Spoils of War: Trade Shocks & Segmented Labor Markets in Spain during WWI*

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Abstract

How does domestic factor mobility influence the welfare effects of trade shocks? This paper examines this question using an event-study design to analyze the impact of a large trade shock on Spain during World War I, which led to uneven labor reallocation, wage growth, and price increases across provinces. I estimate a spatial equilibrium model that incorporates limited labor mobility, resulting in competition within segmented regional labor markets. The model reveals that while localized nominal income gains occurred, they were partially offset by rising consumer prices. Overall, the trade shock increased welfare by 2.54 percent. However, a counterfactual scenario with lower mobility costs suggests that the economy was constrained by segmented labor markets, highlighting the importance of labor mobility for realizing the full welfare gains from trade.

JEL Code: D5, F11, F12, F15, F16, N9, N14, R12, R13

Keywords: Gains from Trade, Labor Mobility, Economic Geography

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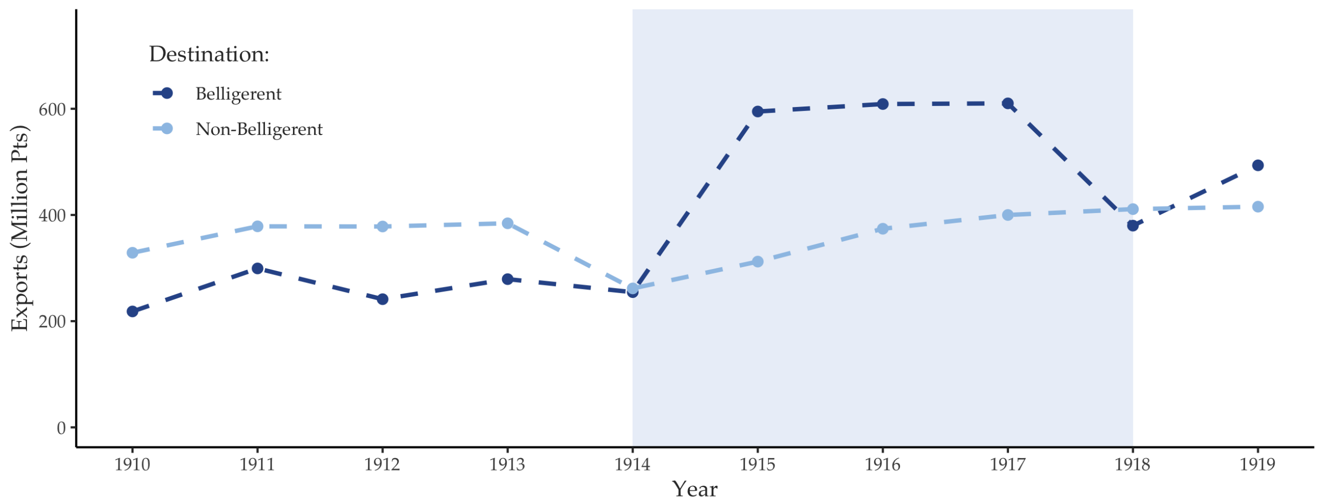
1 Introduction

A large body of empirical research has documented the uneven effects of trade shocks on local labor markets, highlighting changes in employment, wages, and economic activity across regions and sectors (Autor, Dorn and Hanson, 2016*a*; Topalova, 2010; Kovak, 2013; Dix-Carneiro and Kovak, 2017; Jaravel and Sager, 2019; McCaig and Pavcnik, 2018; Adao, Arkolakis and Esposito, 2019). While much of this literature has examined how negative shocks - such as declines in demand for domestic goods or increased import competition - affect local economies, less is known about the impacts of positive trade shocks that lead to sudden increases in foreign demand. In addition, many studies implicitly treat local labor markets as isolated, overlooking the interconnected network structure through which labor mobility constraints and sectoral linkages shape the distributional effects of shocks. These interactions can lead to localized congestion effects, where asymmetric labor demand shocks result in wage pressures, inflation, and limited labor reallocation, thereby potentially offsetting the gains from trade.

This paper addresses this gap in the literature by examining the effects of a large, positive trade shock on interconnected local labor markets with limited factor mobility, using a natural experiment as its empirical basis. It focuses on how labor mobility frictions and the network structure of labor markets shape the distributional and aggregate welfare effects of trade shocks. The study combines a reduced-form evidence from a unique historical with insights from a spatial equilibrium model that accounts for labor mobility costs across regions and sectors, providing a framework to analyze both the direct effects of trade shocks and the spillovers within a network of interlinked markets. By combining reduced-form evidence on localized wage pressures and labor reallocation with this model, the paper quantifies the welfare gains from trade under different scenarios of labor market integration. The findings highlight that limited mobility and localized congestion effects can significantly constrain the potential gains from trade, providing new insights into trade dynamics in segmented economies.

At the core of this study is a historical natural experiment involving a substantial international trade shock to the Spanish economy during World War I (1914-1918). Despite remaining neutral during the conflict, Spain faced an exogenous increase in foreign demand for its goods, driven by the reduced industrial capacity of belligerent countries, such as France, and heightened wartime demand. This shock resulted in uneven impacts across Spain's regions and sectors, illustrated by a significant rise in exports during this period (see Figure 1). Spain's economy at the time was marked by considerable labor market segmentation, leading to varied sectoral reallocations and a sharp increase in consumer prices in response to the shock (see Figure 2). The analysis relies on a unique spatial panel dataset that combines newly hand-collected data on trade records, detailed employment surveys from all Spanish provinces, and consumer price data from 1910 to 1920. This comprehensive dataset allows for an in-depth examination of how the trade shock's uneven incidence interacted with segmented labor markets to shape economic outcomes in Spain.

Figure 1. Aggregate Trade Levels



Notes: Aggregate exports (in million pesetas) by destination, categorized by whether the destination country was a belligerent during World War I. Belligerent countries include primary participants whose trade with Spain was not disrupted by the frontline, such as France, Italy, and the United Kingdom. Non-belligerent countries exclude the United States and other countries that joined the war later. The blue shaded area represents the World War I period. The data are sourced from digitized trade statistics at the product-destination level.

To motivate the empirical analysis of how trade shocks affect connected labor markets and to illustrate their impact on wages and labor allocations, I begin by developing a generic model of an economy with interconnected local labor markets subject to external (foreign) demand shocks to analyze their effects on wages and labor allocations. I demonstrate that uneven trade shocks across tightly connected labor markets intensifies competition for workers via direct and indirect spillover effects across local labor markets, leading to wage pressures and limited labor reallocation. The own and cross-price elasticities of the labor supply system determine the relative strength of direct and indirect effects. Consequently, increased wages may translate into higher consumer prices, potentially offsetting income gains and resulting in uneven wage and price growth throughout the economy.

Motivated by these insights, I proceed by presenting novel evidence from a historical natural experiment involving a substantial, exogenous trade shock to the Spanish economy during World War I (1914-1918), driven by increased demand from belligerent nations for Spanish goods. This shock created significant spatial and sectoral heterogeneity in its impact on local labor markets. Utilizing a unique spatial panel dataset that includes newly hand-collected data on trade records, employment surveys, and consumer price data from 1910 to 1920, I employ an event-study regression design to disentangle the direct effects of the shock from indirect spillovers across interconnected regions. The analysis reveals that regions directly exposed to the trade shock experienced notable wage increases and a sharp rise in consumer prices, driven by localized competition for labor and increased demand for goods. Indirect effects were also significant, as wage and price pressures extended to nearby regions through labor mobility frictions. Labor reallocations were more limited, occurring mainly within regions rather than across them, highlighting the constraints of spatial mobility during this period. The findings demonstrate that the welfare gains from trade were strongly influenced by the degree of labor market integration;

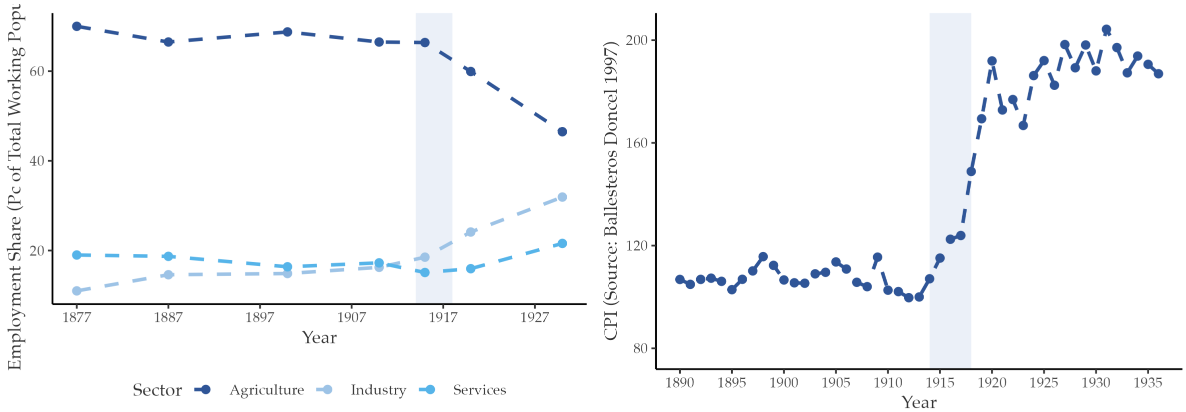
simulations suggest that more integrated markets would have facilitated greater labor reallocation and reduced inflationary pressures, leading to higher overall gains from trade.

To explain these empirical findings, I extend a standard economic geography model by incorporating imperfect labor mobility. The model introduces a tractable framework in which workers face reallocation decisions impeded by sectoral and spatial mobility frictions. This approach allows for rich interactions between connected local labor markets and enables the tracing of how an external demand shock propagates through these markets. To evaluate the welfare effects of such a shock, I build on the sufficient statistic approach to gains from trade by Arkolakis, Costinot and Rodriguez-Clare (2012) and derive a closed-form expression that incorporates domestic reallocation. Within this framework, spatial and sectoral labor flows serve as sufficient statistics to quantify and decompose the gains from trade, separating the contributions of spatial and sectoral reallocation from the spatially heterogeneous effects on real income.

Using the model structure and data from the World War I shock, I estimate key parameters, including labor supply and trade elasticities, as well as mobility frictions. By simulating the Spanish economy in the absence of the WWI shock, I recover counterfactual labor and trade flows, which I use to quantify and decompose the welfare gains from trade. The results show that while labor reallocation positively contributes to the gains from trade, this is partially offset by countervailing price effects, suggesting that competition among local labor markets for a limited pool of workers induces localized inflation, thereby constraining the overall gains. The decomposition exercise further illustrates that accounting for the spatially heterogeneous patterns of reallocation and price dynamics is quantitatively significant and substantially adjusts the gains from trade derived from more traditional methods that rely solely on changes in trade openness. The baseline model demonstrates that incorporating spatial heterogeneity increases the estimated welfare gains from 1.5% to 2.54%. Finally, I simulate a scenario where Spain's labor market is more spatially integrated, showing that greater labor mobility would lead to higher reallocational gains and reduced inflationary pressures, thereby enhancing the overall gains from trade. This exercise underscores the qualitative channels through which labor reallocation affects the welfare gains from trade.

Related literature. This paper contributes to several strands of research in international trade, labor economics, and economic geography. First, it adds to the extensive literature on the impacts of trade shocks on local labor markets. A significant body of research has focused on the adverse effects of negative trade shocks, such as the impact of import competition on local labor markets in advanced economies, exemplified by the "China shock" literature (Autor, Dorn and Hanson, 2016*b*; Acemoglu et al., 2016). These studies primarily examine the distributional consequences of negative shocks, like job losses, wage declines, and the hollowing out of certain sectors. In contrast, this paper shifts the focus to a positive trade shock—a large exogenous increase in foreign demand for Spanish goods during World War I. By examining the effects of a positive shock that resulted from Spain's neutral position while key

Figure 2. (1) Aggregate Composition of the Economy and (2) Evolution of the Spanish CPI



Notes: (Panel 1) Employment shares in Spain across the primary (agriculture), secondary (industry/manufacturing), and tertiary (services) sectors from 1877 to 1930. The data series is constructed from census data, using the calculations of Harrison (1978) for 1877-1900, and based on the author's own calculations for 1900-1930. The blue shaded area represents the World War I period. Detailed information on the construction of a consistent data series from census data is available in the online appendix. (Panel 2) Consumer Price Index (CPI) from 1890 to 1936, as provided by Ballesteros Doncel (1997), normalized to 100 in 1913. The blue shaded area again indicates the World War I period.

trading partners were engaged in war, the paper provides new insights into how both the benefits and costs of trade shocks unfold across regions. The findings reveal that even beneficial trade shocks can produce uneven outcomes in segmented labor markets, including wage pressures, inflation, and limited labor reallocation.

Second, this paper addresses a gap in the literature regarding the interconnectedness of local labor markets and the resulting localized congestion effects. Much of the literature employ a regression-based approach, which implicitly treats local labor markets as isolated entities, abstracting away from the rich network structure that connects them via labor mobility and sectoral linkages. Some studies have incorporated this feature Monte, Redding and Rossi-Hansberg (2018) explore the impact of productivity shocks across local labor markets that are connected by commuting linkages in output and input markets (trade and migration frictions). Caliendo, Dvorkin and Parro (2019) characterize the dynamic evolution of the spatial equilibrium incorporating migration linkages. Adao, Arkolakis and Esposito (2019) revisit the implications of the 'China shock' employing a reduced-form system that takes general equilibrium feedback into account. What remains overlooked is how asymmetric shocks can lead to congestion effects in the labor market where heightened competition for a limited pool of workers induces wage pressures and inflation. By developing a spatial equilibrium model that explicitly accounts for these interconnections, this paper shows that limited labor mobility can significantly affect the welfare outcomes of trade shocks through these congestion effects. The model demonstrates how the network structure of local labor markets shapes both the direct and indirect effects of shocks, revealing that the uneven incidence of a trade shock across connected labor markets can cause inflationary pressures and limit the gains from trade.

Third, this paper contributes to the literature on quantifying the gains from trade using sufficient statistics. Recent contributions have extended the initial work of (Arkolakis, Costinot and Rodriguez-

Clare, 2012) to allow for multiple sectors with different trade elasticities (Ossa, 2015), or workers with heterogeneous productivities across sectors (Galle, Rodriguez-Clare and Yi, 2017; Kim and Vogel, 2020; Lee, 2020), and other complexities. However, most studies do not adequately consider the interaction between spatial and sectoral reallocation, particularly under the conditions of limited mobility and localized congestion effects. This paper extends the sufficient statistic approach to explicitly include both spatial and sectoral labor reallocation within a network of connected local labor markets.[1] This extension allows for a more comprehensive measure of welfare gains that accounts not only for changes in trade openness but also for dynamic gains from the reallocation of labor, adjusted for localized congestion effects. By decomposing welfare gains into components driven by spatial and sectoral labor flows, the analysis reveals that traditional methods of calculating gains from trade may significantly underestimate the effects in economies with segmented labor markets and mobility frictions.

Outline. The remainder of the paper is structured as follows. Section 2 describes a general model of a spatial equilibrium model with labor market linkages and illustrates the impact of the a trade-shock. Section 3 introduces the historical background, the various data sources and the construction of the data and gives reduced form evidence on the trade shock and its effect local labor markets. Section 4 describes the quantitative model, the estimation of the model as well as the welfare quantification. Finally, Section 5 concludes.

2 A simple of model of trade with connected labor markets

To motivate our empirical analysis of the incidence of a trade shock across connected labor markets and to illustrate the qualitative and quantitative effects on wages and labor allocations, consider a stylized example of a simple economy with connected labor markets and external (i.e., foreign) demand.[2]

Setup. Let there be a number of locations within a country, $i, j \in \mathbb{D} = \left\{1, \ldots, N^D\right\}$. Labor demand, $\ell_{i,D}$, is assumed to be twice differentiable and a decreasing function of wages in location i, i.e., $\frac{\partial \ell_{i,D}}{\partial w_i} < 0$. Furthermore, each location is subject to foreign demand, e_i, and labor demand is thus given by an increasing function of external demand, $\frac{\partial \ell_{i,D}}{\partial e_i} > 0$, i.e.,

$$\ell_{i,D} = f\left(w_i, e_i, \Omega\right) \qquad \forall i$$

where $\Omega = \{w_1, \ldots, w_{N^D}, e_1, \ldots, e_{N^D}\}$ summarizes wages and foreign demand elsewhere.

[1] Kim and Vogel (2020) conduct a similar analysis that considers imperfect worker reallocation when calculating the welfare effects of the China shock on U.S. labor markets. However, their approach abstracts from bilateral reallocation, limiting their ability to capture the complex interactions between closely connected labor markets, which is a central focus of this study. Additionally, their empirical implementation does not consider the impact of trade shocks on consumer prices.

[2] Derivations can be found in the online appendix Section G.1. Furthermore, the closed-form expressions for a location case are also available in that online appendix section.

In many spatial settings, labor will be imperfectly mobile and inelastically supplied. We will examine such settings and represent labor supply by a location-specific labor supply function, $\ell_{i,S}$, which is again twice differentiable and an increasing function of wages in location i, w_i. However, employment across labor markets is seen as a gross substitute by the worker, and therefore, labor supply in i is a decreasing function of wages in other locations, e.g., j, w_j. Labor supply is given by

$$\ell_{i,S} = f\left(w_i, \ldots, w_{N^D}, \Omega\right) \qquad \forall i$$

Labor is imperfectly mobile, and supply in i is increasing in local wages, w_i, but decreasing in wages elsewhere, w_j. Labor demand is decreasing in wages in location i, but increasing in a parameter that represents demand shifts, e_i.[3]

Let ρ_i and ρ_j be the elasticity of labor demand with regard to demand shifts, and let ψ_{ii} and ψ_{ij} be the own-wage and cross-wage elasticity of labor supply, respectively. The key outcomes of interest can be analyzed by examining the labor market clearing condition, i.e.,

$$\ell_{i,D}\left(w_i, e_i, \Omega\right) = \ell_{i,S}\left(w_1, \ldots, w_{N^D}, \Omega\right)$$

where Ω summarizes labor allocations and demand across the domestic spatial economy.

Labor allocations and their response to foreign demand shocks. Now, consider a (small) demand shift across all labor markets ($d \ln e_i > 0$), and solving for wage and employment changes that satisfy labor market clearing across all locations, we obtain,[4]

$$d \ln \ell_i \approx \beta_{ii} \times d \ln e_i + \sum_j \beta_{ij} \times d \ln e_j \tag{2}$$

where $\beta_{ii} \propto \rho_i$, $\beta_{ij} \propto \psi_{ij}\rho_j$. Furthermore, β_{ii} and β_{ij} are linear combinations of the reduced-form effect of the demand shock on wages across local labor markets, where the weights are given by the own-wage and cross-wage elasticities of labor supply.

The reduced-form system clarifies the role of uneven shocks: First, given the assumptions above, both α_1 and β_{ii} are positive, implying that the *direct effect* of an increase in local demand is to increase wages and labor allocations. Second, α_2 is positive and β_{ij} is negative, implying that the *indirect effect* of demand shocks elsewhere induces wage pressure and reduces labor allocations. The strength of this channel depends on how connected the two local labor markets are, as measured by the cross-wage elasticity ψ_{ij}. Therefore, if trade shocks only affect a small set of tightly connected local labor markets,

[3] For simplicity, we assume that labor demand is independent of wages elsewhere. This amounts to assuming that output markets are completely segmented between i and j. This can be relaxed, and the qualitative predictions will hold regardless as long as the indirect impact of wages elsewhere on labor demand does not exceed in magnitude the indirect effects on labor supply.

[4] For brevity, we illustrate the implications of the model for labor allocations. Similar illustrations can be given for wage allocations, i.e.,

$$d \ln w_i \approx \gamma_{ii} \times d \ln e_i - \sum_j \gamma_{ij} \times d \ln e_j \tag{1}$$

where γ_{ii} is the reduced-form effect of foreign trade demand in location i on wages in location i, and γ_{ij} summarizes the indirect effects of trade shocks elsewhere. As shown in the online appendix Section G.1, we have that $\gamma_{ii} \propto \rho_i$ and $\gamma_{ij} \propto \psi_{ij}$.

the consequence is heightened competition for a limited pool of workers, wage pressure, and limited reallocation. Increased wages, in turn, may pass through into increases in consumer prices, offsetting income gains. In the aggregate, uneven wage and price growth might be the result.[5]

3 Reduced-form evidence

This section empirically analyzes the impact of a large, exogenous trade shock on Spain's local labor markets during World War I, using this historical event as a natural experiment. Leveraging a unique spatial panel dataset that includes trade records, employment surveys, and consumer price data from 1910 to 1920, the section employs an event-study regression design to assess how the shock affected local wages, labor allocations, and prices across regions. The analysis distinguishes between direct effects on regions exposed to increased foreign demand and indirect spillovers to interconnected regions, influenced by labor mobility frictions. The results provide insights into spatial heterogeneity in economic adjustments and the role of labor market integration in shaping the welfare gains from trade.

Historical background. At the beginning of the 20th century, Spain remained at a relatively low level of industrial development.[6] According to census data, in 1900 roughly 70% of the working population worked in agriculture and only 12.5% worked in manufacturing. Industrialization proceeded only slowly, with the industrial sector growing marginally in total employment by 3%, adding a little less than 40,000 jobs nationwide in the first decade of the century. At that time, the largest share of the industrial sector was made up of sectors associated with primary goods, such as the exploitation of mines or the production of construction material.

In terms of the spatial distribution of the population, most of the population was still concentrated in predominantly rural and agricultural areas such as Andalucía[7] or Castilla y León.[8] Major urban centers such as Oviedo, Valencia, Bilbao, Madrid, and Barcelona concentrated most of the industrial activity, as

[5] The online appendix Section G.2 provides an extension of this model for an arbitrary number of local labor markets. In that setting, the effect on wages and employment across local labor markets can be written in terms of a direct and indirect (general equilibrium) effect. Furthermore, while the general equilibrium adjustments might be difficult to express in closed form, an approximate reduced-form characterization in terms of own-wage and cross-wage labor supply elasticities is feasible.

