implementing equation (2) and having as dependent variable the log of sales from domestic transaction-level and customs data (columns 1 to 3) and the log of sales from corporate tax data (columns 4 to 6) looking at the period 2009 to 2013. The sample is restricted to the service sector and to those firm-year observations that appear in the two datasets. The independent variables are defined in Section 4.2, and take their value in year $t+5$. Standard errors are clustered at the ISIC 4-digit sector level.

Table A.10: Effect on Firm Exit

	Exit $\{0, 1\}$		
	(1)	(2)	(3)
China Beef Export Shock	-0.104***	-0.104***	-0.105***
	(0.0366)	(0.0366)	(0.0360)
Export Shock		0.00378***	0.00251
		(0.00141)	(0.00156)
Import Shock			-0.140**
			(0.0636)
Sector FE $\times \ln t$	✓	✓	✓
Observations	67,730	67,730	67,730

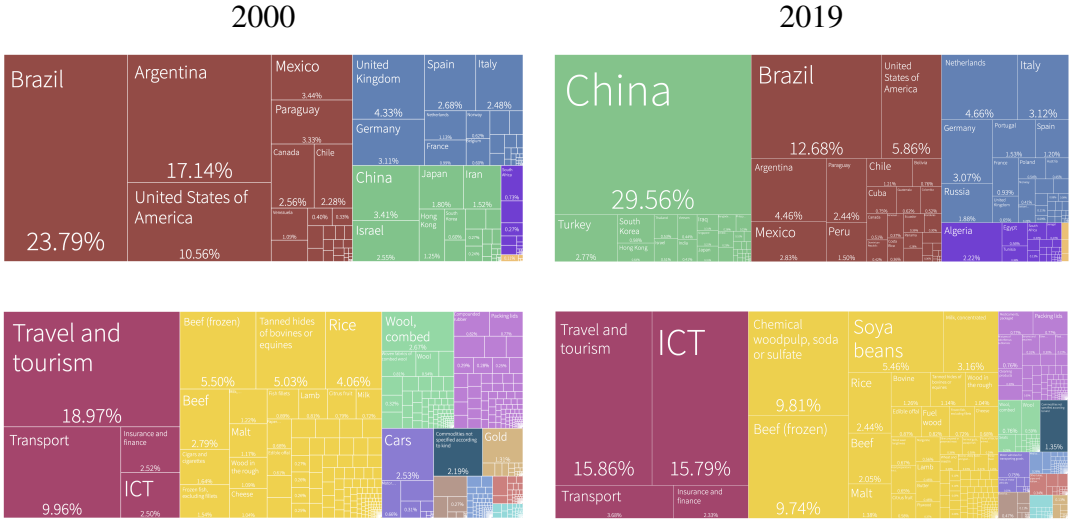
Notes. * p-value< 0.1; ** p-value<0.05; *** p-value<0.01. The unit of observation is a supplier to a beef exporter in a given year. The table reports the coefficient estimates obtained when implementing a logit regression specification having a dummy for firm exit as dependent variable, the same main regressors as in equation (2), and sector-specific duration dependence modeled as the interaction of sector fixed effects with $\ln t$ where t is the time period variable equal to 1 in 2014, 2 in 2015, etc. Standard errors are clustered at the ISIC 4-digit sector level.

Figure A.1: China Share of Imports and Exports by Sector: Changes 2000 to 2017



Notes. The figures plot, for selected countries, the change in the Chinese share of exports against the change in the Chinese share of imports by 2-digit sector over the period 2000 to 2017. Data from COMTRADE via The Growth Lab at Harvard University (2019).

