Which routes to inflation?

An analysis of the impact of global shipping cost shocks on import prices and market dynamics.

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Abstract

This paper examines the impact of rising air and maritime transport costs on the prices of imported goods in the European Union during the 2021-2022 inflationary surge. By building a unique dataset covering all Extra-European imports at the product level, we construct an index of transport shocks based on air and sea freight prices, differentiated by routes and accounting for exposure to the shock. We find that the elasticity at a 1% shock for China on the cost of air and sea transport on cumulative import price changes peaks one year after the shock, around 0.15. When restricting to a sample for which the share of sea and air freight sum to one, after a 1% increase in transport costs, import prices increase on average by 0.24%, 13 months after the shock. The effect persists for roughly 18 months. We then develop a model *à la* Atkeson and Burstein [2008] to explain the incomplete pass-through of transport cost shocks. The mechanism relies on a reallocation of market shares toward domestic firms, who increase their markups while foreign firms reduce theirs. The model predicts that a 10% rise in transport costs leads to a 7-9% increase in foreign price indexes and a 0.9-1.9% rise in domestic price indexes, resulting in an overall aggregate price index increase of 4%. We plan to extend this analysis by incorporating price rigidities, which should attenuate the short-term impact of the shock while generating greater persistence in the medium-run, thereby bringing the model closer to the empirical evidence.

Keywords: Inflation, Transport costs, Supply chain disruption

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1 Introduction

After three decades of price stability, inflation in most Western economies began rising sharply in mid-2021. In 2022, inflation peaked at 9.0 %, 6.3%, and 7.5% in the United Kingdom, the United States, and the Eurozone, respectively [Reis, 2022]. While inflation gradually receded in 2023, understanding the drivers of this surge remains crucial. Multiple factors have been identified: the rapid post-COVID-19 rebound, disruptions in global value chains, microchip production constraints, and the energy crisis.

While the price of transport has decreased over the last decades, they surged after and during the pandemic. The rapid revival of demand, particularly from China, collided with insufficient supply of ships and containers. Bottlenecks emerged in ports – especially in China – causing severe congestion and value chain disruptions [Bai et al., 2024]. Similarly, from the beginning of March 2020, air freight, based on regular lines and passenger flights, was affected by restrictions imposed during the pandemic and the price of air freight continued to increase from the second half of 2021.

Despite extensive attention to energy, metal commodity, and food price shocks, the contribution of rising transport costs to inflation remains underexplored. Carrière-Swallow et al. [2022] found that a one-standard-deviation increase in global shipping costs increases domestic headline inflation by approximately 0.15 percentage points, with effects varying by countries' integration into global value chains, import shares, and monetary policy strength. However, their aggregate-level analysis does not distinguish between transport modes or account for country-specific transport price variations. Moreover, different goods exhibit heterogeneous vulnerability to transport shocks – perishable goods, for instance, are particularly sensitive to air freight disruptions.

First, we quantify the impact of transport cost increases on manufacturing import prices in the European Union at a highly disaggregated level, incorporating product-specific vulnerability to transport shocks. We construct a unique dataset covering all extra-European manufacturing imports from 2017 to 2023 at the CN-8-digit product level, including shares transported by each mode and container type (by value and quantity). Our dataset encompasses 27 European declarants (excluding the United Kingdom) and 214 extra-European partners. While the ratio between cost, insurance, and freight (CIF, value at importer border) and free on board (FOB, value at exporter border) is the standard transport cost indicator, it can only serve as a proxy when examining cross-exporter variations [Hummels, 2007, Hummels and Lugovskyy, 2006, Gaulier et al., 2008]. We instead use precise measures: the Drewry price index for containerized maritime freight across 8 routes, the Baltic Exchange Dry Index (BDI) for bulk goods, and the Traffic Air Cargo (TAC) index for air freight. Section 3 details our dataset construction methodology.

We focus our empirical analysis on China, Europe's largest trading partner, whose ports experienced particularly severe bottlenecks during the pandemic [Bai et al., 2024]. In particular, the zero-Covid policy in Shanghai in the spring of 2022 led to port closures and substantial delays in production and international container trade in manufacturing. Section 4 presents key descriptive evidence. From the second half of 2021, total extra-European import values increased faster than quantities. The frequency of price adjustments and positive price changes accelerated in 2021-2022. Simultaneously, air and sea freight prices from Shanghai surged: the Drewry price index for the Shanghai-Rotterdam route peaked at 14807 on October 7, 2021 (it was only 2325 USD per 40ft container on January 03), while the TAC index peaked at 5254 USD per tonne on December 09, 2021 (it was only 1552 on January 02, 2020).

Then, we estimate the effect of these transport cost increases on import prices during 2018-2023. Using weighted transport price estimates based on quantity and value shares by transport mode, we employ first-difference and cumulative local projection estimators to quantify the shock's impact, following Jordà [2005]. Section 5 presents the empirical strategy, and our main results can be found in section 6. The elasticity at a 1% shock for China on the cost of air and sea transport on cumulative price changes, peaked one year after the shock, around 0.15. When restricting to a sample for which the share of sea and air freight sum to one, after a 1% increase in transport costs, import prices increase on average by 0.24%, 13 months after the shock. The effect is quite persistent, lasting 18 months. Import prices increase by less than the shock and respond with a lag. This suggests the existence of price rigidities and incomplete pass-through of the shock into prices.

Our last contribution is to simulate a shock on the price of transport, underlying the channel explaining the incomplete pass-through of transport cost shocks. Based on Atkeson and Burstein [2008], our model, presented in section 7, is an extension of De Loecker, Eeckhout and Mongey [2021] for an open economy with two countries. In this model, there is a finite number of firms within each sector. The demand elasticity is a decreasing function of the market shares. The markup is no longer constant, like in Ghironi and Melitz [2005], but is an increasing function of the market shares. An increase in transport costs, implies a reallocation of market shares towards the domestic firms, increasing domestic markups at the expense of foreign firms for which markups decrease. Import prices increase by less than the shock, while the price of goods produced domestically also increases. We calibrate the model in section 8 on the European Union, using the level of concentration and the import shares as our key moments. Finally, we simulate a shock on the price of transport in section 9. We find that after a 10% increase in transport costs, the aggregate foreign and domestic price indexes are expected to increase respectively to 7-9% and 0.9-1.9%, resulting in a rise in the aggregate price index of 4%.

2 Literature review

This paper builds on and tries to contribute to three different strands of literature. First it underlines the importance of transport costs, in still impacting aggregate economic variables. Focusing on price variations, our paper tries to contribute to understanding better the causes of the recent inflation surge of 2021-2022. Finally, it builds on the large literature on pass-through and tries to quantify market disruption after a shock in the price of transport.

First this project builds on the existing literature regarding the importance of shipping costs on trade. One might have thought the world was becoming flat. Transport costs gradually decreased, particularly with the development of containers. Before containerization, shipping activities were highly labor intensive. It was time-consuming to load and unload freight on ships, trains or trucks. The container facilitated intermodal transports. Using a dataset on dry bulk freight rates over the period 1850-2020, Jacks and Stuermer [2021] found that they followed a downward path with a cumulative decline of 79%. [Hummels, 2007], examining air freight, came to the same conclusions. The price of air freight decreased from \$3.87 in 1955 to less than \$0.30 in 2004 (expressed in 2000 U.S. dollars). Despite this downward trend, twenty years ago, Anderson and van Wincoop [2004] showed that trade costs were still high, particularly for poor countries. The ad valorem tax equivalent (a constant percentage of the producer price per unit traded) is about 170%, which can be decomposed into "21% transportation costs, 44% border-related trade barriers and 55% retail and wholesale distribution costs (2.7=1.21*1.44*1.55)" [Anderson and van Wincoop, 2004]. Transport costs still have implications for global trade and prices. In early February 2024, The Canal of Suez was affected by disruption and global exports had declined by more than 7%. [Dunn and Leibovici, 2024]. Carrière-Swallow et al. [2022], using the BDI index for sea freight, at the aggregate level, found a significant increase in import prices, Producer Price Index (PPI), headline, and core inflation, as well as inflation expectations. Our paper contributes to this literature by finding evidence of the impact of an increase in transport costs on the price of goods imported from China to Europe. To the best of our knowledge, our paper is the first to use an index for the cost of transport, that incorporates both air and sea freight, and the first to conduct an analysis at the product level. We also contribute to the discussion about the form of transport cost by providing descriptive evidence of asymmetry in the price of maritime transport.

Our empirical analysis attempts to contribute to understanding the drivers explaining the inflation surge of 2021-2022, by finding evidence of an effect of the price of sea and air transport on the price of imported goods from China at destination to Europe. Joussier, Martin and Mejean [2022] found that, while energy shocks were fully pass-through by firms, the impact on manufacturing inflation was limited, accounting for approximately 10% of total PPI growth. di Giovanni et al. [2022] found that foreign shocks and global supply chain bottlenecks played a greater role in explaining inflation in the Eurozone over the period 2020-2021. Our paper also relies on recent studies about the effects of supply chain disruptions during the COVID-19 pandemic on inflation (Finck and Tillmann [2023] for the euro area and Gordon and Clark [2023] for the US). Bai et al. [2024] documented that supply chain shocks drove inflation in 2021 but, in 2022, traditional supply and demand shocks also played a role in explaining inflation in the US. They measured global supply chain disturbance by building a new index based on the Automatic Identification System, which gives instantaneous information about container ships in major ports of the world. Finck and Tillmann [2023] also found that global supply chain shock caused a drop in euro area real economic activity and a strong increase in consumer prices.

Finally, our project tries to contribute to the literature on incomplete pass-through. Atkeson and Burstein [2008] proposed a trade model generating incomplete pass-through in the presence of imperfect competition and trade costs, which was then widely used in theoretical and empirical works [Amiti, Itskhoki and Konings, 2019]. We develop a model close to De Loecker, Eeckhout and Mongey [2021], which proposed a general equilibrium economy with endogenous markups in which two channels explain changes in market power: competition (number of potential competitors) and technology shock. Our paper is also inspired from Edmond, Midrigan and Xu [2015], which studied the procompetitive gains from international trade with a model *à la* Atkeson and Burstein [2008], comparing the extreme cases of autarky and a simulated economy based on Taiwanese data. We extend De Loecker, Eeckhout and Mongey [2021] with a two-country economy, emphasizing the importance of transport cost as a key channel in the reallocation of market power, assuming, as in Edmond, Midrigan and Xu [2015], that the two countries are perfectly symmetric in terms of sector and aggregate productivity. We quantify market disruptions at the firm, sector and aggregate level after a transport cost shock and their consequences on consumption, price indexes, market concentration and imports.

3 Data and Stylized facts

This paper is based on an original dataset of Extra-European trade flows, incorporating vulnerability to transport shocks and several indexes for the price of transport at a monthly frequency over the period 2017-2023.

First, we use the COMEXT dataset from EUROSTAT to recover the import prices, and quantities imported in the European Union for the period 2017-2023. This dataset includes all trade flows for the European Union. We focus our analysis on extra-European import flows, examining the increase in transport costs, particularly maritime and air freight. To remove the effect of Brexit, we exclude the United Kingdom from the analysis. We compute the share transported by one of the main modes of transport: rail, road, air, sea, and inland waterway, as well as the share containerized at the HS6 level. We assume that the shares are similar for each CN8 within the HS6 nomenclature. We define prices as unit values while ensuring the units are consistent over the time period within a declarant $\times$ partner $\times$ CN8 relationship. To avoid contamination effects due to the presence of energy goods, we focus our analysis on the manufacturing sector at the 2 digit level as defined in the ISIC, United Nations systems. We further exclude from this dataset motor vehicles, transported by Ro-Ro cargo, for which the price of transport could be different from the one used for shipping containerized goods (the list of products excluded is provided in the Appendix, Tables A.1 and A.2). We also remove medical products identified by the World Bank and the World Trade Organization as essential during the pandemic (listed in the Appendix, Tables A.3, A.4, A.5, A.6). The sample includes 41,552,616 observations, a total of 8,547 CN8 products.

Then, we extract indicators for the price of sea and air freight. Direct transport charge data are available at disaggregated levels and are considered of good quality. For instance, Hummels and Lugovskyy [2006] used transport costs for New Zealand but they remain limited to a small number of countries or localities. Due to the difficulty in accessing such data, researchers often use the ratio between the cost of insurance and freight (CiF, the value at the importer border) and the free on board (FoB, value at the exporter border) values. As a given trade flow is counted twice, comparing these two values gives an indicator of the price of transport. They can be compared across pairs of countries and are publicly available for a broad range of countries and years at aggregated and disaggregated levels (COMTRADE dataset). However, as mentioned in Gaulier and al. (2008), the CIF/FoB ratio suffers from measurement errors, and differences in registration methods across countries. Moreover, this estimate does not distinguish by modes of transport. Sea and air freight are affected by different shocks. To differentiate the impact of transport costs on the price of imported goods, we use indexes from consulting companies for our estimates of the price of transport for containerized and non-containerized maritime flows, and air freight. There are two kinds of sea freight, tramp and liner shipping. Liner shipping is based on regular routes, with fixed departure and port calls. Tramp shipping is an agreement between the ship owner and the charterer for cargo transportation. It is not regular and is based on the demand from the charterer. Even if we cannot capture the price of tramp shipping, we can use information about shipping routes, which likely provides a good estimate for the price of maritime freight. We extract the Drewry indexes for the containerized maritime freight, which is available for eight shipping routes from January 2017 to January 2024. It captures information about potential perturbations of the supply chain, among others: security charge, canal fees/surcharges, cargo declaration fees and port congestion surcharges. Several private consulting firms provide indexes for the price of maritime freight. To ensure the shock on the price of transport was not due to the specific methodology used by Drewry, we compare this index with other companies (Figure A.1 in the Appendix). They are very similar. The correlation between the Freightos and the Drewry price indexes was 0.9992 over the period 2017-2024. They are seasonally adjusted and include a currency adjustment factor. In addition to these indexes for the price of containerized goods, we extract the Baltic Dry index (BDI) from the London-based Exchange for solid bulk, goods not packed and loaded directly into a vessel (Figure A.2). It is based on more than twenty routes and is a composite of the index for different sizes of vessels. Finally, we extract the TAC index, to estimate the cost of air freight, which includes 17 routes and all costs paid to carriers. We are able to extract only the BDI and the TAC indexes at a worldwide level. Further details about the methodology used to calculate these indexes are provided in the Appendix A. The TAC index is only available from 2018.

Finally, we recover the price of crude oil and the World Food Index from the International Monetary Fund (IMF) and the U.S. Dollars to Euro Spot Exchange Rate from the St. Louis FED.

4 Descriptive statistics

In the rest of the analysis, we restrict our sample to imports from China, as China is the primary trading partner with the European Union, representing 19.8% and 29.8% of the quantity and value of manufacturing goods imported in Europe for the period 2017-2023. The dataset includes all imports from China in the manufacturing sectors, a total of 7,894 different goods (CN8) and 5,670,725 observations. We choose this country to reduce the measurement errors in our estimate for the price of transport, using the Shanghai-Rotterdam route as our estimator for the cost of sea freight. Moreover, Chinese ports were particularly impacted by bottlenecks in 2021, causing congestion and increasing delays for delivery.

After the pandemic, because of a combination of factors affecting both demand and supply, the monthly imported prices increased while in parallel, the price of maritime and air freight rose. This section recovers four stylized facts about the increase in import and freight prices before and during the inflationary period.

4.0.1 Fact 1: Variations in total quantity and value imported

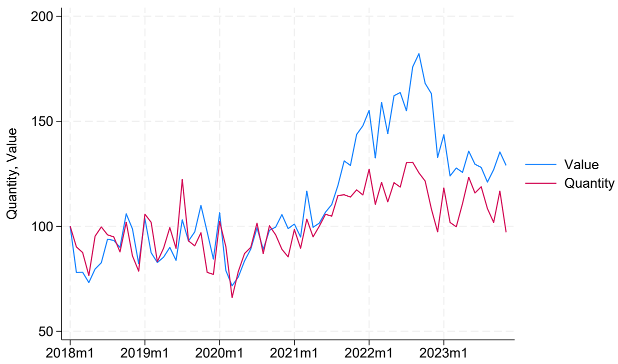
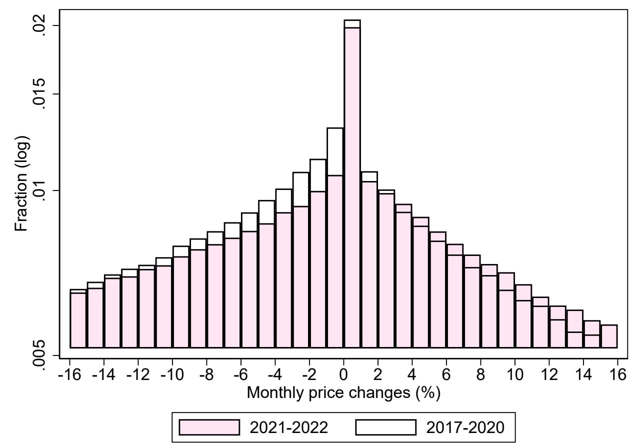


Figure 4.1: Quantity and value of imported manufacturing goods from China (100 in January 2018)

Figure 4.2: Distribution of monthly price changes



Notes: The first figure plots the total value and quantity of imported manufacturing goods from China relative to January 2018. The second figure plots the distribution of monthly price changes for Chinese imports over the 2017-2020 and the inflationary period 2021-2022. Medical products (list in the Appendix, Tables A.3, A.4, A.5 and A.6) and motor vehicles (Tables A.1 and A.2 in the Appendix) are excluded. The dataset includes all imports from China in the manufacturing sectors, a total of 7,894 different goods (CN8) and 5,670,725 observations.

In Figure 4.1, we plot the total value and quantity imported from China by the European partners, relative to the level of January 2018. We observe a drop in both total value and quantity at the beginning of 2020. During this period, Chinese production dropped as well as European demand because of lockdowns. At the end of 2020, with the increase in the demand for Chinese goods, and the reopening of China, the total quantity and value imported increased, recovering their pre-pandemic level. It further increased from 2021. Interestingly, from the middle of 2021, values increased more than the quantities imported. The gap peaked in September 2022 at 56 points and then narrowed from the end of 2022. Similar findings can be found for all Extra-European imports (Figure A.3 in the Appendix). Figure 4.2 explores further the monthly price variations and suggests, that indeed, prices were more likely to change and these variations being positive during the high inflationary period.

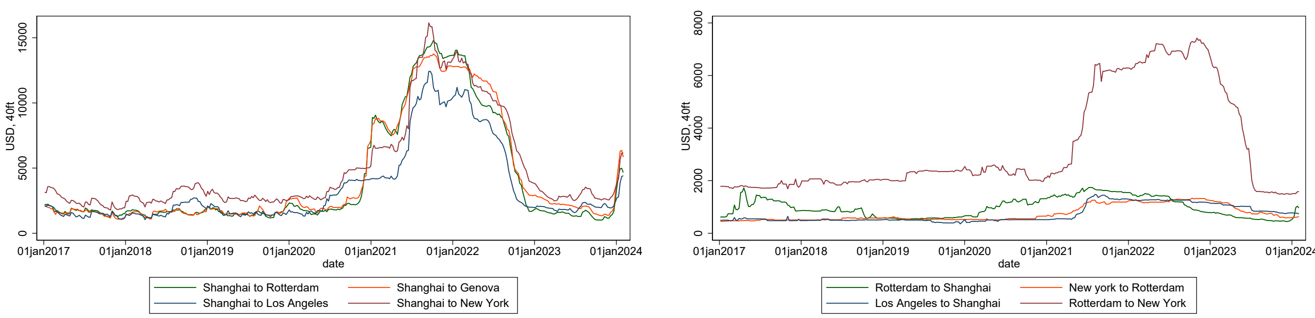
4.0.2 Fact 2: Monthly import price variations

In Figure 4.2, we present the distribution of monthly price changes over the pre-inflationary period 2017-2020 and during the inflationary period 2021-2022. There is a right shift in the distribution of the monthly price changes, suggesting that the frequency of positive price variations increases after 2021. Moreover, the mass of price changes around 0 is lower after 2021, which means that the prices adjust more frequently after 2021. We find the same empirical evidence as Lafrogne Joussier, Martin and Mejean [2022] for producer prices. Price adjustments are a combination of a change in their frequency and their size. We conduct similar analyses for all Extra-European imports and get similar evidence in favor of a right shift of monthly price variations (Figure A.4 in the Appendix). Nevertheless, we do not find evidence of a lower mass of price changes around 0 at the aggregate level. In parallel to this inflationary period for the price of imported goods, the price of sea and air freight increased abruptly.

4.0.3 Fact 3: Transport prices

The price of sea freight, measured by the Drewry price, increased from the second half of 2020, before stabilizing at the end of 2022 for all routes. However, this change in the Drewry price index was heterogeneous depending on shipping routes. While the price for shipping goods from China increased sharply from the end of 2020, the rise in this index was significantly lower for routes at the destination to China. This asymmetry in transport prices can be explained by differences in demand for ships and the limited capacity of containers and cargo. Once in Europe, vessels coming from China must return to Chinese ports, sometimes not at full capacity. Similar asymmetry can be observed for the transatlantic route. This underlines the importance of distinguishing by route while studying transport prices. In the Appendix, we report the BDI price index for goods in bulk (Figure A.2) at a monthly frequency and worldwide level. We observe similar trends to the one observed for the Drewry price index at the worldwide level (Figure 4.3). Because of the large heterogeneity across routes, we assume in further analysis that the variations in the BDI are similar to those observed with the Drewry price index, and keep the Drewry price index Shanghai-Rotterdam as our indicator for the price of sea freight between China and Europe. The Drewry price index for the Shanghai-Rotterdam route peaked at 14807 on October 7, 2021, while it was only 2325 USD per 40ft container on January 03, 2020.

Figure 4.3: Drewry Price Indexes

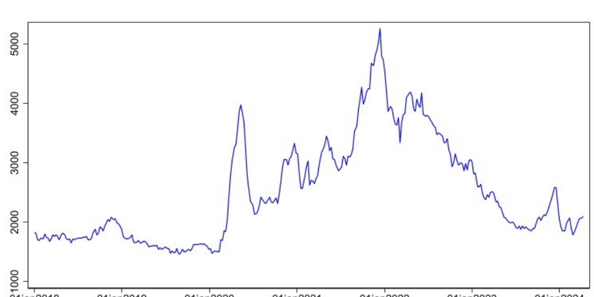


(a) Shipping routes from China (b) Shipping routes to China and Transatlantic route

Notes: The Drewry price index is a weekly indicator for the price of a 40ft container.

Moreover, the variation in the price of air freight underlines the importance of distinguishing by transport mode. Sea and air freight are affected by different shocks during the period considered. Figure 4.4 gives the TAC index over the period 2018-2023. We observe a peak in March 2020. During this period, most of the passenger flights were canceled due to the pandemic, which affected the air freight. The TAC index peaked at 5254 USD per tonne on December 09, 2021, while it was only 1552 on January 02, 2020.

Figure 4.4: Traffic Air Cargo Price index

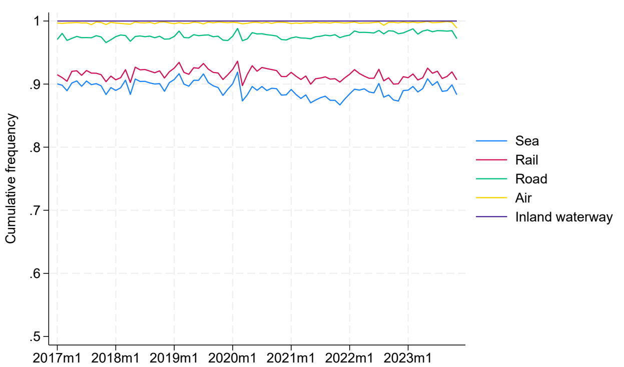


Notes: This figure presents the Traffic Air Cargo price index at a weekly frequency over the period 2018-2024.