[6] After missing the first wave of the industrial revolution in the first half of the 19th century (Harrison, 1978), the Spanish economy underwent a period of rapid industrialization in the second half of the 19th century, fueled by market integration due to the expansion of the railroad network, which in turn resulted in the devolution of industrial capacity to the peripheral provinces with the cotton industry in Catalonia and metallurgy in the Basque country developing especially rapidly (Nadal, 1975). However, industrialization soon came to an early halt with the census data showing little increase in industrial employment from 1887 onwards. This is also mirrored by very low GDP per head growth rates averaging 0.6 percent between 1883–1913 (Prados de la Escosura, 2017). Some authors attribute the low levels of growth to limited demand for manufacturing goods domestically as well as little capacity to compete with goods from countries such as Germany, France, and the UK that were more advanced in terms of their industrialization (Harrison, 1978).

[7] Andalucía comprises eight provinces: Almería, Cádiz, Córdoba, Granada, Huelva, Jaén, Málaga and Seville, with major industrial activity located in Seville and Mining employment in Huelva

[8] Castilla y León comprises nine provinces: Ávila, Burgos, León, Palencia, Salamanca, Segovia, Soria, Valladolid and Zamora with major industrial activity centered in Valladolid.

Figure 3. Spatial Distribution of Manufacturing Employment

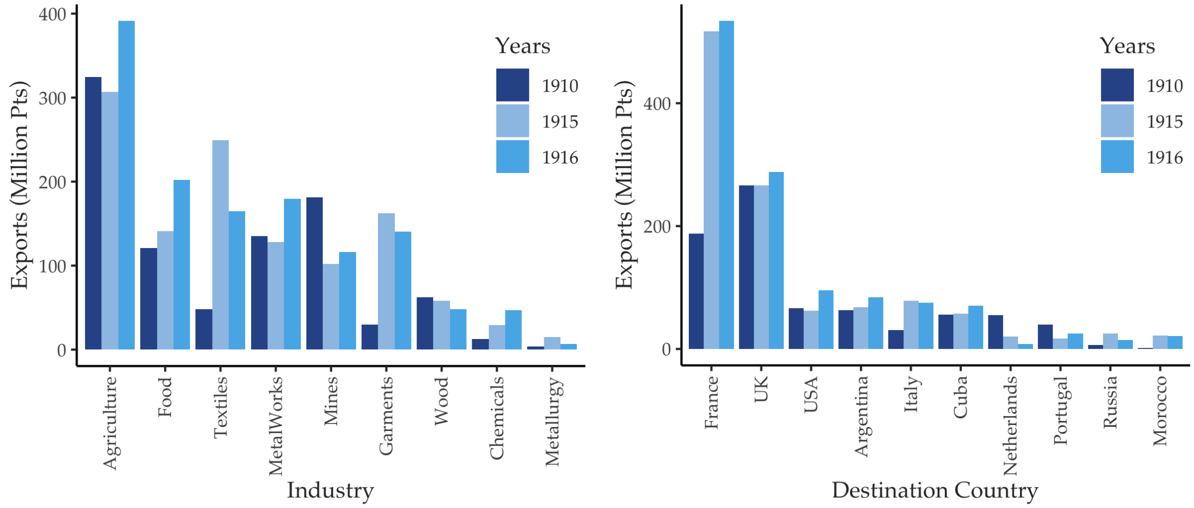
Notes: Map of total manufacturing and mining employment by province in 1910 (excluding Canary Islands and North African possessions). Source data is the 1910 census.

can be seen in Figure 3, indicating the spatial distribution of manufacturing employment. The industrial structure of those urban centers was heterogeneous.

In terms of internal migration, up until the 1920s, the Spanish economy was marked by perennially low levels of internal migration, with net migration never amounting to more than 5% of the population at a decennial rate—as has been previously discussed by the literature (Silvestre, 2005).[9] Finally, in terms of external markets, at the end of the 19th century, (former) colonies and other Latin American markets played a particularly important role, while after the loss of the colonies Spain's exports shifted more towards European countries with France and Great Britain taking up the biggest share of exports (compare the right-hand side in Figure 4). Most of the exports were raw materials or agricultural products consistent with the low developmental status of Spain at the time as depicted on the left-hand side in Figure 4. In general, Spain ran a trade deficit for most of the beginning of the 20th century except for the short period under consideration in this paper.

[9]Explanations focus mainly on an insufficient release of agricultural workers to urban areas, driven either by supply-based factors—such as low agricultural productivity and demographic dynamism—or demand-based factors—such as the lack of pull of industry and services until at least WWI. Either explanation is perfectly consistent with the point of view that substantial push or pull factors were required to overcome the economic, linguistic, or sociological barriers that impeded spatial and sectoral mobility. For a complete discussion and references of demand-based and supply-based explanation see Section 2 in Silvestre (2005).

Figure 4. Top Export Sectors and Destinations (1910, 1915, 1916)



Notes: Aggregate exports (in million pesetas) by sector; aggregate exports (in million pesetas) by destination country. Exports reported for top seven sectors and top six destinations respectively according to their rank in 1915. The source data are the digitized product-destination level trade statistics, as discussed in the online appendix.

Data. To examine the impact of WWI on both trade flows and local labor markets, I construct a regionally disaggregated dataset for Spain between 1910–1920 that covers hand-collected information on wages, employment levels, prices, and exports across local labor markets. This dataset allows me for the first time to analyze the impact of the trade shock taking both external trade and internal labor reallocation into account.

I rely on six principal data sources that together describe manufacturing and agricultural employment, external trade, migration patterns, consumer prices, the transportation network, and the housing market.[10]

First, I obtain disaggregated information regarding wages and labor quantities across local labor markets. Digitizing historical surveys by the Ministry of Labor (Ministerio de Trabajo, 1927), I obtained wages and employment levels across 48 different provinces[11] and 23 different industries[12] for 1914, 1920, and 1925. Second, I augment this industry survey with additional data from the censuses to obtain and impute agricultural employment for the same years. Third, I digitized trade statistics for the years 1910–1919 and obtained quantity and values of exports across 383 product categories across 77 different destination countries. I also constructed a correspondence between product-level data and industry-level labor market data using an additional publication that lists the official correspondence

[10] See the online appendix for detailed information on references for data sources and details on data construction.

[11] The census for 1910 lists 49 different provinces. They mostly correspond to the modern administrative units called *provincias*—provinces—which are in turn roughly the NUTS3 level administrative units of Spain. There are some minor differences, e.g., in how different off-continental administrative units are being treated. For my analysis, I drop the Canary Islands from the sample since their distance from the mainland makes it hard to argue that they are similarly integrated as other provinces.

[12] The industries included are: Books, Ceramics, Chemicals, Construction, Decoration, Electricity, Food, Forest, Furniture, Garments, Glass, Leather, Metal Works, Metallurgy, Mines, Paper, Public, Public Industry, Textiles, Tobacco, Transport, Varias, Wood.

between industries and occupations (Instituto Nacional de Prevision Social, 1930). Fourth, I follow Silvestre (2005) and use the province-level data on inhabitants that are born in another province as published in the censuses to impute (net) migration flows between provinces. Fifth, I obtain detailed information on province-level consumer prices of key agricultural and non-agricultural goods from the bulletins of the Institute for Social Reforms (Gomez-Tello et al., 2018). Sixth, to obtain transportation cost within Spain and between Spain and France, I georeferenced the Spanish railroad network in 1920—as can be seen in Figure A.6—and then used Dijkstra's algorithm to obtain bilateral distances between provincial capitals along the shortest path of the railroad network. I also augment the graph with the French railroad network and impute the shortest distance to Paris. Mirroring the importance of Latin American destination markets, I include the location of Cuba in the transportation network and assign foreign trade—except for French trade—to that location. Finally, I compute the housing expenditure share as well as stock and rental rates from different statistical yearbooks.[13]

The WWI trade shock. In a first step, I examine the WWI trade shock through the lens of the trade records. The export shock was large from an aggregate point of view. In 1915, aggregate exports increased by 40% compared to 1914 and stayed at a high level for as long as the war lasted.[14]

Most of the increase was due to differential increase of belligerent countries compared to non-belligerent countries as shown in Figure 1: The trade to belligerent countries tripled, while trade with non-belligerent countries remained at a relatively low level and only grew in the later war years above pre-war levels. To examine this more formally, and to create confidence that the changes in aggregate exports were driven by changes in belligerent destinations and not by domestic confounding industry trends, I analyze the export data taken from the annual export statistics. Specifically, I run the following event study specification:

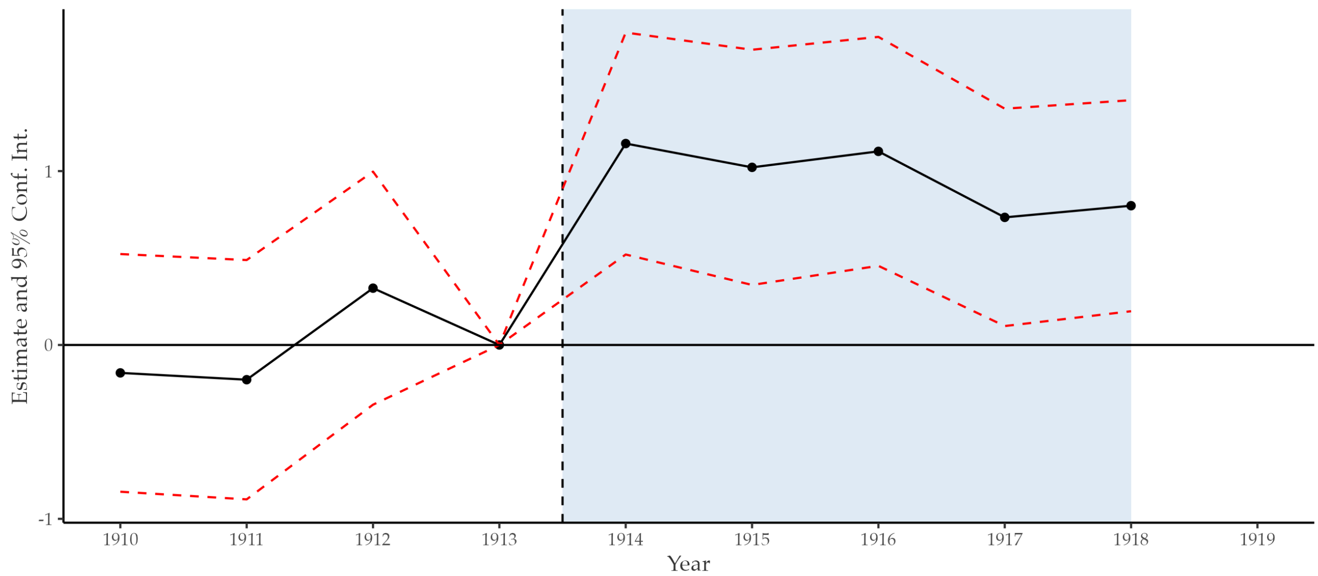
$$\log\left(X_{i,p,t}\right) = \sum_{t\neq 1913} \beta_t \times \text{Belligerent}_i + \mu_{i,p} + \mu_{t,p} + \varepsilon_{i,p,t} \tag{3}$$

where $X_{i,p,t}$ refers to the total value of Spanish exports at time t for product p to destination country i as reported in the annual publications, Belligerent_i is a dummy that takes a value of 1 for countries that participated actively in WWI throughout the war and where trade flows were not directly affected because of war-related spatial disturbances (this excluded Germany and Austria-Hungary from the group of belligerent countries—the frontline and maritime warfare disrupted transportation to these destinations). The interpretation of the time-varying coefficient β_t is the differential increase of exports to belligerent countries relative to the omitted year 1913. The equation indicates the most stringent specification with $\mu_{i,p}$ and $\mu_{t,p}$ being fixed effects that control unobserved heterogeneity at the destination-product level and year-product level respectively.

[13]See the online appendix for detailed information on references for data sources and details on data construction.

[14]This increase is probably underestimated since official statistics kept the price for the calculation of values of exported goods at a constant level during the decade under consideration, while it is plausible that increased demand further increased the price.

Figure 5. Belligerent Export Destinations



Notes: Figure plots the estimated coefficient on the dummy variable that indicates that a destination country is a belligerent country. The depicted coefficient corresponds to β_t in the regression equation above. The red dotted lines indicate 95% confidence intervals. The blue shaded area indicates the period of WWI. The source data are the digitized product-destination level trade statistics. More information on data construction can be obtained in the online appendix.

The WWI trade shock across sectors. In a second step, I inspect the sector-specific dynamics in the export data. As was previously shown, the raw data strongly indicates a shift away from primary goods towards manufactured goods, as is evident in Figure 4. However, it is not clear whether these changes in sectoral trade flows are driven by plausibly exogenous demand shifts or by confounding domestic industry trends.

In order to isolate the demand-side effects of war participation, I propose a simple regression that compares Spanish exports towards belligerent and non-belligerent countries, before and after the war, sector by sector, i.e.,

$$\log\left(X_{i,p,t}\right) = \sum_s \theta_s^1 \times \text{WWI}_t \times \text{Belligerent}_i + \beta_1 \times \text{WWI}_t \times \text{Belligerent}_i + \\ \beta_2 \times \text{WWI}_t + \beta_3 \times \text{Belligerent}_i + \mu_{i,p} + \mu_t + \varepsilon_{i,p,t} \tag{4}$$

where—as before—Belligerent_i is a dummy that takes a value of 1 for countries that participated actively in WWI throughout the war, WWI_t is a dummy that takes a value of 1 for the years in which the war took place. I include both the levels and the interactions of the dummy variables and estimate the sector-by-sector coefficient on exports to belligerent countries during the war years. The interpretation of the coefficient θ_s is the differential increase of exports in sector s to belligerent destinations during the war years relative to the pre-period. The indicated specification represents the most stringent one, with $\mu_{i,p}$ referring to a destination-product fixed effect that controls for heterogeneity in the export composition across destination countries, while μ_t represents a year fixed effect that controls for aggregate shocks.

As in the previous subsection, I present results with different sets of fixed effects. Column (1) is the most parsimonious specification with only product and year fixed effects. Concerns about the heterogeneity of export composition across destination countries and product categories interacting with product-specific trends is alleviated by introducing destination and destination-product fixed effects in Columns (2) and (3). As before, all specifications are being estimated using PPML to address concerns about bias from heteroskedasticity and zeros in the data (Silva and Tenreyro, 2006). Across specifications, there is a significant increase in exports to belligerent countries during the war period in key industries such as garments, leather, metallurgy, paper, textiles, and tobacco, and a decrease in books, public industry, and wood.[15]

Empirical strategy. I examine the impact of the trade shock on wages, labor allocations, and consumer prices. Specifically, I am using the yearly surveys of the Spanish government to examine the impact of the shock across sectors and regions within Spain as well as the consumer price database taken from a separate publication of the Institute for Social Reforms (Instituto de Reformas Sociales, 1923).

To examine the effect of the trade shock, I will construct three different measures of exposure at the region-sector level. These measures have a strong resemblance to shift-share instruments, where I use the sector-level estimates of the trade demand shock from the previous section as a proxy for aggregate sector-specific demand shifts and project them on local data by using the local sectoral employment share. I also construct indirect exposure measures that examine to what extent local wage responses in one's own sector depend on the strength of the shock across the remaining local sectors or alternatively close-by provinces. This estimation strategy is conceptually related to Helm (2020) and provides evidence to what extent labor supply is localized and—further—to what extent the concentration of the demand shock across geography and sector affected labor allocation, wage growth, and consumer prices.

Rewriting the reduced-form predictions of the theoretical model for wages from Equation (2) and labor from Equation (1) and introducing multiple sectors into the setup, we obtain the following,[16]

[15] As an alternative simpler specification, we can also estimate the aggregate sector-by-sector effect across all destination countries, i.e.,

$$\log\left(X_{i,p,t}\right) = \sum_s \theta_s^2 \times \text{WWI}_t + \beta_1 \times \text{WWI}_t + \mu_{i,p} + \mu_t + \varepsilon_{i,p,t} \tag{5}$$

This specification has the advantage that it captures more accurately the aggregate effect on sectoral exports and I will be using the coefficients of this regression to construct variables that determine local shock exposure. The Figure A.5 depicts the estimated coefficients and their 95 percent intervals. Detailed regression results can be found in Table A.5. Qualitatively, a similar pattern emerges while quantitatively the point estimates might differ. In general, these regressions indicate a trade demand shock that was quantitatively large and shifted the sectoral export composition consistent with the raw data presented in Figure 4 above.

[16] First, writing Equation (2) for multiple sectors, we obtain,

$$d\ln \ell_{i,s} \approx \beta_{ii,ss} \times d\ln e_{i,s} + \sum_{s'\neq s} \beta_{ii,ss'} d\ln e_{i,s'} + \sum_j \sum_{s'\neq s} \beta_{ij,ss'} d\ln e_{j,s'}$$

where we write more succinctly,

$$d\ln \ell_{i,s} \approx \beta_1 \times d\ln e_{i,s} + \beta_2 \times d\ln \tilde{e}_{ii,s'} + \beta_3 \times d\ln \tilde{e}_{j',s'}$$

and where $d\ln \tilde{e}_{ii,s'} \equiv \sum_{s'\neq s} \beta_{ii,ss'} d\ln e_{i,s'}$, and $d\ln \tilde{e}_{j',s'} \equiv \sum_j \sum_{s'\neq s} \beta_{ij,ss'} d\ln e_{j,s'}$. As illustrated in the previous section, the

$$\begin{pmatrix} d\ln \ell_{i,s} \\ d\ln w_{i,s} \\ d\ln p_{i,s} \end{pmatrix} \approx \beta_1 \times d\ln e_{i,s} + \beta_2 \times d\ln \tilde{e}_{ii,s'} + \beta_3 \times d\ln \tilde{e}_{j',s'}$$

where the first term simply approximates the direct incidence of the trade shock on sector-province outcomes. To construct this, we first approximate the direct incidence of the trade shock with the estimated sector-level exports during WWI as estimated in the previous section, i.e., $d\ln e_{i,s} \propto \theta_s^2$.

The second variable measures the exposure to the trade shock in other sectors within the same province, i.e., $d\ln \tilde{e}_{ii,s'}$. To approximate this, I construct a shift-share type exposure variable that measures to what extent a sector is exposed to the trade demand shock via increased labor demand by other sectors in the same province, where other sectors are weighted by their share in the local labor market, i.e.,

$$\text{Local Shock}_{i,s} \equiv \sum_{r \neq s} \pi_{r|i}^{1914} \text{Shock}_{i,s} \tag{6}$$

where $\pi_{r|i}^{1914}$ refers to the labor share of sector r in province i in the baseline year 1914. The third variable measures the exposure to the trade shock in other provinces, i.e., $d\ln \tilde{e}_{ij,s'}$, which I approximate by measuring the extent to which a sector is exposed to the trade demand shock via increased competition for labor from highly affected proximate provinces. To do so, I construct the following variable,

$$\text{Spatial Shock}_{i,s} \equiv \sum_{j \neq i} \frac{1}{\text{dist}_{ij}} \text{Local Shock}_{j,s} \tag{7}$$

which assumes a spatial decay elasticity of minus 1. I use these measures in an event-study regression design, where I estimate the effect of direct and indirect shock exposure as well as the distance to the French border on wages, labor allocations, and prices. We therefore obtain as our main specification, for wages and labor allocations, the following regression design,

$$\begin{aligned}\begin{pmatrix} \log\left(w_{r,s,c,t}\right) \\ \log\left(\ell_{r,s,c,t}\right) \end{pmatrix} =& \beta_1 \times \text{WWI}_t \times \log \text{DistanceParis}_r + \beta_2 \times \text{WWI}_t \times \text{Local Shock}_{r,s} + \\ & \beta_3 \times \text{WWI}_t \times \text{Spatial Shock}_{r,s} + \beta_4 \times \text{WWI}_t \times \text{Shock}_{r,s} + \\ & \beta_5 \times \text{WWI}_t + \beta_6 \times \text{Local Shock}_{r,s} + \beta_7 \times \text{Shock}_{r,s} + \\ & \beta_8 \times \text{Spatial Shock}_{r,s} + \mu_r + \mu_{c,s} + \varepsilon_{r,s,c,t}\end{aligned} \tag{8}$$

where on the left-hand side I either observe wages and labor allocations within each region-sector (r,s) across multiple types of labor (c) and for each year, i.e., $w_{r,s,c,t}$ and $\ell_{r,s,c,t}$. I enrich the model with an array of fixed effects at the industry, type, and region level. The fully saturated model incorporates region as well as interacted type-industry fixed effects.

reduced-form coefficients have structural interpretations in terms of labor demand and supply elasticities.

For consumer prices, I follow the slightly different specification,

$$\begin{aligned}\log\left(p_{i,p,u,m,t}\right) = & \beta_1 \times \mathrm{WWI}_t \times \log \mathrm{DistanceParis}_{\,r} + \beta_2 \times \mathrm{WWI}_t \times \mathrm{Local\ Shock}_r + \\ & \beta_3 \times \mathrm{WWI}_t \times \mathrm{Spatial\ Shock}_r + \beta_4 \times \mathrm{WWI}_t + \beta_5 \times \mathrm{Local\ Shock}_r + \\ & \beta_6 \times \mathrm{Spatial\ Shock}_r + \mu_{i,u} + \mu_{p,m} + \mu_t + \mu_{u,p} + \varepsilon_{i,p,u,m,t}\end{aligned} \tag{9}$$

where on the left-hand side I have prices which are given at the province (i), product (p), year (t), month (m) level with an additional distinction between rural areas and the capital city (u). I enrich the model with an array of fixed effects at the industry, type, and province level. The fully saturated model incorporates year as well as interacted province-capital, product-month, and capital-product fixed effects to absorb cross-sectional differences in consumer prices across different locations as well as seasonal effects. Notice that the local shock and spatial shock variables are not sector-specific anymore. Since the consumer prices are not matched to any particular sector, I instead construct the shock exposure variables as an aggregate local shock exposure variable and an indirect spatial shock exposure variable only. In each case, the coefficient of interest is the time-varying effect of distance to the French border, as well as the interaction of the direct and indirect shock measure with the war period. Identification relies on parallel (pre-) trends between highly affected local labor markets and less affected local labor markets.