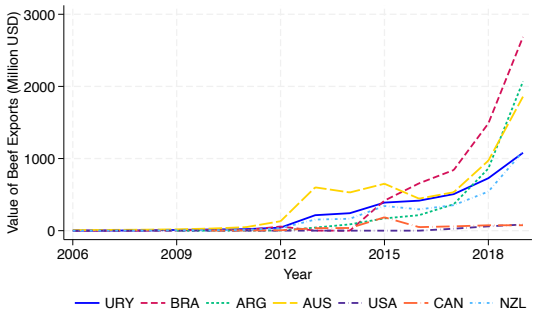
Figure A.2: Uruguay Exports



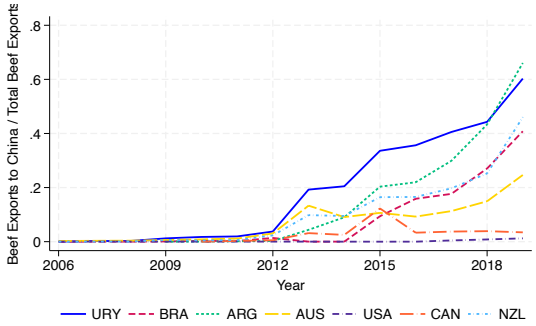
Notes. The figure shows the composition of exports by destination (top) and by category (bottom) and in the years 2000 (left) and 2019 (right). Data from The Growth Lab at Harvard University (2019).

Figure A.3: Beef Exports to China Across Countries

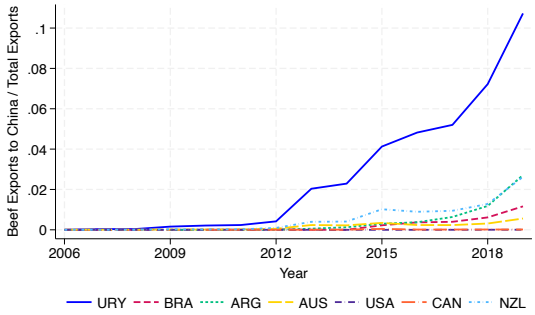
(a) Value of Beef Exports to China



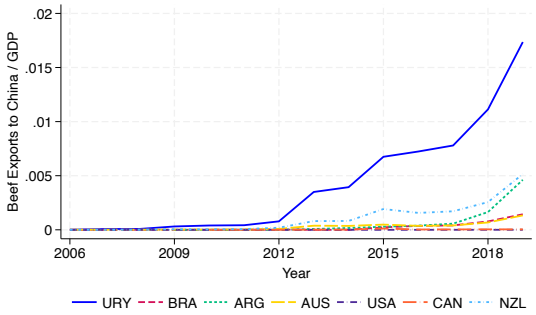
(b) Beef Exports to China as Share of All Beef Exports