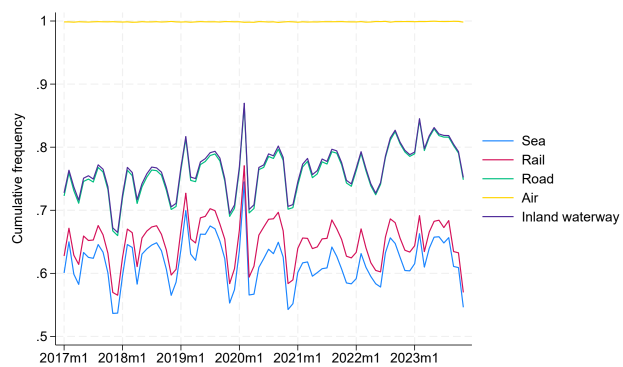
4.0.4 Fact 4: Distribution of the main modes of transport

One possible concern for our identification of the impact of the shock of transport costs on inflation is possible substitution effects. Firms could choose to substitute one mode of transport for another due to disturbances in relation to air and sea freight. Aside from seasonal trends, there is no evidence of substitution from one mode of transport to another, at the aggregate level. One possible reason is the high price of air relative to sea freight for shipping goods over long distances. As Hummels [2007] underlines, when the value-to-weight ratio increases, this leads to a larger share transported by air transport. This is in line with what is advised by shipping companies. Freightos, a leading consulting company on shipping costs advises using air freight when the cost of shipping is less than 15-20% of the value of the good. Indeed, the marginal fuel cost of shipping a good into the air is higher than the cost of floating it on water. The counterpart of more expensive air transport is more reliability, flexibility and timeliness, which are key determinants for shipping certain types of goods such as technological or perishable products. These costs and advantages are more pronounced on larger distances. According to MSC departure times (February 2024), choosing air transport from Barcelona to Valencia may save 2 days, while choosing air transport from Naples to Montreal may save 15 days (MSC departures times, March 2024). Concerning hazardous materials, substitution is sometimes impossible because of strong restrictions for air freight (among others: gases, flammable, toxic, magnetic substances, etc.). While maritime freight represents around 90% of all quantities shipped and air around 2%, in terms of values, more than 20% of all imported goods from China were shipped by air. The share of values transported by the maritime sector drops to 50%. We found similar results by sector. Interestingly, for textiles, we observe the impact of masks, which caused a massive increase in the share transported by air in March 2020, both in value and quantities. By removing masks and other medical products used during the pandemic, the substitution is no longer observable. For these reasons, these products are excluded from the analysis. We report the graph in the Appendix (Figure A.6). We observe similar trends for all Extra-European imports, even if the share of maritime transport is lower, as expected, as it includes countries closer to the European Union. (Figure A.5 in the Appendix).

Figure 4.5: Share of quantities and values transported by the main mode of transport (2017-2023, manufacturing goods)



(a) Quantity



(b) Value

Notes: The dataset includes all imports from China in the manufacturing sectors, a total of 7,894 different goods (CN8) and 5,670,725 observations from January 2017, to December 2023. Medical products (list in the Appendix, Tables A.3, A.4, A.5 and A.6) and motor vehicles (Tables A.1 and A.2 in the Appendix) are excluded. The manufacturing sectors are defined at the ISIC 2-digit level.

5 Empirical strategy

The descriptive statistics suggest that during the inflationary period, transport costs increased and manufacturing import prices were more likely to increase at the end of 2020 and from 2021. We begin our analysis with an accounting identity. The CIF value by definition includes the marginal cost, the markup and the price of transport. We express the import price $I_{ij,t}$ as the product between the marginal cost of production and the markup charged by the firm. Shipping a good to Europe is costly so the marginal cost is scaled up by an iceberg trade cost. As it is standard in the literature, transport costs are modelled as an iceberg-type cost.

$$I_{ij,t} \equiv \mu_{ij,t}\tau_{ij,t}mc_{ij,t}$$

with $I_{ij,t}$, the price of imported goods, $\mu_{ij,t}$, the markup, $\tau_{ij,t}$, the iceberg trade cost and $mc_{ij,t}$, the marginal cost. i, j and t denote respectively the European partner, the product and the time period.
Taking differences in log gives the decomposition of price changes according to variations in marginal costs, markups and iceberg transport costs. ($\Delta \ln I_{ij,t} = \ln I_{ij,t} - \ln I_{ij,t-1}$)

$$\Delta \ln I_{ij,t} = \Delta \ln \mu_{ij,t} + \Delta \ln \tau_{ij,t} + \Delta \ln mc_{ij,t} \tag{1}$$

We measure the transport cost shock by using the observed heterogeneity in transport modes per country × product. This helps to approximate their exposure to (common) transport price increases. We define a transport cost index per European country × product relationship which depends on the price of each mode of transport and shares for air α^a_{ij}, sea α^s_{ij}, road α^{ro}_{ij}, rail α^{ra}_{ij} and inland waterway α^{in}_{ij} transports.

$$P_{ij,t} = \left(P^a_{ij,t}\right)^{\alpha^a_{ij}} \left(P^s_{ij,t}\right)^{\alpha^s_{ij}} \left(P^{ro}_{ij,t}\right)^{\alpha^{ro}_{ij}} \left(P^{ra}_{ij,t}\right)^{\alpha^{ra}_{ij}} \left(P^{in}_{ij,t}\right)^{\alpha^{in}_{ij}} \text{ with } \alpha^a_{ij} + \alpha^s_{ij} + \alpha^{ro}_{ij} + \alpha^{ra}_{ij} + \alpha^{in}_{ij} = 1$$

Taking logs and the first difference, we get our indicator for the changes in transport prices at time t:

$$\Delta\omega_{ij,t} = \alpha^a_{ij}\Delta \ln P^a_{ij,t} + \alpha^s_{ij}\Delta \ln P^s_{ij,t} + \alpha^{ro}_{ij}\Delta \ln P^{ro}_{ij,t} + \alpha^{ra}_{ij}\Delta \ln P^{ra}_{ij,t} + \alpha^{in}_{ij}\Delta \ln P^{in}_{ij,t}$$

To measure the contribution of air and sea freight shocks, we use the mean share of quantity, within a European country × product relationship before the pandemic (before 2020). As an alternative, we could have used the mean value share. Figures B.1, B.2, B.3 and B.4 show the distribution of the weights for air and sea transport adopting the two definitions. For both definitions, the distributions of weights is dual with two mass around 0 and 1, suggesting that, within sectors, products are likely to be transported fully by air or sea, depending on their characteristics. We provide the results of this alternative definition in the Appendix, as a robustness check. We do not have an indicator of transport costs for rail, road, and inland waterway transports. Thus, we assume in the rest of this analysis, that variations in prices of air and sea freights are orthogonal to price variations for rail, road and inland waterways transport costs. In our regressions, we will control for oil price variations as it is likely that they are correlated with road transport price variations. Rail, road and inland waterway represent respectively less than 10% and 15% in quantity and values of all imports from China to Europe (Table B.1 provides the mean shares by sector in the Appendix). We only consider air and sea freight price variations to build a weighted estimator of the price of air and maritime freight. In case of $\alpha^a_{ij} + \alpha^s_{ij} = 1$, the weighted estimator we derive with the price variations of sea and air freight is equal to the change in transport costs.

Another concern about this indicator in the price of transport at t is time inconsistency between the departure and arrival times for sea and air freight. It takes between 30 and 45 days to ship goods by sea from China to Europe, and a charterer usually agrees to a shipping quote with add-ons at the time of booking. We change our definition of the change in transport costs, defining an indicator of the shock of transport cost, at the time the good is delivered. Indeed, we only observe import price variations when a good arrives in Europe. We are interested in the effect of an increase in maritime cost on price variation one month after the container leaves China. As it takes only a few hours to ship goods from China to Europe *via* air freight, there is no time inconsistency for this mode of transport Therefore, our indicator for the shock of air and maritime transport costs for a good arriving at t in Europe is defined as the sum between the weighted difference in log of a proxy for the price of air freight at t (TAC index) and the weighted difference in log of a proxy for the price of maritime freight (measured by the Drewry price index Shanghai-Rotterdam) at $t-1$:

$$\Delta\tilde{\omega}_{ij,t} = \alpha^{a}_{ij}\Delta \ln TAC_{ij,t} + \alpha^{s}_{ij}\Delta \ln Drewry_{ij,t-1}$$

Moreover, some shipping companies offer the option to fix the shipping price when the booking is done in advance, in particular for maritime freight. Thus, studying the dynamic effects of an increase in transport cost is particularly relevant in our analysis. If bookings, are made in advance, we expect today's increase in the price of transport to have an impact with some lags once the good is shipped. Therefore, we first forecast price changes in simple differences and then, we measure the long-difference with the cumulative local projection estimator.

We use local projection method to measure the effect of an increase in air and sea transport costs on the rise of imported goods prices at different horizons. The local projection method does not constrain the shape of the impulse-response function, is more flexible in estimating non-linearities, and is more robust to mispecification than VAR, as the set of coefficients is estimated using a different regression for each horizon [Jordà, 2005]. It does not constrain the response of import price variations to increase or decrease monotonically over time. One question of interest would be to estimate the effect of an increase in transport costs on the rise of imported goods in isolation of potential further fluctuations in the intervention (here fluctuations in transport costs). Recent papers, [de Chaisemartin and D'Haultfoeuille, 2022] showed that the local projection method is not adequate to answer this question, because it also includes past values of the intervention. However, as Jordà [2023] shows, the local projection method is still a valid object to identify "the likely effect on the outcome of an initial intervention at time t, recognizing that the intervention itself generates subsequent interventions" (p.621). Thus, in the following section, we use local projection method to estimate the effect of an increase in transport costs, recognizing that this intervention generates subsequent interventions.

5.1 Forecast in simple differences

We first estimate the local projection equation in simple differences.

$$\Delta \ln I_{ij,t+h} = \delta^h + \sum_{l=1}^{H} \gamma^h_l \Delta \ln I_{ij,t-l} + \sum_{l=0}^{H} \beta^h_l \Delta\tilde{\omega}_{ij,t-l} + \sum_{l=0}^{H} \theta^h_l \Delta X_{ij,t-l} + FE_t + FE_{ij} + \varepsilon_{ij,t+h} \tag{2}$$

with h, being the response horizon in months, $\Delta \ln I_{ij,t}$, the month-over-month log price change of an imported goods j by an European country i, δ^h, the constant. $\Delta X_{ij,t-l}$ is a set of controls. The coefficient of interest is β^h_0, which captures the elasticity of a 1% shock to air and maritime transport costs on monthly price changes at different horizons.

We include product (CN8) $\times$ country fixed FE_{ij} effects to control for the specificity of each product, which could affect the price of transport (weight, volume, perishable goods, ...). For instance, some goods require special packaging, kinds of containers (refrigerated) or there exists strong constraints about the delay to deliver the good (perishable goods). These characteristics are assumed to be invariant with time. We include time fixed effect to control for global context (for instance Chinese production). Adding time fixed effects FE_t helps also to control for global demand affecting shipping costs. We control for the month-over-month growth rate of Dollars to Euro exchange rate. As in Carrière-Swallow et al. [2022], we include the month-over-month growth rate of crude oil and food prices. Including the month-over-month growth rate of crude oil is also likely to be correlated with road transport costs, for which we do not have indicators. The number of lags has been set to twelve, as in Carrière-

Swallow et al. [2022], to control for additive seasonal effects. We estimate this regression for each horizon using Ordinary Least Squares Estimator. Standard errors are clustered at the European country $\times$ product level to adjust for serial correlation, cluster and heteroskedasticity. Clustering by groups is relevant if the number of groups is sufficiently large, otherwise it can create distortions [Cameron, Gelbach and Miller, 2008] and it is recommended to use bootstrapped standard errors instead.

We do not have disaggregated data to get an estimate of the firm's marginal cost. According to equation (1), with our local projection equation, it is possible that the coefficients for transport costs capture both direct changes in transport costs and changes in markups.

5.2 Forecast in cumulative differences

Next, we estimate the elasticity of a 1% increase in air and maritime transport cost at t, given by β_0^h on cumulative price changes. The local projection method measures, in this case, the overall percentage change in the outcome since the cost shock. Similarly, we use the Ordinary Least Squares estimate, with European country $\times$ product, and time fixed effects, and the same set of controls as in equation (2). Standard errors are clustered at the European country $\times$ product level.

$$\ln I_{ij,t+h} - \ln I_{ij,t-1} = \delta^h + \sum_{l=1}^{H} \gamma_l^h \Delta \ln I_{ij,t-l} + \sum_{l=0}^{H} \beta_l^h \Delta \tilde{\omega}_{ij,t-l} + \sum_{l=0}^{H} \theta_l^h \Delta X_{ij,t-l} + FE_t + FE_{ij} + \varepsilon_{ij,t+h} \tag{3}$$

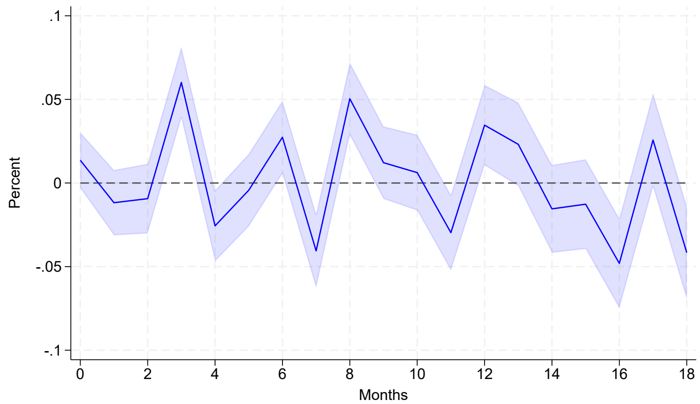
6 Empirical results

Figures 6.1 and 6.2 estimate respectively the first and the cumulative local projection forecast, using observations from the 2018-2023 period. We could not use a longer horizon, as the TAC index is only available from 2018. We find a significant, non-negligible and persistent effect of an increase in import prices after a one percent shock on the price of air and maritime freight cost. Full regression tables can be found in the Appendix (Tables B.3, B.4).

6.1 Forecast in first and cumulative differences

Figure 6.1 estimates equation (2) for all Chinese imports and reports the local projection coefficients and their 95% confidence interval. We observe that the increase in our estimate of air and maritime transport cost has an effect with a lag on import price variation. The coefficients for periods 0 to 2 are insignificant. The elasticity of a 1% shock to air and maritime transport costs on monthly price changes, for the third, sixth, eighth, and twelfth months, are significantly positive, respectively equal to 0.06, 0.027, 0.05, and 0.03 on average. This analysis suggests that import prices do not adjust immediately to a shock in the cost of air and maritime transport. The three peaks we observe may be due to price rigidities, firms adjusting their prices with a lag. Figure C.2 reports a similar analysis, weighting by the mean value share instead of the mean quantity share. The two graphs are very similar, even though under weight as mean share value, variations are slightly amplified. Peaks at two, six and eight months are also significant. We observe significant negative peaks at five and seven months, suggesting that prices tend to decrease following a large increase in the former period. These opposite effects smooth the cumulative price variations. Finally, we observe a significant peak one month after the shock, with weights as mean value shares. The definition with value puts more weight on air freight, which could explain this significant peak. Air freight is sometimes used to overcome disruption in the supply chains under short delays. Price may be more flexible than with maritime freight. We intend to deepen this question in future research. While the first-difference local projection gives indications about the dynamics of price changes, we cannot infer the cumulative effects of a transport cost shock on inflation, with such a regression.

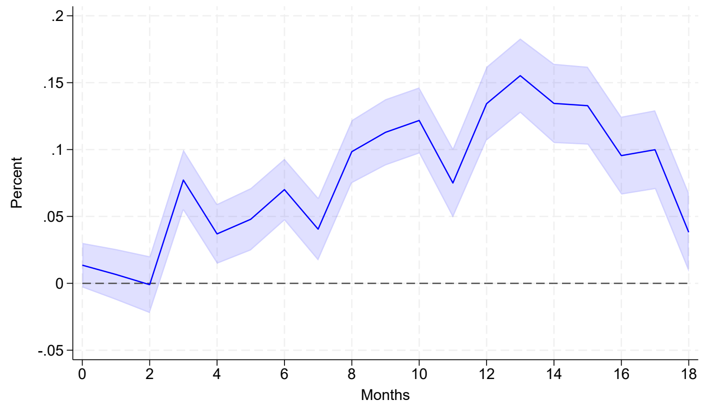
Figure 6.1: First difference local projection estimates



Notes: This figures presents the first-difference local projection coefficients and their 95% confidence interval. If the sum of air and sea coefficients sum to 1, after a 1% shock in air and maritime transport cost at $t = 0$, import prices are likely to increase by 0.06% between the second and the third month after the shock. The full regression table is given in Appendix (Table B.4). Standard errors are clustered at the country $\times$ product level. This specification includes time and country $\times$ product fixed effects.

To obtain smoother estimates of the long-term effects of transport cost shock, we report the long-difference local projection estimate in Figure 6.2, corresponding to equation (3). The full regression table can be found in the Appendix (Table B.3). These estimates measure the approximate percentage change in the outcome, from the period $t-1$ before the shock to h periods in the future. The effect of an increase in the price of transport is highly significant three months after the shock, suggesting that import prices increase after an increase in transport costs. Prices increase with a lag in response to an increase in transport costs. Our coefficients are insignificant for the first three months and then become highly significant and positive. Even if the effects are smoother compared to the first-difference graph, we observe three peaks at three, six, ten and thirteen months, in the cumulative-difference graph. If sea and air weights sum to one, after thirteen months, import prices are predicted to increase by 0.155% compared to the baseline period after a 1% shock. After this peak, import price increases revert 18 months after the shock. The effect is quite persistent, lasting eighteen months. Similar findings can be found under the alternative definition of weights as mean share values (Figure C.1 in the Appendix). The only difference involves the first three periods. The cumulative effects of the shock are amplified, peaking at 0.19% thirteen months after the shock, if sea and air weights sum to one. Our coefficients are now statistically significant. This may also be due to greater weight put on air freight. These results suggest incomplete pass-through of costs into prices. Import prices increase by less than the size of the shock. Our specification explains between 29.2% and 39.4% of the variance over the 18 horizons.

Figure 6.2: Long difference local projection estimates



Notes: This figures presents the cumulative-difference local projection coefficients and their 95% confidence interval. If the sum of air and sea coefficients sum to 1, after a 1% increase in air and maritime transport cost at $t = 0$, import prices are likely to increase by 0.12% 10 months, after the shock compared to the period $t - 1$ before the shock. The full regression table is given in Appendix (Table B.3). Standard errors are clustered at the country × product level. This specification includes time and country × product fixed effects.

6.2 Robustness checks

To test our first assumption regarding the orthogonality of the different transport modes, we conduct a similar analysis for the first (Figure C.4) and the cumulative local projection estimates (Figure C.3) with a restricted sample. We retain only observations for which the sum of the share in quantity for sea and air transport is higher than 0.95. Thus, our coefficients for the price of air and maritime freight can be interpreted as the response to a shock in transport costs, as the sum of weights is close to the one. For first differences, coefficients are larger in magnitude and we still observe significant peaks at 3, 8-9 and 12 months reaching 0.08%, 0.05-0.08% and 0.05%, respectively. For cumulative differences, the coefficients are larger in magnitude. After 9 months, prices increase on average by 0.25% following a 1% shock in transport costs and after 13 months by 0.24%. The effects also revert after 18 months. Confidence intervals are larger, as the sample size is smaller.

From 2020 onward, many shocks affected the economy. Therefore, we report the results under the restricted sample of observations before 2020 (Figure C.5). Due to the short observation period (2018-2019), we can report only the forecast for an 8-months horizon. We find significant coefficients for horizons 1, 2, 3, and 4. However, due to the small sample size, the confidence intervals are extremely large, making interpretation of the coefficients magnitudes irrelevant. Nevertheless, we can infer that the short-term trend we observe is not due to pandemic disruptions, as it was already present before 2020. We conduct a similar exercise for the period 2020-2023, which was affected by the shock (Figure C.7 and C.6). For first differences, we observe three significant positive peaks at 3, 9 and 12 months, respectively reaching 0.06, 0.04 and 0.16. For cumulative differences, we observe a short term effects, (effects for the first and second month are significant), peaking at 3 months (0.11), reverting at 10 months and a long-term effect, with peaks at 12 and 13 months, reaching 0.09. Due to large confidence intervals from 14 months onward, no conclusions can be drawn beyond that horizon. Thus, the long-term impact on air and maritime transport is less smooth than over the period 2018-2023 This may be explained by the existence of long-term contracts, at 12 months on the price of transport. It is possible that during inflation surge, because of higher uncertainty about congestion and transport prices, firms chose to book more in advance sea and air freight at a fixed price, explaining the peak at 12-13 months. Moreover, the coefficients at 0, 1 and 2 months are now significant, and the size of the coefficient at 3 months is larger, which may reflect another effect of uncertainty. Due to uncertain demand and production during the pandemic, firms may also have chosen to book less in advance their freight, which would explain larger short-term effects of transport prices. These two hypotheses should be tested in future research.

We use an alternative specification with time × industry (2-digit, ISIC) fixed effects instead of time fixed effects to control for sector-specific shocks. Due to computational constraints, we randomly select 10% of the country × product relationships in the original sample. Despite larger confidence intervals due to the restricted sample, the magnitude and sign of the first and cumulative differences are similar. Only the first-difference and the cumulative local projection coefficients for the first month are now significantly positive.

Finally, one last limit we aim to address is inconsistency in the CN nomenclature. Because of changes in the CN nomenclature over time, we cannot track price changes over several months reliably with CN8. Instead, we follow the recommendations of Bergounhon, Lenoir and Mejean [2018], and define the lowest level of aggregation "id_conc", ensuring consistency over time in the CN nomenclature, using the algorithm from Behrens and Martin [2015]. We then reaggregate value, quantities, and recalculate shares and prices at the id_conc level. Given our short time period, changes in the nomenclature are limited, and the effects of this aggregation on prices are expected to be limited. Our results are consistent with the baseline estimation.

6.3 Limitations and extensions

This empirical evidence suggests that a shock to transport costs tends to increase import prices and the effect is quite persistent, lasting 18 months. It also suggests incomplete pass-through of transport costs into import prices. The elasticity at a 1% shock on the cost of air and sea transport on cumulative price variations, is around 0.15, 13 months after the shocks. When restricting to the sample for which the sum of shares of air and sea transport is close to 1, after a 1% increase in transport costs, import prices increase on average by 0.24%, 13 months after the shock. However, these results raise questions for future research. First, as our post-shock analysis suggests, price rigidities may exist. This could be explained by the presence of contracts at 12 months. It would be interesting for future research to examine the probability of price adjustment after a shock in the price of transport. Indeed, we hypothesized that what we observed is due to price rigidities, but it could also be due to specific shocks in the data, affecting certain sectors only. If the peak we observe is due to price rigidities, we could also explore further whether these price rigidities are due to contracts between the ship owner and the charterer or, as in the intermediary good market, contracts between a supplier and a buyer.

We could also exploit our full sample and our route-specific estimates to study more deeply the vulnerability of countries to transport cost shocks depending on the level of economic integration, the presence of transport infrastructure and geographical location. We could examine whether there is trade reallocation towards routes less affected by the rise in transport costs. For instance, we could compare Chinese and American export flows at destination to Europe, as they were differently affected by the shock.

Finally, our coefficients may capture both direct effects of changes in transport costs and indirect effects due to markup adjustments, explaining the incomplete pass-through. Indeed, markups may adjust when transport prices increase, or in response to competitor's price changes. For instance, if transport prices increase more for China than for the U.S., Chinese producers would lose competitiveness. They would lose market shares and their markup may decrease. American exporters may benefit from this situation, gaining market shares and increasing their markups. Thus, an increase in a firm's own costs may affect competitors' prices. In future research, we would like to explore this question by exploiting firm-level data and conducting an analysis based on Amiti, Itskhoki and Konings [2019]. We could decompose price changes into the response to own cost shocks and changes in competitor prices. In the next section, we propose a model *à la* Atkeson and Burstein [2008], generating incomplete pass-through due to an endogenous markup, which now depends on the market shares.

7 Model

The increase in transport prices does not transmit one-to-one into the price of an imported good. In this section, we propose a model based on Atkeson and Burstein [2008], with imperfect competition and trade costs. This model helps explain why foreign firms do not increase their prices one-to-one, in response to an increase in their transport costs. This model is an extension of De Loecker, Eeckhout and Mongey [2021] in an open economy with two countries $i \in \{1, 2\}$ that produce and trade a continuum of goods on international markets. The first section presents the theoretical framework; then we quantify the model, based on the European context. First, we consider the benchmark model, a static environment with inelastic labor supply, to isolate the role of transport costs and market dynamics, explaining the incomplete pass-through. Then we study the dynamics of the static equilibrium resulting from a short-term shock in the price of transport.

Time is discrete. There are two classes of agents: firms and households. All prices are denominated in the same currency.

Preferences in country i are given by: $E_0 \sum_{t=0}^{\infty} \beta^t u(c_t^i, l_t^i)$

where c_t^i and l_t^i denote consumption and labor of the representative household, respectively, in the country i at time t. In the benchmark model, labor supply is assumed to be inelastic and normalized to one. The utility function is strictly increasing and strictly concave in consumption.

7.1 Demand for the final goods

As in Atkeson and Burstein [2008], final consumption, denoted c^i is a nested constant elasticity of substitution (CES) aggregator of consumption from within and across a continuum of sectors j, with $j \in [0, 1]$.

At the aggregate level: $$c_{it} = \left[\int_0^1 {c_{jt}^i}^{1-\frac{1}{\eta}} \, dj \right]^{\frac{\eta}{\eta-1}} \tag{4}$$

where $\eta > 1$ denotes the elasticity of substitution across sectors.