Results. Table 1 reports the results for wages, labor allocations, and prices. For each dependent variable, I propose two different specifications, with the first column for each dependent variable always reporting the model including the full set of separate fixed effects, while the second column reports a more saturated specification with interacted fixed effects. For wages and labor allocations, industry, worker type, province, and industry-type fixed effects are included to control for unobserved cross-sectional differences across industries, worker types, and space. For consumer prices, separate year, province, capital, product, and month fixed effects are included to control for spatial and seasonal heterogeneity as well as time-varying aggregate shifts and product-specific time-invariant heterogeneity in prices. One might be concerned about product-level specific seasonal effects, which is why Column (6) introduces product-month fixed effects. Additionally, Column (6) also controls for richer spatial heterogeneity between rural and urbanized areas within provinces by adding a province-capital fixed effect as well as differences in the consumption basket between urbanized and rural areas, by introducing an additional capital-product fixed effect.

Discussion: Direct and indirect effects of trade shocks. The empirical evidence emphasizes the importance of accounting for both the direct exposure to the trade shock as well as the indirect exposure via the network linkages of local labor markets. The most striking picture is painted by the response of wages. Wages are increasing in the direct shock incidence, as measured by proximity to France. Both indirect shock exposure variables have significant and strong positive effects on wage growth also. This

Table. 1. Direct and Indirect Effect on Wages, Labor Allocations and Prices

	Log Wages of Workers in Industry-Region pairs (1908-1919)		Log Number of Workers in Industry-Region pairs (1908-1919)		Log Consumer Prices (Pesetas,1910-1919)	
	(1)	(2)	(3)	(4)	(5)	(6)
WWI Period	0.1450 (0.2831)	0.1211 (0.2634)	-1.292 (1.716)	-1.504 (1.380)		
Local Indirect Shock	-0.2653 (0.3152)	-0.3282 (0.2782)	-9.567*** (1.786)	-9.930*** (0.9937)		
Spatial Indirect Shock	0.6513* (0.3821)	0.5872 (0.3632)	7.536*** (2.212)	7.155*** (1.474)		
WWI Period × Log Distance to France	-0.0907*** (0.0346)	-0.0875*** (0.0321)	0.0146 (0.2071)	0.0530 (0.1662)	-0.0373** (0.0166)	-0.0401** (0.0162)
WWI Period × Direct Shock	0.0612*** (0.0145)	0.0647*** (0.0118)	0.2704*** (0.0861)	0.2833*** (0.0581)		
WWI Period × Local Indirect Shock	0.8573*** (0.0980)	0.8563*** (0.0942)	1.870*** (0.5603)	1.871*** (0.4623)		
WWI Period × Spatial Indirect Shock	0.4470*** (0.0666)	0.4471*** (0.0634)	0.7436** (0.3454)	0.6609** (0.2756)	-1.362*** (0.5276)	-1.228** (0.5184)
WWI Period × Local Shock					2.615** (1.081)	2.786** (1.104)
R^2	0.72344	0.74708	0.45830	0.62402	0.93307	0.93729
Observations	6,454	6,454	6,700	6,700	32,147	32,147
Pseudo R^2	0.89268	0.95474	0.14380	0.22947	0.87174	0.89271
Industry fixed effects	✓		✓			
Gender fixed effects	✓		✓			
Region fixed effects	✓	✓	✓	✓		
Gender-Industry fixed effects		✓		✓		
Year fixed effects					✓	✓
Province fixed effects					✓	
Capital fixed effects					✓	
Product fixed effects					✓	
Month fixed effects					✓	
Province-Capital fixed effects						✓
Capital-Product fixed effects						✓
Product-Month fixed effects						✓

Notes: Table shows the combined regression results for Equations (8) and (9). In Columns (1) and (2), observations are average daily wage rates for female and male workers across province-industry pairs between 1908 and 1919. In Columns (3) and (4), observations are reported numbers of female and male workers across region-industry pairs between 1908 and 1919. In Columns (5) and (6), observations are average reported prices (in pesetas) at the product-province-month level, separately for rural and urban areas (i.e. capital city of each province), between 1910-1919. WWI Period is a dummy variable that takes the value of 1 for the duration of the war, i.e. 1914-1918. Direct shock, local indirect shock and spatial indirect shock as defined in (6) and (7). Log distance to France is the shortest distance to Paris along the Spanish and French railroad network (as explained in Section F.2), originating from either provincial or region capital cities. The data sources for Column (1) through (4) are the yearly surveys of the Spanish government and the source for the consumer prices are the separate publications by the Institute for Social Reforms (as explained in Section F.2). In parantheses (heteroskedasticity) robust standard errors are being reported: *** for 1 percent significance; ** for 5 percent significance; * for 10 percent significance. The regressions are estimated by using the feols command of the fixest package in R. Additional information on data digitization and construction is available in the online appendix.

suggests a quantitatively strong impact of localized competition for workers inducing substantial wage increases. This is similarly mirrored in the spatial tilt in the dynamics of consumer prices with provinces further south experiencing less of a price increase during the war years.

The evidence on labor allocation is a bit more nuanced. Most importantly, no spatial tilt can be detected. Despite a significant spatial bias in wage growth, there seems to be little evidence for additional spatial migration during this period, consistent with an interpretation that spatial mobility was highly inhibited during the period as previously shown by Silvestre (2005). However, direct local shock exposure has a positive and significant effect on labor allocations, indicating that affected sector-regions managed to attract additional workers. Interestingly, indirect local shock exposure is a positive contributing factor, possibly consistent with the interpretation that localized migration within regions across provinces can be induced both by the attractiveness of sector-region, but also by the spatial unit overall.

Overall, the direct and indirect effects across space and sectors indicate a nuanced picture on labor allocations, wage growth, and price inflation, with possibly first-order implications for the welfare consequences of this trade shock. To study the welfare consequences of this trade shock taking both the direct and indirect effects of trade shocks into account, I adopt a more structural approach in the next section.

Notice furthermore, that since the reduced-form parameters have a structural interpretation, we can directly read off from the coefficients the implied labor supply elasticities across sectors and wages. Comparing the wage and labor allocation effect, we find that the implied labor supply elasticity across sector corresponds to a value of 4.48. However, the aggregation of the data here—which is at the region level rather than at the province level—makes it difficult to determine the spatial labor supply elasticity. Nevertheless, the spatial indirect effects are directly related to the spatial labor supply elasticity and imply a value of 1.478.

4 Quantitative Model

I introduce a quantitative framework to capture both the direct and indirect effects of trade shocks on local labor markets. This is done by extending and parameterizing the general model from Section 2. The extension involves a tractable characterization of imperfect labor mobility across both space and sectors, incorporating both domestic and foreign trade.[17]

4.1 Quantitative Model of Trade with Connected Labor Markets

Setup. Consider a set of locations within a country, denoted by $n, i, j, h \in \mathbb{D} = \left\{1, \ldots, N^D\right\}$, and a set of foreign locations, denoted by $k, l, m \in \mathbb{F} = \left\{1, \ldots, N^F\right\}$. Domestic locations vary in their exogenously fixed housing supply, H_i, and their geographical positions relative to each other. The only factor of production is labor. Production occurs across multiple sectors $r, s, t \in \mathbb{S} = \{1, \ldots, S\}$. The model considers two periods. The initial distribution of workers across locations, $[\ell_{n,r}]_{\forall (n,r) \in \mathbb{D} \times \mathbb{S}}$, is given, while the distribution of workers in the second period, $[\ell'_{n,r}]_{\forall (n,r) \in \mathbb{D} \times \mathbb{S}}$, is endogenously determined.

Parameterization. The general model from Section 2 is parameterized by specifying assumptions on labor supply, $\ell_{i,S}(w_1, \ldots, w_N, \Omega)$, and labor demand, $\ell_{i,D}(w_i, e, \Omega)$. Labor demand follows a standard demand system with fixed Cobb-Douglas expenditure shares between housing (δ) and non-housing consumption. There are also fixed Cobb-Douglas expenditures between sectors (α_r) and a constant elasticity of substitution between both foreign and domestic locations within sectors, subject to an elasticity of substitution σ_r. Thus,

$$\ell_{(i,r),D}\left(w_{1,1}, \ldots, w_{N,S}, e_{1,1}, \ldots, e_{N,S}\right) = \frac{1}{w_{i,r}} \left(\sum_{n=1}^{N^D} s_{ni,r} \left(\sum_{r=1}^{S} e_{n,r} \ell_{n,r} \right) + \sum_{l=1}^{N^F} s_{li,r} e_l \right), \tag{10}$$

[17] Detailed derivations are provided in the online appendix.

where $s_{ni,r} = \alpha_r (1-\delta) p_{ni,r}^{1-\sigma_r} P_{n,r}^{\sigma_r - 1}$ represents the sectoral (r) expenditure share on imports from location i, and $e_{n,r}$ denotes the total disposable income of households in location n and sector r. The price index $P_{n,r}$ is the standard CES price index defined over both domestic and foreign locations. Labor supply is defined as an iso-elastic sequential spatial and sectoral choice. The total labor supply to a location is given by:

$$\ell'_{(i,s),S}\left(w_{1,1}, \ldots, w_{N,S}\right) = \sum_{r=1}^{S} \sum_{n=1}^{N} \sigma_{ni,rs} \ell_{n,r}, \tag{11}$$

where the spatio-sectoral labor supply choice, $\sigma_{ni,rs}$, is specified as a sequential stochastic choice. Workers first make a geographical relocation choice from location n to location i and subsequently a sectoral relocation choice from an initial sector r to another sector s. Both the geographical and sectoral reallocation choices are subject to variable geographical and sectoral migration costs, μ_{ni} and μ_{rs}, respectively. Due to the properties of the Frechet distribution and the sequencing of the reallocation choice, labor flows between location n and location i and between sector r and s are multiplicatively separable:

$$\sigma'_{ni,rs} = \sigma'_{ni|r} \sigma'_{rs|i}, \tag{12}$$

where $\sigma_{ni|r}$ is the share of workers originating from sector r in location n who reallocate to location i, and $\sigma_{rs|i}$ is the share of workers who, conditional on choosing location i, relocate from sector r to sector s. The solution is presented by solving backwards. First, conditional on having chosen location i, the probability of relocating from sector r to sector s can be written as:

$$\sigma'_{rs|i} = \frac{(w'_{is|r})^{\nu}}{\left(\Pi'_{i,r}\right)^{\nu}}, \tag{13}$$

where ν is the dispersion parameter of the sector-specific preference shock, $w'_{is|r} \equiv w'_{is}/\mu_{rs}$ is the wage adjusted by the mobility cost, and $\Pi'_{i,r} \equiv \left(\sum_t (w'_{it|r})^{\nu}\right)^{1/\nu}$ is the option value of a worker conditional on having chosen location i and being initially attached to sector r. Before making the sectoral relocation choice, the worker makes a geographical choice by comparing the option values of sectoral reallocation across geographical locations. The geographical reallocation share takes the following closed-form expression:

$$\sigma'_{ni|r} = \frac{\left(v'_{ni|r}\right)^{\gamma}}{\left(\Omega'_{n,r}\right)^{\gamma}}, \tag{14}$$

where γ is the dispersion parameter of the location-specific preference shock, and $v'_{ni|r}$ is the expected utility of moving from location n to location i, conditional on initial attachment to sector r.[18] Finally, $\left(\Omega'_{n,r}\right)^{\gamma} \equiv \sum_j \left(v'_{nj|r}\right)^{\gamma}$ represents the option value of the geographical choice. Labor market clearing

[18] The expected ex-ante utility, i.e., prior to observing and forming expectations over the sectoral preference shocks, that an individual derives from moving from location n to location i can be expressed in terms of the option value of being in that location-sector $\Pi'_{i,r} \equiv \left(\sum_t (w'_{it}/\mu_{rt})^{\nu}\right)^{1/\nu}$, multiplied by a stochastic location-specific preference shock κ_i, and adjusted by

determines the equilibrium of this economy:

$$\ell_{(i,s),S}\left(w_{1,1},\ldots,w_{N,S}\right)=\ell_{(i,r),D}\left(w_{1,1},\ldots,w_{N,S},e_{1,1},\ldots,e_{N,S}\right), \tag{15}$$

which is equivalent to the goods market clearing condition in standard trade or economic geography models. The model also requires a balanced trade condition:

$$\left(\sum_{r=1}^{S} e_{n,r}\ell_{n,r}\right)=\sum_{r=1}^{S}\left(\sum_{i=1}^{N} s_{ni,r}\left(\sum_{r=1}^{S} e_{n,r}\ell_{n,r}\right)+\sum_{l=1}^{N^F} s_{nl,r}\left(\sum_{r=1}^{S} e_{n,r}\ell_{n,r}\right)\right), \tag{16}$$

as well as a housing market clearing condition:

$$H_n r_n=\delta\left(\sum_{r=1}^{S} e_{n,r}\ell_{n,r}\right), \tag{17}$$

where r_n is the rental rate in the housing market and H_n is inelastically supplied.

Sufficient Statistic for Welfare Gains with Connected Labor Markets. To construct a measure of aggregate welfare that accounts for reallocation, I assume that, rather than the initial allocation being fixed, workers receive a location-specific extreme value distributed preference shock that generates and matches the observed allocation of workers across space, as in the canonical quantitative spatial equilibrium model in Redding (2012). The welfare measure focuses on the ex-ante expected utility in the second period while considering the initial allocation of workers in the first period. Given that this initial allocation arises from an EV1 allocation problem, we can construct an aggregate welfare formula. The welfare expression corresponds to the expected utility for a worker across all possible locations and sectors:

$$\mathscr{W}\equiv E\left(\Omega_{n,r}\right)=\delta\left[\sum_{n=1}^{N^D}\sum_{r=1}^{S}\left(\tilde{\rho}_{n,r}\Omega_{n,r}\right)^{\epsilon}\right]^{1/\epsilon},$$

where $\delta=\Gamma\left(\frac{\epsilon}{\epsilon-1}\right)$ and $\Gamma(\cdot)$ is the gamma function. Additionally, $\tilde{\rho}$ is an amenity shifter chosen to fit the distribution of the population across space and sectors. By totally differentiating the welfare expression, integrating for small changes, and solving for the required option values of spatial and sectoral reallocation, we obtain:

$$\left(\frac{\mathscr{W}^1}{\mathscr{W}^0}\right)=\prod_{n=1}^{N^D}\prod_{r=1}^{S}\left(\underbrace{\left(\frac{\sigma^1_{nn|r}}{\sigma^0_{nn|r}}\right)^{-\frac{1}{\gamma}}}_{\text{Spatial Flows}}\underbrace{\left(\frac{\sigma^1_{rr|n}}{\sigma^0_{rr|n}}\right)^{-\frac{1}{\nu}}}_{\text{Sectoral Flows}}\underbrace{\left(\frac{r^1_n}{r^0_n}\right)^{-\delta}}_{\text{Housing Cost}}\underbrace{\prod_{t=1}^{S}\left(\frac{s^1_{nn,t}}{s^0_{nn,t}}\right)^{-\frac{(1-\delta)\alpha_t}{\sigma_t-1}}}_{\text{ACR Gains}}\right)^{\pi_{n,r}}, \tag{18}$$

variable geographical migration cost, μ_{ni}, i.e.

$$v'_{ni|r}\equiv\frac{\delta_i}{\mu_{ni}}\frac{\rho_i\Pi'_{i|r}}{\left(p'_i\right)^{1-\delta}\left(r'_i\right)^{\delta}}\times\kappa_i,$$

where p'_i refers to the price index in location i, r_i refers to the rental rate in the housing market, and δ_i is a location-specific amenity shifter while μ_{ni} is the bilateral spatial migration friction.

where $\sigma^1_{nn|r}$ represents the share of workers initially located in province n and working in sector r who decide to remain in that province, and $\sigma^1_{rr|n}$ represents the share of workers who, in the second period, are located in province n, were initially attached to sector r, and decide to remain in sector r. Intuitively, if more workers decide to either change their sector or their location, it suggests that the option value of a spatial or sectoral change has increased relative to the option to remain. In other words, the remain share (to the power of the negative inverse of the labor supply elasticity) is proportional to changes in the option value and is therefore a sufficient statistic for welfare changes arising from a worker's ability to reallocate. The final two terms capture the static gains from changes in real income across locations, represented by changes in the housing cost and the consumer price index, which can be captured by changes in the expenditure share on locally produced goods.[19] Therefore, given data on trade flows, labor flows, rental rates, and aggregate deficits, we can construct aggregate welfare gains. Furthermore, the formula is log-linear and can easily be decomposed into gains arising from spatial or sectoral reallocation—these are the *dynamic gains from reallocation*—or, alternatively, through the more traditional channel of changes in trade openness.

4.2 Calibration

Given the parameterization I will introduce below, there are 5 global parameters that determine the substitution in the goods market, the housing expenditure share and the elasticity of spatial and sectoral labor supply, $\{\sigma, \delta, \nu, \gamma, \zeta\}$, as well as $2S$ sector-specific parameters that determine sector-specific expenditures and sectoral mobility, $\{\alpha_r, \mu_r\}$, and $3N^D$ province-specific parameters that determine spatial mobility and province-specific mobility out of agriculture $\left\{\rho_n, \zeta_n, \mu_{agri,n}\right\}$, and $N^D \times S$ location-sector specific fundamentals $\{z_{nr}\}$. The foreign sector is calibrated using external trade directly, which corresponds to a set of endowments and sectoral expenditure shares, $\left\{e_l, \alpha_{l,r}\right\}$. An overview of the full set of parameters and their respective calibration method is given in Table 2. The calibration proceeds in four steps.

[19]The online appendix Section G.4 provides detailed derivations.

Table. 2. Parameter Values and Estimation Method

Panel A: Parameters

Parameter	Value	Method
Utility function		
Elasticity of Substitution, σ	3.63	2SLS Estimation (Table A.2)
Sectoral Expenditure Shares, α_r	-	Imputed
Housing Expenditure Share, δ	0.33	Imputed
Location-specific amenity shifter, ρ_n	See Table A.8	Jointly Estimated
Production function		
Sector-Location Productivity (1914), $z_{i,r}$	-	Inversion using equilibrium equations
Reallocation choice		
Migration Distance Elasticity, $\zeta \times \nu$	-1.45	Migration Gravity Results (Table A.1)
Mean Outgoing spatial migration cost shifter, ζ_n	2.80	Migration Gravity Results (Table A.1)
Province-specific Outgoing spatial migration cost shifter, ζ_n	See Table A.8	Match own-migration share in BAP data
Sector-specific dispersion parameter, γ	4.48	Implied by Table 1
Province-specific dispersion parameter, ν	1.478	Implied by Table 1
Agricultural out-migration cost, $\mu_{Agri,n}$	See Table A.8	Jointly Estimated
Sectoral in-migration cost, μ_r	See Table A.7	Jointly Estimated
Transport Cost		
Domestic distance elasticity, θ	-1.769	Reduced-form (Table A.3)
Foreign Trade		
Foreign expenditures, $\{e_l, \alpha_{l,r}\}$		Foreign Trade Statistics

Panel B: Joint Estimation

Target Moment for Joint Estimation	Model and Data Moment
Full set of Province-Sector Labor Allocations	See Figure A.1 for provincial employment fit
$\left(\eta_{i,s} \equiv L_{i,s}^{1920} - \widehat{L}_{i,s}^{1920}\right)$	See Figure A.2 for sectoral employment fit

The table provides a summary of the model's parameterization and estimation process. Five parameters—elasticity of substitution, spatial labor supply elasticity, migration distance elasticity, and domestic distance elasticity—are estimated separately using reduced-form estimations and two-stage least squares (2SLS). The remaining parameters are estimated jointly by matching the province-sector labor allocations before and after the war, as explained below. Panel A shows the parameters, their estimated values, and the methods used for estimation. Panel B presents the moments used for the joint estimation and references the figures that summarize the model's overall fit.

Domestic trade costs. To estimate domestic trade costs I examine the spatial incidence of the trade shock on wages across Spanish local labor market by estimating the following non-linear event study,[20]

$$\log\left(w_{r,s,c,t}\right) = \sum_{t \neq 1914} \beta_t \times \left(\frac{dist_{lr}^{\theta}\pi_i}{\sum_{n=1}^{N^D} dist_{ln}^{\theta}\pi_n}\right) + \mu_{r,c} + \varepsilon_{r,s,c,t} \tag{19}$$

[20]To do so I derive a structural reduced form from the model. Differentiating the goods market clearing condition (15) and substituting to what extent market shares deviate from hypothetical market share of a location in the absence of domestic frictions, one can characterize the impact of an increase in foreign expenditures ($d\ln e_l \neq 0$) on domestic locations taking domestic trade costs into account. In order to derive this, define the hypothetical market share of a location in the absence of domestic frictions as,$\tilde{s}_i = \frac{p_i^{1-\sigma}}{\sum_{n=1}^{N^D} p_n^{1-\sigma}}$. Notice that I can now derive the deviation from this hypothetical market share that is due

where on the left-hand side I observe wages within each region-sector (r,s) across multiple types of labor (c) and for each year, i.e. $w_{r,s,c,t}$. I utilize the direct and indirect shock exposure variables as well as the distance to the French border to determine the driving forces of direct and indirect wage pressures. The coefficient of interest is the time-varying effect of distance to the French border, as well as the interaction of the direct and indirect shock measure with the war period. Identification relies on parallel (pre-) trends between highly affected local labor markets and less affected local labor markets. The parameter of interest is the distance elasticity θ, which measures the distance effect on trade flows within the domestic economy. I enrich the model with region-type fixed effects to control for cross-Sectional heterogeneity of wages across locations and worker types. The final expression can be compared to Autor, Dorn and Hanson (2013): It measures the local exposure to changes in external demand as a function of difference in geographical position of different locations and their productivity, as a approximated by their share of the domestic industry. The point estimate is $\theta = 1.77$, which is consistent with the estimate by Wolf (2009) for intra-national trade flows via railroads in Germany during the same time period. The full results are presented in Table A.3.