(c) Beef Exports to China as Share of All Exports

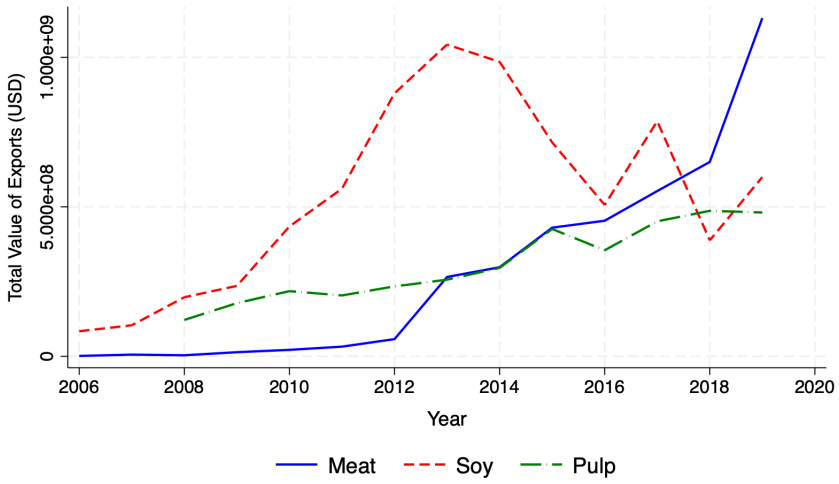


(d) Beef Exports to China as Share of GDP



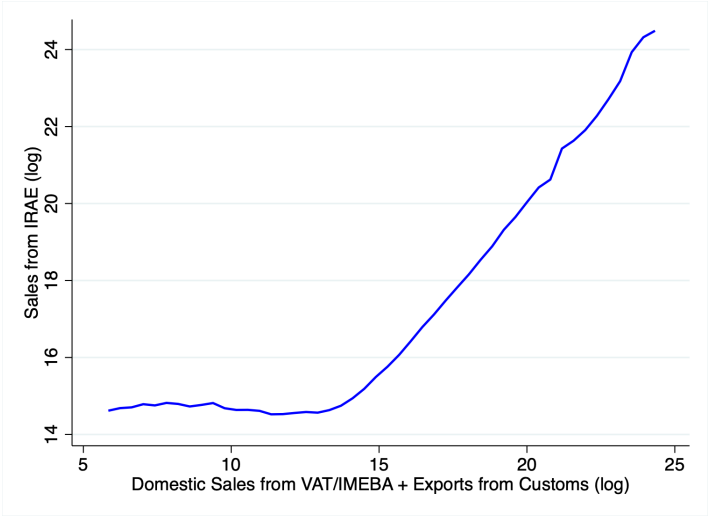
Notes. The figures show the evolution of beef exports to China over time in value and in relationship to the aggregate value of beef exports, aggregate value of exports, and country's GDP.

Figure A.4: Uruguay Exports to China



Notes. The figure plots the value of meat, soy, and pupl exports to Chna over time. Values are in Uruguayan Pesos. Data from COMTRADE via The Growth Lab at Harvard University (2019).

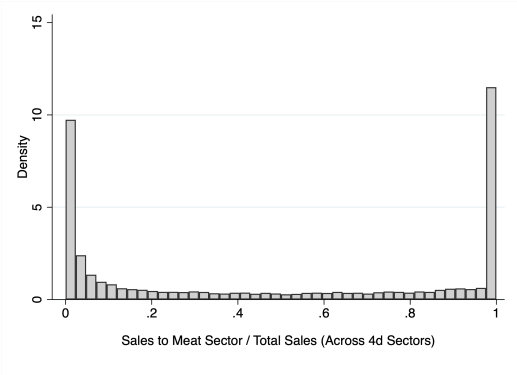
Figure A.5: Validation of Total Sales



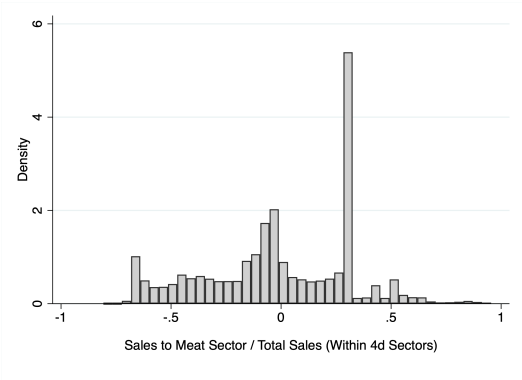
Notes. The figure plots the local polynomial smoothing of the relationship between (log) sales from corporate tax data against the (log) sales from domestic transactions and customs data for all years from 2014 to 2019.