At the good level: $$c_{jt}^i = \left[\sum_{k=1}^{2K} {c_{jkt}^i}^{\frac{\rho-1}{\rho}} \right]^{\frac{\rho}{\rho-1}} \tag{5}$$

where $\rho > \eta > 1$ denotes the elasticity of substitution between goods within sectors. Goods k are more substitutable within sectors than across sectors. Each good k is distinct. As in Atkeson and Burstein [2008], goods are imperfect substitutes ($\rho < \infty$). There are $2K$ different varieties of goods which can either be produced domestically or abroad in each sector.

The household chooses the optimal quantity of goods to consume c_{jkt}^i to maximize utility. Each period, he can buy assets traded on the international markets. His income is given by his revenue from labor and returns on assets. Labor supply is inelastic, $l_t^i = 1$ The budget constraint is given by:

$$\int_0^1 \sum_{k=1}^{2K} P_{jkt}^i c_{jkt}^i dj + X_t^i \leq W_t^i l_t^i + X_{t-1}^i R_{t-1}$$

Solving the household's minimization problem yields the inverse demand functions and the theoretical price indexes at both levels of aggregation (mathematical details can be found in the Appendix E)

At the aggregate level:

The inverse demand function: $\dfrac{P^i_{jt}}{P^i_t} = \left(\dfrac{c^i_{jt}}{c^i_t}\right)^{-\frac{1}{\eta}}$

The theoretical aggregate price index: $P^i_t = \left[\int_0^1 {P^i_{jt}}^{1-\eta} dj\right]^{\frac{1}{1-\eta}}$

As the sector consumption becomes perfectly substitutable, $\eta \to \infty$, a small change in the relative price index of a sector j compared to the aggregate price index results respectively in an infinite or a zero demand for this sector if the price decreases or increases by a small amount ε.

At the sectoral level:

The inverse demand function: $\dfrac{P^i_{jkt}}{P^i_{jt}} = \left(\dfrac{c^i_{jkt}}{c^i_{jt}}\right)^{\frac{-1}{\rho}}$

The theoretical sector price index: $P^i_{jt} = \left[\sum_{k=1}^{2K} {P^i_{jkt}}^{1-\rho}\right]^{\frac{1}{1-\rho}}$

As the goods become perfectly substitutable, $\rho \to \infty$, a small change in the relative price index of a good k compared to the sector price index results respectively in an infinite or a zero demand for this good if the price decreases or increases by a small amount ε.

Finally, at the equilibrium, the terms of trade are satisfied: $\dfrac{c_{it}}{c_{-it}} = \dfrac{P_{-it}}{P_{it}}$

7.2 Intermediate production

Each firm, within each sector, produces a distinct type of good k with a constant returns to scale production function: $y^i_{jkt} = z^i_{jk} l^i_{jkt}$. In this model, countries are perfectly symmetric in terms of aggregate and sectoral productivity: $Z^i = Z^{-i} = Z$ and $z^i_j = z^{-i}_j = z_j$ but idiosyncratic productivity is drawn from a log-normal distribution with parameter θ: $z \sim \log \mathcal{N}(0, \theta)$. Idiosyncratic productivity is constant over time. As the two countries are perfectly symmetric in terms of productivity, preferences and, labor supply, the wage levels equalize in both countries: $W_{it} = W_{-it} = W_t$. Productivity does not vary over time, allowing us to isolate the role of transport costs. Labor is the only production input; there is no capital. Firms do not incur fixed costs of exporting. Due to this simplification from the original model of Atkeson and Burstein [2008], there is no need to model firm entry and exit decisions in the foreign market after a shock. We assume the number of firms K in each country is exogenous. Atkeson and Burstein [2008] showed that the assumption of zero fixed costs does not change the quantitative implications of the model in terms of market concentration, measured by the median Herfindahl-Hirschmann index.

Good producers play a Cournot game. In this benchmark model, each firm chooses quantities to produce to serve domestic and foreign markets. In the latter case, it must pay an additional iceberg-type trade cost $\tau_t \geq 1$, which scales up its marginal cost of production. Exporters in the two countries face symmetric iceberg trade costs. Trade costs evolve stochastically, following an autoregressive process of order 1:

$$\log \tau_{t+1} = \rho_\tau \log \tau_t + \epsilon_t$$

with $\epsilon_t \sim \mathcal{N}(0, \sigma_\tau^2)$. The parameter $0 < \rho_\tau \leq 1$ determines the persistence of a shock. Now, we solve for the firm's equilibrium, dropping time subscripts for the sake of clarity. We solve for the static Nash equilibrium of firms. The equations we derived in this section hold for every periods.

The measure of sectoral and aggregate productivities are defined, similarly as in Edmond, Midrigan and Xu [2015], as the weighted average of domestic and foreign firms' idiosyncratic productivities serving the domestic market i:

$$z_j = \left(\sum_{l=1}^{K} {z_{jl}^i}^{\rho-1} + \tau^{1-\rho} \sum_{l=1}^{K} {z_{jl}^{*i}}^{\rho-1} \right)^{\frac{1}{\rho-1}}$$

$$Z = \left(\int_0^1 z_j^{\eta-1} \right)^{\frac{1}{\eta-1}}$$

where z_{jl}^{*-i}, denotes the productivity of foreign firms exporting to the domestic market. The cost of transport acts as a shifter in the idiosyncratic productivity of the firm producing for the foreign market. The marginal costs for domestic firms producing for domestic and foreign markets are given respectively by $\frac{W}{z_{jk}}$ and $\tau \frac{W}{z_{jk}}$.

The goods market clearing conditions impose that, at all levels of aggregation, the quantities produced by domestic and foreign firms for the domestic market equalize to the quantity consumed in the domestic market $y_j^i = c_j^i$, $Y^i = c^i$, $q_{jk}^i = c_{jk}^i$, $q_{jk}^{*i} = c_{jk}^{*i}$ for all countries, sectors and firms. A good producer wants to maximize its profit from its production for the domestic and foreign markets separately. Quantities produced and price indexes of a good sold in the domestic (foreign) market and produced by a foreign (domestic) firm are denoted by an asterisk.

Solving for the domestic market

In particular, a firm in the domestic market chooses its production for the domestic market i, q_{jk}^i by solving the maximization program (mathematical details in the Appendix E):

$$\max_{q_{jk}^i} P_{jk}^i q_{jk}^i - q_{jk}^i \frac{W}{z_{jk}^i}$$

subject to the inverse demand function:

$$\left(\frac{P_{jk}^i}{P^i} \right) = \left(\frac{q_{jk}^i}{y_j^i} \right)^{\frac{-1}{\rho}} \left(\frac{y_j^i}{Y^i} \right)^{\frac{-1}{\eta}}$$

Firms recognize that the sectoral production y_j^i and price level P_j^i change when they solve the maximization problem. They account for strategic interactions with the other firms in sector j. The quantities from the other firms q_{jl}^i operating in the sector and serving country i, with $l \neq k$, the final consumption price P^i, the wage level W and aggregate quantity Y^i are taken as given.

Solving for the foreign market

Similarly, the domestic firm k chooses the optimal quantity to export q_{jk}^{*-i} to the foreign country $-i$. The problem is the same; only the marginal cost of producing is scaled up by the iceberg trade cost. Similarly, firms recognize that the sectoral production y_j^{-i} and price level P_j^{-i} change when they solve the maximization problem. They take into account the strategic interaction with the other firms in sector j. The quantities from the other firms q_{jl}^{-i} operating in the sector and serving country $-i$, with $l \neq k$, the final consumption price P^{-i}, the wage level W and aggregate quantity Y^i are taken as given.

$$\max_{q_{jk}^{*-i}} P_{jk}^{*-i} q_{jk}^{*-i} - q_{jk}^{*-i} \tau \frac{W}{z_{jk}}$$

subject to the inverse demand function:

$$\left(\frac{P_{jk}^{*-i}}{P^{-i}} \right) = \left(\frac{q_{jk}^{*-i}}{y_j^{-i}} \right)^{\frac{-1}{\rho}} \left(\frac{y_j^{-i}}{Y^{-i}} \right)^{\frac{-1}{\eta}}$$

The unique Cournot-Nash equilibrium, gives firm k two prices, the first to serve the domestic market and the second to serve the foreign market. Both are markups over marginal cost (mathematical details are in the Appendix E). Firms' market shares in domestic and foreign markets are calculated as their share of revenues in the corresponding market.

$$\textit{For the domestic market: } P_{jk}^i = \frac{\epsilon(s_{jk}^i)}{\epsilon(s_{jk}^i) - 1} . \frac{W}{z_{jk}} \tag{6}$$

with the market share of the firm in market i, in sector j

$$s_{jk}^i = \frac{P_{jk}^i q_{jk}^i}{\sum_{l=1}^K P_{jl}^i q_{jl}^i + \sum_{l=1}^K P_{jl}^{*i} q_{jl}^{*i}} = \left(\frac{P_{jk}^i}{P_j^i} \right)^{1-\rho}$$

Using expressions for the inverse demand, prices indexes, and equilibrium prices, the quantity produced is:

$$q_{jk}^i = \left(\frac{P_{jk}^i}{P_j^i} \right)^{-\rho} \left(\frac{P_j^i}{P^i} \right)^{-\eta} Y^i$$

$$\textit{For the foreign market: } P_{jk}^{*-i} = \frac{\epsilon(s_{jk}^{*-i})}{\epsilon(s_{jk}^{*-i}) - 1} . \tau \frac{W}{z_{jk}}$$

with the market share of the firm in market $-i$, in sector j

$$s_{jk}^{*-i} = \frac{P_{jk}^{*-i} q_{jk}^{*-i}}{\sum_{l=1}^K P_{jl}^{-i} q_{jl}^{-i} + \sum_{l=1}^K P_{jl}^{*-i} q_{jl}^{*-i}} = \left(\frac{P_{jk}^{*-i}}{P_j^{-i}} \right)^{1-\rho}$$

Using the expression for the inverse demand, the prices indexes and the equilibrium prices, the quantity produced is given by:

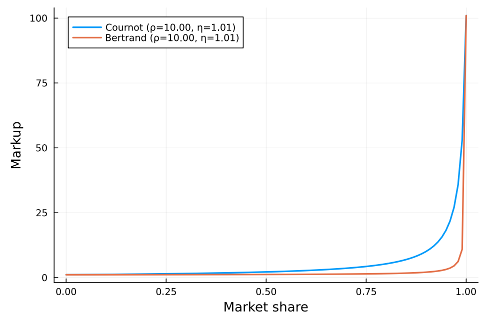
$$q_{jk}^{*-i} = \left(\frac{P_{jk}^{*-i}}{P_j^{-i}} \right)^{-\rho} \left(\frac{P_j^{-i}}{P^{-i}} \right)^{-\eta} Y^{-i} \tag{7}$$

$\epsilon(s^i_{jk}) > 1$ and $\epsilon(s^{*-i}_{jk}) > 1$ are the demand elasticities a domestic firm k located in country i faces to serve domestic and foreign markets in sector j. $s^i_{jk} \in [0,1]$ and $s^{*-i}_{jk} \in [0,1]$ denote the market share a domestic firm has respectively in the domestic and the foreign market. Under Cournot competition, this elasticity is given by:

$$\epsilon(s) = \left(\frac{1}{\eta}s + (1-s)\frac{1}{\rho}\right)^{-1}$$

7.3 A model generating incomplete pass-through

Figure 7.1: Markups as a function of the market share, under Cournot and Bertrand competition



Notes: This figure displays the markups, as a function of the market shares under Cournot and Bertrand competition. At the limit, for both specifications, when $s = 0$, $\mu(s) = \frac{\rho}{\rho-1} \approx 1.111$ and when $s = 1$, $\mu(s) = \frac{\eta}{\eta-1} \approx 100.99$

In contrast to the model presented by Ghironi and Melitz [2005], the markup of each firm is no longer constant, as demand elasticity is a weighted average of the good and sectoral elasticities: $\mu(s) = \frac{\epsilon(s)}{\epsilon(s)-1}$. In the limit, when the elasticity of substitution between goods ρ approaches infinity, the distinction between goods disappears. The model becomes Ricardian, as only the elasticity between sectors matters. The assumption $\rho > \eta$ ensures that each firm in a sector charges a distinct price for its product.

The markup is a strictly increasing and strictly convex function of the market share (proof in the Appendix E), under the assumption that $\rho > \eta > 1$. In the limit, when a firm's market share within a sector and country tends to zero, the firm's market power is not sufficient to sustain a high markup. Its markup is determined only by the high demand elasticity between goods ρ, $\mu(s) = \frac{\rho}{\rho-1}$. Conversely, when the market share approaches one (the monopoly case), the firm's markup is maximized and determined only by sectoral demand elasticity: $\mu(s) = \frac{\eta}{\eta-1}$. When $\eta = \rho$, the markup reduces to that in the monopolistic competition, where markup over marginal cost is constant and given by: $\frac{\rho}{\rho-1}$. This corresponds to the Ghironi and Melitz [2005]'s model. In our model however, markup dispersion depends both on the difference between ρ and η and the dispersion of market shares.

The assumption that $\rho > \eta$ and the finite number of firms within each sector allows firms to not fully pass through an increase in their marginal cost into their prices. When a group of firms experiences an increase in their marginal costs, their market share and thus their markup decrease, raising their price less than the increase in their marginal cost. When the iceberg trade cost increases, it scales up the marginal cost of foreign firms. They lose competitiveness; their market share decreases, which decreases their markups. On the contrary, domestic firms benefit from this increase in the iceberg trade cost. Their market shares increase, which raise their markups. When the transport cost $\tau \to \infty$, the economy converges to autarky. Foreign firms' market shares in the domestic market become infinitesimal and in the limit, only domestic firms serve the domestic market. This is what we observe in our quantitative exercise in section 9.

7.4 Extensions with Bertrand competition

The implications under Bertrand competition are similar to those under Cournot. The equilibrium for Bertrand is similar to that for Cournot; only the expression for the elasticity of substitution changes (derivations in the Appendix E):

$$\epsilon(s) = \rho(1-s) + \eta s$$

With $\rho > \eta > 1$, the markup is still an increasing function of the market share s. It is equal to $\frac{\rho}{\rho-1}$ and $\frac{\eta}{\eta-1}$ respectively if $s = 0$ and $s = 1$. Under the assumption of zero fixed cost of exporting and price competition, as ρ gets large, it approaches the standard Bertrand model. It is still a strictly increasing and convex function of the market share (see the mathematical Appendix E for further details). Under Bertrand competition, markups, for the same parameters are lower (Figure 7.1). However, Bertrand competition rewards cost-efficient firms more than Cournot competition does. This results in more asymmetric market shares [Amir and Jin, 2001].

These firms-level dynamics have implications at the sectoral and aggregate level.

7.5 Aggregation

Symmetry implies that all aggregate and sectoral variables are identical across both countries. In this section, we define a sectoral μ_j^i and an aggregate markup μ^i. We consider the example of the domestic market i. The equilibrium conditions, resulting from equation 6 are given by:

$$P_{jk}^i = \mu_{jk}^i \frac{W}{z_{jk}} \qquad P_j^i = \mu_j^i \frac{W}{z_j^i} \qquad P^i = \mu^i \frac{W}{Z} \tag{8}$$

Similarly, for a domestic firm serving the foreign market:

$$P_{jk}^{*-i} = \mu_{jk}^{*-i} \frac{W}{z_{jk}} \tag{9}$$

Extending De Loecker, Eeckhout and Mongey [2021] to our open economy, we can show that markups at the sectoral and aggregate levels are determined by relative productivities (see mathematical Appendix E for further details):

$$\mu_j^i = \left(\sum_{k=1}^{K} \left(\frac{z_{jk}}{z_j}\right)^{\rho-1} \left(\frac{1}{\mu_{jk}^i}\right)^{\rho-1} + \tau^{1-\rho} \sum_{k=1}^{K} \left(\frac{z_{jk}^*}{z_j}\right)^{\rho-1} \left(\frac{1}{\mu_{jk}^{*i}}\right)^{\rho-1} \right)^{\frac{1}{1-\rho}} \tag{10}$$

Similarly, the economy-level aggregate is defined as:

$$\mu^i = \left(\int_0^1 \left(\frac{z_j}{Z}\right)^{\eta-1} \left(\frac{1}{\mu_j^i}\right)^{\eta-1} dj \right)^{\frac{1}{1-\eta}}$$

Finally, we calculate the import share for a country i, given by the ratio between the expenditure for goods produced abroad for the domestic market $\sum_{k=1}^{K} p_{jk}^{*i}.q_{jk}^{*i}$ and total expenditure:

$$i^i = \frac{\int_0^1 \left(\sum_{k=1}^{K} p_{jk}^{*i}.q_{jk}^{*i}\right) dj}{P^i Y^i} = 1 - \frac{\int_0^1 \left(\sum_{k=1}^{K} p_{jk}^{i}.q_{jk}^{i}\right) dj}{P^i Y^i}$$

The total expenditure is given by: $P^iY^i = \int_0^1 \left(\sum_{k=1}^K p^{*i}_{jk}.q^{*i}_{jk} + \sum_{k=1}^K p^i_{jk}.q^i_{jk}\right) dj$

In addition to markups at the sectoral and aggregate level, it is useful, for our quantitative exercise to define a sales weighted average of markups, extending De Loecker, Eeckhout and Mongey [2021] to our open economy (see mathematical Appendix E for further details), denoted $\bar{\mu}$. A change in sales-weighted markups captures compositional changes across and within firms. Indeed, firms can increase their markups while keeping their sales constant, or sales can increase as a result of an increase in the markup.

$$\bar{\mu^i} = \int_0^i \sum_{k=1}^K \left(\frac{p^i_{jk}q^i_{jk}}{P^iY^i}\mu^i_{jk}\right) + \sum_{k=1}^K \left(\frac{p^{*i}_{jk}q^{*i}_{jk}}{P^iY^i}\mu^{*i}_{jk}\right) dj$$

This measure can be re-expressed, using the definition of the import share:

$$\bar{\mu^i} = i^i(\mu_{for}) + (1 - i^i)(\mu_{dom})$$

With μ_{for} and μ_{for} respectively the sales-weighted average foreign and domestic markups (derivation in the Appendix E).

$$\mu^i_{for} = \int_0^i \sum_{k=1}^K \frac{p^{*i}_{jk}q^{*i}_{jk}\mu^{*i}_{jk}}{\int_0^i \sum_{k=1}^K p^{*i}_{jk}q^{*i}_{jk}dj}dj$$
$$\mu^i_{dom} = \int_0^i \sum_{k=1}^K \frac{p^i_{jk}q^i_{jk}\mu^i_{jk}}{\int_0^i \sum_{k=1}^K p^i_{jk}q^i_{jk}dj}dj$$

Measuring concentration

Market power, driven by unequal repartition of market shares can be measured using the Herfindahl-Hirschman Index. It is an average of the market shares of all firms operating in the market, weighted by their market shares:

$$HHI^i_j = \sum_{k=0}^K {s^i_{jk}}^2 + \sum_{k=0}^K {s^{*i}_{jk}}^2$$

It lies between $\frac{1}{2K}$ and 1. If the HHI equals $\frac{1}{2K}$, the market is competitive, all firms have identical market share. On the contrary, in the monopoly case where one firm has a market share of one, the HHI equalts 1. Agencies usually calculate this indicator using percentages instead of ratio for the market shares. The HHI^i_j calculated above is thus scaled by a factor of 10,000. According to the U.S. Department of Justice, agencies usually consider that markets with a Herfindahl index below 1,000 to be "unconcentrated, between 1,000 and 1,800 to be moderately concentrated, above 1,800 to be highly concentrated". The level of concentration within sector is expected to be higher when there is greater heterogeneity in terms of idiosyncratic productivity within a sector. More competitive firms can thus exert greater market power. The same logic applies to sectoral markups, which we expect to move in the same direction as the sectoral HHI. This is what we observe in our quantitative exercise.

We compute the aggregate HHI using the method presented in the CompNet Productivity Report 2023 of the European Union. [1]. Following any partition of firms (e.g. sectors), the HHI can be written as a weighted mean of the sectoral HHIs over the J sectors, where weights are the squared shared on total revenue for each sector. We compute the HHI for domestic firms including the revenue from serving both domestic and foreign markets. The

[1] CompNet (2023), "Firm Productivity Report", p.74 URL: `https://www.comp-net.org/fileadmin/_compnet/user_upload/CompNet_Productivity_Report_-_July_2023.pdf`

aggregate HHI for firms located in country i is given by:

$$HHI^i = \int_0^i \left(HHI^i_j . \left(\left(\frac{P^i_j}{P_i} \right)^{1-\eta} \right)^2 \right) dj \tag{11}$$

where HHI^i_j is the HHI at the sectoral level.

7.6 Labor market

Labor is assumed to be immobile across countries but mobile within and across sectors. Households inelastically supply one unit of labor. The labor-clearing condition should satisfy $\int_0^1 l^i_j dj = 1$ with l_j, the labor demand at the sectoral level: $l_j = \sum_{k=1}^K l^i_{jk} + \sum_{k=1}^K l^{*-i}_{jk}$. l^i_{jk} and l^{*-i}_{jk} denote the labor demand of a domestic firm for producing q^i_{jk} and q^{*-i}_{jk} goods for domestic and foreign markets respectively.

8 Calibration

Our model generates incomplete pass-through due to a reallocation of market shares towards the most productive firms (domestic). We now quantify the predictions of our model, using the European context for calibration. In this qualitative exercise, we simulate the model assuming that labor supply is inelastic and normalized to one in both countries. As in Edmond, Midrigan and Xu [2015], both countries are symmetric in terms of aggregate and sectoral productivity and $W = 1$ is set to be the numeraire. As part of future research, we intend to solve for a fixed point in which labor supply is elastic, as in De Loecker, Eeckhout and Mongey [2021]. Our model has five parameters: K, η, ρ, τ, and θ. As in Atkeson and Burstein [2008], we use a constant number of domestic firms in each sector $K = 20$. In our exercise, we simulate the model for 1000 sectors, totaling 40,000 firms. We choose η and ρ as in Atkeson and Burstein [2008]. η is closed to one to keep sectoral expenditure shares roughly constant. The aggregate HHI is therefore expected to be close to the mean HHI. Anderson and van Wincoop [2004] concluded that the elasticity of demand for imports at the sectoral level ranges from 5 to 10. We choose the upper bound of this interval to make the import demand at the sectoral level quite elastic. These values are consistent with the literature. Edmond, Midrigan and Xu [2015] estimated within and across sector elasticities of substitution of 10.5 and 1.24, respectively.

We choose the remaining parameters to match two key moments in the European market. First, θ controls the distribution of idiosyncratic productivities within sectors, which determines concentration. Following Bighelli et al. [2023], the European domestic HHI was approximately 2100-2150 in 2016. This European concentration index incorporates intra-European trade flows but does not capture the impact of external trade flows to Europe. The authors used the HHI as a "shape of the firm-sales distribution, which reflects, among others, differences in production technologies across firms." (p.463) This measure is relevant for our calibration, as we assumed that our two countries are perfectly symmetric in terms of aggregate and sectoral productivity. With our calibration, we find an aggregate domestic HHI of 2123.38. We use the same method to estimate the domestic HHI as in Edmond, Midrigan and Xu [2015]. They define the weights to calculate the sectoral domestic HHI as the ratio of market shares for serving the domestic market to the sum of domestic firms' market shares. Our estimated productivity parameter is $\theta = 0.32$. In comparison, Atkeson and Burstein [2008] choose 0.39 to get a median sector moderately concentrated (HHI of 1500). While we used this measure to calibrate our model, we want to measure the impact of transport costs on concentration, so, what we call in the next section "Aggregate sectoral HHI" is a function of all firms (domestic and foreign) active in the market, as defined in equation (11).

Moreover, we choose the level of transport costs τ to match the imports of goods and services as a share of GDP in the European Union. Before the COVID-19 crisis, according to the World Bank national and OECD accounts data, it was around 44-45% for the European Union (44%, 45.3% and 45.9% in 2017, 2018 and 2019, respectively)[2]. The import share obtained with our specification is 45.22%. The gross trade cost obtained is 1.04. In comparison, Edmond, Midrigan and Xu [2015] set their own trade cost to 1.129.

Parameter	Description	Value
ρ	Within-sector-elasticity of substitution	10
η	Across-sector-elasticity of substitution	1.01
θ	Log-normal parameter, idiosyncratic productivity	0.32
K	Number of firms in each sector in each country	20
τ	Gross trade cost	1.04

Table 8.1: Benchmark parameters

9 Quantification of the transport cost shock

9.1 Comparative statics

In this section, we use our benchmark model to study the importance of trade costs on firms' markup and competitiveness by comparing it to the extreme case of an autarky economy that opens to trade. As iceberg trade costs increase, the number of firms exporting positive quantities decreases. This exercise illustrates the effects of lower trade and transport costs. With openness to trade, market shares are reallocated toward domestic firms. We also report the results for Bertrand competition. We use the same underlying parameters and productivity draws for both Bertrand and Cournot specifications. The differences in the prediction of these two types of model, cannot be attributable to differences in productivity and parameters. We simulate the economy for 1000 sectors, totaling 40,000 firms. Labor supply is fixed to one and $W = 1$. The algorithm is our own (more details are provided in the Appendix E.5). The full tables about our index of concentration at the firm, sector and aggregate level can be found in the Appendix (Tables D.1, D.2, D.3 and D.4).