Trade elasticity. I exploit the differential impact of the trade shock across locations and sectors to estimate the elasticity of substitution. The estimation proceeds in two steps: First, I invert the equilibrium conditions to obtain market share shifters, which themselves are functions of the the location-sector specific fundamentals, $\{z_{ni}\}$, that rationalize the equilibrium distribution of labor payments. Specifically, I obtain factor prices adjusted to the demand curvature. Combining the market clearing condition (10) and the balanced trade condition (30) we can obtain a system of equations in terms of prices only,

$$\left(p_{is,t}\right)^{\epsilon_s} = \sum_{n=1}^{N^D} \tau_{ni}^{-\epsilon_s} \left(\sum_{k=1}^{N^D} \tau_{nk}^{-\epsilon_s} \left(p_{ks,t}\right)^{-\epsilon_s} \right)^{-1} s_{nD,t} \frac{e_{ns,t}}{y_{is,t}} + \sum_{l=1}^{N^F} \tau_{li}^{-\epsilon_s} \left(\sum_{k=1}^{N^D} \tau_{kj}^{-\epsilon_s} \left(p_{ks,t}\right)^{-\epsilon_s} \right) \frac{e_{ls,t}}{y_{is,t}}$$

where $\left(p_{is,t}\right)^{\epsilon_s}$ refers to the origin prices introduced above. Standard results in economic geography imply that this equation can be solved to find the unique vector of provincial origin prices (up to normalization) for each sector, $\{p_{is,t}^{\epsilon_s}\}$, as employed by Allen and Donaldson (2020).

In a second step, I can use the assumption of marginal cost pricing, i.e. $p_{i,r} = \frac{w_{i,r}}{z_{i,r}}$, to obtain a log-linear expression of prices as a function of sector-province employment levels and wages, i.e.

$$\epsilon \log p_{i,r,t} = \mu_{i,r} + \mu_{r,t} + \epsilon \log w_{i,r,t} - \log z_{i,r,t} \tag{20}$$

to trade costs, as, $\frac{s_{li}}{\tilde{s}_i} = (\tau_{li})^{1-\sigma} \times \left(\sum_{n=1}^{N^D} \tau_{ln}^{1-\sigma} \tilde{s}_n\right)^{-1}$. We obtain,

$$d \ln y_i = \sum_{l=1}^{N^F} \frac{e_l}{y_i} \left(\frac{(\tau_{li})^{1-\sigma} \tilde{s}_i}{\sum_{n=1}^{N^D} \tau_{ln}^{1-\sigma} \tilde{s}_n} \right) d \ln e_l \approx \sum_{l=1}^{N^F} \frac{e_l}{y_i} \left(\frac{dist_{li}^{\theta} \pi_i}{\sum_{n=1}^{N^D} dist_{ln}^{\theta} \pi_n} \right) d \ln e_l$$

where in the final step we can empirically approximate the hypothetical market shares with the observed labor share of that location and trade costs are approximated with the inverse of distance along the transportation network and where $\pi_n = \ell_n / \bar{\ell}$ is the share of workers in a given location, θ is the domestic trade elasticity.

where relative changes in origin-prices of sector s in province i, $\frac{p_{is,t+1}}{p_{is,t}}$, are a function of relative changes in wages and employment levels in that sector-province. The responsiveness of origin prices with regard to wages is pinned down by the trade elasticity, $\epsilon \equiv \sigma - 1$. We can define the structural residual as $\eta_{i,s,t} \equiv \log z_{i,r,t}$, which traces the unobserved productivity evolution at the sector-province level. Additionally, I include the full set of province-industry as well sector-year fixed effects. The former control for unobserved cross-sectional heterogeneity and effectively translate the regression into a panel estimation, while the latter control for sector-year specific demand shocks as well as differences in the normalization in each year that is being induced by the procedure in the previous subsection, where prices are only identified up-to-scale.

To overcome endogeneity issues[21], I will exploit the features of the natural experiment to estimate the model. Specifically, I will be using the four measures of direct and indirect exposure, three of which are the previously constructed measures that determine to what extent a location is directly or indirectly affected by the WWI trade demand shock: Recall that the first measure in Equation (6) simply consitutes the log change in sector-level exports during WWI as estimated in the previous section. The second variable in Equation (6), constructs a shift-share type local exposure variable that measures to what extent a sector is exposed to the trade demand shock via increased labor demand by other sectors in the same province. Finally, the variable from Equation (7) measures to what extent a sector is exposed to the trade demand shock via increased competition for labor via highly affected proximate provinces. I will also exploit the spatial incidence of the shock, as proxied by the distance to Paris. The demand shock increases labor demand and therefore exerts wage pressure.

Columns (2) through (4) in Table A.2 indicate the results for the 2SLS. While Column (2) suffers from a weak first stage, indicated by a low F-Stat, Column (3) and (4) provide comparable stronger results. Given the better first stage performance of the specification in Column (3), I choose this estimate to calibrate the model in the simulations, which implies a $\sigma = 3.63$.

Migration costs. I estimate geographical reallocation frictions by exploiting the additional information on geographical mobility provided provided in the census. I run a gravity regression using the information in the censuses on the number of workers who live in a certain province but were born in another province, that is BAP^t_{ni} for a worker who was born in province i but now lives in province j. Additionally, a gross

[21] A natural concern is the endogeneity of wages, $w_{i,s}$. The model implies that as a result of increases in productivity, $\frac{z_{is,t+1}}{z_{is,t}} > 0$, labor demand will increase and move along the upward sloping labor supply curve, with increases in wages and employment levels as a result. This implies that the model structure indicates a positive correlation between the residual, $\eta^t_{i,s}$, and the wages and employment levels, which will in turn induce a downward bias for the estimation of ϵ_s. The naive OLS results depicted in Table A.2 shows theoretically invalid negative trade elasticities, consistent with the model implied bias. An instrument is therefore necessary to remedy the situation. The exclusion restriction for any instrument is given by,

$$E\left[(\eta_{i,s,t} - \eta_{i,s,t})|\mathbf{z}_t\right] = E\left[\log \frac{z_{is,t+1}}{z_{is,t}}|\mathbf{z}_t\right] = 0$$

where $\mathbf{z}_t$ denotes the vector of instruments and $(\eta_{i,s,t} - \eta_{i,s,t}) = \log \frac{z_{is,t+1}}{z_{is,t}}$ denotes the structural error of the panel regression.

measure can be constructed. The difference in this stock of foreign born workers, $BAP_{i,j}^{t} - S \times BAP_{i,j,t-1}$ - adjusted for survivability rate S as explained in Section F.2 - is informative about the net inflow of foreign born workers, either directly from the province under consideration or indirectly from other provinces. The data is adjusted so that the 1920s data shows the same number of total inhabitants born in a given province as the 1930s data, adding the additional population in their origin provinces. Parameterizing the spatial reallocation cost as,

$$\mu_{ni} = \zeta_n^1 \times \zeta \times distance_{ni}^{\zeta^2}$$

where ζ_i^1 determines the outgoing migration share for each province, ζ determines the average outgoing migration share across all provinces, and ζ^2 determines the sensitivity of migration shares with regard to distance between provinces.

$$\log \ell_{ni,t} = \gamma_n + \delta_i + \beta_1 \log \text{dist}_{ni} + \beta_2 \text{Stay}_{ni,t} + \epsilon_{ni,t} \tag{21}$$

where $\text{Stay}_{ni,t}$ takes on a value of 1 if the origin province is the same as the destination province. Table A.1 presents the results for the data in 1920, 1930, and gross flows all estimated using pseudo poisson maximum likelihood (ppml). Column (4) implements the multinomial pseudo maximum likelihood estimator (Sotelo, 2019) that is robust towards differences in the absolute level of migration flows across outgoing provinces. Across all specifications, conditional on migrating distance is an important determinant with the distance elasticity given by $\beta_1 = \zeta_2 \times \nu \in [-1.434, -1.455]$.

Sectoral migration costs. In order to estimate sectoral switching costs, I fit the model to changes in labor market conditions at the province-sector-level from before to after the war. A key concern is that migration decisions were made during the war based on wage dynamics that are not part of the available data. In order to estimate the remaining parameters that are consistent with the labor allocations after the end of the war and wage dynamics induced by the export shock during war, I proceed in two steps. In a first step, given data for 1914, that is wages $[w_{n,r}]_{\forall(n,r)\in\mathbb{D}\times\mathbb{S}}$, labor allocations $[\ell_{n,r}]_{\forall(n,r)\in\mathbb{D}\times\mathbb{S}}$, fixed housing supply $[H_n]_{\forall n\in\mathbb{D}}$, external demand $[e_{l,r}]_{\forall(l,r)\in\mathbb{F}\times\mathbb{S}}$, the national external trade deficit $\bar{d}'$, a parameterization of domestic and foreign trade costs, i.e. $[\tau_{ni}]_{\forall(n,i)\in\mathbb{D}x\mathbb{D}}$ and $[\tau_{nl}, \tau_{ln}]_{\forall(n,l)\in\mathbb{D}x\mathbb{F},\forall(l,n)\in\mathbb{F}x\mathbb{D}}$ respectively, the cross-sectional market clearing condition (10) and the balanced trade condition (30) give rise to an excess demand system that can be solved to obtain the unique (up-to-scale) set of productivities that rationalize the equilibrium in 1914, $[z_{n,r}^{1914}]_{\forall(n,r)\in\mathbb{D}\times\mathbb{S}}$. In a second step, with the baseline productivities in hand, I feed in the average external trade levels between 1915 and 1916, and given a guess for the parameter vector, $\boldsymbol{\beta}$, and solve for the fixed point that generates mobility patterns that are consistent with market clearing wages during the war, i.e.

$$\widehat{L}_{i,s}^{1920} = \sum_{n,r} \sigma_{ni,rs}^{1914\rightarrow 1920} \left(\mathbf{w}^{\text{WWI}} \left(\widehat{L}_{i,s}^{1920} \right) \right) L_{n,r}^{1914}$$

where $\widehat{L}_{i,s}^{1920}$ refers to the estimated stock of workers in province i and sector s in 1920, and $L_{n,r}^{1914}$ refers to the observed size of industry r and province j, and $\sigma_{ni,rs}^{1914\rightarrow 1920} \left(\mathbf{w}^{\text{WWI}} \left(\widehat{L}_{i,s}^{1920} \right) \right)$ is the closed form for migration flows between province n to province i and sector r to sector s.[22] The optimization problem is then given by,

$$\hat{\boldsymbol{\beta}} = \arg\min_{\beta \in B} \boldsymbol{\eta}(\boldsymbol{\beta})' \boldsymbol{\eta}(\boldsymbol{\beta})$$

where $\boldsymbol{\eta}$ is the stacked vector of structural errors, $\eta_{i,s}(\boldsymbol{\beta}) = L_{i,s}^{1920} - \widehat{L}_{i,s}^{1920}$. In the quantitative model presented in the previous section, I introduced a general set of sector-to-sector bilateral switching costs (i.e. μ_{rs}). The relatively aggregated nature of the data makes the estimation of the full set of parameters infeasible. Instead, I estimate a destination specific adjustment costs in the spirit of Kambourov (2009) for all sectors except for agriculture which has an origin and destination specific switching cost. This captures both the idea that in order to switch from agriculture to manufacturing a relocation within provinces to urbanized areas is necessary. It also quantitatively performs better, since the parameter allows us to pin down the strength of flows from agriculture to all other manufacturing sectors in a tractable way - a quantitatively important flow to rationalize the labor flows in the period.

By implication, the structural procedure then chooses $\boldsymbol{\beta} = (\mu_{ag,1}, \ldots, \mu_{ag,n}, \mu_2, \ldots, \mu_S)$ to minimize the distance between the observed and the estimated employment size of each sector-province observation. With spatial frictions being calibrated to the values obtained in the previous subsection, the size of the sectoral switching cost, μ_s, is informed by the persistence of sectoral employment size in the presence of local wage disparities between sectors. An important caveat is that sectoral switching costs can only be identified in a scenario where workers do not reallocate despite a positive wage differential.

The results of the migration cost estimation are reported in the online appendix: Geographical switching cost is presented in Table A.8 while sectoral switching cost is presented in Table A.7. Spatial frictions are prohibitively high implying low levels of internal migration with only 24pc of the reallocations taking place spatially. Finally, labor is highly sticky, with a high degree of heterogeneity across sectors. Agriculture as a sector tends to be especially sticky across all provinces with a high degree of heterogeneity, nevertheless absolutely speaking agriculture releases most of the labor. This is to say that wage differentials are so large that high switching costs are necessary to justify the lack of mobility.

The results for the spatial and sectoral labor supply elasticities are imputed from the reduced-form results in Table 1 and calibrated to these values throughout the fitting procedure. As discussed previously, the results imply a spatial labor supply elasticity (ν) of 1.48 and a sectoral labor supply elasticity (γ) of 4.48. In general, the literature provides few estimates for the migration elasticity with some work in the context of developing countries suggesting relatively low values between 2 and 4 (Bryan and Morten, 2019; Morten and Oliveira, 2018; Tombe and Zhu, 2019). These estimates are broadly consistent with those estimates, but point towards the differential importance of spatial compared to sectoral mobility.

[22]Recall that,

$$\sigma_{ni,rs}^{1914\to1920}\left(\mathbf{w}^{\mathrm{WWI}}\left(\widehat{L}_{i,s}^{1920}\right)\right) = \sigma_{ij|r}^{1914\to1920}\sigma_{j,s|r}^{1914\to1920}$$

that is the bilateral migration flows between sectors and provinces is a composite between outgoing migration between province i and province j in sector s and workers who upon arrival in province i sort into sector r.

The model is fitted to match both provincial population numbers and aggregate sectoral numbers. The model is sufficiently saturated to fit the observed data well on these dimension as can be seen by Figures A.1 and A.2 in the appendix. These figures compare the predicted sectoral and provincial employment numbers to the observed data in 1920.

4.3 Results

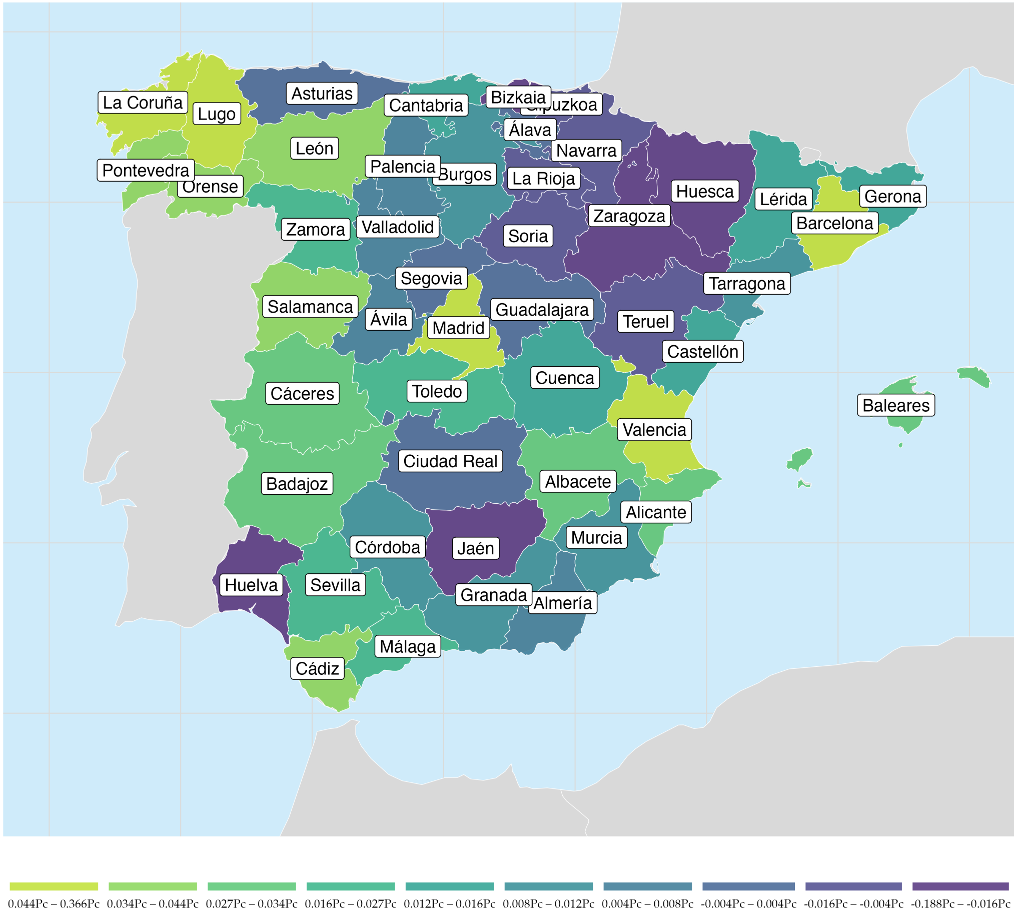
The previous paragraph presented the estimation of the parameterized model. In order to fully quantyify and decompose the gains from trade using Equation (18), both the trade and labor flows in the shocked, $\left\{, \sigma^1_{nn|r}, \sigma^1_{rr|n}, s^1_{nn}\right\}$, and non-shocked scenario, $\left\{\sigma^0_{nn|r}, \sigma^0_{rr|n}, s^0_{nn}\right\}$, are required, as well as market clearing wages and rental rates,$\left\{r^0_n, w^0_{nr}, r^1_n, w^1_{nr}\right\}$. Neither are directly observed in the historical data sources. The fully estimated model, however, allows me to simulate labor flows, expenditure shares and trade flows as well as market clearing prices that are consistent with a scenario where Spain would not have benefited from an external demand shock. These flows and prices can then be used to quantify and decompose welfare gains from trade. In a final step, this subsection then evaluates both the shocked and non-shocked flows while lowering the spatial segmentation of the Spanish labor market as well. Effectively, this exercise traces out the qualitative and quantitative importance of (spatial) labor market segmentation for gains from trade.

Results: Spain without WWI. I begin by simulating labor flows, trade flows and prices for the non-shocked scenario, $\left\{\sigma^0_{nn|r}, \sigma^0_{rr|n}, s^0_{nn,r}, r^0_n, w^0_{n,r}\right\}$. To do so, I first recover the baseline productivities as in the joint estimation procedure for 1914. In a second step, calibrating the model to the baseline productivities and keeping external trade levels fixed to the 1914 level, I solve for the labor reallocation flows $[\sigma'_{ni,rs}]_{\forall(n,i,r,s)}$ that are consistent with labor market clearing (11), as well as goods market clearing and housing market clearing. I also solve for the wages, implied domestic trade flows and rental rates that are consistent with this equilibrium.

Before turning towards the welfare implications, I analyze the counterfactual patterns of economic activity, across both space and sectors with a particular focus on counterfactual labor allocations and how they compare to the observed labor allocations. The sectoral composition is strikingly different between the counterfactual scenario and the data as shown in Figure A.4. There is high degree of reallocation from the agricultural sector towards the manufacturing sector in general, with industries that are affected by the trade shock growing the most. Spatially, there are very small differences in regional growth between the two scenarios (cp Figure A.3), consistent with the finding that most of the adjustment is due to within-provincial reallocation rather than between-provincial allocation.

Quantifying the welfare effects for the WWI Shock. With the simulated labor flows, trade flows and prices for the non-shocked scenario $\left\{\sigma^0_{nn|r}, \sigma^0_{rr|n}, s^0_{nn,r}, r^0_n, w^0_{n,r}\right\}$, the only missing information to quantify the welfare effects of the WWI shock are the same variables for the shocked-scenario,

Figure 6. Spatial Distribution of Gains from Trade



Notes: Chloropleth map of the contributions towards aggregate welfare gains by province (in percentage points). Province-specific contributions to aggregate welfare are calculated using Equation (18), specifically,

$$\frac{\mathscr{W}_n^1}{\mathscr{W}_n^0} = \prod_{r=1}^{S} \left(\underbrace{\left(\frac{\sigma^1_{nn|r}}{\sigma^0_{nn|r}}\right)^{-\frac{1}{\gamma}}}_{\text{Spatial Flows}} \underbrace{\left(\frac{\sigma^1_{rr|n}}{\sigma^0_{rr|n}}\right)^{-\frac{1}{\nu}}}_{\text{Sectoral Flows}} \frac{u^1_{nr|r}}{u^0_{nr|r}} \right)^{\pi_{n,r}}$$

where $\left\{\sigma^0_{nn|r}, \sigma^0_{rr|n}, u^0_{nr|r}\right\}$ are the counterfactual labor flows and utility levels obtained from the counterfactual simulation for Spain without WWI as described in Section **??** and $\left\{\sigma^1_{nn|r}, \sigma^1_{rr|n}, u^1_{nr|r}\right\}$ are obtained from the fitted model as described and estimated in Section **??**. The results represent the decomposed results from the couterfactual comparison in Row (2) of Panel A of Table 3.