Figure A.6: Linkages to Beef Sector and Beef Exporters

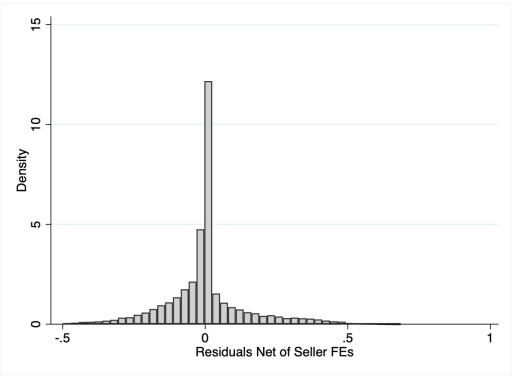
(a) Across Sectors



(b) Within Sectors

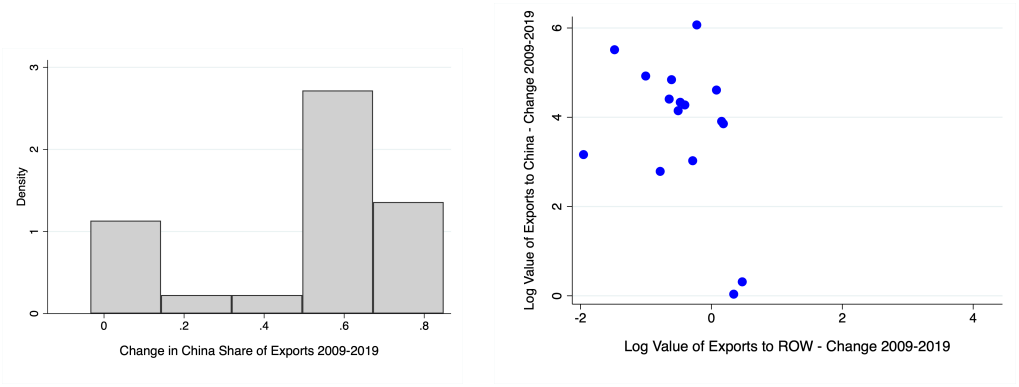


(c) Within Firms



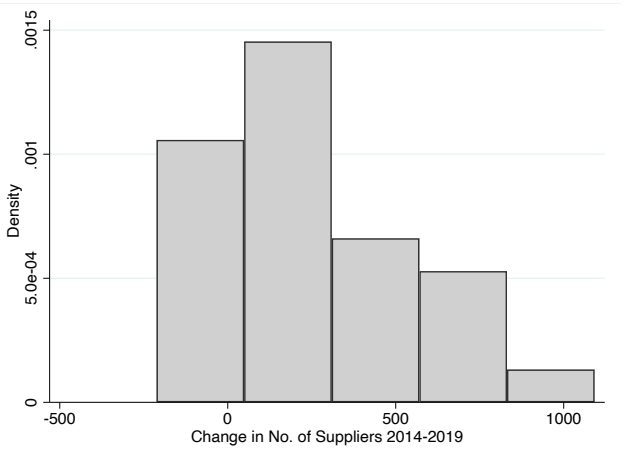
Notes. The figure in panel a plots the distribution of the beef sector linkage measure across sectors, excluding firms with no linkages with the beef sector. The figure in panel b plots the residuals of the same measure after netting out 4-digit sector fixed effects. The figure in panel c plots instead the distribution of the exporter specific linkage measure, showing the residuals net of supplier fixed effects.