At the firm level, in autarky, the distribution of market shares and markups is shifted to the right compared to the open economy. Market concentration increases, resulting in higher markups and market shares for domestic firms, at the expense of foreign firms for which markups reach the lower bound of 1.111 in case of zero market shares. At the sectoral level, this translates into a a rightward shift in the distribution of sector markups and HHI, suggesting that concentration increases at the sectoral level. Firms have greater market shares and can use their market power to charge higher markups. The market becomes more concentrated and markups charged by domestic firms increase. Similar observations can be made at the aggregate level. Interestingly, the skewness of our measure of sectoral productivity dispersion (standard deviations) at the sectoral level is always lower than the skewness of sectoral markups for all specifications, suggesting that productivity differences across firms are amplified in terms of markups. Bertrand competition yields similar conclusions. Quantities produced under Bertrand competition are expected to be higher, while prices and markups tend to be lower. Bertrand competition tends to reward more cost-efficient firms than Cournot competition does. This results in more asymmetric market shares [Amir and Jin, 2001]. At the firm level, the distribution of market shares and markups is more asymmetric (higher skewness) under Bertrand competition, both in autarky and in the benchmark model. For all specifications (autarky or not) and all measures of markups, HHI and market shares, the skewness is always higher under Bertrand competition, at the firm level.

Thus, a reduction in trade costs and openness to trade, leads to lower markups, leading to lower prices, and more competition due to the presence of foreign firms. This is consistent with the findings of Edmond, Midrigan and Xu [2015] for Taiwan. Under extensive misallocation, when dominant producers are exposed to greater competitive pressure, there are pro-competitive gains from international trade.

[2]World Bank, "World Trade Indicators", URL: `https://wits.worldbank.org/CountryProfile/en/Country/WLD/Year/2018`

9.2 Response to a short-term shock

In this section, we investigate how aggregate variables change over time from steady-state to steady-state when the iceberg trade cost increases after a short-term shock. We simulate the model for a 10% shock to iceberg trade costs. Shock persistence is set quite high, at $\rho_\tau = 0.95$. For computational reasons, we simulate the economy for 100 sectors. According to the law of large numbers, results are close to the one observed with 1,000 sectors, at the benchmark value of $\tau = 1.04$. We plot deviations from the benchmark calibrated model ($\tau = 1.04$). Results are presented in Figure 9.1. Our model predictions are consistent with what we observed in our empirical analysis, although the magnitudes are larger in this quantitative exercise. Following a shock in trade costs, the price of foreign goods is predicted to increase by less than the shock.

9.2.1 Benchmark model: Cournot competition

In response to 10% increase in iceberg trade costs, foreign prices are predicted to increase by only 7%, when the shock occurs. This incomplete pass-through is explained in our model by a reallocation of market shares toward the most productive firms. Foreign firms lose in competitiveness at the benefit of domestic firms.

In response to a 10% shock in the iceberg trade cost, the aggregate productivity falls by 3%. This shock changes the relative competitiveness in favor of domestic firms by scaling up foreign firms' marginal cost. Foreign firms bear the extra cost of exporting, reducing their market shares, and thus their sales-weighted markup drops by 1.6%, when the shock occurs. As a result, prices charged by foreign firms increase by less than the size of the shock. Concentration within sectors increases, as domestic firms benefit from this increase in trade costs. The aggregate HHI increases by approximately 4%, while the import share drops by 11%, when the shock occurs. The sales-weighted domestic markup rises by around 1.4% and this increase overcomes the drop in markups for foreign firms, resulting in an increase in the aggregate sales-weighted markup by 0.5%, when the shock occurs. Aggregate profit, driven by an increase in market power for domestic firms increases by more than the size of the shock. Indeed, while consumption drops by more than 0.8% the aggregate price increases by 4% when the shock occurs. This increase in concentration results in a welfare loss for the consumer, whose consumption decreases, while domestic firms gain from this decrease in market competition.

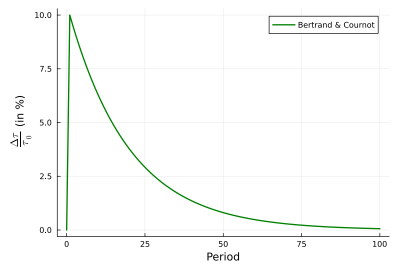
9.2.2 Robustness check: Bertrand competition

As a robustness check, we conduct the same simulation for Bertrand competition, using the same benchmark parameters and same productivity draws as in the Cournot case. The dynamics we described under Cournot competition are robust to a change in specification to Bertrand competition. There is an incomplete pass-through of transport costs to foreign prices. Foreign prices are expected to rise by 9% in response to a 10% increase in transport costs, when the shock occurs. Pass-through is higher under Bertrand, as markup adjustments are predicted to be smaller than in the Cournot case.

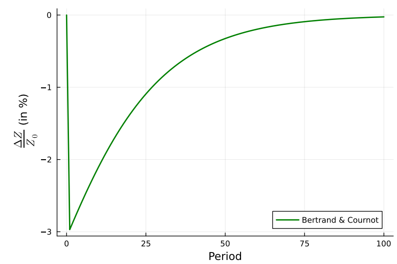
Although under Bertrand competition, market shares are more responsive to changes in trade costs, changes in domestic and foreign markups are smaller. As in the Cournot case, the shock reallocates market shares toward domestic firms, which gain in competitiveness. The HHI increases more than in the Cournot case (10% against 4%). More competitive firms are rewarded more under Bertrand competition, and this leads to more asymmetric market shares than under Cournot [Amir and Jin, 2001]. Adjustments of foreign and domestic markups, are smaller. The ratio of domestic and foreign sales-weighted markups remains lower. Interestingly, the increase in the sales-weighted aggregate markup is comparable to the Cournot case (approximately 0.5% when the shock occurs).

The implications under Bertrand competition in terms of aggregate consumption, prices, and sales-weighted aggregate markups are similar to the Cournot case. Under Bertrand competition, changes in the aggregate prices, reflected by changes in the aggregate markup are slightly lower. However, changes in aggregate consumption are slightly larger. Changes in import share and profit are amplified compared to the Cournot case.

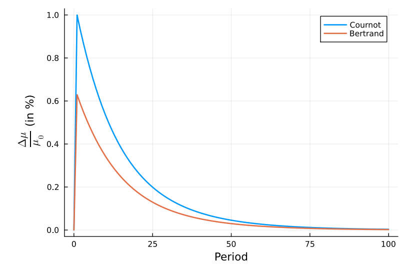
Figure 9.1: Impulse responses to a 10% iceberg trade cost shock (Bertrand and Cournot competitions)



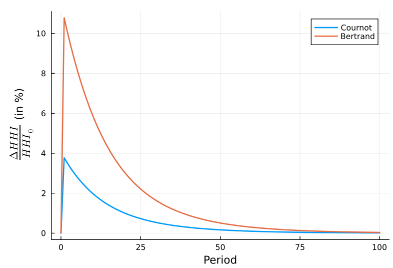
(a) Iceberg trade cost



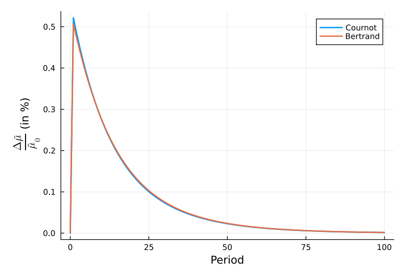
(b) Aggregate productivity



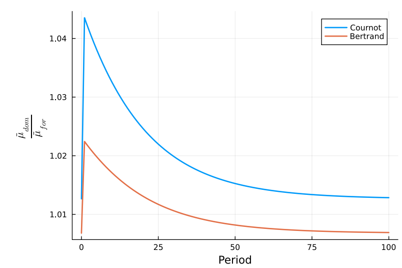
(c) Aggregate markup



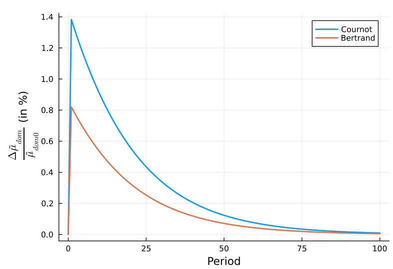
(d) Aggregate HHI



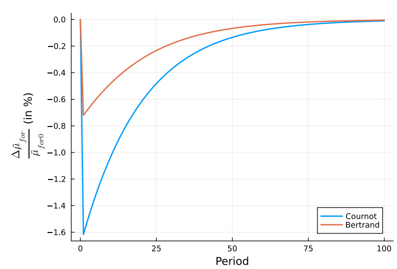
(e) Sales weighted aggregate markup



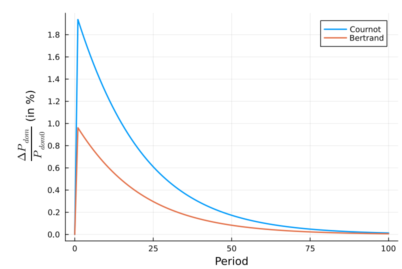
(f) Ratio domestic/foreign markups



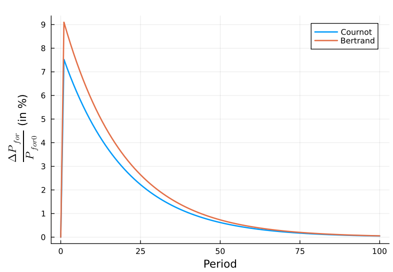
(g) Sales weighted domestic markup



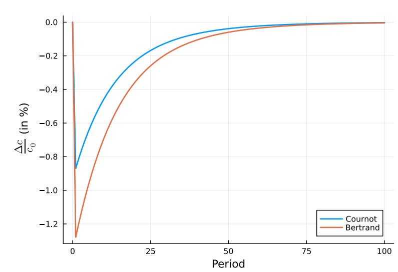
(h) Sales weighted foreign markup



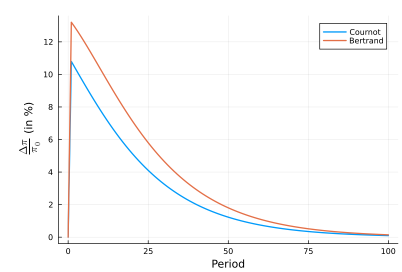
(i) Domestic price index



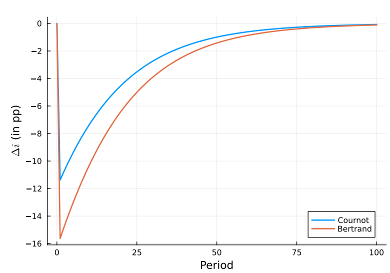
(j) Foreign price index



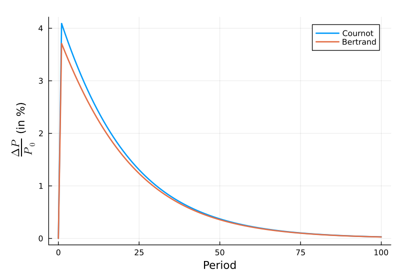
(l) Aggregate consumption



(m) Aggregate profit



(n) Import share



(o) Aggregate price index

Notes: These figures show the impulse response to a 10% shock to the iceberg trade cost. The persistence is set to 0.95. The economy is simulated for 100 sectors, so a total of 4,000 firms, with the same draw in productivity for both specifications. Under the assumption of Bertrand competition, the aggregate consumption is predicted to fall by more than 1.2% after a 10% increase in the iceberg trade costs.

9.3 Limitations and extensions

If our model fits well the empirical evidence of an incomplete pass-through of transport costs, we assume that prices can adjust freely. Thus, the market reacts immediately to the shock in our simulations. However, our empirical analysis suggests that import prices adjust with a lag, and price rigidities may exist. These rigidities may be due to seller $\times$ buyer relationships in markets for intermediary goods or to differential transport costs. First, buyers and suppliers of intermediate goods may commit to certain quantities and prices through contracts. A foreign firm affected by a transport shock may not be able to freely adjust its prices, and the same applies to a domestic firm. Price rigidities could amplify markup adjustments, resulting in further increases in prices. To test this hypothesis, we intend to extend our model, with sticky prices *à la* Calvo, such that domestic and foreign firms can adjust their prices with a probability λ and commit to prices and quantities at those prices. In the case of price rigidities due to contracts between shipowners and charterers, if firms commit to certain prices for a certain number of periods, this would explain why the shock is long-lasting. We could also extend the model by assuming that not all foreign firms are affected by a shock to transport prices at the same time. This may attenuate the shock's impact on price increases but result in more persistent effects.

Moreover, in our model, we assume that labor supply is inelastic. This provides no predictions regarding changes in labor supply and wage levels. One possible extension is to relax this assumption by solving for the optimal level of labor supply as in De Locker and al. (2022). Thus, we could furthermore explore how labor supply and wages change in case of transport cost shock.

We assume that the shock to transport cost is a short-term shock, as in the post-pandemic context. Even if the COVID-19 shocks was temporary, some shocks on the price of transport may be permanent. For instance, Panama experienced a critical drought and imposed restrictions on the number of vessels allowed to cross the Canal. Prior to the water shortage, as many as 38 ships a day moved through the Canal. In July 2023, authorities reduced the average to 32 vessels, and to 24 in January 2024. Approximately 5% of global maritime trade uses the Atlantic-Pacific shortcut, as does 40% of U.S. container traffic. With global warming, this water shortage may become permanent, forcing ships to detour around the Cape Horn. We could extend the model by including capital accumulation and elastic labor supply in the benchmark model and studying the transition between two steady states before and after a permanent shock to transport costs.

Finally, we assume that iceberg trade costs are symmetric, however, this is not empirically accurate (Figure 4.3). We can relax this assumption by simulating a one-side shock to transport cost, to study the relative impacts on the two countries in terms of price levels, markup adjustments, and consumption levels.

10 Conclusion

Using an original dataset and a new index of transport prices, this paper provides new evidence that transport costs still matter. The elasticity at a 1% shock for China on the cost of air and sea transport on cumulative price changes is approximately 0.15. When restricting to a sample for which the shares of sea and air freight sum to one, after a 1% increase in transport costs, import prices increase on average by 0.24%, 13 months after the shock. The effect is quite persistent, lasting 18 months.

In our model, this incomplete pass-through results from a reallocation of market shares toward more competitive domestic firms. Foreign firm markups increase by less than the size of the shock. Our model predicts, after a 10% trade cost shock, an increase in the domestic price index of 4%, due to an increase in domestic and foreign price indexes of 0.9-1.9% and 7-9%, respectively.

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A Appendix: Dataset

A.1 The Comext database

Table A.1: Motor vehicles nomenclature (HS 2017)

HS4	Description
8601	Rail locomotives powered from an external source of electricity or by electric accumulators.
8602	Other rail locomotives; locomotive tenders.
8603	Self-propelled railway or tramway coaches, vans and trucks, other than those of heading 86.04.
8604	ailway or tramway maintenance or service vehicles, whether or not self-propelled (for example, workshops, cranes, ballast tampers, trackliners, testing coaches and track inspection vehicles).
8605	Railway or tramway passenger coaches, not self-propelled; luggage vans, post office coaches and other special purpose railway or tramway coaches, not self-propelled (excluding those of heading 86.04).
8606	Railway or tramway goods vans and wagons, not self-propelled.
8701	ractors (other than tractors of heading 87.09).
8702	Motor vehicles for the transport of ten or more persons, including the driver.
8703	Motor cars and other motor vehicles principally designed for the transport of persons (other than those of heading 87.02), including station wagons and racing cars.
8704	Motor vehicles for the transport of goods.
8705	Special purpose motor vehicles, other than those principally designed for the transport of persons or goods (for example, breakdown lorries, crane lorries, fire fighting vehicles, concretemixer lorries, road sweeper lorries, spraying lorries, mobile workshops, mobile radiological units).
8709	Works trucks, self-propelled, not fitted with lifting or handling equipment, of the type used in factories, warehouses, dock areas or airports for short distance transport of goods; tractors of the type used on railway station platforms; parts of the foregoing vehicles.
8710	Tanks and other armoured fighting vehicles, motorised, whether or not fitted with weapons, and parts of such vehicles.
8711	Motorcycles (including mopeds) and cycles fitted with an auxiliary motor, with or without side-cars; side-cars.
8716	Trailers and semi-trailers; other vehicles, not mechanically propelled; parts thereof.

Notes: This table lists the product codes excluded from the analysis (motor vehicles)

Table A.2: Motor vehicles nomenclature (HS 2022)

HS4	**Description**
8601	Rail locomotives powered from an external source of electricity or by electric accumulators.
8602	Other rail locomotives; locomotive tenders.
8603	Self-propelled railway or tramway coaches, vans and trucks, other than those of heading 86.04.
8604	Railway or tramway maintenance or service vehicles, whether or not self-propelled (for example, workshops, cranes, ballast tampers, trackliners, testing coaches and track inspection vehicles).
8605	Railway or tramway passenger coaches, not self-propelled; luggage vans, post office coaches and other special purpose railway or tramway coaches, not self-propelled (excluding those of heading 86.04).
8606	Railway or tramway goods vans and wagons, not self-propelled.
8701	Tractors (other than tractors of heading 87.09).
8702	Motor vehicles for the transport of ten or more persons, including the driver.
8703	Motor cars and other motor vehicles principally designed for the transport of persons (other than those of heading 87.02), including station wagons and racing cars.
8704	Motor vehicles for the transport of goods.
8705	Special purpose motor vehicles, other than those principally designed for the transport of persons or goods (for example, breakdown lorries, crane lorries, fire fighting vehicles, concrete mixer lorries, road sweeper lorries, spraying lorries, mobile workshops, mobile radiological units).
8709	Works trucks, self-propelled, not fitted with lifting or handling equipment, the type used in factories, warehouses, dock areas or airports for short distance transport of goods; tractors of the type used on railway station platforms; parts of the foregoing vehicles.
8710	Tanks and other armoured fighting vehicles, motorised, whether or not fitted with weapons, and parts of such vehicles.
8711	Motorcycles (including mopeds) and cycles fitted with an auxiliary motor, with or without side-cars; side-cars.
8716	Trailers and semi-trailers; other vehicles, not mechanically propelled; parts thereof.

Notes: This table lists the codes excluded from the analysis (motor vehicles)

Table A.3: COVID-19, product list (HS 2017)

HS 6	Description (short)
220710	Undenatured ethyl alcohol, of actual alcoholic strength of $=80\%$
284700	Hydrogen peroxide, whether or not solidified with urea
300120	Extracts of glands or other organs or of their secretions, for organo-therapeutic uses
300190	Dried glands and other organs for organo-therapeutic uses; heparin and its salts, ...
300212	Antisera and other blood fractions
300213 300214 300215 300219	Immunological products
300220	Vaccines for human medicine
300290	Human blood; animal blood; toxins, cultures of micro-organisms and similar products
300310 300320 300331 300339 300341 300342 300343 300349 300360 300390 300410 300420 300431 300432 300439 300441 300442 300443 300449 300450 300460 300490	Medicaments
300510	Dressings, adhesive: and other articles having an adhesive layer, packed for retail sale for medical, surgical, dental or veterinary purposes
300590	Wadding, gauze, bandages and the like put up for retail sale for medical, surgical, dental or veterinary purposes
300610	Sterile surgical catgut, similar sterile suture materials,...

Notes: This table lists the medical products excluded from the analysis.

Table A.4: COVID-19, product list (HS 2017)

HS 6	Description (short)
300620	Reagents for determining blood groups or blood factors
300630	Opacifying preparations for x-ray examinations; diagnostic reagents for administration to patients
300650	First-aid boxes and kits
300670	Gel preparations designed to be used in human or veterinary medicine ...
340111 340130	Hand soap
340212	Cationic organic surface-active agents
340213	Non-ionic organic surface-active agents
340220	Other cleaning products
350400	Peptones and their derivatives; other protein substances and their derivatives, n.e.s.; ...
350790	Enzymes and prepared enzymes, n.e.s.
370110	Photographic plates and film in the flat, sensitised, unexposed, for X-ray
370210	Photographic film in rolls, unexposed, for X-ray
380894	Disinfectants, put up in forms or packings for retail sale
382100	Prepared culture media for the development or maintenance of micro-organisms
382200	Diagnostic or laboratory reagents on a backing, prepared diagnostic or laboratory reagents and certified reference materials
382499	Hand sanitizer
390421	Chlorine
391610 391620 391690	Raw Materials to produce masks
392329	Sharps container boxes
392390	Bio-hazard bag
392620	Articles of apparel and clothing accessories produced by the stitching or sticking together of plastic sheeting
392690	Face masks
401490	Hygienic or pharmaceutical articles
401511	Surgical gloves, of vulcanised rubber
401519 401590	Gloves, mittens and mitts, of vulcanised rubber

Notes: This figure lists the medical products excluded from the analysis.

Table A.5: COVID-19, product list (HS 2017)

HS 6	**Description (short)**
481810	Hand drying tissue
530310 530390 560410 560600 600240 600290	Raw Materials to produce masks
560311 560312 560313 560314 560391 560392 560393 560394	Textile raw material for masks and coveralls
590700	Disposable chemical protective overalls
611300 611420 611430 611490 611610 621030 621040 621050 621132 621133 621139 621142 621143 621149 621600	Protective garments
621010	Protective clothing
621020	Gloves
621790	Medical Masks
630790	Face masks
650500	Disposable medical headwear
650610	Other medical headwear
701710	Laboratory, hygienic or pharmaceutical glassware, of fused quartz or other fused silica

Notes: This table lists the medical products excluded from the analysis.

Table A.6: COVID-19, product list (HS 2017)

HS 6	Description (short)
701720	Laboratory, hygienic or pharmaceutical glassware having a linear coefficient of expansion = 5 x 10 -6 per Kelvin within a temperature range of 0°C to 300°C
701790	Laboratory, hygienic or pharmaceutical glassware n.e.s
721790 732690 760410 760429 761699	Raw Materials to produce masks
841391	Flow-splitter, for oxygen supply
841920	Medical, surgical or laboratory sterilizers
842129	Fit test kit
842139	Oxygen concentrators
842199	Full face mask filters anti-aerosol FFP3
847989	Humidifier, non-heated
900490	Protective spectacles and visors
901050	Apparatus and equipment ....; negatoscopes X
901110	Stereoscopic optical microscopes X
901180	Optical microscopes X
901811	Electro-cardiographs X
901812	Ultrasonic scanning apparatus X
901813	Magnetic resonance imaging apparatus X
901814	Scintigraphic apparatus
901819	Other electro-diagnostic apparatus X
901820	Ultraviolet or infra-red ray apparatus used in medical, surgical, dental or veterinary sciences X
901831	Syringes, with or without needles, used in medical, surgical, dental or veterinary sciences
901832	Tubular metal needles and needles for sutures, used in medical, surgical, dental or veterinary sciences
901839	Needles, catheters, cannulae and the like, used in medical, surgical, dental or veterinary sciences
901890	Instruments and appliances used in medical, surgical or veterinary sciences, n.e.s. X

Notes: This table lists the medical products excluded from the analysis.

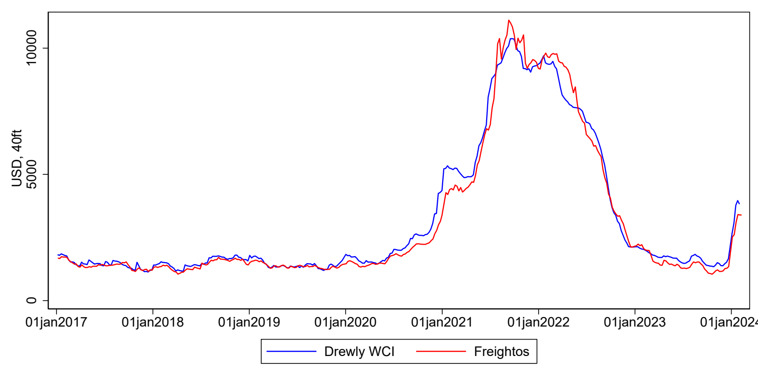
A.2 Indicators for the price of transport

The data for the cost of transport are usually private. In order to obtain these datasets, we used webscraping techniques using Python. Among those available, we chose the Drewry World Container Index for maritime containerized traffic, the Baltic Price Index for bulk maritime traffic and the Traffic Air Cargo Index for air freight.