$\left\{\sigma^1_{nn|r}, \sigma^1_{rr|n}, s^1_{nn,r}, r^1_n, w^1_{n,r}\right\}$. Labor flows are directly obtained from the fitted model. To trace out the dynamic effects of a temporary trade shock, I compute two different sets of market clearing wages. The first one is consistent with market clearing prices while the trade shock persists and is obtained by feeding in the average external trade levels between 1915 and 1916, computing the implied labor reallocation flows $[\sigma'_{ni,rs}]_{\forall(n,i,r,s)}$ that are consistent with labor market clearing (11), as well as goods market clearing and housing market clearing, $\left\{s^1_{nn,r}, r^1_n, w^1_{n,r}\right\}$. In a second step, I remove the external demand shock again and feed in the trade levels for 1919. Keeping labor allocations fixed, but recalculating the wages, prices and housing rental rates that are consistent with market clearing, I obtain the prices after the WWI shock has dissipated, i.e. $\left\{s^2_{nn,r}, r^2_n, w^2_{n,r}\right\}$.

Using these values allows me to examine the dynamics of the gains from trade from a temporary trade shock. Calculating and decomposing the welfare gains using Equation (18)[23], I can determine both the overall gains from trade associated with the WWI shock period and right after. It is also possible to decompose the gains and determine to what extent they are driven by sectoral, spatial adjustments, traditional ACR type gains that pin down changes in the real income, as well as changes due to increases in the housing costs or the trade deficit. The results for this baseline evaluation are reported in Panel A of Table 3. Row (1) reports the results for the second step, where wages are calculated while the shock persists, and Row (2) calculates the gains for when the shock has already dissipated. There are two important conclusions here: On the one hand, the aggregate ACR formula is misleading and understates the gains from trade - omitting both the spatial variability in rental rates, wages and price indices, as well as the dynamic contribution to the gains from trade from increased labor mobility, both sectorally and spatially. The adjustment increases the total welfare by approximately 70 percent both during and after the war. On the other hand, inflationary pressure substantially offsets gains from trade. Furthermore, in Figure 6, I plot the spatial distribution of the gains from trade after the shock dissipated. The map indicates a highly uneven picture, with most of the welfare gains being generated in the most industrialized provinces of Barcelona, Asturias, Valencia and Madrid, emphasizing again the heterogeneous impact of trade shocks within countries. What is interesting, is that welfare gains are driven by different qualitative channels in different provinces. In Figure A.7 in the online appendix, I plot the welfare contribution from spatial and sectoral mobility across provinces. Gains from improvements in the sectoral mobility are concentrated in the metropolitan areas that directly benefited from the shock,i.e. in industrial centers and provinces closer to the French border.

Spatial gains are more widespread and are prominent in the rural provinces that form the hinterland of Madrid, Barcelona, the Basque country and Asturias. This pattern speaks to the qualitative importance of spatial mobility in dissipating the welfare gains from trade across space.

Gains from trade under different degrees of labor market segmentation. In a final step, I examine the sensitivity of the gains from trade, adjusting either the (spatial) segmentation of the labor market, or the spatial bias of the trade shock, or both. Panel B of Table 3 presents the results when I simulate both the effects of the trade shock and the counterfactual non-shocked scenario with lower spatial migration costs. Panel C presents the results when I remove the spatial bias of the shock by placing Spanish provinces at equal distance to France and lower the domestic trade cost. Panel D presents the results when both the spatial migration cost is lowered and the spatial bias of the shock is removed. Not surprisingly, as labor markets become more integrated the gains from trade increase. What is interesting are the channels through which this arises. As a primary effect, lower spatial migration cost increases spatial reallocation, while lower domestic trade costs increases the trade openness of locations and increases the ACR column. More interestingly, increased spatial mobility lowers the inflationary pressure

[23] In the online appendix Subsection (G.5) I develop an extension of the formula that accounts for trade imbalances. The adjustment factor is proportional and separately reported in the final column of Table 3.

Table. 3. Welfare and Simulation Results

Welfare Changes from (in %)	Dynamic Gains Spatial	Dynamic Gains Sectoral	Static Gains ACR	Static Gains Rental	Static Gains Wage	Static Gains Inflation	Total Total	Total Deficit
Panel A: Baseline Result								
(1a) External Trade fixed at 1914 level (rel. to WW1)	0.07	0.30	1.50	-0.21	2.79	-1.91	2.54	-7.70
(1b) External Trade fixed at 1914 level (rel. to 1920)	0.07	0.30	1.06	-0.15	2.23	-1.77	1.75	-2.32
Panel B: Integrated Labor Markets								
(2a) No Spatial Mobility Cost ($\zeta = 0$, $\nu = 2$, rel. to WWI)	0.44	0.27	1.36	-0.18	2.57	-1.81	2.65	-7.70
(2b) No Spatial Mobility Cost ($\zeta = 0$, $\nu = 2$, rel. to 1920)	0.44	0.27	1.18	-0.07	2.04	-1.73	2.14	-2.32
Panel C: Even Trade Shock								
(3a) Removing Spatial Bias in Trade Shock (rel. to WWI)	0.03	0.34	1.76	-0.19	3.00	-2.07	2.86	-7.70
(3b) Removing Spatial Bias in Trade Shock (rel. to 1920)	0.03	0.34	0.73	-0.12	2.42	-2.13	1.27	-2.32
Panel D: Even Trade shock & Integrated Labor Market								
(4a) Even Trade Shock & No Spat. Friction (rel. to WWI)	0.35	0.29	1.77	-0.13	2.92	-2.14	3.06	-7.70
(4b) Even Trade Shock & No Spat. Friction (rel. to 1920)	0.35	0.29	0.72	-0.06	2.35	-2.21	1.43	-2.32

Notes: Table reports the welfare decomposition using Equation (18) relying on the couterfactual values. Panel A reports the baseline results. Panel B reports the counterfactual simulations, where the mean spatial migration cost, ζ, is being lowered. Panel C simulates a counterfactual where the WWI shock does not feature an uneven spatial incidence by removing differences in domestic transport cost to foreign locations and lowering the distance elasticity on trade costs ($\theta = .3$). Panel D combines the counterfactual experiment of Panel B and C. Reported numbers are in percentage points.

and therefore increases the gains from trade. Local labor markets are less subject to localized competition and the shock can dissipate more evenly across space, taking advantage of the labor supply across the whole of Spain rather than the narrowly provided labor supply in the north-eastern provinces. This reinforces the insight from the theoretical model, that uneven trade shocks cause price pressure and that factor mobility plays an essential role in mitigating this.

5 Conclusion

This paper provides new reduced-form and quantitative evidence to illustrate how segmented domestic labor markets influence the welfare effects of trade. I argue that under conditions of imperfect factor mobility, an external demand shock can enhance allocative efficiency. However, if the shocks are unevenly distributed, they lead to localized increases in wages and consumer prices rather than reallocation, which constrains the potential reallocative benefits from trade.

To support this argument, I present new evidence from a historical natural experiment: an international trade demand shock to the Spanish economy during World War I (1914-1918), caused by Spain's key trading partners participating in the war. This shock, driven by increased demand for Spanish goods from belligerent countries, was substantial and external to Spain's economy. I show that the adjustment of local wages and consumer prices followed a distinct spatial pattern influenced by the direct and indirect effects of the shock, with labor adjustments being mostly localized.

To explain these empirical findings, I incorporate imperfect labor mobility into a standard economic geography model. By introducing a tractable worker reallocation mechanism where mobility is constrained by sectoral and spatial frictions, the model captures the complex interactions between local labor markets and how an external demand shock affects interconnected local markets. I estimate the model and simulate the Spanish economy without the WWI shock, finding that real income gains were highly heterogeneous across regions and that limited labor mobility inadequately transmitted these gains across space. Consequently, the Spanish economy experienced significant labor market congestion, limiting the benefits from trade.

This paper underscores the importance of considering the domestic disaggregated distribution of economic activity and factor reallocation across local labor markets to fully understand the welfare gains of an aggregate shock. It highlights the need to account for the domestic network structure of local labor markets in both reduced-form and quantitative analyses.

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Part

Online Appendix

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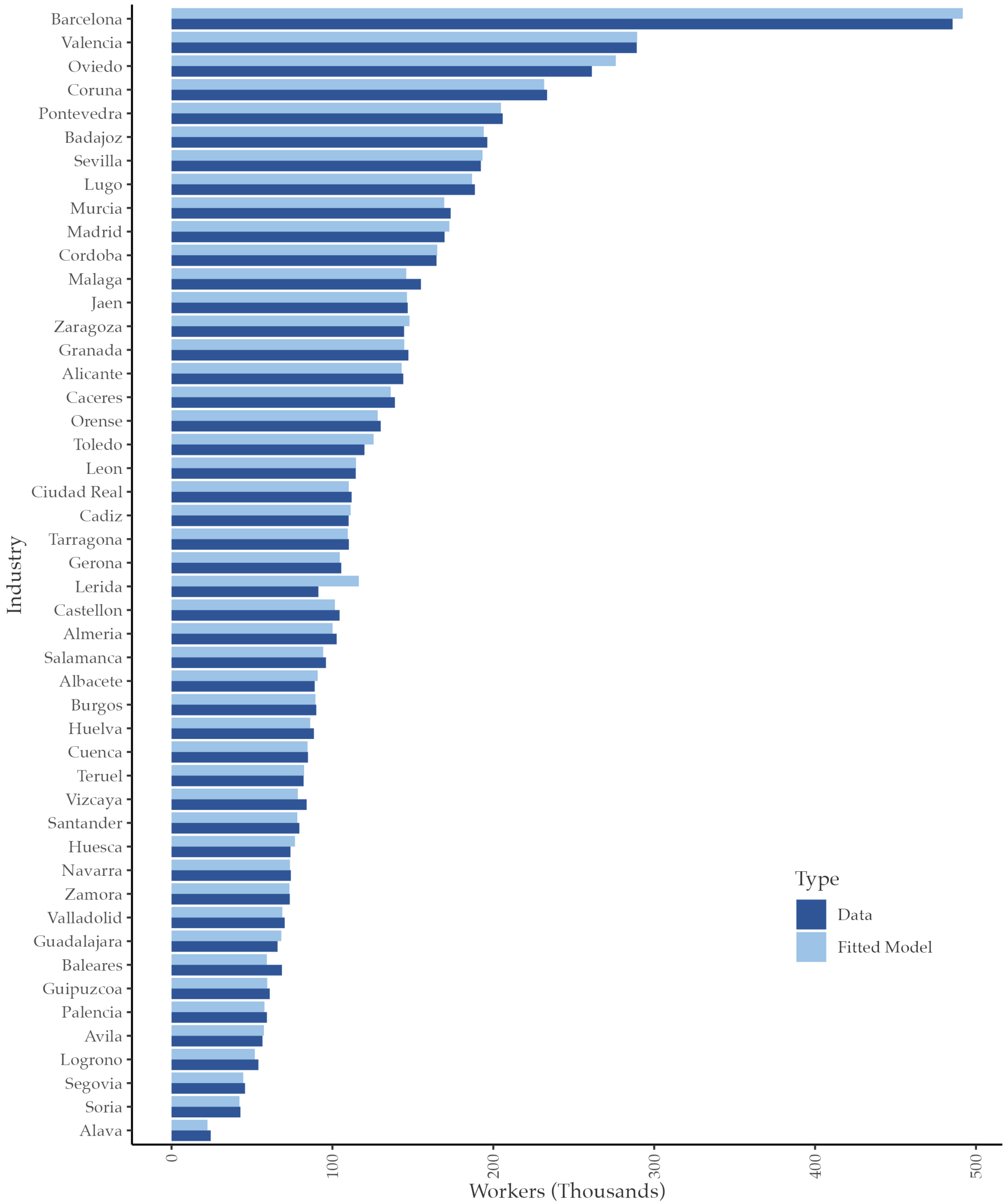
A Additional Tables and Figures

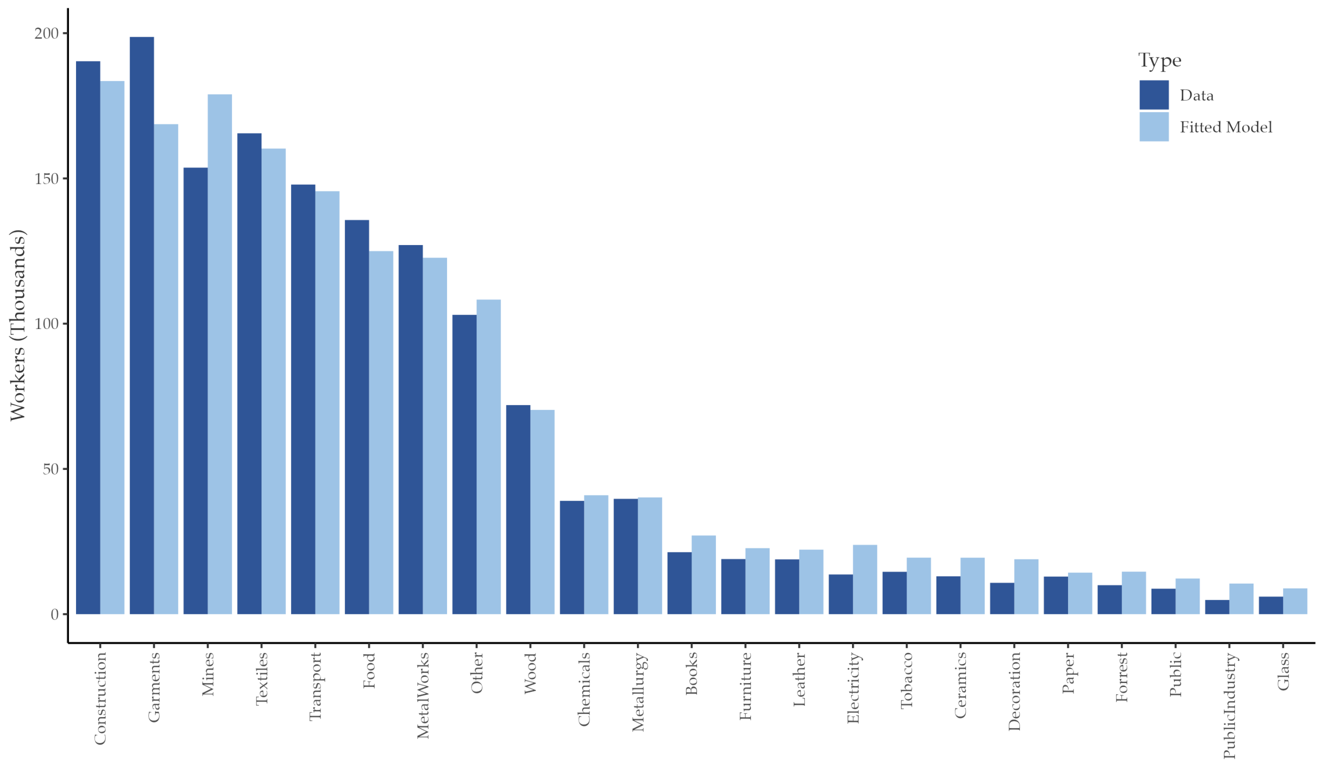
B Figures

Figure A.1. Model Fit: Provincial Employment (1920 Data vs Fitted Model)



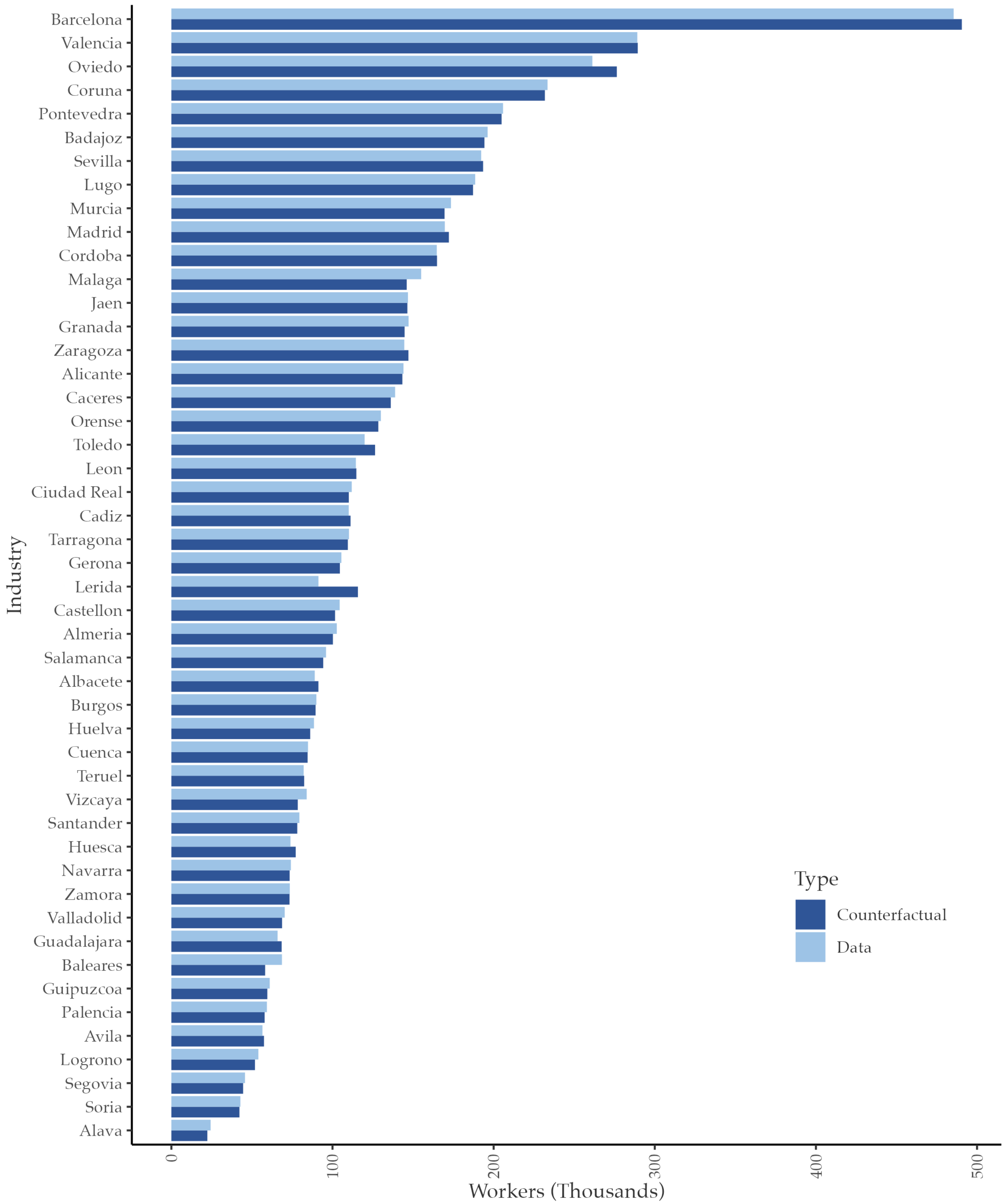
Notes: Figure reports the model fit of the joint estimation for provincial employment across manufacturing and agriculture. Observed data are employment levels for manufacturing and agriculture for each province, constructed from the salarios publication and the census. Fitted model are the labor allocations implied by the fully estimated dynamic model for 1920 and aggregated by province (as described in Section 4). Additional details on data construction and sources can be found in the online appendix.

Figure A.2. Model Fit: Sectoral Employment (1920 Data vs Fitted Model)



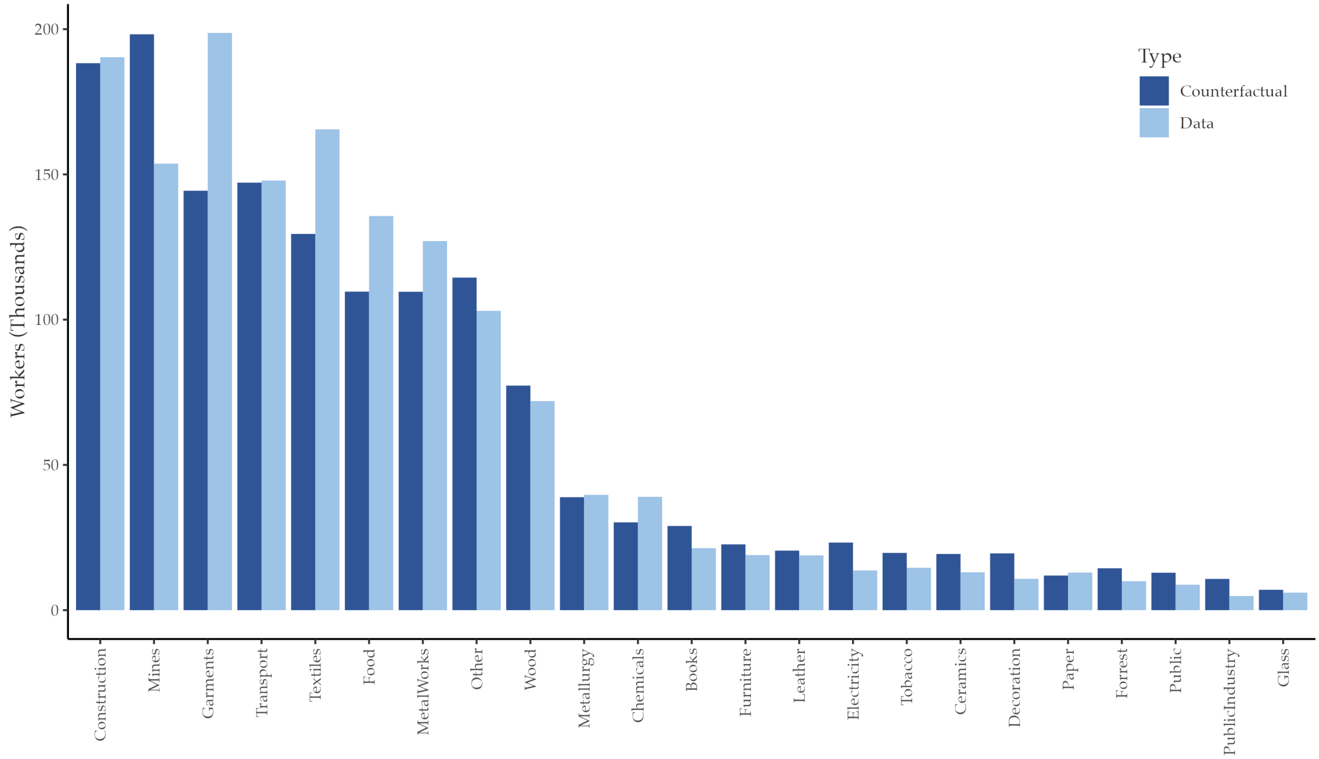
Notes: Figure reports the model fit of the joint estimation for sectoral employment across manufacturing and agriculture. Observed data are employment levels for manufacturing and agriculture for each sector, constructed from the salarios publication and the census. Fitted model are the labor allocations implied by the fully estimated dynamic model for 1920 and aggregated by sector (as described in Section 4). Additional details on data construction and sources can be found in the online appendix.