Figure A.7: Exports to China Over Time: Variation Across Exporters



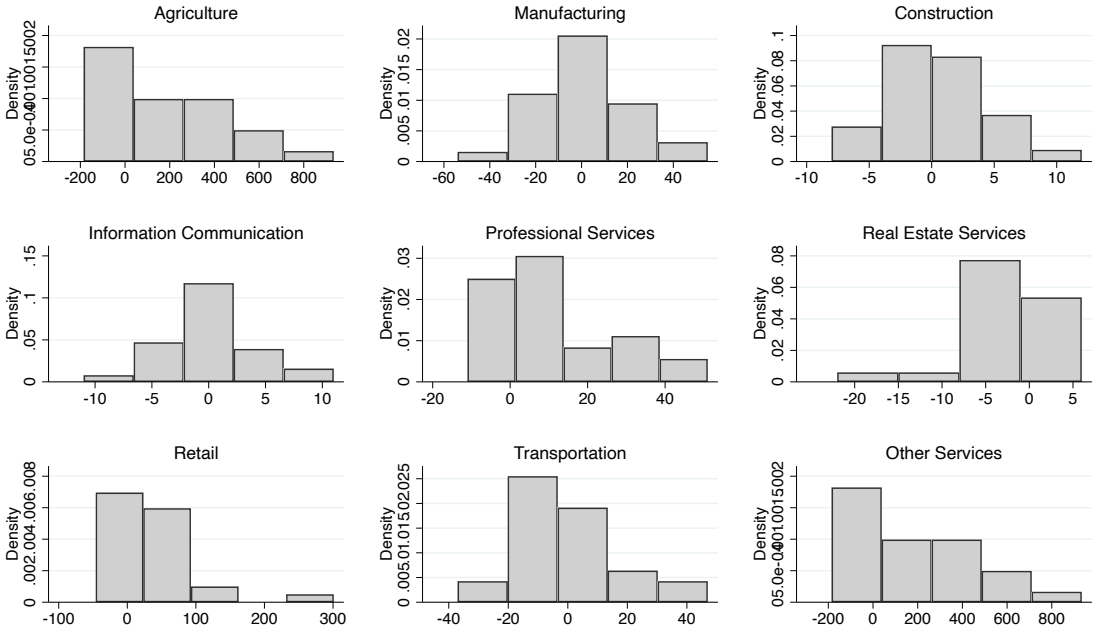
Notes. The left panel shows the distribution of changes in the China share of exports at the beef exporter level between the years 2009 and 2019. The right panel plots instead the change in the (log) value of exports to China against the corresponding change in exports towards the rest of the world.

Figure A.8: Suppliers to Beef Exporters: Changes 2014-2019



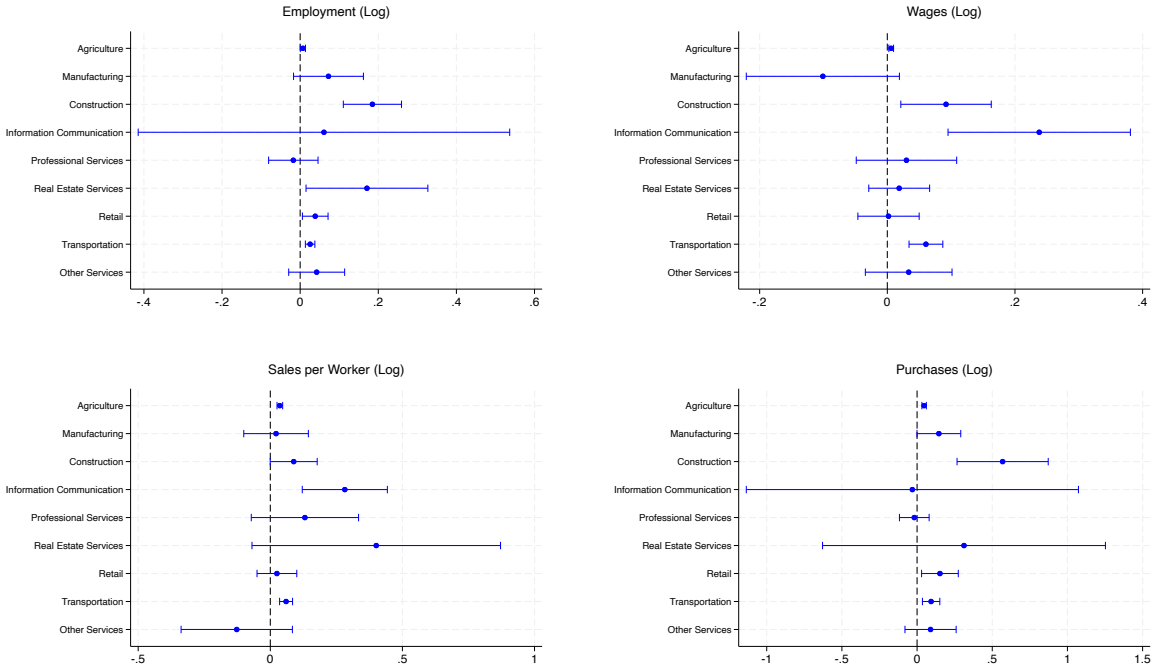
Notes. The figures plots the distribution across beef exporters of the change in the number of suppliers between 2014 and 2019.