Drewry World Container Index

This index reports the container freight rates for the major maritime roads. It is a weekly indicator for the price of a 40ft container. A 40ft container is one of the most widely used in the shipping industry. It is multimodal and can be transported by sea, rail, inland waterway or road. It is collected for the following routes: Shanghai-Rotterdam, Rotterdam-Shanghai, Shanghai-Genoa, Shanghai-Los-Angeles, Los-Angeles-Shanghai, Shanghai-New York, New York-Rotterdam, Rotterdam-New-York. The World Container Index is a composite of these routes, weighted for the quantities and volumes transported. It includes possible surcharges, that affected the shipping industry and the different routes: "bunker adjustment factor (emergency adjustment if any), currency adjustment factor, peak season surcharge, equipment management fee/surcharge, port additional/port dues, emergency risk surcharge, port security charge, carrier security charge, submission of cargo declaration fee /US automated manifest fee, Suez Canal transit fee/surcharge, Panama Canal surcharge, Gulf of Aden surcharge, Port congestion surcharge"[3]. Other indicators for the price of containerized freight exist. Some only concern the freight index at the departure of Chinese ports such as the Shanghai Containerized Freight based on 12 routes from Chinese ports. The dynamics for Atlantic and Asia-Europe freight being different, these indicators would be inadequate to capture them. Drewry is not the only consulting firm providing a containerized index for several routes. Among others, the other leading indexes are that the Freightos Container Index based on 12 routes and the Xeneta Shipping index available for different types of containers. I chose the Drewry price index, as the data for the eight routes were extractable. However, the methodology of these indicators is similar and they are strongly correlated. Figure A.1 displays the Drewry World Container Index and the Freightos World Container index, for 40ft containers. The correlation (0.992 over the period 2017-2024) is almost perfect between the two indicators, suggesting that the choice of the Drewry price index may not lead to misleading results.

Figure A.1: World container indexes



Notes: This figure presents the Drewry World Container Index and the Freightos Baltic Index at a weekly frequence over the period 2017-2024.

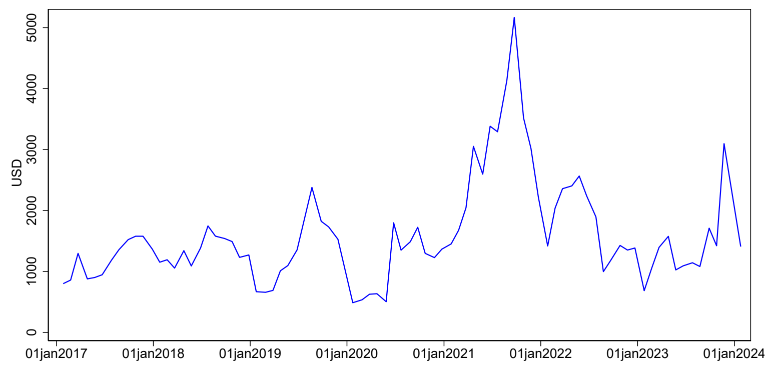
Baltic dry price index (BDI)

In addition to these indexes for containerized shipping, some products are transported in bulk. It can be either in solid bulk such as the agricultural products, minerals and ores and industrial solids, or in liquid bulk such as petroleum products, chemicals and edibles. It refers to the transportation of goods in large quantity, usually not packed and loaded directly into a vessel. The reference indicator for the price of transport for bulk materials

[3] Drewry, 'World Container Index: Correlations and methodology' (2022). URL: `https://www.drewry.co.uk/logistics-executive-briefing/logistics-executive-briefing-articles/world-container-index-correlations-and-methodology#:~:text=METHODOLOGY%3A%20Drewry%20World%20Container%20Index&text=The%20Index%20consists%20of%208,in%20USD%20per%2040ft%20Container.`

is the Baltic Dry Index from the London-based Baltic Exchange for solid bulk. It covers 100% of the bulk dry cargo in transit on the world's oceans. It does not incorporate information about containerized goods or liquid fuel. It is a composite of the dry bulk timecharter average: the Baltic Capesize Index (40%), the Baltic Panamax Index (30%) and the Baltic Supramax Index (30%). These indicators concern different sizes of vessels. Panamax and NewPanamax are terms for the size limits through the Panama Canal (deadweight of 65,000–80,000 tonnes). Capesize vessels have been restricted from passing through major sizes due to their size, forcing them to transit via the Cape of Good Hope or the Cape Horn (130,000 – 210,000 deadweight tonnage). Supramax are suitable for ports with limited infrastructure with their typical 52,000-60,000 tonnes deadweight. In total more than 20 routes are used to build the BDI. The BDI was not freely available for different routes. As we focused our analysis on the price of manufacturing goods by differentiating the routes, we assumed that the container indexes reflect the dynamics of the goods shipped in bulk. While this index exists at a weekly frequency, we could only extract the BDI at a monthly level. The dynamics in the world BDI are close to the ones we observe in the container price index (correlation of 0.7203 over the period 2017-2024).

Figure A.2: Baltic dry price Index (BDI)



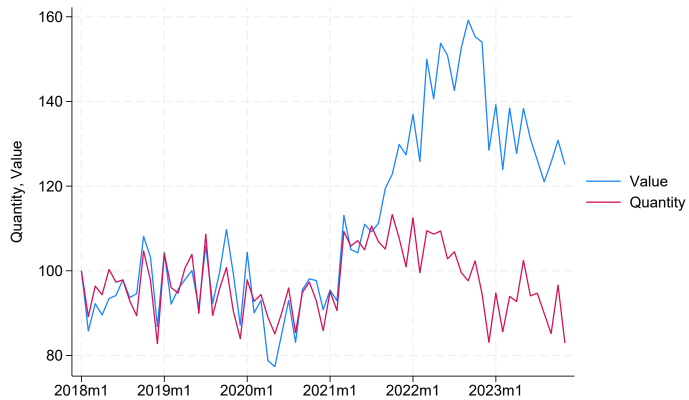
Notes: This figure shows the Baltic dry price index at a monthly frequence over the period 2017-2024.

Traffic Air Cargo Price index (TAC)

Finally, we use the Traffic Air Cargo index, the leading air cargo indicator, to estimate the cost of air freight. This index is done in collaboration with the Baltic Exchange. It is calculated as the ratio between all cost paid to carriers and the actual weight and is expressed in dollars per kilograms. It includes 17 routes. We were able to extract the data only for the world index from 2018 and not for all routes. We observe that the dynamic are different than those for maritime freight. Indeed, part of the air freight is done with passenger flights, whose traffic was reduced dramatically during the pandemic, explaining part of the increase in the index.

A.3 Descriptive figures for all Extra-European manufacturing imports

Figure A.3: Quantity and value of all Extra-European imported manufacturing goods (100 in January 2018)



Notes: This figure plots the total value and quantity of all Extra-European imported manufacturing goods in the European Union relative to January 2018 level. Medical products (list in the Appendix, Tables A.3, A.4, A.5 and A.6) and motor vehicles (Tables A.1 and A.2 in the Appendix) are excluded.

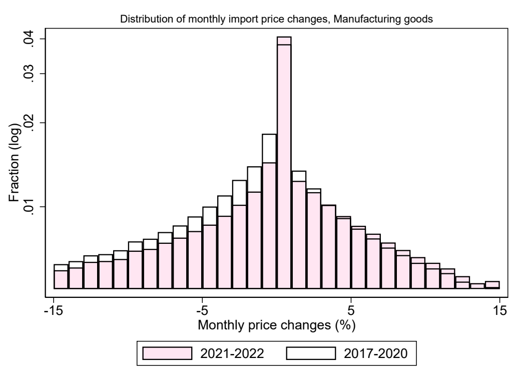
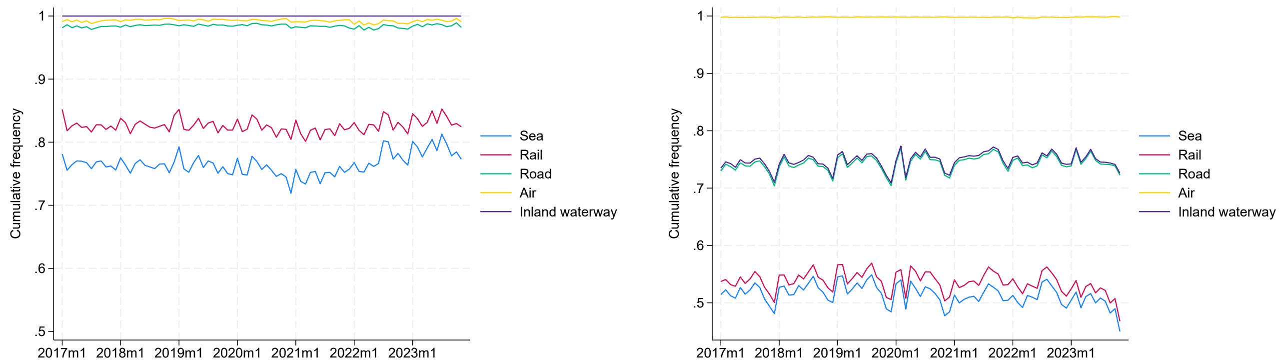


Figure A.4: Distribution of monthly price changes

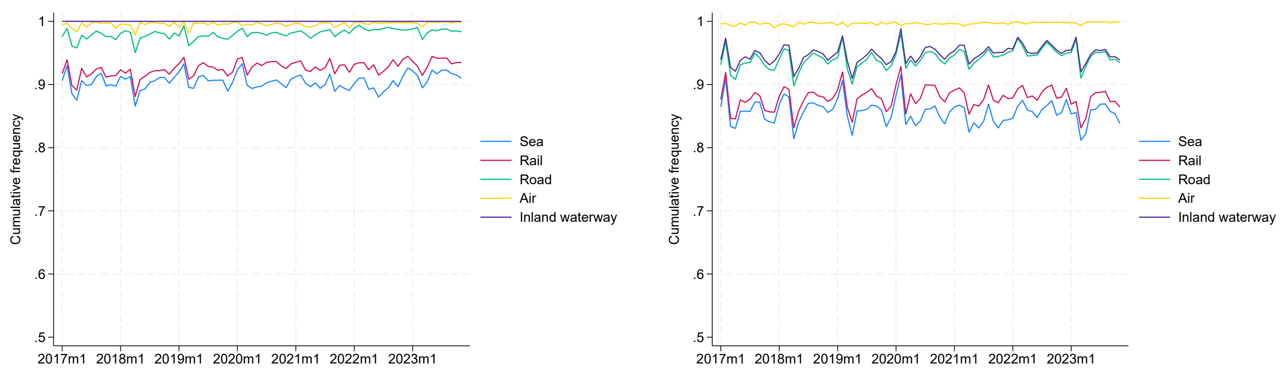
Notes: This figure plots the distribution of monthly price changes for all Extra-European imports over the 2017-2020 and the inflationary period 2021-2022. Medical products (list in the Appendix, tables A.3, A.4, A.5 and A.6) and motor vehicles (Tables A.1 and A.2 in the Appendix), are excluded. The sample includes 41,552,616 observations, a total of 8,547 CN8 products.

Figure A.5: Share of quantities and values transported by the main mode of transport (2017-2023, manufacturing goods)

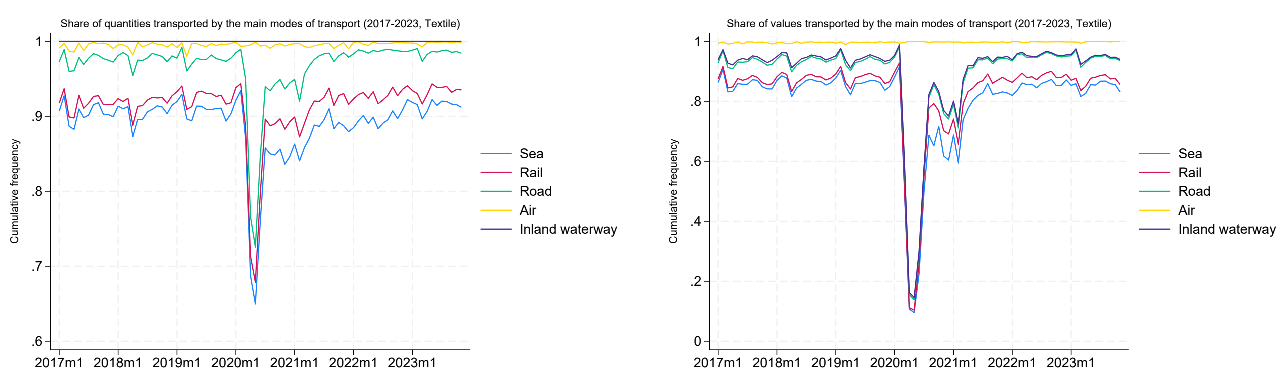


Notes: The dataset includes all Extra-European imports in the manufacturing sectors, a total of 8,547 different goods (CN8) and 41,552,616 observations from January, 2017, to December, 2023. Medical products (list in the Appendix, Tables A.3, A.4, A.5 and A.6) and motor vehicles (Tables A.1 and A.2 in the Appendix) are excluded. The manufacturing sectors are defined at the ISIC 2-digit level.

Figure A.6: Share of quantities and values transported by the main mode of transport (2017-2023, textile goods, ISIC 13)



(a) Quantity (no COVID-19 products) (b) Value (no COVID-19 products)

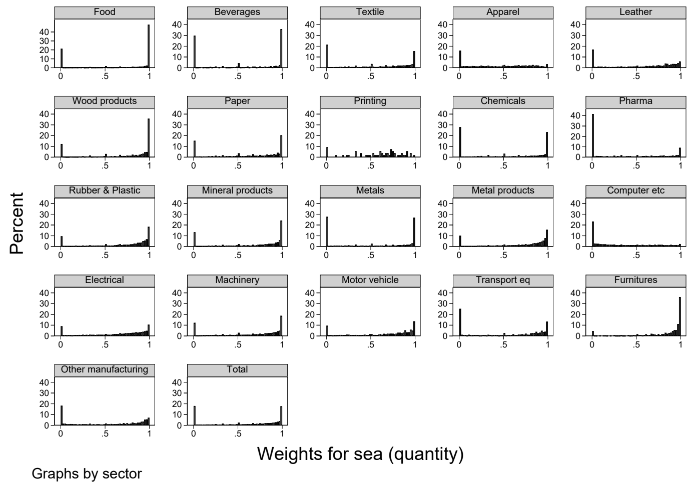


(c) Quantity, including COVID-19 products (d) Value, including COVID-19 products

Notes: The dataset includes all imports from China in the textile sector from January, 2017, to December, 2023. The manufacturing sectors are defined at the ISIC 2 digit level.

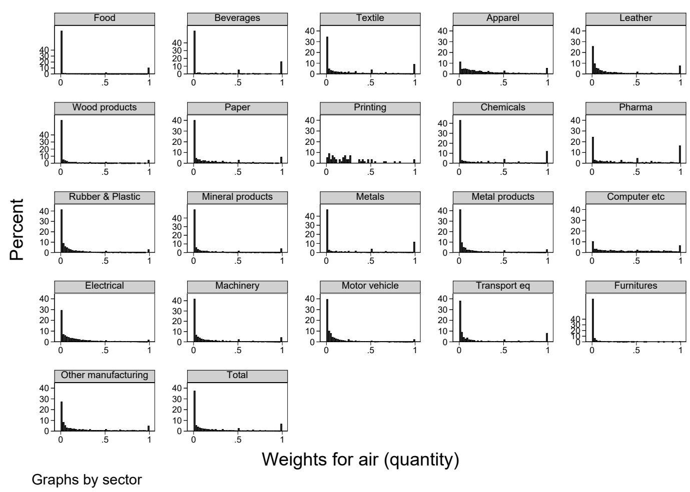
B Appendix: Local projection estimates: Baseline

Figure B.1: Distribution of weights for sea transportation (quantity)



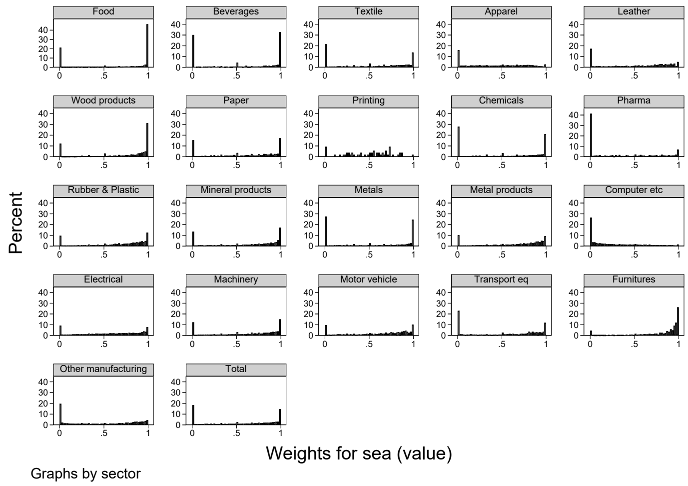
Notes: This figure presents the distributions of weights per European country × product relationships. Each weight is defined as the average of shares (quantity) transported by sea over the period 2017-2019.

Figure B.2: Distribution of weights for air transportation (quantity)



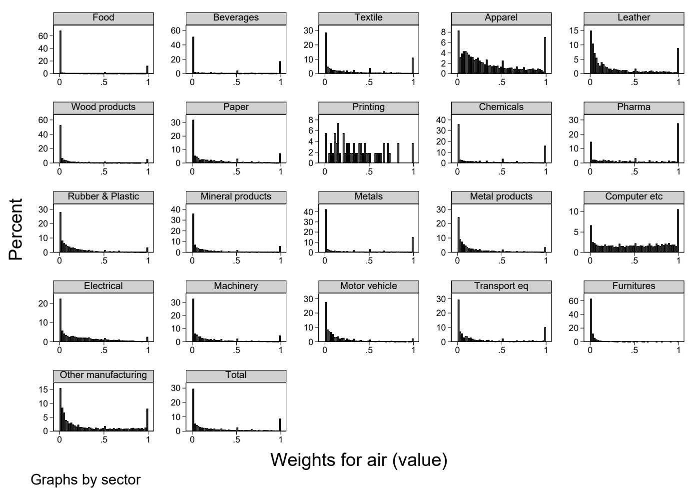
Notes: This figure presents the distributions of weights per European country × product relationships. Each weight is defined as the average of shares (quantity) transported by air over the period 2017-2019.

Figure B.3: Distribution of weights for sea transportation (value)



Notes: This figure presents the distributions of weights per European country × product relationships. Each weight is defined as the average of shares (value) transported by sea over the period 2017-2019.

Figure B.4: Distribution of weights for air transportation (value)



Notes: This figure presents the distributions of weights per European country × product relationships. Each weight is defined as the average of shares (value) transported by air over the period 2017-2019.

Table B.1: Mean shares per sector (2017-2019)

	Value (mean of shares)					Quantity (mean of shares)					
Sector	Sea	Air	Rail	Road	I.W.	Sea	Air	Rail	Road	I.W.	Obs
Food	0.78	0.10	0.01	0.09	0.00	0.79	0.08	0.01	0.09	0.00	67677
Beverages	0.71	0.16	0.01	0.10	0.00	0.72	0.14	0.01	0.10	0.00	3736
Textile	0.62	0.23	0.02	0.11	0.00	0.65	0.20	0.02	0.11	0.00	200775
Apparel	0.49	0.31	0.02	0.15	0.00	0.51	0.27	0.02	0.15	0.00	188119
Leather	0.60	0.22	0.02	0.14	0.00	0.65	0.18	0.02	0.13	0.00	76642
Wood products	0.78	0.10	0.02	0.09	0.00	0.81	0.07	0.02	0.09	0.00	41201
Paper	0.65	0.20	0.02	0.12	0.00	0.69	0.16	0.02	0.11	0.00	55418
Printing	0.53	0.32	0.02	0.12	0.00	0.64	0.22	0.03	0.10	0.00	1550
Chemicals	0.63	0.24	0.01	0.11	0.00	0.65	0.19	0.01	0.10	0.00	176627
Pharma	0.47	0.41	0.01	0.10	0.00	0.50	0.31	0.01	0.10	0.00	19800
Rubber/Plastics	0.70	0.15	0.02	0.11	0.00	0.75	0.11	0.03	0.11	0.00	98724
Mineral products	0.69	0.17	0.03	0.10	0.00	0.74	0.12	0.03	0.10	0.00	106538
Metals	0.62	0.23	0.02	0.12	0.00	0.64	0.20	0.03	0.11	0.00	97286
Metal products	0.68	0.18	0.02	0.11	0.00	0.74	0.12	0.03	0.11	0.00	197166
Computer etc	0.33	0.50	0.02	0.13	0.00	0.41	0.40	0.02	0.13	0.00	234380
Electrical	0.61	0.24	0.02	0.12	0.00	0.68	0.16	0.03	0.12	0.00	224284
Machinery	0.66	0.18	0.03	0.12	0.00	0.70	0.14	0.03	0.11	0.00	317305
Motor vehicle*	0.65	0.15	0.03	0.16	0.00	0.69	0.11	0.03	0.16	0.00	40826
Transport eq	0.63	0.21	0.02	0.11	0.00	0.67	0.17	0.03	0.11	0.00	31824
Furnitures	0.85	0.03	0.03	0.08	0.00	0.87	0.02	0.03	0.08	0.00	27918
Other	0.54	0.30	0.02	0.12	0.00	0.59	0.24	0.02	0.11	0.00	152274

Notes: This table gives the mean of the shares of values and quantity, by sectors and the number of observations, before the pandemic (2020). A monthly observation is defined as a partner $\times$ product relationship. The mean quantity share for sea is lower than in Figure 5. This can be explained because here we calculated mean shares and then averaged by sectors before the pandemic. It does not incorporate the contribution of each good to total values and quantities. "Motor vehicle" includes only parts and accessories for motor vehicles. Motor vehicles and medical products are excluded as in the other graphs and tables.

Table B.2: Mean weights per sector (2017-2019)

	Value (mean of weights)					Quantity (mean of weights)					
Sector	Sea	Air	Rail	Road	I.W.	Sea	Air	Rail	Road	I.W.	Obs
Food	0.68	0.19	0.01	0.10	0.00	0.69	0.16	0.01	0.10	0.00	6553
Beverages	0.57	0.28	0.01	0.11	0.00	0.57	0.27	0.01	0.11	0.00	551
Textile	0.53	0.31	0.02	0.13	0.00	0.54	0.28	0.02	0.12	0.00	12768
Apparel	0.43	0.37	0.02	0.15	0.00	0.46	0.32	0.02	0.14	0.00	7924
Leather	0.52	0.30	0.01	0.14	0.00	0.55	0.27	0.01	0.13	0.00	3267
Wood products	0.72	0.14	0.02	0.11	0.00	0.73	0.12	0.03	0.11	0.00	2723
Paper	0.59	0.25	0.02	0.13	0.00	0.61	0.21	0.02	0.12	0.00	3224
Printing	0.49	0.36	0.02	0.11	0.00	0.58	0.27	0.03	0.10	0.00	54
Chemicals	0.51	0.33	0.01	0.13	0.00	0.52	0.28	0.01	0.12	0.00	13806
Pharma	0.35	0.52	0.01	0.11	0.00	0.36	0.40	0.01	0.10	0.00	1270
Rubber/Plastics	0.66	0.19	0.02	0.12	0.00	0.69	0.15	0.02	0.11	0.00	4152
Mineral products	0.63	0.22	0.03	0.11	0.00	0.67	0.17	0.03	0.11	0.00	5428
Metals	0.53	0.31	0.02	0.13	0.00	0.54	0.27	0.02	0.13	0.00	8198
Metals products	0.63	0.22	0.02	0.11	0.00	0.68	0.17	0.02	0.11	0.00	8124
Computer etc.	0.30	0.52	0.01	0.13	0.00	0.36	0.43	0.02	0.13	0.00	9814
Electrical	0.57	0.27	0.02	0.12	0.00	0.64	0.19	0.02	0.12	0.00	8563
Machinery	0.62	0.22	0.03	0.12	0.00	0.65	0.19	0.03	0.12	0.00	17160
Motor vehicle*	0.62	0.18	0.03	0.16	0.00	0.66	0.14	0.03	0.16	0.00	1755
Transport eq.	0.54	0.28	0.02	0.11	0.00	0.55	0.24	0.02	0.11	0.00	1610
Furnitures	0.82	0.06	0.03	0.09	0.00	0.83	0.04	0.03	0.08	0.00	1073
Other	0.49	0.34	0.02	0.12	0.00	0.53	0.27	0.02	0.12	0.00	5988

Notes: This table gives the mean of the weights with value and quantity definitions, by sectors and the number of country × product relationships, before the pandemic (2020). The mean weight (quantity definition) for sea is lower than in Figure 5. This can be explained because here we calculated mean shares and then averaged by sectors before the pandemic. It does not incorporate the contribution of each good to total values and quantities. "Motor vehicle" includes only parts and accessories for motor vehicles. Motor vehicles and medical products are excluded as in the other graphs and tables.