Figure A.3. No WWI Cfl: Provincial Employment (1920 Data vs Cfl)



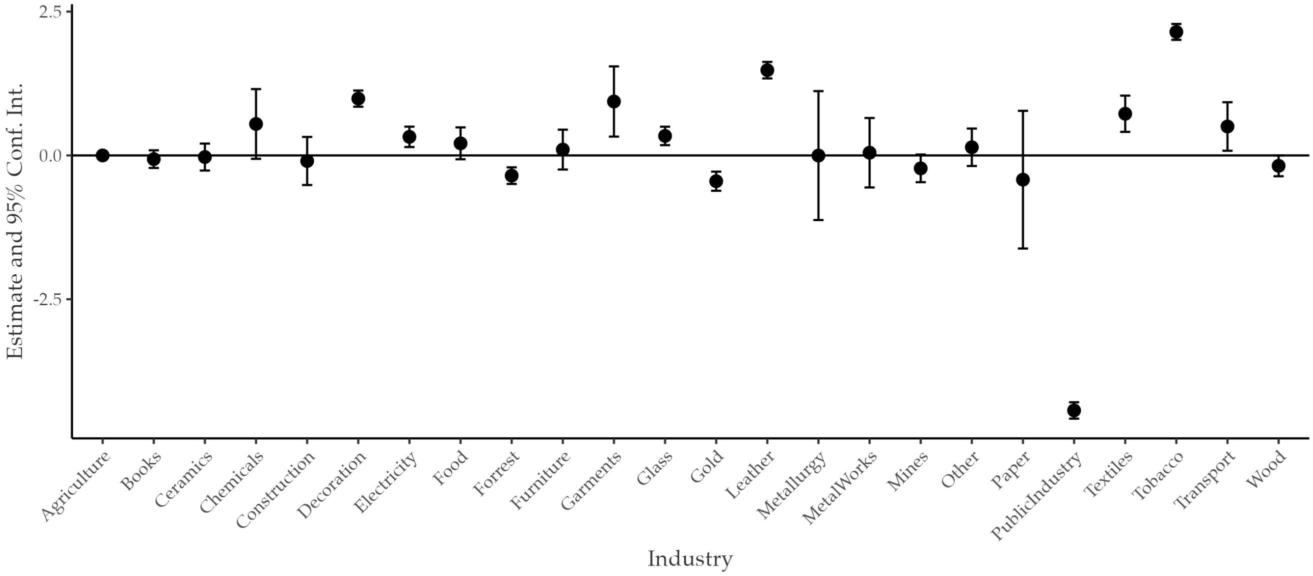
Notes: Figure reports the model fit of the joint estimation for sectoral employment across manufacturing and agriculture. Observed data are employment levels for manufacturing and agriculture for each province, constructed from the salarios publication and the census. The counterfactual data series are the labor allocations implied by the fully estimated dynamic model when instead of the WWI shock the model is being calibrated to 1914 trade levels instead. Labor allocations are presented for 1920 and aggregated by province (as described in Section 4). Additional details on data construction and sources can be found in the online appendix.

Figure A.4. No WWI Cfl: Sectoral Employment (1920 Data vs Cfl)



Notes: Figure reports the model fit of the joint estimation for sectoral employment across manufacturing and agriculture. Observed data are employment levels for manufacturing and agriculture for each sector, constructed from the salarios publication and the census. The counterfactual data series are the labor allocations implied by the fully estimated dynamic model when instead of the WWI shock the model is being calibrated to 1914 trade levels instead. Labor allocations are presented for 1920 and aggregated by sector (as described in Section 4). Additional details on data construction and sources can be found in the online appendix.

Figure A.5. Sectoral Heterogeneity of the Trade Shock



Notes: Figure shows the sector-specific shifts in export demand as estimated in Equation (5). The regressions are estimated by PPML using the fixpois command of the fixest package in R. The source data are the digitized product-destination level trade statistics. More information on data construction can be obtained in the online appendix.

C Regression Tables

Table. A.1. Migration Gravity

	Born in another Province Census 1920	Born in another Province Census 1930	Imputed Gross Flows Census 1920 and 1930	Bilateral migration share (σ_{ni}) Census 1920
	(1)	(2)	(3)	(4)
Log Bilateral Distance	-1.450*** (0.0454)	-1.455*** (0.0476)	-1.434*** (0.0556)	-1.450*** (0.0476)
Internal Move	3.285*** (0.0952)	3.193*** (0.0995)	2.796*** (0.1168)	3.380*** (0.0891)
Observations	2,209	2,209	1,881	2,209
Pseudo R^2	0.98644	0.98493	0.97488	0.67283
Dest. Province fixed effects	✓	✓	✓	✓
Orig. Province fixed effects	✓	✓	✓	✓

Notes: Table reports the results for the migration gravity regression, as in Equation (21). In Column (1) and (2), observations are the stock of residents currently residing in each province, dissected by the province in which they were initially born, in 1920 and 1930, respectively. In Column (3), observations are imputed gross flows, calculated by taking the difference in the observed stock between 1930 and 1920, adjusting for the average survivability rate over 10 years. In Column (4), observations are the shares of residents who were born in different Spanish provinces, out of the total number of residents. Column (1)-(4) are being estimated using PPML using the feols command of the fixest package in R. Following Sotelo (2019), estimating PPML with dependent variable being the share rather than level is a cosnistent way of implement multinomial pseudo maximum likelihood (MNPML). Log Bilateral Distance is the shortest distance between province capital along the Spanish railroad network. Internal Move is a dummy that takes the value of 1 if the observation denotes the stock of residents who were born and currently reside in the same province. In parantheses (heteroskedasticity) robust standard errors are being reported: *** for 1 percent significance; ** for 5 percent significance; * for 10 percent significance. Additional information on data digitization and construction is available in the online appendix.

Table. A.2. Elasticity of Substitution

	Log (adjusted) Prices in Industry-Province pairs (1914,1920)			
	OLS	2SLS		
	(1)	(2)	(3)	(4)
Log Wages of Workers in Industry-Province pairs (1914,1920)	-0.6893*** (0.1065)	2.682 (1.727)	2.633*** (0.7709)	1.900*** (0.6532)
Instrument	-	Direct	Direct/Dist	Direct/Dist/Indirect
R^2	0.96370	0.92159	0.92287	0.93963
Observations	2,182	2,180	2,180	2,162
Pseudo R^2	0.84098	0.64566	0.64982	0.71126
F-test (IV only)		5.0768	30.620	17.293
Wald (IV only), p-value		0.12063	0.00066	0.00370
Industry-Worker Type-Region fixed effects	✓	✓	✓	✓
Year-Industry fixed effects	✓	✓	✓	✓

Notes: Table reports the results of the second stage for estimating the structural Equation (20). In Columns (1)-(4), observations are the (log of) province-sector specific prices, which are obtained by inverting the cross-Sectional equilibrium, as described in Section 4. Log wages are average daily wage rates for female and male workers across province-industry pairs in 1914 and 1920. The first stage predicts the endogenous variables $\log w_{ist}$, denoting (log) wage changes between 1920 and 1914 at the province-sector-level using direct, indirect local, indirect spatial and (log) distance to France as predictors. Direct shock, local indirect shock and spatial indirect shock as defined in (6) and (7). Log distance to France is the shortest distance to Paris along the Spanish and French railroad network, originating from either provincial or region capital cities. The data sources for Column (1) through (4) is the salarios publication. First-stage F-statistic reports the statistical significance of the instrument in the first stage regression, as does the Wald test. The first-stage is estimated with the same set of fixed effects as the second-stage. In parantheses (heteroskedasticity) robust standard errors are being reported: *** for 1 percent significance; ** for 5 percent significance; * for 10 percent significance. The regressions are estimated by using the 2SLS implementation of the feols command of the fixest package in R. Additional information on data digitization and construction is available in the online appendix.

Table. A.3. GMM Estimation of Distance Elasticity

	(Log) Wages of Workers in Industry-Region pairs (1908-1919)	
	(1)	(2)
	OLS	Poisson
Log Distance to France	-0.1866*** (0.0490)	-0.0949** (0.0478)
WWI Period × Log Distance to France	-0.2906*** (0.0665)	
δ		733.5 (1,377.3)
θ		-1.769*** (0.5667)
R^2	0.79686	
Observations	1,102	1,102
Pseudo R^2	1.0489	0.14170
Worker Type-Year fixed effects	✓	✓

Notes: Table reports the results of estimating Equation (19). In Column (1), observations are the log of average daily wage rates for female and male workers across province-industry pairs between 1908 and 1919. In Column (2), observations are average daily wage rates for female and male workers across province-industry pairs between 1908 and 1919. Log distance to France is the shortest distance to Paris along the Spanish and French railroad network (as explained in Section F.2), originating from either provincial or region capital cities. The data sources for Column (1) and (2) are the yearly surveys of the Spanish government (as explained in Section F.2). In parantheses (heteroskedasticity) robust standard errors are being reported: *** for 1 percent significance; ** for 5 percent significance; * for 10 percent significance. The regressions are estimated by using the feols and feNmlm command of the fixest package in R. Additional information on data digitization and construction is available in the online appendix.

Table. A.4. Belligerent Export Destinations

	Exports (Value)		
	(1)	(2)	(3)
Belligerent × Year = 1910	-0.1970 (0.2652)	-0.2356 (0.2950)	-0.0144 (0.1269)
Belligerent × Year = 1911	-0.0516 (0.3124)	-0.1605 (0.2895)	0.1144 (0.1306)
Belligerent × Year = 1912	-0.1904 (0.2619)	-0.1997 (0.2869)	-0.1152 (0.1261)
Belligerent × Year = 1914	0.2649 (0.2608)	0.3267 (0.2787)	0.2197* (0.1163)
Belligerent × Year = 1915	1.058*** (0.2718)	1.159*** (0.2693)	0.9258*** (0.1427)
Belligerent × Year = 1916	0.9330*** (0.2685)	1.022*** (0.2753)	0.6710*** (0.1247)
Belligerent × Year = 1917	1.013*** (0.2817)	1.113*** (0.2781)	0.7110*** (0.1585)
Belligerent × Year = 1918	0.6607*** (0.2553)	0.7338*** (0.2653)	0.4703*** (0.1483)
Belligerent × Year = 1919	0.6684*** (0.2577)	0.8010*** (0.2538)	0.3726** (0.1480)
Observations	80,245	79,907	79,678
Pseudo R^2	0.66364	0.72377	0.92829
Product fixed effects	✓		
Year fixed effects	✓		
Destination fixed effects	✓	✓	
Product-Year fixed effects		✓	✓
Destination-Product fixed effects			✓

Notes: Observations are values of exports (in pesetas) at the product-destination level for a given year. Belligerent Destination is a dummy that takes the value of 1 for the primary belligerent countries where trade was not disrupted by the frontline itself, i.e. i.e. France, Italy and the United Kingdom. The non-belligerent countries exclude the United States and other later participants of WWI. The table shows the regressions results for the event study design described in Equation (3). Two different specifications are reported: One with product and year fixed effects in the first column and the second with interacted product-year fixed effects in the second column. The omitted baseline year is 1913 for both specifications. The regressions are estimated by PPML using the fixpois command of the fixest package in R. The source data are the digitized product-destination level trade statistics. More information on data construction can be obtained in the online ‘. In parantheses (heteroskedasticity) robust standard errors are being reported: *** for 1 percent significance; ** for 5 percent significance; * for 10 percent significance.

D Theoretical Derivations

E Data and Additional Results

In this online appendix I provide additional information on data sources as well as additional figures, tables and derivations. In Section F I provide additional information regarding the data sources being used. In Section G I provide additional derivations, including detailed derivations for the stylized model used in the introduction, as well as derivations for the welfare formula and the extension allowing for trade imbalances. In Section H I include additional figures omitted from the main text. In Section I. Section J provides detailed derivations for the quantitative model. Finally, in Section K, I describe data construction and references for data sources.

F Data sources and data construction

F.1 Data sources

The data used in this paper comes from the following sources:

1. All information regarding **wages and labor quantities across local labor markets and all sectors** are compiled from different national publications. Specifically:
   (a) Yearly reports on wages and labor quantities from the Institute for Social Reform for 1910-1920 (Instituto de Reformas Sociales, 1911, 1912, 1913, 1914, 1915, 1916, 1917, 1918, 1919, 1920, 1921)
   (b) Compilation of the reports from the Ministry of Labor for 1914, 1920 and 1925 (Ministerio de Trabajo, 1927).
   (c) Agricultural employment from census publications (Instituto Geográfico, 1912, 1932, 1922)
2. All information regarding **external trade** are provided by the Spanish customs agency. Specifically:
   (a) Annual Trade Statistics for 1910-1920 (Dirección General de Aduanas, 1911, 1912, 1913, 1914, 1915, 1916, 1917, 1918, 1919, 1920, 1921)

   Note: I used an additional publication that lists the official correspondence between industries and occupations (Instituto Nacional de Prevision Social, 1930), often explicitly stating the associated product as occupation name for an industry. From that I constructed a correspondence table that matches products to industries
3. All information regarding **internal migration** are drawn from a special section of the census publications as previously compiled in (Silvestre, 2005).
4. All information regarding **consumer prices** are obtained from the publications of the Institute for Social Reforms as previously examined by Gomez-Tello et al. (2018). Specifically:
   (a) Consumer prices of key agricultural and non-agricultural products across Spanish provinces throughout the decade are reported in the bulletins of the Institute for Social Reforms (Instituto de Reformas Sociales, 1923)
5. Information regarding **the housing market**, including data on the housing stock and housing expenditures is taken from the statistical yearbooks and the bulletins of the Institute for Social Reforms. Specifically:
   (a) Rental rates as reported in the bulletins of the Institute for Social Reforms (Instituto de Reformas Sociales, 1923)
   (b) Housing stock as reported in the statistical yearbooks (Instituto Nacional de Estadística, 1920)

F.2 Data construction: A spatial dataset for Spain between 1910-1920.

To examine the impact of WWI on both trade flows and local labor markets, I construct a regionally disaggregated dataset for Spain between 1910-1920 that covers handcollected information on wages, employment levels, prices and exports across local labor markets. This dataset allows me for the first time to analyze the impact of the trade shock taking both external trade and internal labor reallocation into account. I rely on six principal data sources that together describe manufacturing and agricultural employment, external trade, migration patterns, consumer prices, the transportation network and the housing market.

Manufacturing employment. I obtain disaggregated information regarding wages and labor quantities across local labor markets. At the beginning of the 20th century, the plight of the working class and their working conditions became a more prominent political issue in Spain. In order to better understand and track the working conditions the Institute for Social Reform - an entity that would later morph into the ministry of labor - started conducting large-scale surveys on working conditions with the first annual report being released in 1907. The institute continued to publish yearly reports covering the whole period of 1910-1920. The surveys were conducted at all public firms and large private enterprises in cities that are larger than 20,000 inhabitants (Casanovas 2004). They covered 23 different industries[1] and 48 different provinces.[2] In the annual reports, the institution reported wages, working hours, and number of employees across local labor markets. The results are available in two different formats. On the one hand, industry-specific results are available across the more geographically aggregated unit of regions, on the other hand, provincial wages are reported but with the industry-specific results missing. Additionally, the Ministry of Labor later published a compilation that offers a more complete picture across local labor markets with employment and wages being reported across province-sector pairs for the years 1914, 1920 and 1925 (Ministerio de Trabajo, 1927).

Agricultural employment. I augment the industry survey with additional data from the census. While the industry survey covers a large range of the manufacturing sector, it does not give further information on the remaining economy. As mentioned before, a crucial feature of the Spanish economy was the large agricultural sector. To account for that, I digitized the occupation-province specific Section of the census for 1900, 1910, 1920, and 1930. I use the 1920 data on agricultural employment to augment the 1920 data. For the 1914 data, I use the 1910 province-specific agricultural employment data and extrapolate by calculating province-specific fertility trends until 1914. Finally, I use data contained in the official Spanish statistical yearbooks on province-specific agricultural mean wages for 1915 and 1920.

External trade. I obtained detailed data regarding exports and imports from annual trade records released by the Spanish custom agency. I digitized the trade statistics for the years 1910-1919. For those years, the quantity of exports in 383 product categories across 77 different destination countries is available. Furthermore, the border agency uses a system of product-level prices to obtain total export values. These prices do not vary throughout and can be interpreted to give the relative pre-war prices across goods. To construct a correspondence between product-level trade data and industry-level labor market data, I used an additional publication that lists the official correspondence between industries and occupations (Instituto Nacional de Prevision Social, 1930), often explicitly stating the associated product as occupation name for an industry. From that I constructed a correspondence table that matches products to industries.[3]

Migration. I augment the data on employment stocks with additional data on migration flows. I follow Silvestre (2005) and use the province level data on inhabitants that are born in another province as published in the censuses. For 1920 and 1930 additional information is available listing not only the stock of migrants which were born in another province, but the identity of their origin province as well. The difference between 1930 and 1920 in the stock of migrants - adjusted for decennial survivability rates - is informative about net migration. In order to construct net migration, I follow Silvestre (2005) and use the decennial census survivability rate between 1921-1930, $S \equiv 0.86$. Net internal migration can be obtained by constructing the survivability adjusted change in stock of migrants, i.e.

$$\text{Internal migrations}_{1930,1920,i,j} = BAP_{i,j,1930} - S \times BAP_{i,j}^{1920}$$

where $BAP_{i,j}^{1920}$ refers to the stock of residents in i who were born in province j in 1920.

Consumer prices. The bulletins of the Institute for Social Reforms contain detailed information on consumer prices of key agricultural and non-agricultural products across Spanish provinces throughout the decade (Instituto de Reformas Sociales, 1923). The data was previously used by Gomez-Tello et al. (2018) and I refer for detailed information to their paper.

[1]The industries included are called: Books, Ceramics, Chemicals, Construction, Decoration, Electricity, Food, Forrest, Furniture, Garments, Glass, Leather, Metal Works, Metallurgy, Mines, Paper, Public, Public Industry, Textiles, Tobacco, Transport, Varias, Wood.

[2]The census for 1910 lists 49 different provinces. They mostly correspond to the modern administrative units called provincias - provinces - which are in turn roughly the NUTS3 level administrative units of Spain. There are some minor differences, e.g. in how different off-continental administrative units are being treated. For my analysis I drop the Canary islands from the sample since their distance from the mainland makes it hard to argue that they are similarly integrated as other provinces.

[3]The correspondence table is available upon request.

Transportation. I georeferenced the Spanish railroad network in 1920. Then, using Dijkstra's algorithm I obtain bilateral distances between provincial capitals along the shortest path of the railroad network. To obtain distances to Paris, I augmented the graph with the French railroad network - as can be seen in Figure A.6 - and further added maritime linkages between important ports in France and Spain. Again using Dijkstra's algorithm, I can obtain the shortest distance along this transportation network between provincial capitals in Spain and Paris which I will use to approximate the transport distance to the French market. All other external markets will be assigned to one location that is sufficiently distant such that domestic transport distances have little impact on the overall transport cost. Mirroring the importance of Latin American destination markets I include the location of Cuba in the transportation network and assign foreign trade - except for French trade - to that location.

Housing market. I compute the housing expenditure share as well as stock and rental rates from different data sources. The statistical yearbooks make available the number of buildings available in a province as well as the inhabitants and thus the effective occupancy rate, the inverse of which is the share of a building that is rented by an average resident. Additionally, average yearly rental expenditure is selectively available across provinces in the bulletins of the Institute for Social Reforms. This yearly rate can be adjusted towards an hourly rate in a province, r_i. Total expenditure on housing can be imputed by firstly multiplying the rental rate and the inverse of the occupancy rate - call this the unit rental rate - with the stock of housing. Calculating total expenditure on housing as a share of total labor income across all provinces defines the expenditure share on housing, which I will refer to as δ.

G Additional derivations

This Section provides additional derivations. Subsection G.1 provides additional derivation for the stylized two location setting in the introduction. Subsection G.2 generalizes this model to an arbitrary number of locations. Subsection G.4 derives the aggregate welfare formula. Finally, Subsection G.5 derives the aggregate welfare formula incorporating trade imbalances.