Figure A.9: Suppliers to Beef Exporters by Sector: Changes 2014-2019



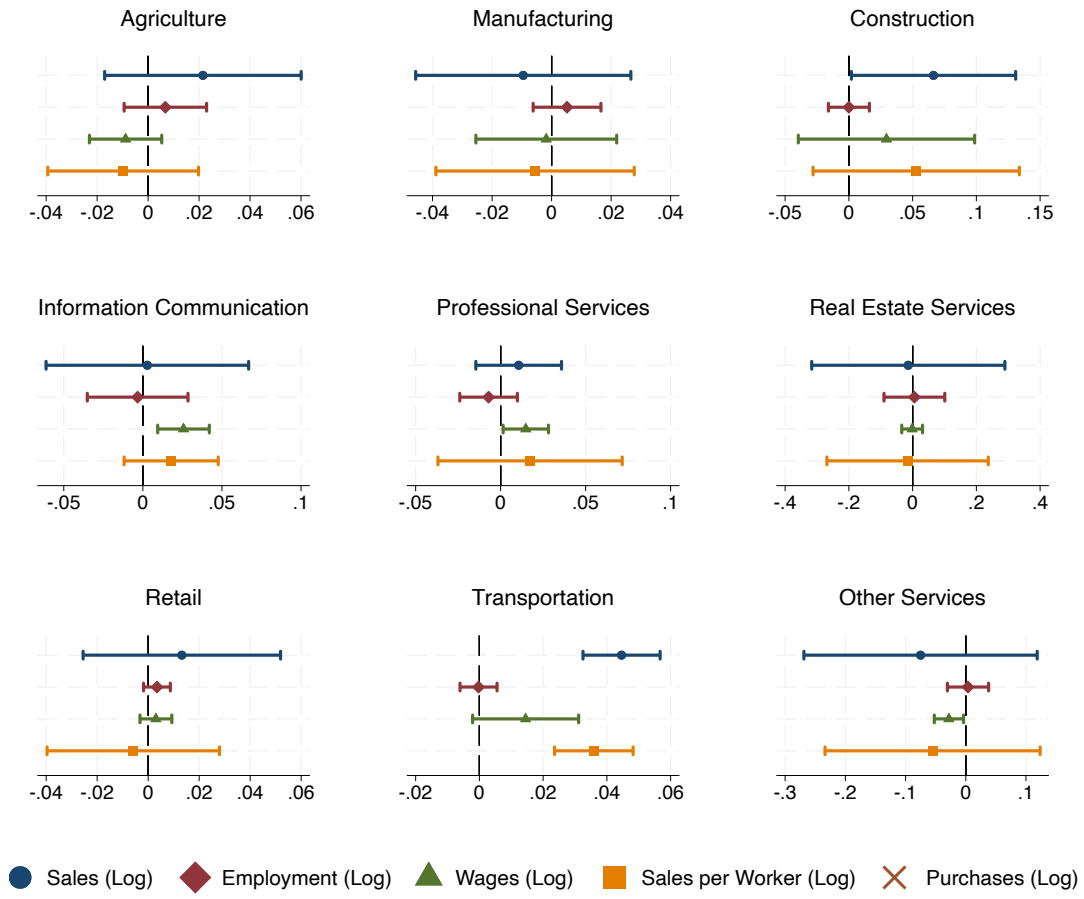
Notes. The figures plots the distribution across beef exporters of the change in the number of suppliers between 2014 and 2019, separately by sector as defined by aggregating ISIC 4-digit classifications.