Table B.3: Cumulative-difference local projection method

	0	1	2	3	4	5
Transport	0.01358	0.00662	-0.00100	0.07722***	0.03696***	0.04790***
	(0.00850)	(0.00970)	(0.01084)	(0.01161)	(0.01140)	(0.01189)
Exchange	-0.27916	-0.04580	1.6285***	-2.2997***	-3.6268***	-4.0409***
rate	(0.20611)	(0.16854)	(0.36603)	(0.45179)	(0.48041)	(0.44418)
Oil	0.34400**	0.49315***	-0.97536***	0.21561***	0.52391***	0.62387***
	(0.16032)	(0.12741)	(0.24145)	(0.08315)	(0.09988)	(0.12127)
Food	-0.19652**	-0.53398***	0.51659***	-0.90240***	-0.54675***	-0.63629
	(0.08506)	(0.09354)	(0.15744)	(0.17412)	(0.19280)	(0.42079)
Obs	1132352	1086844	1065689	1043468	1021422	999601
R^2	0.292	0.339	0.367	0.384	0.389	0.390

	6	7	8	9	10	11	12
Transport	0.07005***	0.04049***	0.09844***	0.11289***	0.12174***	0.07500***	0.13431***
	(0.01177)	(0.01199)	(0.01203)	(0.01263)	(0.01261)	(0.01321)	(0.01407)
Exchange	-1.10449***	-2.70468***	-5.2124***	-2.9903***	-5.2548***	-1.04311***	-0.89788**
rate	(0.32682)	(0.35843)	(0.41244)	(0.52402)	(0.80344)	(0.27329)	(0.36063)
Oil	-0.06927	0.12995***	0.02012	-0.38164***	0.24122***	-0.07777***	-0.19674***
	(0.05763)	(0.04270)	(0.03749)	(0.04015)	(0.03817)	(0.01635)	(0.01608)
Food	1.0588***	0.97568***	1.4499***	1.42699***	1.0256***	1.94654***	0.71152***
	(0.11323)	(0.18490)	(0.14966)	(0.19331)	(0.30253)	(0.32146)	(0.23592)
Obs	978018	956490	935051	913847	892654	871343	849524
R^2	0.394	0.391	0.384	0.369	0.346	0.327	0.341

	13	14	15	16	17	18
Transport	0.15525***	0.13449***	0.13280***	0.09548***	0.09989***	0.03819**
	(0.01420)	(0.01511)	(0.01486)	(0.01486)	(0.01503)	(0.01512)
Exchange	7.54126***	-2.29421***	3.93706***	1.82795***	-1.46627**	-2.6316***
rate	(0.90199)	(0.58450)	(0.70504)	(0.565012)	(0.61193)	(0.57516)
Oil	0.30210***	-.056111**	-0.18413***	-0.03297	-0.12700***	-0.07711**
	(0.04625)	(0.02332)	(0.05578)	(0.03322)	(.031867)	(0.03332)
Food	-2.07535***	1.65524***	-1.35746***	-0.73264***	0.554668***	-0.58399***
	(0.35248)	(0.219079)	(0.313780)	(0.15216)	(0.12726)	(0.13854)
Obs	827941	806652	785426	764187	743023	721823
R^2	0.362	0.387	0.403	0.410	0.413	0.416

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Notes: Standard errors are clustered at country × product level. Standard errors are given in parentheses. Coefficients for oil, food and exchange rate are without lags (occurring at time $t = 0$). We add country × product and time-fixed effects. All control variables are log first differences at the time of the shock, $t = 0$.

Table B.4: First-difference local projection method

	0	1	2	3	4	5
Transport	0.01358	-0.01178	-0.00935	0.06013***	-0.02563**	-0.00432
	(0.00850)	(0.00995)	(0.01063)	(0.01086)	(0.01082)	(0.01109)
Exchange	-0.27916	0.19179	0.85165**	-0.27515	-2.36315***	-2.0693***
rate	(0.20611)	(0.18105)	(0.37275)	(0.34611)	(0.51259)	(0.54891)
Oil	0.34400**	0.33173**	-0.77380***	-0.25593***	0.39025***	0.58630***
	(0.16032)	(0.15068)	(0.19987)	(0.08427)	(0.12439)	(0.14446)
Food	-0.19652**	-0.39505***	0.67494***	0.09863	-0.77125***	-1.70644***
	(0.08506)	(0.08123)	(0.16282)	(0.13199)	(0.27242)	(0.43395)
Obs	1132352	1086844	1043991	1022728	1000681	978855
R^2	0.292	0.012	0.009	0.008	0.008	0.008

	6	7	8	9	10	11	12
Transport	0.02736**	-0.04057***	0.05036***	0.01217	0.00620	-0.02968***	0.03459***
	(0.01113)	(0.01125)	(0.01108)	(0.01105)	(0.01154)	(0.01153)	(0.01224)
Exchange	1.4351***	0.49013	-0.17849	3.8142***	1.44755*	0.90241**	0.70063
rate	(0.33061)	(0.40361)	(0.44639)	(0.58543)	(0.84429)	(0.38164)	(0.48514)
Oil	-0.26022***	0.15180***	0.10561**	-0.02841	0.12478**	-0.12903***	-0.20454***
	(0.07141)	(0.05894)	(0.05375)	(0.03851)	(0.05366)	(0.02455)	(0.02078)
Food	-0.08083	-0.70281***	-0.40823***	-0.77724***	-1.533***	2.15376***	0.45671
	(0.11374)	(0.17679)	(0.13913)	(0.15200)	(0.25201)	(0.47291)	(0.36861)
Obs	957335	935948	914621	893511	872672	851906	830573
R^2	0.008	0.008	0.008	0.009	0.009	0.008	0.007

	13	14	15	16	17	18
Transport	0.02314*	-0.01546	-0.01266	-0.04806***	0.02568*	-0.04158***
	(0.01273)	(0.01338)	(0.01367)	(0.01369)	(0.01430)	(0.01422)
Exchange	4.7969***	-3.51792***	4.10564***	-0.17231	-3.54523***	-2.37274***
rate	(1.27042)	(0.66020)	(0.91778)	(0.76736)	(0.81857)	(0.43426)
Oil	0.24071***	0.09826***	-0.02998	0.03416	-0.13268***	0.01654
	(0.06243)	(0.03057)	(0.03993)	(0.04475)	(0.04401)	(0.02454)
Food	-2.3888***	0.62104***	-1.93878***	-0.59322***	0.83731***	-1.34917***
	(0.52395)	(0.18174)	(0.36629)	(0.18890)	(0.13177)	(0.21359)
Obs	809111	788179	767535	746888	726228	705557
R^2	0.007	0.007	0.007	0.007	0.007	0.006

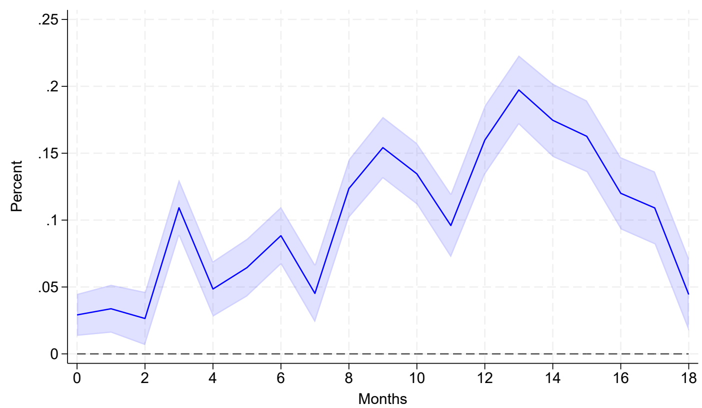
$^{*}\ p < 0.10$, $^{**}\ p < 0.05$, $^{***}\ p < 0.01$

Notes: Standard errors are clustered at country × product level. Standard errors are given in parentheses. Coefficients for oil, food and exchange rate are without lags (occurring at time $t = 0$). We add country × product and time-fixed effects. All control variables are log first differences at the time of the shock, $t = 0$.

C Appendix: Local projection estimates: Robustness checks

C.1 Alternative definition for weights (value)

Figure C.1: Long difference local projection estimates, alternative definition for weights (value)



Notes: This figures presents the cumulative-difference local projection coefficients and their 95% confidence interval. Weights are defined with value shares. If air and sea weights sum to 1, after a 1% cost in transport cost at $t = 0$, import prices are likely to increase by 0.15% 9 months, after the shock compared to the period $t - 1$ before the shock. The full regression table is given in Appendix (Table C.1). Standard errors are clustered at the country × product level. This specification includes time and country × product fixed effects. Weights are defined as value shares.

Table C.1: Cumulative-difference local projection method, alternative definition for weights (value)

	0	1	2	3	4	5
Transport	0.02912***	0.03374***	0.02644***	0.10922***	0.04848***	0.06446***
	(0.00800)	(0.00913)	(0.01015)	(0.01079)	(0.01055)	(0.01101)
Obs	1132352	1086844	1065689	1043468	1021422	999601
R^2	0.292	0.339	0.367	0.384	0.389	0.390

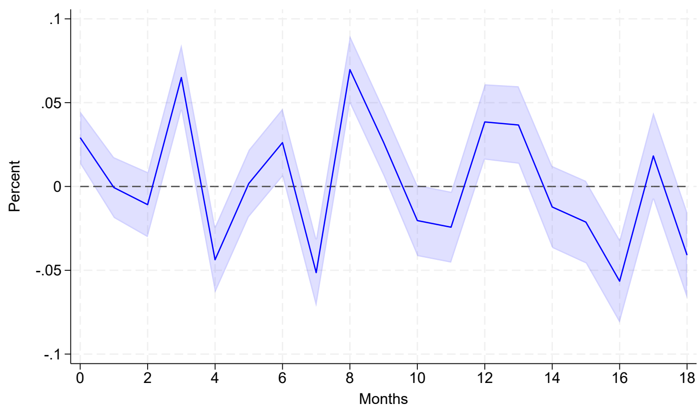
	6	7	8	9	10	11	12
Transport	0.08834***	0.04519***	0.12359***	0.15419***	0.13460***	0.09594***	0.15981***
	(0.01095)	(0.01109)	(0.01117)	(0.01172)	(0.01171)	(0.01217)	(0.01316)
Obs	978018	956490	935051	913847	892654	871343	849524
R^2	0.394	0.391	0.384	0.369	0.347	0.327	0.341

	13	14	15	16	17	18
Transport	0.19730***	0.17460***	0.16264***	0.12004***	0.10910***	0.04438***
	(0.01316)	(0.01399)	(0.01367)	(0.01377)	(0.01389)	(0.01392)
Obs	827941	806652	785426	764187	743023	721823
R^2	0.362	0.387	0.404	0.410	0.413	0.416

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Notes: Standard errors are clustered at country × product level. Standard errors are given in parentheses. We add country × product and time-fixed effects. Weights are defined as value shares.

Figure C.2: First difference local projection estimates, alternative definition for weights (value)



Notes: This figures presents the fist-difference local projection coefficients and their 95% confidence interval. Weights are defined with value shares. If air and sea weights sum to 1, after a 1% cost in transport cost at $t = 0$, import prices are likely to increase by 0.07% between the second and the third month, after the shock compared to the period $t - 1$ before the shock. The full regression table is given in Appendix (Table C.2). Standard errors are clustered at the country × product level. This specification includes time and country × product fixed effects. Weights are defined as value shares.

Table C.2: First-difference local projection method, alternative definition for weights (value)

	0	1	2	3	4	5
Transport	0.02912***	-0.00065	-0.01084	0.06501***	-0.04372***	0.00178
	(0.00800)	(0.00925)	(0.00992)	(0.01012)	(0.01010)	(0.01026)
Obs	1132352	1086844	1043991	1022728	1000681	978855
R^2	0.292	0.013	0.009	0.009	0.008	0.008

	6	7	8	9	10	11	12
Transport	0.02616**	-0.05141***	0.06971***	0.02627***	-0.02034*	-0.02429**	0.03849***
	(0.01035)	(0.01043)	(0.01032)	(0.01022)	(0.01081)	(0.01079)	(0.01147)
Obs	957335	935948	914621	893511	872672	851906	830573
R^2	0.008	0.008	0.008	0.009	0.009	0.008	0.007

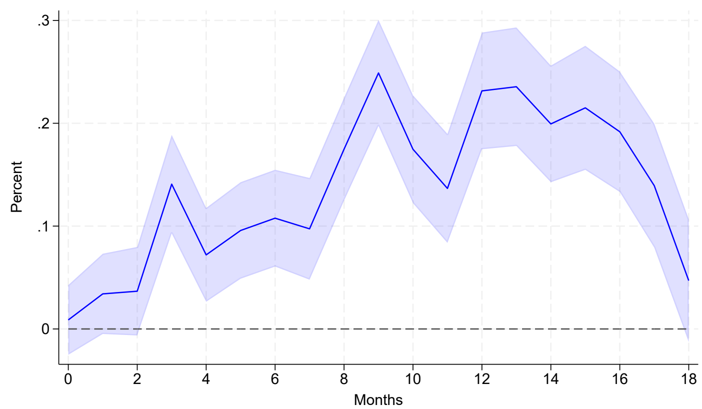
	13	14	15	16	17	18
Transport	0.03669***	-0.01222	-0.02126*	-0.05649***	0.01823	-0.04094***
	(0.01179)	(0.01247)	(0.01257)	(0.01267)	(0.01328)	(0.0132)
Obs	809111	788179	767535	746888	726228	705557
R^2	0.007	0.007	0.007	0.007	0.007	0.007

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Notes: Standard errors are clustered at country × product level. Standard errors are given in parentheses. We add country × product and time-fixed effects. Weights are defined as value shares.

C.2 Restricted sample, $(\alpha^a_{ij} + \alpha^s_{ij} > 0.95)$

Figure C.3: Long difference local projection estimates, restricted sample $(\alpha^a_{ij} + \alpha^s_{ij} > 0.95)$



Notes: This figures presents the cumulative-difference local projection coefficients and their 95% confidence interval. The sample is restricted to country × product relationships for which the sum of share (quantity definition) transported by air and sea is higher than 0.95 and sum approximately to one. After a 1% cost in transport cost at $t = 0$, import prices are likely to increase by 0.17% 10 months, after the shock compared to the period $t - 1$ before the shock. The full regression table is given in Appendix (Table C.3). Standard errors are clustered at the country × product level. This specification includes time and country × product fixed effects.

Table C.3: Cumulative-difference local projection method, restricted sample $(\alpha^a_{ij} + \alpha^s_{ij} > 0.95)$

	0	1	2	3	4	5
Transport	0.00877	0.03412*	0.03670*	0.14082***	0.07202***	0.09578***
	(0.01730)	(0.01991)	(0.02196)	(0.02442)	(0.02327)	(0.02395)
Obs	583092	560439	549531	538148	526837	515619
R^2	0.297	0.337	0.363	0.380	0.384	0.386

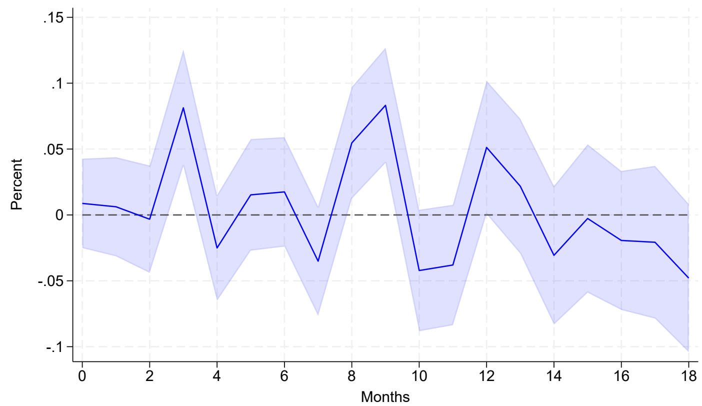
	6	7	8	9	10	11	12
Transport	0.10772***	0.09736***	0.17478***	0.24893***	0.17476***	0.13665***	0.23149***
	(0.02400)	(0.02523)	(0.02552)	(0.02629)	(0.02677)	(0.02704)	(0.02896)
Obs	504518	493459	482493	471652	460779	449801	438607
R^2	0.390	0.386	0.381	0.371	0.354	0.337	0.351

	13	14	15	16	17	18
Transport	0.23555***	0.19936***	0.21502***	0.19177***	0.13935***	0.04703
	(0.02941)	(0.02893)	(0.03078)	(0.02990)	(0.03076)	(0.03050)
Obs	427586	416646	405671	394710	383806	372923
R^2	0.368	0.390	0.406	0.411	0.415	0.417

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Notes: Standard errors are clustered at country × product level. Standard errors are given in parentheses. We add country × product and time-fixed effects. The sample is restricted to country × product relationships for which the sum of share (quantity definition) transported by air and sea is higher than 0.95.

Figure C.4: First-difference local projection estimates, restricted sample ($\alpha_{ij}^{a} + \alpha_{ij}^{s} > 0.95$)



Notes: This figures presents the first-difference local projection coefficients and their 95% confidence interval. The sample is restricted to country × product relationships for which the sum of share (quantity definition) transported by air and sea is higher than 0.95, and sum approximately to one. After a 1% cost in transport cost at $t = 0$, import prices are likely to increase by 0.081% between the second and the third month, after the shock compared to the period $t - 1$ before the shock. The full regression table is given in Appendix (Table C.4). Standard errors are clustered at the country × product level. This specification includes time and country × product fixed effects.

Table C.4: First-difference local projection method, restricted sample ($\alpha_{ij}^{a} + \alpha_{ij}^{s} > 0.95$)

	0	1	2	3	4	5
Transport	0.00877	0.00621	-0.00325	0.08132***	-0.02507	0.01525
	(0.01730)	(0.01920)	(0.02079)	(0.02258)	(0.02048)	(0.02160)
Obs	583092	560439	539052	528097	516784	505544
R^2	0.297	0.011	0.008	0.008	0.007	0.007

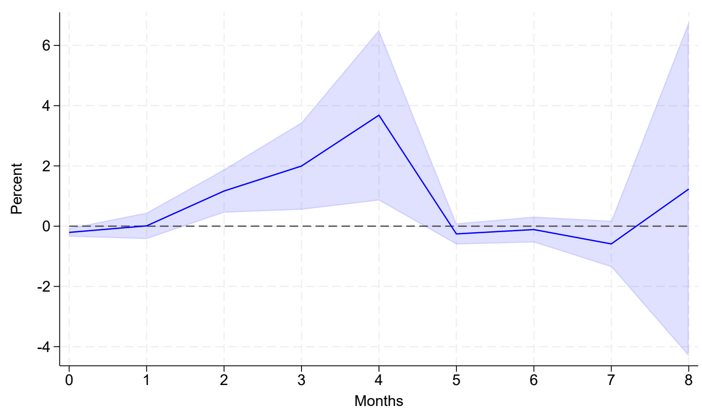
	6	7	8	9	10	11	12
Transport	0.01750	-0.03509*	0.05468**	0.08322***	-0.04218*	-0.03799	0.05125**
	(0.02118)	(0.02116)	(0.02163)	(0.02230)	(0.02351)	0.02332)	(0.02582)
Obs	494464	483456	472516	461714	451026	440308	429318
R^2	0.007	0.007	0.008	0.008	0.008	0.008	0.007

	13	14	15	16	17	18
Transport	0.02184	-0.03064	-0.00269	-0.01936	-0.02073	-0.04793*
	(0.02614)	(0.02682)	(0.02872)	(0.02691)	(0.02957)	(0.02868)
Obs	418339	407624	396955	386255	375575	364922
R^2	0.007	0.007	0.007	0.006	0.006	0.006

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$
Notes: Standard errors are clustered at country × product level. Standard errors are given in parentheses. We add country × product and time-fixed effects. The sample is restricted to country × product relationships for which the sum of share (quantity definition) transported by air and sea is higher than 0.95.

C.3 Local projection estimates before 2020

Figure C.5: Long difference local projection estimates, restricted sample (before 2020)



Notes: This figures presents the cumulative-difference local projection coefficients and their 95% confidence interval. The sample is restricted to observations before 2020. The full regression table is given in Appendix (Table 11.13). Standard errors are clustered at the country × product level. This specification includes time and country × product fixed effects.

Table C.5: Cumulative-difference local projection method, restricted sample before 2020

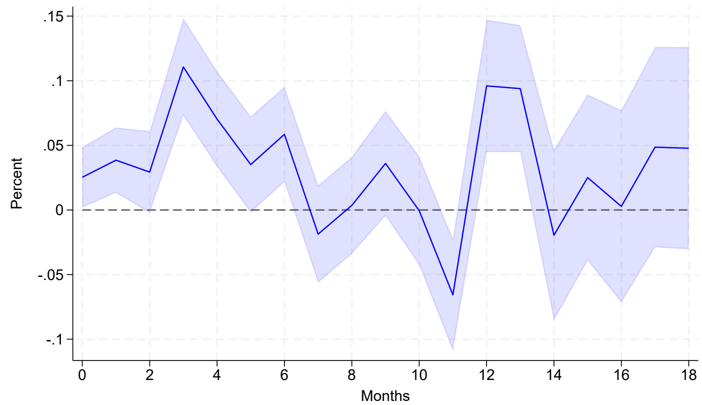
	0	1	2	3	4
Transport	-0.20655*	0.01096**	1.16735***	1.99592***	3.68450***
	(0.07340)	(0.22322)	(0.36740)	(0.73983)	(1.44576)
Obs	194301	171192	152016	132639	113372
R^2	0.401	0.470	0.503	0.514	0.487

	5	6	7	8
Transport	-0.25626	-0.11215	-0.58860	1.23244
	(0.17949)	(0.21856)	(0.39288)	(2.83198)
Obs	94083	74986	56204	37446
R^2	0.456	0.478	0.472	0.481

Notes: Standard errors are clustered at country × product level. Standard errors are given in parentheses. We add country × product and time-fixed effects. The sample is restricted to observations before 2020.

C.4 Local projection estimates after 2020

Figure C.6: Long difference local projection estimates, restricted sample (after 2020)



Notes: This figures presents the cumulative-difference local projection coefficients and their 95% confidence interval. The sample is restricted to observations after 2020. If air and sea weights sum to 1, after a 1% cost in transport cost at $t = 0$, import prices are likely to increase by 0.09% 13 months, after the shock compared to the period $t - 1$ before the shock. The full regression table is given in the Appendix (Table 11.14). Standard errors are clustered at the country × product level. This specification includes time and country × product fixed effects.

Table C.6: Cumulative-difference local projection method, restricted sample after 2020

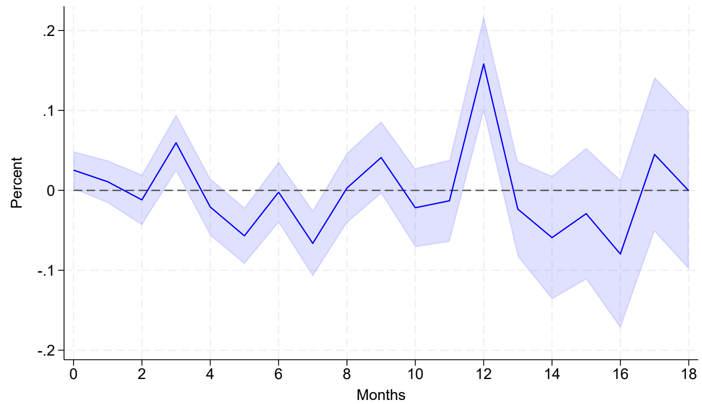
	0	1	2	3	4	5
Transport	0.02531**	0.03855***	0.02933*	0.11068***	0.07035***	0.03515*
	(0.01194)	(0.01291)	(0.01616)	(0.01919)	(0.01885)	(0.01896)
Obs	693359	657756	636399	614482	592658	571047
R^2	0.306	0.348	0.374	0.393	0.402	0.408

	6	7	8	9	10	11	12
Transport	0.05854***	-0.01866	0.00353	0.03601*	-0.00054	-0.06573***	0.09604***
	(0.01881)	(0.01918)	(0.01918)	(0.02071)	(0.02146)	(0.02214)	(0.02614)
Obs	549664	528345	507104	485960	464731	443334	422644
R^2	0.415	0.415	0.407	0.395	0.382	0.378	0.401

	13	14	15	16	17	18
Transport	0.09391***	-0.01950	0.02507	0.00280	0.04860	0.04779
	(0.02503)	(0.03368)	(0.03281)	(0.03793)	(0.03954)	(0.03991)
Obs	401925	381316	360881	340442	320101	299838
R^2	0.422	0.441	0.451	0.451	0.450	0.450

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$
Notes: Standard errors are clustered at country × product level. Standard errors are given in parentheses. We add country × product and time-fixed effects. The sample is restricted to observations after 2020.

Figure C.7: First difference local projection estimates, restricted sample (after 2020)



Notes: This figures presents the first-difference local projection coefficients and their 95% confidence interval. The sample is restricted to observations after 2020. If air and sea weights sum to 1, after a 1% cost in maritime and air transport cost at $t = 0$, import prices are likely to increase by 0.06% between the second and the third month, after the shock. The full regression table is given in Appendix (Table C.7). Standard errors are clustered at the country × product level. This specification includes time and country × product fixed effects.