G.1 Stylized example: Uneven trade shocks

The labor market clearing condition in this simple example is given by,

$$\ell_{i,D}(w_i, e_i) = \ell_{i,S}(w_i, w_j)$$

$$\ell_{j,D}(w_j, e_j) = \ell_{j,S}(w_i, w_j)$$

Totally differentiating this condition for i and j and solving for wage changes in each market,

$$d\ln w_i = \frac{1}{(\psi_{ii} - \zeta_i)}(\rho_i d\ln e_i - \psi_{ij} d\ln w_j)$$

$$d\ln w_j = \frac{1}{(\psi_{jj} - \zeta_j)}(\rho_j d\ln e_j - \psi_{ji} d\ln w_i)$$

where ρ_i is the elasticity of labor demand with regard to demand shifts, ψ_{ii} and ψ_{ij} is the own-wage and cross-wage elasticity of labor supply, respectively, and ζ_i is the labor demand elasticity. It is assumed that,

$$\psi_{ij} \equiv \frac{d\ln \ell_{i,S}}{d\ln w_j} < 0 \qquad \psi_{ii} \equiv \frac{d\ln \ell_{i,S}}{d\ln w_i} > 0$$

$$\zeta_i \equiv \frac{d\ln \ell_{i,D}}{d\ln w_i} < 0 \qquad \rho_i \equiv \frac{d\ln \ell_{i,D}}{d\ln e_i} > 0$$

which implies that labor markets from the point of view of the worker are substitutes. In matrix notation,

$$\begin{pmatrix} d\ln w_i \\ d\ln w_j \end{pmatrix} = \begin{bmatrix} 0 & \frac{-\psi_{ij}}{(\psi_{ii}-\zeta_i)} \\ \frac{-\psi_{ji}}{(\psi_{jj}-\zeta_j)} & 0 \end{bmatrix} \begin{pmatrix} d\ln w_i \\ d\ln w_j \end{pmatrix} + \begin{bmatrix} \frac{\rho_i}{(\psi_{ii}-\zeta_i)} & 0 \\ 0 & \frac{\rho_j}{(\psi_{jj}-\zeta_j)} \end{bmatrix} \begin{pmatrix} d\ln e_i \\ d\ln e_j \end{pmatrix}$$

$$\begin{pmatrix} d\ln w_i \\ d\ln w_j \end{pmatrix} = \frac{1}{1 - \frac{\psi_{ij}\psi_{ji}}{(\psi_{ii}-\zeta_i)(\psi_{jj}-\zeta_j)}} \begin{bmatrix} 1 & \frac{\psi_{ij}}{(\psi_{ii}-\zeta_i)} \\ \frac{\psi_{ji}}{(\psi_{jj}-\zeta_j)} & 1 \end{bmatrix} \begin{bmatrix} \frac{\rho_i}{(\psi_{ii}-\zeta_i)} & 0 \\ 0 & \frac{\rho_j}{(\psi_{jj}-\zeta_j)} \end{bmatrix} \begin{pmatrix} d\ln e_i \\ d\ln e_j \end{pmatrix}$$

Solving for the wage changes,

$$\begin{pmatrix} d\ln w_i \\ d\ln w_j \end{pmatrix} = \begin{bmatrix} \alpha_1 & \alpha_2 \\ \alpha_3 & \alpha_4 \end{bmatrix} \begin{pmatrix} d\ln e_i \\ d\ln e_j \end{pmatrix}$$

where,

$$\alpha_1 = \frac{\rho_i}{\delta(\psi_{ii} - \zeta_i)} \qquad \alpha_2 = \frac{\psi_{ij}\rho_j}{\delta(\psi_{ii} - \zeta_i)(\psi_{jj} - \zeta_j)}$$

$$\alpha_3 = \frac{\psi_{ji}\rho_j}{\delta(\psi_{ii} - \zeta_i)(\psi_{jj} - \zeta_j)} \qquad \alpha_4 = \frac{\rho_i}{\delta(\psi_{ii} - \zeta_i)}$$

$$\delta \equiv \left(1 - \frac{\psi_{ij}\psi_{ji}}{(\psi_{ii} - \zeta_i)(\psi_{jj} - \zeta_j)}\right)$$

where α_1 and α_4 is the reduced-form direct effect and α_2 and α_3 are the indirect effects due to the interaction between local labor markets. Notice that, since $\zeta_i < 0$ and as long as $\delta > 0$, the denominator is positive for all parameters. The nominator is positive for the direct effects (α_1,α_4) , but negative for the indirect effects (α_2,α_3). Reinserting into the labor supply condition,

$$d\ln\ell_i = \psi_{ii}\left(\alpha_1 d\ln e_j + \alpha_2 d\ln e_i\right) + \psi_{ij}\left(\alpha_3 d\ln e_j + \alpha_4 d\ln e_i\right)$$
$$d\ln\ell_j = \psi_{jj}\left(\alpha_1 d\ln e_j + \alpha_2 d\ln e_i\right) + \psi_{ji}\left(\alpha_3 d\ln e_j + \alpha_4 d\ln e_i\right)$$

simplifying,

$$\begin{pmatrix} d\ln\ell_i \\ d\ln\ell_j \end{pmatrix} = \begin{bmatrix} \beta_1 & \beta_2 \\ \beta_3 & \beta_4 \end{bmatrix} \begin{pmatrix} d\ln e_i \\ d\ln e_j \end{pmatrix}$$

where β_1 and β_4 is the reduced-form direct effect of demand shocks on labor allocations, and where β_2 and β_3 are the indirect effects due to interactions between local labor markets. The solution implies that they are linear combinations of the reduced-form direct and indirect effect on wages, i.e.

$$\beta_1 = \psi_{ii}\alpha_1 + \psi_{ij}\alpha_3 \qquad \beta_2 = \psi_{ii}\alpha_2 + \psi_{ij}\alpha_4$$
$$\beta_3 = \psi_{jj}\alpha_1 + \psi_{ji}\alpha_3 \qquad \beta_4 = \psi_{jj}\alpha_1 + \psi_{ji}\alpha_4$$

Notice that given the assumptions above, the direct effects are positive, since the own-wage elasticity is positive ($\psi_{ii} > 0$), the direct effect on wages is positive ($\alpha_1 > 0$), and the indirect effect on wages is negative($\alpha_3 < 0$), as well as the cross-wage elasticity($\psi_{ij} < 0$). In contrast, the indirect effects are negative.

G.2 The spatial impact of uneven trade shocks

By expanding on the simple model in the introduction, I examine the impact of uneven trade shocks across an arbitrary number of connected local labor markets. In particular, this Section shows how the direct and indirect exposure to local demand shock depends on labor market linkages between connected local labor markets and determines adjustments in employment and wages across the spatial economy. Furthermore, the general equilibrium adjustments can be approximated by a closed-form expression that depends on a weighted index of demand shocks elsewhere.

Setting. Let there be a number of locations within a country $i, j \in \mathbb{D} = \{1, \ldots, N^D\}$. Labor demand, $\ell_{i,D}$, is assumed to be twice differentiable, a decreasing function of wages in location i, $\frac{\partial \ell_{i,D}}{\partial w_i} < 0$, and an increasing function of external demand, $\frac{\partial \ell_{i,D}}{\partial e_i} > 0$, and a function of location specific parameters, θ_i, which in our setting will be fixed. Labor demand is thus given by,

$$\ell_{i,D} = f(w_i, e_i, \theta_i) \qquad \forall i$$

In many spatial settings instead, labor will be imperfectly mobile and inelastically supplied. We will examine such settings and represent labor supply by a location specific labor supply function, $\ell_{i,S}$, which is gain twice differentiable, an increasing function of wages in location i, w_i. However, employment across labor markets is seen as a gross substitute by the worker, and therefore, labor supply in i is a decreasing function in wages in other locations e.g. j, w_j. Labor supply is furthermore conditioned by the location specific parameter, θ_i, and is given by,

$$\ell_{i,S} = f(w_i, \ldots, w_{N^D}, \theta_i) \qquad \forall i$$

Labor market clearing across all labor markets is given by the following system of Equations, we obtain, the following system of Equations,

$$\ell_{i,D}(w_i, e, m_i) = \ell_{i,S}(w_1, \ldots, w_N, \theta_i) \qquad \forall i$$

The effect on wages of a demand shock across connected local labor markets. Now, consider a (small) demand shift across all labor markets ($d \ln e_i > 0$). Totally differentiating the labor market clearing condition for wage changes, we obtain,

$$d \ln w_i = \frac{\rho_i}{(\psi_{ii} - \zeta_i)} d \ln e_i - \sum_j \frac{\psi_{ij}}{(\psi_{ii} - \zeta_i)} d \ln w_j \qquad \forall i$$

ρ_i is the elasticity of labor demand with regard to changes in external demand, and ζ_i is the labor demand elasticity, and where ψ_{ii} is the own-wage labor supply elasticity, and ψ_{ij} is the cross-wage labor supply elasticity. Notice that, $(\psi_{ii} - \zeta_i) > 0$ since $\zeta_i < 0$. The general equilibrium effect of demand shocks across connected local labor markets can then be written as,[4]

$$d \ln w_i = \underbrace{\frac{\rho_i}{(\psi_{ii} - \zeta_i)} d \ln e_i}_{\text{Direct Effect}} + \underbrace{\sum_j \frac{-\psi_{ij}}{(\psi_{ii} - \zeta_i)} \left(\frac{\rho_j}{(\psi_{jj} - \zeta_j)} \right) \mathrm{d}\ln e_j + \ldots}_{\text{Indirect Effect}} \tag{22}$$

where the first term is the direct effect on wages. The second term is an indirect effect, that depends on how interconnected labor markets are, as indicated by the presence of the cross-wage elasticity, ψ_{ij}. The expression weights labor demand

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[4]Writing in short-form,

$$\mathrm{d}\ln \mathbf{w} = \mathbf{V}\mathrm{d}\ln \mathbf{w} + \mathbf{T}\mathrm{d}\ln \mathbf{e}$$

where $\mathbf{T}$ is a matrix with 0 diagonals and off-diagonal entries being given by, $\mathbf{V} \equiv \left[\frac{-\psi_{ij}}{(\psi_{ii} - \zeta_i)}\right]_{ij}$ and $\mathbf{T}$ is a diagonal matrix with off-diagonal entries being 0 and diagonal entries given by, $\mathbf{T} \equiv \left[\frac{\rho_i}{(\psi_{ii} - \zeta_i)}\right]_{ii}$. We can solve for the reduced form effect on wages,

$$\mathrm{d}\ln \mathbf{w} = (\mathbf{I} - \mathbf{V})^{-1}\mathbf{T}\mathrm{d}\ln \mathbf{e}$$

and we can then re-express the Leontief inverse in a Neumann series and obtain an expression for wage changes with regard to an external demand shock. The derivations apply the well-known result for leontief-minkowski matrices,

$$\sum_k \mathbf{V}^k = (\mathbf{I} - \mathbf{V})^{-1}$$

which states that the geometric power series converges to the leontief inverse (Jorgenson, Bear and Wagner, 1962).

shocks elsewhere by ψ_{ij}. The overall indirect effect in location i is then nothing more than a weighted index of direct effects elsewhere. This can be seen by explicitly rewriting the formula in terms of direct effects,

$$d\ln w_i \approx d\ln w_i^{Direct} - \sum_j \gamma_{ij} d\ln w_j^{Direct}$$

where $\gamma_{ij} \propto \psi_{ij}$, that is the weights are proportional to the cross-wage labor supply elasticity, which again mirrors the connectedness between local labor markets. When mobility is impeded by geographical distance then ψ_{ij} will decreases in distance. This implies that the magnitude of the indirect effect will depend on the geographical incidence of the shock. Specifically, the more concentrated the shock across tightly linked labor markets, the more dramatic the local wage response. Since labor market linkages decay with distance, this implies that spatially concentrated shocks have different wage and price effects than more dispersed shocks.

The effect on employment. Having solved for wage changes across local labor markets, we can find the resulting employment allocations. Totally differentiating labor supply, we obtain,

$$d\ln \ell_i = \psi_{ii} d\ln w_i + \sum_j \psi_{ij} d\ln w_j \tag{23}$$

where as before, ψ_{ii} and ψ_{ij}, represent the own-wage and cross-wage labor supply elasticity. Plugging in the (first-order) approximate wage changes from above we obtain an approximate reduced-form expression for labor changes,

$$d\ln \ell_i \approx \underbrace{\frac{\psi_{ii}\rho_i}{(\psi_{ii}-\zeta_i)} d\ln e_i}_{\text{Direct Effect}} + \underbrace{\sum_j \frac{\psi_{ij}\rho_j}{(\psi_{jj}-\zeta_j)} d\ln e_j}_{\text{Indirect Effect}} \tag{24}$$

as above, the effect can be written in terms of a direct and indirect effect.

G.3 A Tractable Model of Imperfect Sectoral and Spatial Mobility

I begin by introducing a quantitative framework that can account for the direct and indirect effect of trade shocks across local labor markets. To do so, I extend an otherwise standard multi-sector economic geography model (Allen and Arkolakis, 2014; Redding, 2012; Caliendo and Parro, 2015; Caliendo, Dvorkin and Parro, 2019) by emdedding a tractable description of imperfect labor mobility across space and sectors, as well as incorporating domestic and foreign trade. The section sets up the model and derives a tractable and decomposable expression for gains from trade in terms of spatial and sectoral labor flows.

Setup. Let there be a number of locations within a country $n, i, j, h \in \mathbb{D} = \{1, \ldots, N^D\}$. Let there also be a number of foreign locations $k, l, m \in \mathbb{F} = \{1, \ldots, N^F\}$. Domestic locations are heterogeneous in their exogenously fixed housing supply, H_i, and their geographical location relative to one another. The only factor of production is labor. In each location production occurs across multiple sectors $r, s, t \in \mathbb{S} = \{1, \ldots, S\}$. There are only two periods and the initial distribution of workers across locations $[\ell_{n,r}]_{\forall(n,r)\in\mathbb{D}\times\mathbb{S}}$, is given, while the distribution of workers in the second period, $[\ell'_{n,r}]_{\forall(n,r)\in\mathbb{D}\times\mathbb{S}}$, is endogenously determined.

Preferences. Workers residing in location n and providing labor to sector s consume a Cobb-Douglas aggregate of housing and a consumption bundle: $U_n = \left(\frac{C_n}{1-\delta}\right)^{1-\delta}\left(\frac{H_n}{\delta}\right)^{\delta}$ where δ is the expenditure share on housing. C_n is a Cobb-Douglas aggregate of sector-specific CES aggregates of origin-differentiated goods of both domestic and foreign origin. The indirect utility and the optimal price index of this problem is given by,

$$u_{n,r} = \frac{\rho_n e_{n,r}}{p_n^{(1-\delta)} r_n^{\delta}}, \quad p_n = \prod_{r=1}^{S} \left(p_{n,r}\right)^{\alpha_r} \quad p_{n,r} = \left[\sum_{i=1}^{N^D}\left(p_{ni,r}\right)^{1-\sigma_r} + \sum_{l=1}^{N^F}\left(p_{nl,r}\right)^{1-\sigma_r}\right]^{\frac{1}{1-\sigma_r}}$$

where, the expenditure shares add up to 1, i.e. $\sum_{r=1}^{S}\alpha_r = 1$ and where $\sigma_r > 1$ is the elasticity of substitution between varieties within a sector and where $v_{n,r}$ represents the disposable income of a representative worker residing in location n and providing labor to sector s.

Households in foreign locations l spend a fixed endowment e_l across domestic locations. They consume a CES aggregate of origin-differentiated goods across domestic locations. The indirect utility and the optimal price index that households derive from consuming across domestic locations is given by,

$$u_l = \frac{e_l}{\prod_{r=1}^{S}\left(p_n^r\right)^{\alpha_{l,r}}}, \quad \sum_{r=1}^{S}\alpha_{l,r} = 1 \quad p_{l,r} = \left(\sum_{i=1}^{N^D}\left(p_{li,r}\right)^{1-\sigma_r}\right)^{\frac{1}{1-\sigma_r}}$$

where $\sigma_r > 1$ is again the elasticity of substitution between varieties within a sector and where e_l represents the endowment of workers in location l.

Domestic trade shares. Applying Roy's identity, demand in location n for sector r specific varieties produced in domestic locations i and foreign locations l are given by,

$$q_{ni,r}\left(\boldsymbol{p}_{n,r}\right) = \frac{\left(p_{ni,r}\right)^{-\sigma_r}}{\sum_{j=1}^{N^D}\frac{1}{d}\left(p_{nj,r}\right)^{1-\sigma_r} + \sum_{k=1}^{N^F}\left(p_{nk,r}\right)^{1-\sigma_r}}\left(1-\delta\right)\alpha_r\sum_{r=1}^{S}e_{n,r}\ell_{n,r}$$

$$q_{nl,r}\left(\boldsymbol{p}_{n,r}\right) = \frac{\left(p_{nl,r}\right)^{-\sigma_r}}{\sum_{j=1}^{N^D}\frac{1}{d}\left(p_{nj,r}\right)^{1-\sigma_r} + \sum_{k=1}^{N^F}\left(p_{nk,r}\right)^{1-\sigma_r}}\left(1-\delta\right)\alpha_r\sum_{r=1}^{S}e_{n,r}\ell_{n,r}$$

where $\boldsymbol{p}_n^r$ refers to the price vector for sector-specific r goods available in location $n$and produced in all other locations.

Foreign trade shares. Applying Roy's identity, demand in location l for the good produced in location i is given by,

$$q_{li,r}\left(\boldsymbol{p}_{l,r}\right) = \frac{p_{li,r}^{-\sigma_r}}{\sum_{j=1}^{N^D}p_{lj,r}^{1-\sigma_r}}\alpha_{l,r}e_l$$

where $\boldsymbol{p}_l$ refers to the price vector for sector-specific r goods available in location l of the goods produced in all other locations. We can then define expenditure shares of domestic locations for domestic and foreign varieties, which are given by,

$$s_{ni,r} = \alpha_r (1-\delta) \frac{p_{ni,r}^{1-\sigma_r}}{\sum_{i=1}^{N^D} \left(p_{ni,r}\right)^{1-\sigma_r} + \sum_{l=1}^{N^F} \left(p_{nl,r}\right)^{1-\sigma_r}}$$

$$s_{nl,r} = \alpha_r (1-\delta) \frac{p_{nl,r}^{1-\sigma_r}}{\sum_{i=1}^{N^D} \left(p_{ni,r}\right)^{1-\sigma_r} + \sum_{l=1}^{N^F} \left(p_{nl,r}\right)^{1-\sigma_r}}$$

And expenditure shares by foreign location on domestic varieties are given by,

$$s_{li,r} = \alpha_{l,r} \frac{\left(p_{li,r}\right)^{1-\sigma_r}}{\sum_{j=1}^{N^D} \left(p_{lj,r}\right)^{1-\sigma_r}}$$

Reallocation choice. Between the first and second period, workers can reallocate between domestic local labor markets to respond to changes in factor returns. Workers can both change their location and their sector. To obtain a parsimonious but flexible description of the problem, I specify reallocation in terms of a sequential stochastic choice. The initial allocation of workers across locations and sectors is given, $[\ell_{n,s}]_{\forall (n,s) \in \mathbb{D} \times \mathbb{S}}$, but workers can choose their location and sector for the second period. They first make a geographical relocation choice from location n to location i and subsequently a sectoral reloction choice moving from an initial sector r to another sector s. Both the geographical reallocation choice and the sectoral reallocation choice is subject to variable geographical and sectoral migration cost, μ_{ni} and μ_{rs} respectively. The properties of the Frechet distribution and the sequencing of the reallocation choice imply that labor flows between location n and location i and between sector r and s take on a multiplicatively separable form,

$$\sigma'_{ni,rs} = \sigma'_{ni|r} \sigma'_{rs|i} \tag{25}$$

where $\sigma_{ni|r}$ is the share of workers that originate from sector r in location n and reallocate to location i, and where $\sigma_{rs|i}$ is the share of workers that conditional on having chosen location i and choose to relocate from sector r to sector s. I present the solution to the problem by solving backwards. First, conditional on having chosen location i the probability of relocating from sector r to sector s can be written as,

$$\sigma'_{rs|i} = \frac{(w'_{is|r})^{\nu}}{\left(\Pi'_{i,r}\right)^{\nu}} \tag{26}$$

where ν is the dispersion parameter of the sector-specific preference shock, $w'_{is|r} \equiv w'_{is}/\mu_{rs}$ represents the wage adjusted by the mobility cost, and $\Pi'_{i,r} \equiv \left(\sum_t (w'_{it|r})^{\nu}\right)^{1/\nu}$ represents the option value of a worker conditional on having chosen location i and being initially attached to sector r. Prior to making the sectoral relocation choice, the worker makes a geographical choice. In a first step the worker therefore compares the different option values of the sectoral reallocation choice across geographical locations. The geographical reallocation share takes on the following closed form form expression,

$$\sigma'_{ni|r} = \frac{\left(v'_{ni|r}\right)^{\gamma}}{\left(\Omega'_{n,r}\right)^{\gamma}} \tag{27}$$

where γ is the dispersion parameter of the location-specific preference shock, $v'_{ni|r}$ is the expected utility of location from n to i conditional on initial attachment to sector r[5] and where finally $\left(\Omega'_{n,r}\right)^{\gamma} \equiv \sum_j \left(v'_{nj|r}\right)^{\gamma}$ represents the option value of the

[5]The expected ex-ante utility, i.e. prior to observing and forming expectations over the sectoral preference shocks, that an individual derives from moving from location n to location i can be expressed in terms of the option value of being in that location-sector $\Pi'_{i,r} \equiv \left(\sum_t (w'_{it}/\mu_{rt})^{\nu}\right)^{1/\nu}$, multiplied by a stochastic location-specific preference shock κ_i, and adjusted by variable geographical migration cost, μ_{ni}, i.e.

$$v'_{ni|r} \equiv \frac{\delta}{\mu_{ni}} \frac{\rho_i \Pi'_{i|r}}{\left(p'_i\right)^{1-\delta} \left(r'_i\right)^{\delta}} \times \kappa_i$$

geographical choice.

Production. Production is as before given by a constant return to scale production technology,

$$q_{i,r} = z_{i,r}\ell_{i,r}$$

where $z_{i,r}$ denotes a productivity shifter for sector r in location i and $\ell_{i,r}$ denotes the number of workers employed there. Goods can be traded between locations within and between countries, but transport is subject to iceberg variable trade costs, implying that delivering a unit of any good from location n to location i requires shipping $\tau_{ni} \geq 1$ units of the good. Therefore, the price that a representative worker faces in location i for any good from location $n$is given by,

$$p_{ni,r} = \tau_{ni} mc_{i,r} = \frac{\tau_{ni} w_{i,r}}{z_{i,r}} \tag{28}$$

where z_i captures as before the productivity of a given location and iceberg variable trade costs satisfy $\tau_{ni} > 1$ and $\tau_{nn} = 1$, that is we normalize trade costs within a location to 1, and $mc_{i,r} = w_{i,r}/z_{i,r}$ is the marginal cost of production in location i and sector r.