Figure A.10: Effect Heterogeneity by Sector for Other Outcomes



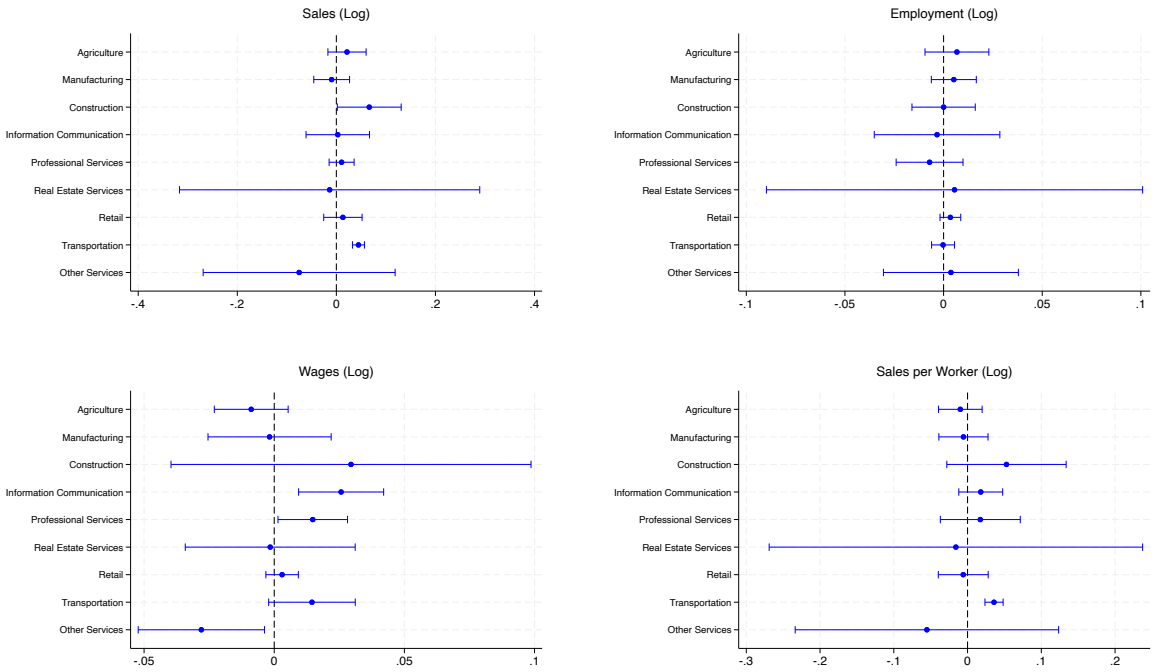
Notes. The figure shows graphically the estimated coefficients of the China beef export shock variable and their 90% confidence intervals, obtained when implementing the specification in equation (2) separately for suppliers in specific sectors—which we construct by aggregating ISIC 4-digit classifications—and having as dependent variables the log of employment (top left figure), the log of wages (top right), the log of sales per worker (bottom left), and the log of total purchases (bottom right).

Figure A.11: Second-Order Effect Heterogeneity by Sector and Outcome



Notes. The figure shows graphically the estimated coefficients of the China beef export shock variable and their 90% confidence intervals, obtained when implementing the specification in equation (**??**) separately for suppliers in specific sectors—which we construct by aggregating ISIC 4-digit classifications—and having as dependent variables the log of sales, log of employment, log of wages, log of sales per worker, and log of total purchases.

Figure A.12: Second-Order Effect Heterogeneity by Sector



Notes. The figure shows graphically the estimated coefficients of the China beef export shock variable and their 90% confidence intervals, obtained when implementing the specification in equation (**??**) separately for suppliers in specific sectors—which we construct by aggregating ISIC 4-digit classifications—and having as dependent variables the log of employment (top left figure), the log of wages (top right), the log of sales per worker (bottom left), and the log of total purchases (bottom right).