Table C.7: First-difference local projection method, restricted sample after 2020

	0	1	2	3	4	5
Transport	0.02531**	0.01080	-0.01190	0.05952***	-0.02081	-0.05689***
	(0.01194)	(0.01359)	(0.01613)	(0.01806)	(0.01825)	(0.01803)
Obs	693359	657756	623968	602746	581116	559639
R^2	0.306	0.011	0.008	0.007	0.007	0.007

	6	7	8	9	10	11	12
Transport	-0.00225	-0.06630***	0.00295	0.04106*	-0.02173	-0.01305	0.15817***
	(0.01946)	(0.02108)	(0.02235)	(0.02307)	(0.02518)	(0.02617)	(0.03073)
Obs	538443	517393	496405	475507	454656	433725	413380
R^2	0.007	0.007	0.006	0.007	0.007	0.006	0.006

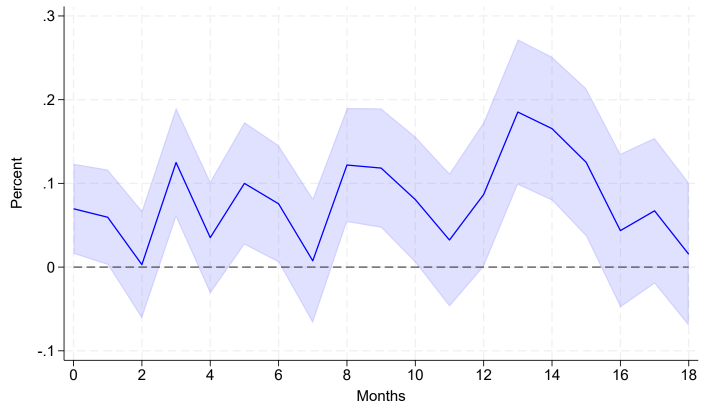
	13	14	15	16	17	18
Transport	-0.02346	-0.05912	-0.02913	-0.07963*	0.04497	-0.00044
	(0.03044)	(0.03940)	(0.04195)	(0.04735)	(0.04936)	(0.05011)
Obs	392962	372639	352569	332608	312685	292873
R^2	0.006	0.007	0.006	0.006	0.006	0.006

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Notes: Standard errors are clustered at country × product level. Standard errors are given in parentheses. We add country × product and time-fixed effects. The sample is restricted to observations after 2020.

C.5 Industry × time fixed effects

Figure C.8: Long difference local projection estimates, industry × time fixed effects



Notes: This figures presents the cumulative-difference local projection coefficients and their 95% confidence interval. If air and sea weights sum to 1, after a 1% cost in transport cost at $t = 0$, import prices are likely to increase by 0.09% 12 months, after the shock compared to the period $t - 1$ before the shock. The full regression table is given in Appendix (Table C.8). Standard errors are clustered at the country × product level. This specification includes industry (ISIC 2 digits) × time and country × product fixed effects.

Table C.8: Cumulative-difference local projection method, industry × time fixed effects

	0	1	2	3	4	5
Transport	0.06970**	0.05957**	0.00297	0.12495***	0.03525	0.10002***
	(0.02742)	(0.02904)	(0.03291)	(0.03344)	(0.03420)	(0.03733)
Obs	114371	109791	107645	105381	103134	100924
R^2	0.311	0.358	0.375	0.391	0.394	0.394

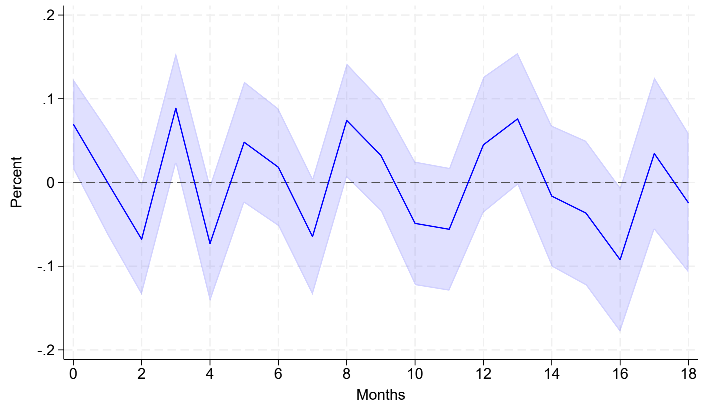
	6	7	8	9	10	11	12
Transport	0.07562**	0.00750	0.12193***	0.11832***	0.08066**	0.03234	0.08671**
	(0.03571)	(0.03804)	(0.03474)	(0.03638)	(0.03842)	(0.04058)	(0.04411)
Obs	98730	96562	94404	92267	90121	87972	85800
R^2	0.404	0.398	0.392	0.384	0.369	0.347	0.368

	13	14	15	16	17	18
Transport	0.18523***	0.16540***	0.12510***	0.04356	0.06726	0.01538
	(0.04430)	(0.04379)	(0.04512)	(0.04681)	(0.04440)	(0.04369)
Obs	83649	81526	79394	77281	75148	72954
R^2	0.385	0.403	0.415	0.420	0.419	0.420

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Notes: Standard errors are clustered at country × product level. Standard errors are given in parentheses. This specification includes industry (ISIC 2 digits) × time and country × product fixed effects.

Figure C.9: First difference local projection estimates, industry × time fixed effects



Notes: This figures presents the first-difference local projection coefficients and their 95% confidence interval. If the air and sea weights sum to 1, after a 1% cost in transport cost at $t = 0$, import prices are likely to increase by 0.09% between the second and the third month, after the shock. The full regression table is given in Appendix (Table C.9). Standard errors are clustered at the country × product level. This specification includes industry (ISIC 2 digits) × time and country × product fixed effects.

Table C.9: First-difference local projection method, industry × time fixed effects

	0	1	2	3	4	5
Transport	0.06970	0.00034	-0.06786**	0.08866***	-0.07289**	0.04812
	(0.02742)	(0.03210)	(0.03393)	(0.03389)	(0.03545)	(0.03695)
Obs	114371	109791	105464	103296	101041	98821
R^2	0.311	0.026	0.023	0.024	0.023	0.022

	6	7	8	9	10	11	12
Transport	0.01821	-0.06470*	0.07410**	0.03237	-0.04886	-0.05591	0.04500
	(0.03583)	(0.03561)	(0.03475)	(0.03398)	(0.03765)	(0.03744)	(0.04140)
Obs	96628	94463	92316	90198	88077	85993	83880
R^2	0.022	0.021	0.021	0.022	0.022	0.021	0.020

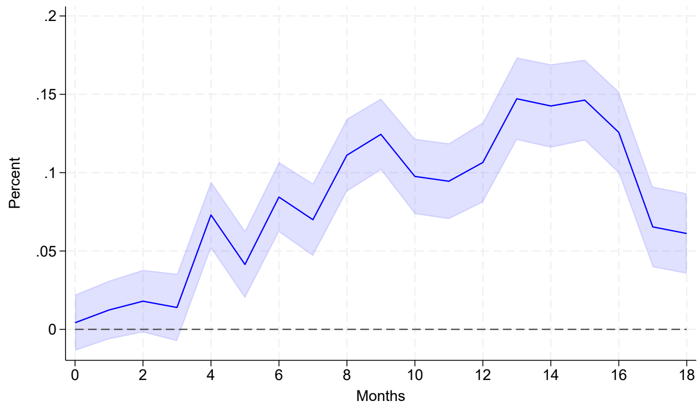
	13	14	15	16	17	18
Transport	0.07599*	-0.01626	-0.03654	-0.09224**	0.03457	-0.02440
	(0.04019)	(0.04296)	(0.04406)	(0.04407)	(0.04647)	(0.04255)
Obs	81758	79706	77646	75588	73530	71413
R^2	0.020	0.020	0.020	0.021	0.021	0.021

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Notes: Standard errors are clustered at country × product level. Standard errors are given in parentheses. We add country × product and industry (ISIC, 2 digits) × time-fixed effects.

C.6 Time-consistent product code

Figure C.10: Long difference local projection estimates, Time-consistent product code



Notes: This figures presents the cumulative-difference local projection coefficients and their 95% confidence interval. If air and sea weights sum to 1, after a 1% cost in transport cost at $t = 0$, import prices are likely to increase by 0.11% 12 months, after the shock compared to the period $t - 1$ before the shock. The full regression table is given in Appendix (Table C.8). Standard errors are clustered at the country × product level. This specification includes time and country × product fixed effects.

Table C.10: Cumulative-difference local projection method, Time-consistent product code

	0	1	2	3	4	5
Transport	0.00423	0.01236	0.01799*	0.01397	0.07301***	0.04142***
	(0.00914)	(0.00953)	(0.01018)	(0.01096)	(0.01091)	(0.01101)
Obs	1969947	1920066	1871412	1833661	1796213	1759184
R^2	0.418	0.420	0.424	0.426	0.424	0.425

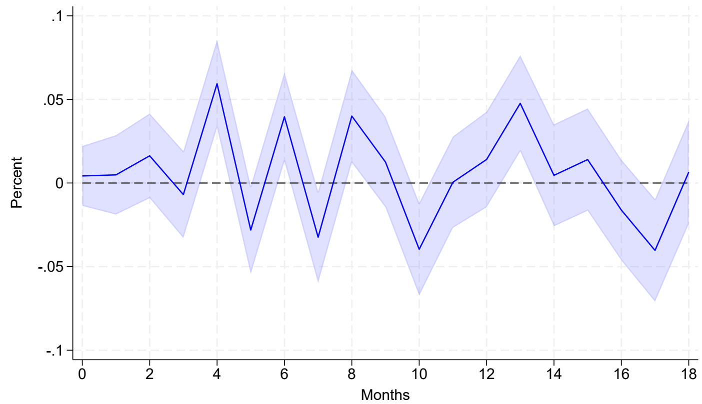
	6	7	8	9	10	11	12
Transport	0.08443***	0.06998***	0.11115***	0.12446***	0.09761***	0.09453***	0.10652***
	(0.01227)	(0.01183)	(0.01234)	(0.01165)	(0.02677)	(0.02704)	(0.01301)
Obs 1722257		1685594	1648998	1612551	1576191	1539665	1503255
R^2	0.427	0.427	0.428	0.425	0.420	0.415	0.421

	13	14	15	16	17	18
Transport	0.14717***	0.14256***	0.14629***	0.12573***	0.06540***	0.06118***
	(0.01345)	(0.01357)	(0.01316)	(0.01330)	(0.01315)	(0.01310)
Obs	1467089	1431227	1395429	1359280	1323144	1287003
R^2	0.428	0.434	0.438	0.441	0.443	0.444

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Notes: Standard errors are clustered at country × product level. Standard errors are given in parentheses. This specification includes time and country × product fixed effects.

Figure C.11: First difference local projection estimates, Time-consistent product code



Notes: This figures presents the first-difference local projection coefficients and their 95% confidence interval. If the air and sea weights sum to 1, after a 1% cost in transport cost at $t = 0$, import prices are likely to increase by 0.06% between the third and the fourth month, after the shock. The full regression table is given in the Appendix (Table C.11). Standard errors are clustered at the country $\times$ product level. This specification includes time and country $\times$ product fixed effects.

Table C.11: First-difference local projection method, Time-consistent product code

	0	1	2	3	4	5
Transport	0.00423	0.00486	0.01626	-0.00691	0.05940***	-0.02812**
	(0.00914)	(0.01211)	(0.01292)	(0.01328)	(0.01344)	(0.01342)
Obs	1969947	1918392	1869799	1822231	1784629	1747422
R^2	0.418	0.003	0.003	0.003	0.003	0.003

	6	7	8	9	10	11	12
Transport	0.03959**	-0.03244**	0.04004***	0.01253	-0.03964***	0.00045	0.01408
	(0.01357)	(0.01395)	(0.01419)	(0.01386)	(0.01414)	(0.01393)	(0.01459)
Obs	1710513	1673832	1637387	1601044	1564827	1528514	1492342
R^2	0.003	0.003	0.003	0.003	0.003	0.003	0.003

	13	14	15	16	17	18
Transport	0.04766***	0.00459	0.01402	-0.01617	-0.04030***	0.00648
	(0.01467)	(0.01556)	(0.01402)	(0.01540)	(0.01566)	(0.01584)
Obs	1456291	1420790	1385254	1349745	1313954	1278106
R^2	0.002	0.002	0.002	0.002	0.002	0.002

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Notes: Standard errors are clustered at country $\times$ product level. Standard errors are given in parentheses. We add country $\times$ product and time-fixed effects.

D Appendix: Model: Comparative statics

Table D.1: Market power at the firm level (1)

	Cournot		Bertrand	
	Benchmark	Autarky	Benchmark	Autarky
All firms				
Market shares				
Mean	0.0250	0.0500	0.025	0.0500
p10	0.0001	0.0005	$3.12e^{-5}$	0.0001
p25	0.0006	0.0025	0.0002	0.0006
p50	0.0044	0.0164	0.0016	0.0047
p75	0.0260	0.0684	0.0129	0.0343
p90	0.0812	0.1542	0.0720	0.1606
p99	0.2185	0.3177	0.3500	0.5657
$\frac{p90}{p10}$	788.65	333.17	2305.34	1580.41
Standard errors	0.0463	0.0726	0.0645	0.1121
Skewness	2.97	2.12	4.02	3.38
Markups				
Mean	1.142	1.177	1.115	1.120
p10	1.111	1.112	1.111	1.111
p25	1.112	1.114	1.111	1.111
p50	1.116	1.129	1.111	1.112
p75	1.140	1.192	1.113	1.115
p90	1.208	1.311	1.120	1.132
p99	1.417	1.620	1.171	1.255
$\frac{p90}{p10}$	1.087	1.179	1.007	1.019
Standard errors	0.064	0.110	0.011	0.031
Skewness	3.78	3.04	5.42	8.23

Notes: This table gives the unconditional distribution of market shares and markups, including foreign and domestic firms. The model was simulated for 1000 sectors, a total of 40,000 firms. The parameters and the productivity draws used for the Cournot and the Bertrand specifications were identical. Skewness is Type 1 definition according to Joanes and Gill [1998].

Table D.2: Market power at the firm level (2)

	Cournot		Bertrand	
	Benchmark	Autarky	Benchmark	Autarky
Domestic firms				
Market shares				
Mean	0.0274	0.0500	0.0285	0.0500
p10	0.0001	0.0005	$3.784e^{-5}$	0.0001
p25	0.0007	0.0025	0.0002	0.0006
p50	0.0052	0.0164	0.0019	0.0047
p75	0.0296	0.0684	0.0154	0.0343
p90	0.0897	0.1542	0.0842	0.1606
p99	0.2287	0.3177	0.3770	0.5657
$\frac{p90}{p10}$	725.20	333.17	2224.53	1580.41
Standard errors	0.0491	0.0726	0.0712	0.1121
Skewness	2.82	2.12	3.81	3.39
Markups				
Mean	1.145	1.177	1.115	1.120
p10	1.111	1.112	1.111	1.111
p25	1.112	1.114	1.111	1.111
p50	1.117	1.129	1.111	1.112
p75	1.145	1.192	1.113	1.115
p90	1.219	1.311	1.121	1.132
p99	1.436	1.620	1.178	1.256
$\frac{p90}{p10}$	1.097	1.179	1.009	1.019
Standard errors	0.068	0.110	0.012	0.031
Skewness	3.61	3.04	5.15	8.23
Foreign firms				
Market shares				
Mean	0.0226	0	0.0215	0
p10	$8.694e^{-5}$	0	$2.658e^{-5}$	0
p25	0.0005	0	0.0002	0
p50	0.0037	0	0.0014	0
p75	0.0223	0	0.0109	0
p90	0.0736	0	0.0607	0
p99	0.2065	0	0.3052	0
$\frac{p90}{p10}$	847.03	-	2279.54	-
Standard errors	0.0433	0	0.0567	0
Skewness	3.12	-	4.16	-
Markups				
Mean	1.139	1.111	1.114	1.111
p10	1.111	1.111	1.111	1.111
p25	1.112	1.111	1.111	1.111
p50	1.115	1.111	1.111	1.111
p75	1.136	1.111	1.112	1.111
p90	1.198	1.111	1.118	1.111
p99	1.396	1.111	1.160	1.111
$\frac{p90}{p10}$	1.078	1.0	1.006	1.0
Standard errors	0.059	0	0.009	0
Skewness	3.95	-	5.38	-

Notes: This table gives the unconditional distribution of market shares and markups, for foreign and domestic firms separately. The model was simulated for 1000 sectors, a total of 40,000 firms. The parameters and the productivity draws used for the Cournot and the Bertrand specifications under the benchmark model or autarky were identical. Skewness is a type 1 definition according to Joanes and Gill [1998].

Table D.3: Market power at the sectoral level

	Cournot		Bertrand	
	Benchmark	Autarky	Benchmark	Autarky
Conditional distribution (sector level)				
Standard errors, sectoral productivity				
Mean	2.09	1.97	2.09	1.97
p10	1.77	1.67	1.77	1.67
p25	1.87	1.77	1.87	1.77
p50	2.04	1.92	2.04	1.92
p75	2.23	2.10	2.23	2.10
p90	2.53	2.38	2.53	2.38
p99	3.03	2.86	3.03	2.86
$\frac{p90}{p10}$	1.43	1.43	1.43	1.43
Standard error	0.31	0.30	0.31	0.30
Skewness	1.18	1.17	1.18	1.17
HHI				
Mean	1107.58	1553.88	1911.55	3015.36
p10	678.10	1117.61	920.49	1685.39
p25	811.89	1257.03	1176.84	2099.73
p50	1013.14	1477.34	1669.33	2803.13
p75	1281.75	1763.56	2375.90	3664.52
p90	1634.61	2086.59	3390.13	4622.89
p99	2674.05	2795.82	4804.59	6672.11
$\frac{p90}{p10}$	2.41	1.87	3.68	2.74
Standard error	432.95	403.35	972.87	1204.82
Skewness	1.68	1.03	1.17	0.98
Sectoral markups				
Mean	1.285	1.396	1.143	1.191
p10	1.201	1.270	1.123	1.136
p25	1.221	1.306	1.127	1.145
p50	1.259	1.362	1.136	1.166
p75	1.317	1.444	1.151	1.202
p90	1.398	1.557	1.178	1.273
p99	1.666	1.923	1.218	1.552
$\frac{p90}{p10}$	1.164	1.226	1.049	1.121
Standard error	0.0968	0.136	0.0229	0.0810
Skewness	2.13	2.01	1.57	3.13

Notes: This table gives the conditional distribution of market shares and markups, all firms separately. The model was simulated for 1000 sectors, a total of 40,000 firms. The parameters and the productivity draws used for the Cournot and the Bertrand specifications under the benchmark model or autarky were identical. Skewness is a type 1 definition according to Joanes and Gill [1998].

Table D.4: Market power at the aggregate level

	Cournot		Bertrand	
	Benchmark	Autarky	Benchmark	Autarky
Aggregate implications				
Market power				
HHI	1107.56	1553.87	1911.52	3015.33
Aggregate markup	1.282	1.390	1.143	1.189
Sales-weighted markup	1.259	1.334	1.142	1.183
Sales-weighted domestic markup	1.266	1.334	1.146	1.065
Sales-weighted foreign markup	1.251	1.111	1.183	1.111
Ratio domestic/foreign markup	1.012	1.201	1.007	1.066
Import share (%)	45.22	0	43.10	0

Notes: This table gives the aggregate variables for the Cournot and Bertrand models under autarky and in the benchmark model. The model was simulated for 1000 sectors, a total of 40,000 firms. The parameters and the productivity draws used for the Cournot and the Bertrand specifications under the benchmark model or autarky were identical.

E Mathematical Appendix

E.1 The inverse demand functions and the theoretical price indexes

At the aggregate level

Solving for the inverse demand function at the aggregate level:

We can find the inverse demand function by solving the household's minimization problem.

The expenditure minimization problem is such that the household wants to find the right mix among different sectors such that he minimizes his expenditure while still achieving the same level of utility (so the same consumption level as utility is strictly increasing in consumption). The expenditure is given by:

$$\int_0^1 P_j^i c_j^i dj$$

The minimization problem can be rewritten as:

$$\min_{c_j^i} \int_0^1 P_j^i c_j^i dj$$
$$\text{s.t.} \quad \left[\int_0^1 {c_j^i}^{1-\frac{1}{\eta}} dj\right]^{\frac{\eta}{\eta-1}} \geq \bar{c}$$

The constraint must be binding at the optimum, as the utility function is strictly increasing in consumption.

The Lagrangian of this problem is:

$$\mathcal{L} = \int_0^1 P_j^i c_j^i dj - \lambda \left(\left[\int_0^1 c_j^{i\,1-\frac{1}{\eta}} dj \right]^{\frac{\eta}{\eta-1}} - \bar{c} \right)$$

The first order condition gives

$$\frac{\partial \mathcal{L}}{\partial c_j^i} = 0 \Leftrightarrow P_j^i = \lambda \left(\frac{\eta - 1}{\eta} \right) c_j^{i\,-\frac{1}{\eta}} \left(\frac{\eta}{\eta - 1} \right) \left[\int_0^1 c_j^{i\,1-\frac{1}{\eta}} dj \right]^{\frac{1}{\eta-1}}$$
$$\Leftrightarrow P_j^i = \lambda c_j^{i\,-\frac{1}{\eta}} c^{i\,\frac{1}{\eta}} \quad \text{because} \quad c^i = \left[\int_0^1 c_j^{i\,1-\frac{1}{\eta}} dj \right]^{\frac{\eta}{\eta-1}}$$
$$\Leftrightarrow \frac{P_j^i}{\lambda} = \left(\frac{c_j^i}{c^i} \right)^{-\frac{1}{\eta}}$$

$\lambda = P^i$ as the Lagrangian multiplier is equal to the price index.

Finally, we get an expression the inverse demand functions for the output of individual tradeable sectors :

$$\frac{P_j^i}{P^i} = \left(\frac{c_j^i}{c^i} \right)^{-\frac{1}{\eta}}$$

Solving for the price index :

The expenditure is given by:

$$P^i c^i = \int_0^1 P_j^i c_j^i dj = \int_0^1 P_j^i c^i \left(\frac{P_j^i}{P^i} \right)^{-\eta} dj$$
$$P^i c^i = c^i P^{i\eta} \int_0^1 P_j^{i\,1-\eta} dj$$
$$P^i = \left[\int_0^1 P_j^{i\,1-\eta} dj \right]^{\frac{1}{1-\eta}}$$

At the sectoral level

Inverse demand function within sectors

We set up the minimization problem:

The expenditure is given by:

$$\sum_{k=1}^{2K} c_{jk}^i P_{jk}^i$$

The minimization problem can be rewritten as:

$$\min_{c^i_{jk}} \sum_{k=1}^{2K} c^i_{jk} P^i_{jk}$$

$$\text{s.t.} \quad \left[\sum_{k=1}^{2K} {c^i_{jk}}^{\frac{\rho-1}{\rho}}\right]^{\frac{\rho}{\rho-1}} \geq \tilde{c}_j$$

The constraint should be binding at the optimum.

Then the Lagrangian of this problem would be:

$$\mathcal{L} = \sum_{k=1}^{2K} c^i_{jk} P^i_{jk} - \lambda \left(\left[\sum_{k=1}^{2K} {c^i_{jk}}^{\frac{\rho-1}{\rho}}\right]^{\frac{\rho}{\rho-1}} - \tilde{c}_j \right)$$

The first order condition gives

$$\frac{\partial \mathcal{L}}{\partial c^i_{jk}} = 0 \Leftrightarrow c^i_{jk} = \lambda \left(\frac{\rho-1}{\rho}\right) {c^i_{jk}}^{-\frac{1}{\rho}} \left(\frac{\rho}{\rho-1}\right) \left[\sum_{k=1}^{2K} {c^i_{jk}}^{\frac{\rho-1}{\rho}}\right]^{\frac{1}{\rho-1}}$$

$$\Leftrightarrow P^i_{jk} = \lambda {c^i_{jk}}^{-\frac{1}{\rho}} {c^i_j}^{\frac{1}{\rho}} \quad \text{because} \quad c^i_j = \left[\sum_{k=1}^{2K} {c^i_{jk}}^{\frac{\rho-1}{\rho}}\right]^{\frac{\rho}{\rho-1}}$$

$$\Leftrightarrow \frac{c^i_{jk}}{\lambda} = \left(\frac{c^i_{jk}}{c^i_j}\right)^{-\frac{1}{\rho}}$$

$\lambda = P_{ij}$ as the Lagrangian multiplier is equal to the sectoral price index.

Finally, we get an expression for the inverse demand functions for goods within a sector:

$$\frac{P^i_{jk}}{P^i_j} = \left(\frac{c^i_{jk}}{c^i_j}\right)^{\frac{-1}{\rho}}$$

Theoretical price index within sectors

The expenditure is given by :

$$P^i_j c^i_j = \sum_{k=1}^{2K} P^i_{jk} c^i_{jk}$$

$$P^i_j c^i_j = \sum_{k=1}^{2K} P^i_{jk} \left(\frac{P^i_{jk}}{P^i_j}\right)^{-\rho} c^i_j$$

We deduce the price index at the sectoral level:

$$P^i_j = \left(\sum_{k=1}^{2K} {P^i_{jk}}^{1-\rho}\right)^{\frac{1}{1-\rho}}$$

E.2 Equilibrium prices: Cournot and Bertrand competition

We solve for the equilibrium prices of a domestic firm located in i serving the domestic market. First, we derive the inverse demand function by multiplying the two we derived above

$$\frac{P_j^i}{P^i} = \left(\frac{c_j^i}{c^i}\right)^{-\frac{1}{\eta}}$$

$$\frac{P_{jk}^i}{P_j^i} = \left(\frac{c_{jk}^i}{c_j^i}\right)^{\frac{-1}{\rho}}$$

$$\left(\frac{P_{jk}^i}{P^i}\right) = \left(\frac{c_{jk}^i}{c_j^i}\right)^{\frac{-1}{\rho}} \left(\frac{c_j^i}{c^i}\right)^{\frac{-1}{\eta}}$$

Good markets clear so: $c_{jk}^i = q_{jk}^i$, $c_j^i = y_j^i$, $c^i = Y^i$

Cournot competition

Firms recognize that the sectoral production y_j^i and price level P_j^i change when they solve for the maximization problem. They take into account the strategic interaction with the other firms in sector j. The quantities from the other firms q_{jl}^i operating in the sector and country of interest, with $l \neq k$, the final consumption price P^i, the wage level W and aggregate quantity Y^i are taken as given. We take the derivative according to y_j^i and q_{jk}^i.
The firm wants to maximize its profit (revenue minus total cost) subject to the inverse demand function by choosing the optimal level of production: q_{jk}^i for the market in country i. We solve for the domestic firm serving the domestic market.

$$\max_{q_{jk}^i} P_{jk}^i q_{jk}^i - q_{jk}^i MC_{jk}^i$$

With $MC_{jk}^i = \frac{W}{z_{jk}}$, the marginal cost of the firm

subject to:

$$\left(\frac{P_{jk}^i}{P^i}\right) = \left(\frac{q_{jk}^i}{y_j^i}\right)^{\frac{-1}{\rho}} \left(\frac{y_j^i}{Y^i}\right)^{\frac{-1}{\eta}}$$

We can rearrange the firm's inverse demand function:

$$P_{jk}^i = {q_{jk}^i}^{\frac{-1}{\rho}} {y_j^i}^{\frac{1}{\rho}-\frac{1}{\eta}} P^i {Y^i}^{\frac{-1}{\eta}}$$

I denote $X^i = P^i {Y^i}^{\frac{-1}{\eta}}$, for clarity as they are taken as given by the firm (no need to take the derivative).

The firms choose quantity. Substituting the constraint into the objective function, the problem can be rewritten as:

$$\max_{q_{jk}^i} \Pi_{jk}^i = {q_{jk}^i}^{\frac{-1}{\rho}} {y_j^i}^{\frac{1}{\rho}-\frac{1}{\eta}} X^i q_{jk}^i - q_{jk}^i MC_{jk}^i$$

$$\max_{q_{jk}^i} \Pi_{jk}^i = {q_{jk}^i}^{\frac{\rho-1}{\rho}} {y_j^i}^{\frac{1}{\rho}-\frac{1}{\eta}} X^i - q_{jk}^i MC_{jk}^i$$

Taking the first order condition:

$$\frac{\partial \Pi^i_{jk}}{\partial q^i_{jk}} = 0 \Leftrightarrow MC^i_{jk} = \left(1 - \frac{1}{\rho}\right) q^i_{jk}{}^{\frac{-1}{\rho}} y^i_j{}^{\frac{1}{\rho}-\frac{1}{\eta}} X^i + \left(\frac{1}{\rho} - \frac{1}{\eta}\right) q^i_{jk}{}^{1-\frac{1}{\rho}} y^i_j{}^{\frac{1}{\rho}-\frac{1}{\eta}-1} \frac{\partial y^i_j}{\partial q^i_{jk}} X^i$$

$$\Leftrightarrow MC^i_{jk} = \left(1 - \frac{1}{\rho}\right) q^i_{jk}{}^{\frac{-1}{\rho}} y^i_j{}^{\frac{1}{\rho}-\frac{1}{\eta}} X^i + \left(\frac{1}{\rho} - \frac{1}{\eta}\right) q^i_{jk}{}^{\frac{-1}{\rho}} \left[\frac{\partial y^i_j}{\partial q^i_{jk}} \frac{q^i_{jk}}{y^i_j}\right] y^i_j{}^{\frac{1}{\rho}-\frac{1}{\eta}} X^i$$

Under CES demand systems, $\left[\frac{\partial y^i_j}{\partial q^i_{jk}} \frac{q^i_{jk}}{y^i_j}\right] = s^i_{jk}$ and $P^i_{jk} = q^i_{jk}{}^{\frac{-1}{\rho}} y^i_j{}^{\frac{1}{\rho}-\frac{1}{\eta}} X^i$

$$MC^i_{jk} = \left(1 - \frac{1}{\rho}\right) P^i_{jk} + \left(\frac{1}{\rho} - \frac{1}{\eta}\right) P^i_{jk} s^i_{jk}$$

Rearranging we get :

$$P^i_{jk} = \left[1 - \frac{1}{\rho} + s^i_{jk}\left(\frac{1}{\rho} - \frac{1}{\eta}\right)\right]^{-1} MC^i_{jk}$$

The vector of equilibirum price (6) is then obtained:

$$P^i_{jk} = \left[1 - \frac{1}{\epsilon(s^i_{jk})}\right]^{-1} MC^i_{jk}$$

$$P^i_{jk} = \frac{\epsilon(s^i_{jk})}{\epsilon(s^i_{jk}) - 1} MC^i_{jk}$$

with $\epsilon(s^i_{jk}) = \left[\frac{1}{\rho}(1 - s^i_{jk}) + \frac{1}{\eta} s^i_{jk}\right]^{-1}$ and $MC^i_{jk} = \frac{W}{z_{jk}}$ The market share, is given by $s^i_{jk} = \frac{P^i_{jk} q^i_{jk}}{\sum_{l=1}^{2K} P^i_{jl} q^i_{jl}}$ and can be rewritten as a function of prices using $\frac{P^i_{jk}}{P^i_j} = \left(\frac{q^i_{jk}}{y^i_j}\right)^{\frac{-1}{\rho}}$ and $P^i_j = \left[\sum_{k=1}^{2K} P^i_{jk}{}^{1-\rho}\right]^{\frac{1}{1-\rho}}$ to get (17):

$$s^i_{jk} = \frac{P^i_{jk} q^i_{jk}}{\sum_{l=1}^{K} P^i_{jl} q^i_{jl} + \sum_{l=1}^{K} P^{*i}_{jl} q^{*i}_{jl}} = \left(\frac{P^i_{jk}}{P^i_j}\right)^{1-\rho}$$

Solving for the foreign firm operating in the domestic market is straight forward. Only the marginal cost is scaled by the iceberg trade cost: $MC^i_{jk} = \tau \frac{W}{z_{jk}}$

Bertrand competition

Now, we solve the equilibrium prices under Bertrand competition. Firms, instead of choosing quantities, choose prices. Firms recognize that the sectoral production y^i_j and price level P^i_j change when they solve for the maximization problem. They take into account the strategic interaction with the other firms in sector j. The quantities from the other firms q^i_{jl} operating in the sector and country of interest, with $l \neq k$, the final consumption price P^i, the wage level W^i and aggregate quantity Y^i are taken as given. We take the derivative according to P^i_j and P^i_{jk}.

We rearrange the inverse demand function:

$$q^i_{jk} = \left(\frac{P^i_{jk}}{P^i_j}\right)^{-\rho} \left(\frac{P^i_j}{P^i}\right)^{-\eta} Y^i$$

Now, we solve the problem for a domestic firm serving the domestic market

The firm wants to maximize its profit (revenue minus total cost)

$$\max_{P^i_{jk}} P^i_{jk} q^i_{jk} - q^i_{jk} MC^i_{jk}$$

subject to the inverse demand function:

$$q^i_{jk} = \left(\frac{P^i_{jk}}{P^i_j}\right)^{-\rho} \left(\frac{P^i_j}{P^i}\right)^{-\eta} Y^i$$

With $MC^i_{jk} = \frac{W}{z^i_{jk}}$, the marginal cost of the firm

Firms choose prices. We substitute q^i_{jk} in the objective function using the inverse demand function. The maximization problem can be rewritten as:

$$\max_{P^i_{jk}} \left(P^i_{jk} - MC^i_{jk}\right) \left(\frac{P^i_{jk}}{P^i_j}\right)^{-\rho} \left(\frac{P^i_j}{P^i}\right)^{-\eta} Y^i$$
$$\max_{P^i_{jk}} \left(P^i_{jk} - MC^i_{jk}\right) {P^i_{jk}}^{-\rho} {P^i_j}^{\rho-\eta} {P^i}^{\eta} Y^i$$
$$\max_{P^i_{jk}} \left(P^i_{jk} - MC^i_{jk}\right) {P^i_{jk}}^{-\rho} {P^i_j}^{\rho-\eta} X^i$$

I denote $X^i = {P^i}^{\eta} Y^i$, for clarity as they are taken as given by the firm (no need to take the derivative).

For the rest of the derivations, note that:

$$P^i_j = \left[\sum_{k=1}^{2K} {P^i_{jk}}^{1-\rho}\right]^{\frac{1}{1-\rho}}$$
$$\frac{\partial P^i_j}{\partial P^i_{jk}} = {P^i_{jk}}^{-\rho} \left[\sum_{k=1}^{2K} {P^i_{jk}}^{1-\rho}\right]^{\frac{1}{1-\rho}-1} = \left(\frac{P^i_{jk}}{P^i_j}\right)^{-\rho}$$

Moreover, the revenue is:

$$r^i_{jk} = P^i_{jk} q^i_{jk}$$
$$r^i_{jk} = P^i_{jk} ({P^i_{jk}}^{-\rho} {P^i_j}^{\rho-\eta}) X^i$$
$$r^i_{jk} = {P^i_{jk}}^{1-\rho} {P^i_j}^{\rho-\eta} X^i$$

This implies that the revenue shares are:

$$s^i_{jk} = \frac{r^i_{jk}}{\sum_{l=1}^{2K} r^i_{jl}} = \frac{{P^i_{jk}}^{1-\rho} {P^i_j}^{\rho-\eta} X^i}{\sum_{l=1}^{2K} {P^i_{jl}}^{1-\rho} {P^i_j}^{\rho-\eta} X^i} = \frac{{P^i_{jk}}^{1-\rho}}{\sum_{l=1}^{2K} {P^i_{jl}}^{1-\rho}}$$
$$s^i_{jk} = \frac{{P^i_{jk}}^{1-\rho}}{{P^i_j}^{1-\rho}} \quad \text{by definition of } P^i_j$$

Finally we have:

$$s^i_{jk} = \left(\frac{P^i_{jk}}{P^i_j}\right)^{1-\rho} = \frac{\partial P^i_j}{\partial P^i_{jk}} \frac{P^i_{jk}}{P^i_j}$$

We derive the first order condition of the firm:

$$\frac{\partial \pi^i_{jk}}{\partial P^i_{jk}} = 0 \Leftrightarrow {P^i_{jk}}^{-\rho} {P^i_j}^{\rho-\eta} X^i - \rho(P^i_{jk} - MC^i_{jk}) {P^i_{jk}}^{-\rho-1} {P^i_j}^{\rho-\eta} X^i + (\rho-\eta)(P^i_{jk} - MC^i_{jk}) {P^i_{jk}}^{-\rho} {P^i_j}^{\rho-\eta-1} \frac{\partial P^i_j}{\partial P^i_{jk}} X^i = 0$$

$$\Leftrightarrow {P^i_{jk}}^{-\rho} {P^i_j}^{\rho-\eta} - \rho(P^i_{jk} - MC^i_{jk}) {P^i_{jk}}^{-\rho-1} {P^i_j}^{\rho-\eta} + (\rho-\eta)(P^i_{jk} - MC^i_{jk}) {P^i_{jk}}^{-\rho} {P^i_j}^{\rho-\eta-1} \frac{\partial P^i_j}{\partial P^i_{jk}} = 0$$

$$\Leftrightarrow P^i_{jk} - \rho(P^i_{jk} - MC^i_{jk}) + (\rho-\eta)(P^i_{jk} - MC^i_{jk}) \frac{P^i_{jk}}{P^i_j} \frac{\partial P^i_j}{\partial P^i_{jk}} = 0$$

$$\Leftrightarrow P^i_{jk} - \rho(P^i_{jk} - MC^i_{jk}) + (\rho-\eta)(P^i_{jk} - MC^i_{jk}) s^i_{jk} = 0$$

$$\Leftrightarrow -P^i_{jk} + \rho(P^i_{jk} - MC^i_{jk}) - (\rho-\eta)(P^i_{jk} - MC^i_{jk}) s^i_{jk} = 0$$

$$P^i_{jk} = \frac{\rho - (\rho-\eta)s^i_{jk}}{\rho - 1 - (\rho-\eta)s^i_{jk}} MC^i_{jk}$$

Which can be rewritten as:

$$P^i_{jk} = \frac{\epsilon(s^i_{jk})}{1 - \epsilon(s^i_{jk})} MC^i_{jk} \quad \text{with} \quad \epsilon(s^i_{jk}) = \rho(1 - s^i_{jk}) + \eta s^i_{jk}$$

E.3 Concavity of the markup

For Cournot:

The markup is a strictly increasing function of the market share, as long as $\rho > \eta > 1$:

$$\frac{\partial \mu(s)}{\partial s} = \left(\frac{1}{\eta} - \frac{1}{\rho}\right) \frac{1}{\left(1 - \left(\frac{1}{\eta}s + (1-s)\frac{1}{\rho}\right)\right)^2} > 0$$

The markup is a strictly convex function of the market share, as long as $\rho > \eta > 1$:

$$\frac{\partial^2 \mu(s)}{\partial^2 s} = \left(\frac{1}{\eta} - \frac{1}{\rho}\right) . \frac{2\left(\frac{1}{\eta} - \frac{1}{\rho}\right)\left(1 - \left(\frac{1}{\eta}s + (1-s)\frac{1}{\rho}\right)\right)}{\left(1 - \left(\frac{1}{\eta}s + (1-s)\frac{1}{\rho}\right)\right)^4} > 0$$

Indeed, this ratio is positive if:

$$1 - \left(\frac{1}{\eta}s + (1-s)\frac{1}{\rho}\right) > 0$$

We can show that: $\frac{\partial}{\partial s}\left(1 - \left(\frac{1}{\eta}s + (1-s)\frac{1}{\rho}\right)\right) = \frac{1}{\rho} - \frac{1}{\eta} < 0$ This ratio is strictly decreasing with s. Moreover, $s \in [0,1]$. When $s = 1$, this ratio is minimized and reduced to $1 - \frac{1}{\eta} > 0$ So $\frac{\partial^2 \mu(s)}{\partial^2 s} > 0$

For Bertrand:

The markup is a strictly increasing function of the market share, as long as $\rho > \eta > 1$:

$$\frac{\partial \mu(s)}{\partial s} = \frac{\rho - \eta}{(\rho - 1 - (\rho-\eta)s)^2} > 0$$

The markup is a strictly convex function of the market share, as long as $\rho > \eta > 1$:

$$\frac{\partial^2 \mu(s)}{\partial^2 s} = (\rho - \eta) . \frac{2(\rho-\eta)(\rho - 1 - (\rho-\eta)s)}{(\rho - 1 - (\rho-\eta)s)^4} > 0$$

Indeed, this ratio is positive if:

$$\frac{\rho-1}{\rho-\eta} > s$$

which is always true as $\rho > \eta > 1$.

E.4 Derivation of the markup

At the sectoral level:

From the definition of the theoretical price index at the sectoral level:

$$P_j^i = \left[\sum_{k=1}^{2K} {P_{jk}^i}^{1-\rho}\right]^{\frac{1}{1-\rho}}$$

Which can be re-expressed, using the definition of the equilibrium prices and the symmetry argument for sectoral productivity:

$$P_j^i = \left[\sum_{k=1}^{K}\left(\mu_{jk}^i \frac{W}{z_{jk}}\right)^{1-\rho} + \sum_{k=1}^{K}\left(\tau \mu_{jk}^{*i} \frac{W}{z_{jk}^*}\right)^{1-\rho}\right]^{\frac{1}{1-\rho}}$$

$$P_j^i = \left[\sum_{k=1}^{K}\left(\mu_{jk}^i \frac{z_j}{z_{jk}} \frac{W}{z_j}\right)^{1-\rho} + \left(\mu_{jk}^{*i} \frac{z_j}{z_{jk}^*} \tau \frac{W}{z_j}\right)^{1-\rho}\right]^{\frac{1}{1-\rho}}$$

$$P_j^i = \left[\sum_{k=1}^{K}\left(\mu_{jk}^i \frac{z_j}{z_{jk}}\right)^{1-\rho} + \tau^{1-\rho}\sum_{k=1}^{K}\left(\mu_{jk}^{*i} \frac{z_j}{z_{jk}^*}\right)^{1-\rho}\right]^{\frac{1}{1-\rho}} \frac{W}{z_j}$$

$$P_j^i = \left(\sum_{k=1}^{K}\left(\frac{z_{jk}}{z_j}\right)^{\rho-1}\left(\frac{1}{\mu_{jk}^i}\right)^{\rho-1} + \tau^{1-\rho}\sum_{k=1}^{K}\left(\frac{z_{jk}^*}{z_j}\right)^{\rho-1}\left(\frac{1}{\mu_{jk}^{*i}}\right)^{\rho-1}\right)^{\frac{1}{1-\rho}} \frac{W}{z_j}$$

So, we can deduce the expression for the markup:

$$\mu_j = \left(\sum_{k=1}^{K}\left(\frac{z_{jk}}{z_j}\right)^{\rho-1}\left(\frac{1}{\mu_{jk}^i}\right)^{\rho-1} + \tau^{1-\rho}\sum_{k=1}^{K}\left(\frac{z_{jk}^*}{z_j}\right)^{\rho-1}\left(\frac{1}{\mu_{jk}^{*i}}\right)^{\rho-1}\right)^{\frac{1}{1-\rho}}$$

At the aggregate level

From the definition of the theoretical price index at the aggregate level and the symmetry argument for sector and aggregate productivity, we can deduce the aggregate markup:

$$P^i = \left[\int_0^1 P_j^{i\,1-\eta} dj\right]^{\frac{1}{1-\eta}}$$

$$P^i = \left[\int_0^1 \left(\mu_j^i \frac{W}{z_j}\right)^{1-\eta} dj\right]^{\frac{1}{1-\eta}}$$

$$P^i = \left[\int_0^1 \left(\mu_j^i \frac{Z}{z_j}\frac{W}{Z}\right)^{1-\eta} dj\right]^{\frac{1}{1-\eta}}$$

$$P^i = \left[\int_0^1 \left(\mu_j^i \frac{Z}{z_j}\right)^{1-\eta} dj\right]^{\frac{1}{1-\eta}} \frac{W}{Z}$$

$$\mu^i = \left(\int_0^1 \left(\frac{z_j}{Z}\right)^{\eta-1} \left(\frac{1}{\mu_j^i}\right)^{\eta-1} dj\right)^{\frac{1}{1-\eta}}$$

Sales-weighted average markup

$$\bar{\mu^i} = i^i(\mu_{for}) + (1-i^i)(\mu_{dom})$$

$$\bar{\mu^i} = i^i(\int_0^i \sum_{k=1}^K \frac{p_{jk}^{*i} q_{jk}^{*i} \mu_{jk}^{*i}}{\int_0^i \sum_{k=1}^K p_{jk}^{*i} q_{jk}^{*i} dj} dj) + (1-i^i)(\int_0^i \sum_{k=1}^K \frac{p_{jk}^{i} q_{jk}^{i} \mu_{jk}^{i}}{\int_0^i \sum_{k=1}^K p_{jk}^{i} q_{jk}^{i} dj} dj)$$

$$\bar{\mu^i} = \frac{\int_0^1 \left(\sum_{k=1}^K p_{jk}^{*i} . q_{jk}^{*i}\right) dj}{P^i Y^i} .(\int_0^i \sum_{k=1}^K \frac{p_{jk}^{*i} q_{jk}^{*i} \mu_{jk}^{*i}}{\int_0^i \sum_{k=1}^K p_{jk}^{*i} q_{jk}^{*i} dj} dj) + \frac{\int_0^1 \left(\sum_{k=1}^K p_{jk}^{i} . q_{jk}^{i}\right) dj}{P^i Y^i} .(\int_0^i \sum_{k=1}^K \frac{p_{jk}^{i} q_{jk}^{i} \mu_{jk}^{i}}{\int_0^i \sum_{k=1}^K p_{jk}^{i} q_{jk}^{i} dj} dj)$$

$$\bar{\mu^i} = \int_0^i \sum_{k=1}^K \left(\frac{p_{jk}^i q_{jk}^i}{P^i Y^i} \mu_{jk}^i\right) + \sum_{k=1}^K \left(\frac{p_{jk}^{*i} q_{jk}^{*i}}{P^i Y^i} \mu_{jk}^{*i}\right) dj$$

With μ_{for} and μ_{for} respectively the sales-weighted average foreign and domestic markups:

$$\mu_{for} = \int_0^i \sum_{k=1}^K \frac{p_{jk}^{*i} q_{jk}^{*i} \mu_{jk}^{*i}}{\int_0^i \sum_{k=1}^K p_{jk}^{*i} q_{jk}^{*i} dj} dj$$

$$\mu_{dom} = \int_0^i \sum_{k=1}^K \frac{p_{jk}^{i} q_{jk}^{i} \mu_{jk}^{i}}{\int_0^i \sum_{k=1}^K p_{jk}^{i} q_{jk}^{i} dj} dj$$

and the import share:

$$i^i = \frac{\int_0^1 \left(\sum_{k=1}^K p_{jk}^{*i} . q_{jk}^{*i}\right) dj}{P^i Y^i} = 1 - \frac{\int_0^1 \left(\sum_{k=1}^K p_{jk}^{i} . q_{jk}^{i}\right) dj}{P^i Y^i}$$

E.5 Algorithm for the benchmark model

The algorithm to simulate the benchmark model is based on the following steps

1. Idiosyncratic productivities are drawn from a log normal distribution. Countries are perfectly symmetric in terms of sectoral, aggregate productivities and the number of firms in each sector. Wages and labor supply are normalized to one in both countries.

2. Given the equation (6) defining the equilibrium prices, we solve for the market shares, the markups, and the prices. We check that the market shares sum to one.

3. We calculate the sector and aggregate markups from equations (9-10). We check that the values obtained satisfy the equilibrium conditions (8)

4. We calculate the aggregate production in both countries, normalizing labor and wages to one.

From the sectoral labor clearing condition, we have:

$$l_j^i = \sum_{k=1}^{K} l_{jk}^i + \sum_{k=1}^{K} l_{jk}^{*-i}$$

Using the definition of the production function, this expression can be re-expressed:

$$l_j^i = \sum_{k=1}^{K} \frac{q_{jk}^i}{z_{jk}} + \sum_{k=1}^{K} \frac{q_{jk}^{*-i}}{z_{jk}}$$

From the equilibrium quantities:

$$l_j^i = \sum_{k=1}^{K} \frac{1}{z_{jk}} \left(\frac{P_{jk}^i}{P_j^i}\right)^{-\rho} \left(\frac{P_j^i}{P^i}\right)^{-\eta} Y^i + \sum_{k=1}^{K} \frac{1}{z_{jk}} \left(\frac{P_{jk}^{-i}}{P_j^{-i}}\right)^{-\rho} \left(\frac{P_j^{-i}}{P^{-i}}\right)^{-\eta} Y^{-i}$$

Normalizing the aggregate labor supply $l^i = 1$, and using the symmetry argument $Y^i = Y^{-i}$, gives the expression for Y^i:

$$Y^i = \left(\int_0^1 \left(\sum_{k=1}^{K} \frac{1}{z_{jk}} \left(\frac{P_{jk}^i}{P_j^i}\right)^{-\rho} \left(\frac{P_j^i}{P^i}\right)^{-\eta} + \sum_{k=1}^{K} \frac{1}{z_{jk}} \left(\frac{P_{jk}^{*-i}}{P_j^{-i}}\right)^{-\rho} \left(\frac{P_j^{-i}}{P^{-i}}\right)^{-\eta}\right) dj\right)^{-1}$$

5. Given the aggregate production in each country, we can calculate the quantity produced by each firm with equation (7) and sectors with equation (5). We check possible mistakes by ensuring that the aggregate quantities given by equation (4) is equal to the one found in 4.

6. Finally, we check that the labor market clears. We calculate the labor demand at the disaggregated level then we sum to get the sectoral labor demand. We sum the sectoral labor demand to ensure that it is equal to the labor supply normalized to 1.