Equilibrium. The equilibrium of the model can be formulated in terms of four market clearing conditions. First, goods market clearing implies that total factor income equals total income derived both from foreign and domestic sales,

$$w_{i,r}\ell_{i,r} = \sum_{n=1}^{N^D} s_{ni,r}\left(\sum_{r=1}^{S} e_{n,r}\ell_{n,r}\right) + \sum_{l=1}^{N^F} s_{li,r} e_l \tag{29}$$

Second, balanced trade implies that total disposable income in a location equals total imports of that locations both foreign and domestic,

$$\left(\sum_{r=1}^{S} e_{n,r}\ell_{n,r}\right) = \sum_{r=1}^{S}\left(\sum_{i=1}^{N} s_{ni,r}\left(\sum_{r=1}^{S} e_{n,r}\ell_{n,r}\right) + \sum_{l=1}^{N^F} s_{nl,r}\left(\sum_{r=1}^{S} e_{n,r}\ell_{n,r}\right)\right) \tag{30}$$

Third, total expenditure on housing services has to equal the total returns to housing,

$$H_n r_n = \delta\left(\sum_{r=1}^{S} e_{n,r}\ell_{n,r}\right) \tag{31}$$

Fourth, and finally, the above conditions hold both in the first and second period, but while labor allocations are given in the first period, in the second period there is a reallocation choice. Spatial labor market clearing implies,

$$\ell_i' = \sum_n \sum_r \sigma_{ni|r}\ell_{n,r} \tag{32}$$

Sector-province labor market clearing is given by,

$$\ell_{i,s}^{'} = \sum_{r=1}^{S}\sum_{n=1}^{N} \sigma_{ni,rs}\ell_{n,r} \tag{33}$$

which implies that the total number of workers in a location in the second period is equal to the total number of workers that have reallocated to that location from the previous period.

G.4 Aggregate welfare in the quantitative model

To construct a measure of aggregate welfare that takes reallocation into account, I assume that rather than the initial allocation being fixed, workers receive a location-specific extreme value distributed preference shock that gives rise to and matches the observed allocation of workers across space as in the canonical quantitative spatial equilibrium model in Redding (2012). The welfare expression that corresponds to the first step, and expresses the value of being able to choose any of the domestic location by summing up over the migration value of each one location, that is,

$$\mathscr{W} \equiv E\left(\Omega_{n,r}\right) = \delta\left[\sum_{n=1}^{N^D}\sum_{r=1}^{S}\left(\tilde{\rho}_{n,r}\Omega_{n,r}\right)^{\epsilon}\right]^{1/\epsilon}$$

where $\delta = \Gamma\left(\frac{\epsilon}{\epsilon-1}\right)$ and $\Gamma(\cdot)$ is the gamma function and we impose $\epsilon > 1$ to obtain a finite value for the expected utility. Additionally, $\tilde{\rho}$ corresponds to an amenity shifter that is chosen to exactly fit the distribution of the population across space. Following Redding (2012), I use this measure of expected utility as a proxy for aggregate welfare. Conditional on the initial allocation, workers face a reallocation choice subject to switching costs and a new set of independently drawn extreme value distributed preferences shocks as stated above and as before Ω_n' corresponds to the expected utility of that choice,

$$\Omega_{n,r}' = \tilde{\delta}\left[\sum_{j=1}^{N^D}\left(v_{nj|r}'\right)^{\gamma}\right]^{1/\gamma}$$

where again $\delta = \Gamma\left(\frac{\gamma}{\gamma-1}\right)$ and $\Gamma(\cdot)$ is the gamma function and we impose $\gamma > 1$ to obtain a finite value for the expected utility. Totally differentiating the welfare expression, we obtain,

$$\begin{aligned}\frac{d\mathscr{W}'}{\mathscr{W}'} &= \sum_{n=1}^{N^D}\sum_{r=1}^{S}\frac{d\Omega_{n,r}'}{\Omega_{n,r}'} \times \frac{\left(\tilde{\rho}_{n,r}\Omega_{n,r}\right)^{\epsilon}}{\sum_{n=1}^{N^D}\sum_{r=1}^{S}\left(\tilde{\rho}_{n,r}\Omega_{n,r}\right)^{\epsilon}} \\ &= \sum_{n=1}^{N^D}\sum_{r=1}^{S}\frac{d\Omega_{n,r}'}{\Omega_{n,r}'} \times \pi_{i,r}\end{aligned}$$

where $\pi_{i,r} = \frac{\ell_{i,r}}{\sum_i\sum_r \ell_{i,r}}$ is the population share observed in the data in the baseline period. Integrating, we obtain,

$$\begin{aligned}\int_{\mathscr{W}^0}^{\mathscr{W}^1}\frac{\mathrm{d}\mathscr{W}'}{\mathscr{W}'} &= \sum_{n=1}^{N^D}\sum_{r=1}^{S}\pi_{i,r} \times \int_{\Omega_{n,r}^0}^{\Omega_{n,r}^1}\frac{d\Omega_{n,r}'}{\Omega_{n,r}'} \\ \ln\left(\frac{\mathscr{W}^1}{\mathscr{W}^0}\right) &= \sum_{n=1}^{N^D}\sum_{r=1}^{S}\pi_{n,r}\ln\left(\frac{\Omega_{n,r}^1}{\Omega_{n,r}^0}\right) \\ \left(\frac{\mathscr{W}^1}{\mathscr{W}^0}\right) &= \prod_{n=1}^{N^D}\prod_{r=1}^{S}\left(\frac{\Omega_{n,r}^1}{\Omega_{n,r}^0}\right)^{\pi_{n,r}}\end{aligned}$$

where $\pi_{i,r} = \frac{\ell_{i,r}}{\sum_i\sum_r \ell_{i,r}}$ is the population share observed in the data in the baseline period. From (27) we can construct an expression for changes in the option value $\Omega_{n,r}$,

$$\hat{\Omega}_{n,r} = \hat{v}_{nn|r}\left(\hat{\sigma}_{nn|r}\right)^{-\frac{1}{\gamma}}$$

where hatted variables, $\hat{x} = x'/x$, denote changes and where the option value only depends on the change in the expected utility from remaining and the share of workers who choose to remain in their origin province. From the definition of the exepcted utility, we can obtain,

$$\hat{v}_{nn|r} = \hat{\delta}_n\hat{\Pi}_{n|r}$$

which only depends on the change in the expected value of the sectoral relocation choice. Again, from the definition of the sectoral relocation share (26) we can obtain,

$$\hat{\Pi}_{n,r} = \hat{w}_{nr|r}\left(\hat{\sigma}_{rr|i}\right)^{-\frac{1}{\nu}}$$

combining with the result above we obtain,

$$\hat{\Omega}_{n,r} = \hat{u}_{nr|r}\left(\hat{\sigma}_{rr|i}\right)^{-\frac{1}{\nu}}\left(\hat{\sigma}_{nn|r}\right)^{-\frac{1}{\gamma}}$$

and substituting back in,

$$\left(\frac{\mathscr{W}^1}{\mathscr{W}^0}\right) = \prod_{n=1}^{N^D}\prod_{r=1}^{S}\left(\underbrace{\left(\frac{\sigma_{nn|r}^1}{\sigma_{nn|r}^0}\right)^{-\frac{1}{\gamma}}}_{\text{Spatial Flows}}\underbrace{\left(\frac{\sigma_{rr|n}^1}{\sigma_{rr|n}^0}\right)^{-\frac{1}{\nu}}}_{\text{Sectoral Flows}}\frac{u_{nr|r}^1}{u_{nr|r}^0}\right)^{\pi_{n,r}}$$

where $\sigma^1_{nn|r}$ represents the share of workers initially located in province n and working sector r and deciding to remain in that province, while $\sigma^1_{rr|n}$ represents the share of workers who in the second period will be located in province n, were initially attached to sector $r$and decide to remain in sector r. Intuitively, if more workers decide to either change their sector or their location, then this is informative about the option value of a spatial or sectoral change to have increased, relative to the remain option. In other words, the remain share (to the power of the negative inverse of the labor supply elasticity) is proportional to changes in the option-value and therefore a sufficient statistic for welfare changes that arise due to the ability of the worker being able to reallocate. This approach is intimately related to the argument that conditional choice probabilities can be used to infer continuation values in dynamic discrete choice problems (Hotz and Miller, 1993). Even though, it is here stated in the context of two period model, the approach is much more general and a similar expression for welfare can be derived for multi-period or infinite horizon models. The final term represents cross-Sectional improvements in the indirect utility of workers across locations. This term can be constructed using the tools by Arkolakis, Costinot and Rodriguez-Clare (2012) and Ossa (2015), which gives us,

$$\hat{u}_{n,r} = \frac{\left(\hat{w}_{n,r}\right)^{\delta}}{\left(\hat{r}_n\right)^{\delta}} \frac{\left(\hat{w}_{n,r}\right)^{(1-\delta)}}{\prod_{r=1}^{S}\left(\hat{w}_{n,r}\right)^{(1-\delta)\alpha_r}} \prod_{r=1}^{S}\left(\hat{s}_{nn,r}\right)^{\frac{(\delta-1)\alpha_r}{\sigma_r-1}}$$

substituting into above formula gives us the expression in the main text,

$$\left(\frac{\mathscr{W}^1}{\mathscr{W}^0}\right) = \prod_{n=1}^{N^D}\prod_{r=1}^{S}\left(\underbrace{\left(\frac{\sigma^1_{nn|r}}{\sigma^0_{nn|r}}\right)^{-\frac{1}{\gamma}}}_{\text{Spatial Flows}} \underbrace{\left(\frac{\sigma^1_{rr|n}}{\sigma^0_{rr|n}}\right)^{-\frac{1}{\nu}}}_{\text{Sectoral Flows}} \underbrace{\left(\frac{r^1_n}{r^0_n}\right)^{-\delta}}_{\text{Housing Cost}} \underbrace{\prod_{t=1}^{S}\left(\frac{s^1_{nn,t}}{s^0_{nn,t}}\right)^{-\frac{(1-\delta)\alpha_t}{\sigma_t-1}}}_{\text{ACR Gains}}\right)^{\pi_{n,r}}$$

G.5 Trade Imbalances

To reflect the change in trade deficits in the analysis, I incorporate exogenous trade imbalances as in Dekle, Eaton, and Kortum (2007) and Caliendo and Parro (2015). However, instead of an additive formulation, I instead model trade balances as a multiplicative scalar that adjusts the disposable income available to the representative agent. Furthermore, I distinguish between domestic and external trade, and while external trade might be unbalanced, domestic trade is assumed to be balanced. Consider the domestic and external trade balance condition separately. As before, trade is balanced domestically, implying that domestic income is equal to domestic expenditure,

$$d_1 y_n = \sum_{r=1}^{S}\left(\sum_{i=1}^{N} s_{ni,r} y_n\right)$$

where d_1 is defined as the fraction of income that is being derived from domestic sales and y_n denotes the disposable income, such that,

$$y_n = \sum_{r=1}^{S} e_{n,r}\ell_{n,r}$$

Externally, trade is possibly unbalanced, such that expenditures on foreign goods might be below or above income derived from foreign goods, i.e.

$$(1-d_1)\, y_n = d_2 \times \sum_{r=1}^{S}\sum_{l=1}^{N^F} s_{nl,r} y_n$$

where the left hand side denotes income derived from foreign sales and the right hand side denotes expenditures on foreign goods. As before, d_1, is the fraction of income that is being derived domestically. On the right hand side, d_2 is the proportion of foreign income that is being expended on foreign goods. where d_2 is defined as,

$$d_2 = \frac{\sum_{l=1}^{N^F}\sum_{r=1}^{S} X_{nl.r}}{\sum_{l=1}^{N^F}\sum_{r=1}^{S} X_{ln,r}}$$

To derive the total price index, combine,

$$y_n = \sum_{r=1}^{S}\sum_{i=1}^{N} s_{ni,r} y_n + d_2 \times \sum_{r=1}^{S}\sum_{l=1}^{N^F} s_{nl,r} y_n$$

Dividing by income and noticing that $s_{ni,r} = \left(p_{ni,r}\right)^{1-\sigma_r} p_{n,r}^{\sigma_r - 1}$, we obtain,

$$p_{n,r}^{1-\sigma} = \sum_{i=1}^{N^D} p_{ni,r}^{1-\sigma} + d_2 \sum_{l=1}^{N^F} p_{nl,r}^{1-\sigma}$$

which allows us to express the price index in terms of the weighted domestic and external prices, i.e.

$$p_{n,r} = \left(\sum_{i=1}^{N^D} p_{ni,r}^{1-\sigma} + d_2 \sum_{l=1}^{N^F} p_{nl,r}^{1-\sigma}\right)^{\frac{1}{1-\sigma}}$$

This implies that the indirect utility and the optimal price index of this problem is given by,

$$u_{n,r} = \frac{\rho_n e_{n,r}}{p_n^{(1-\delta)} r_n^{\delta}}, \quad p_n = \prod_{r=1}^{S}\left(p_{n,r}\right)^{\alpha_r} \quad p_{n,r} = \left[\sum_{i=1}^{N^D}\left(p_{ni,r}\right)^{1-\sigma_r} + d_2 \sum_{l=1}^{N^F}\left(p_{nl,r}\right)^{1-\sigma_r}\right]^{\frac{1}{1-\sigma_r}}$$

Combining and factoring out the trade imbalance term we obtain,

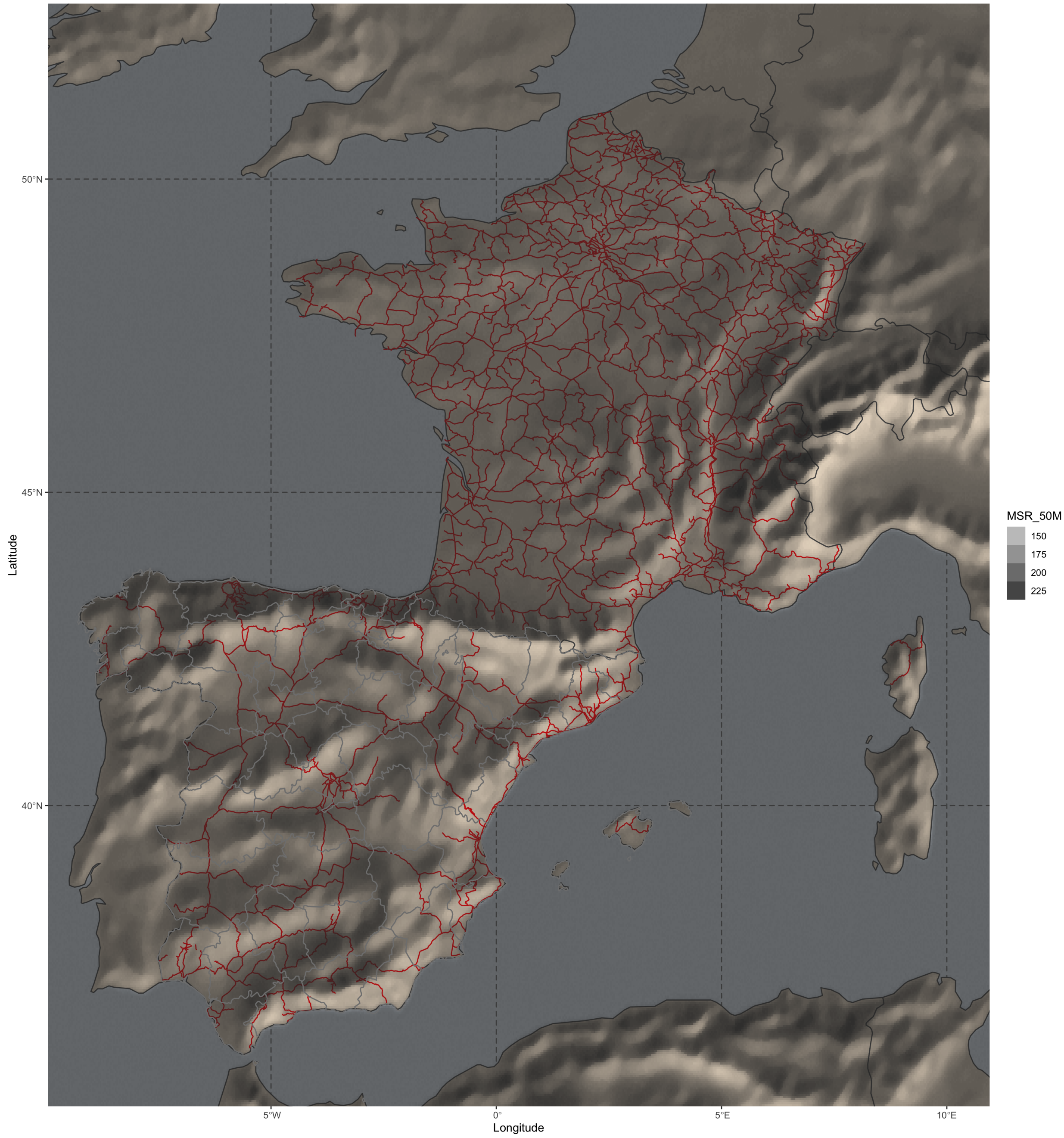
$$u_{n,r} = d_2^{-\sum_r \frac{(1-\delta)\alpha_r}{1-\sigma_r}} \frac{\rho_n e_{n,r}}{r_n^{\delta} \prod_{r=1}^{S}\left(\left(\sum_{i=1}^{N^D} \frac{1}{d_2} p_{ni}^{1-\sigma_r} + \sum_{l=1}^{N^F} p_{nl}^{1-\sigma_r}\right)^{\frac{(1-\delta)\alpha_r}{1-\sigma_r}}\right)}$$

Following the same derivations as before,

$$\left(\frac{\mathscr{W}^1}{\mathscr{W}^0}\right) = \underbrace{\left(\frac{d_2^1}{d_2^0}\right)^{-\sum_r \frac{(1-\delta)\alpha_r}{1-\sigma_r}}}_{\text{Deficit Adjustment}} \prod_{n=1}^{N^D} \prod_{r=1}^{S} \left(\underbrace{\left(\frac{\sigma^1_{nn|r}}{\sigma^0_{nn|r}}\right)^{-\frac{1}{\gamma}}}_{\text{Spatial Flows}} \underbrace{\left(\frac{\sigma^1_{rr|n}}{\sigma^0_{rr|n}}\right)^{-\frac{1}{\nu}}}_{\text{Sectoral Flows}} \underbrace{\left(\frac{\tilde{r}^1_n}{\tilde{r}^0_n}\right)^{-\delta}}_{\text{Housing Cost}} \underbrace{\prod_{t=1}^{S} \left(\frac{\tilde{s}^1_{nn,t}}{\tilde{s}^0_{nn,t}}\right)^{-\frac{(1-\delta)\alpha_t}{\sigma_t-1}}}_{\text{ACR Gains}} \right)^{\pi_{n,r}}$$

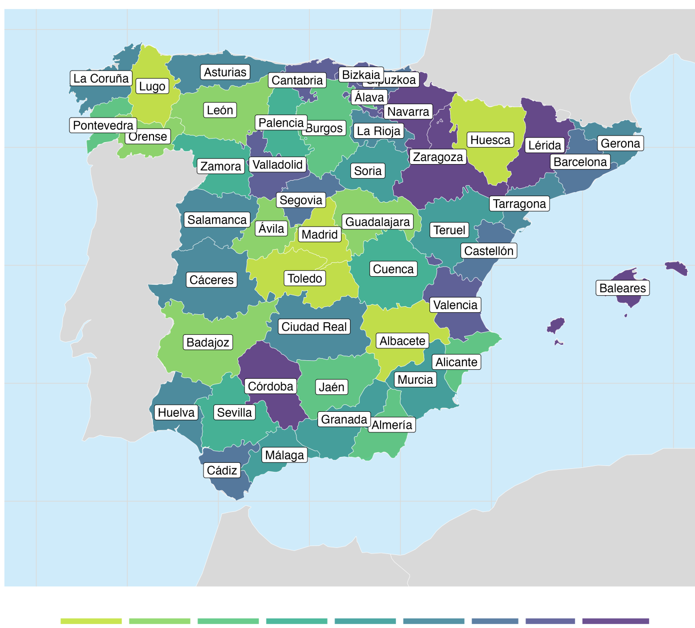
H Additional figures

Figure A.6. Railroad Network Spain/France 1910



Notes: The map depicts the digitized historical railroad network for Spain and Franca ca. 1910. Additional details on data construction and sources can be found in the online appendix.

Figure A.7. Spatial Distribution of Gains from Trade: Sectoral vs Spatial Adjustments



Notes: Chloropleth map of the contributions towards aggregate welfare gains by province (in percentage points). Province-specific contributions to aggregate welfare are calculated using Equation (18). The upper figure presents the reallocative gains from sectoral flows, and is aggregated by province, and the lower figure presents the reallocative gains from spatial flows, and is aggregated by province, i.e.

$$\frac{\mathscr{W}^1_{n,Sectoral}}{\mathscr{W}^0_{n,Sectoral}} = \prod_{r=1}^{S} \left(\underbrace{\left(\frac{\sigma^1_{rr|n}}{\sigma^0_{rr|n}} \right)^{-\frac{1}{\nu}}}_{\text{Sectoral Flows}} \right)^{\pi_{n,r}} \qquad \frac{\mathscr{W}^1_{n,Spatial}}{\mathscr{W}^0_{n,Spatial}} = \prod_{r=1}^{S} \left(\underbrace{\left(\frac{\sigma^1_{nn|r}}{\sigma^0_{nn|r}} \right)^{-\frac{1}{\gamma}}}_{\text{Spatial Flows}} \right)^{\pi_{n,r}}$$

where $\left\{\sigma^0_{nn|r}, \sigma^0_{rr|n}, u^0_{nr|r}\right\}$ are the counterfactual labor flows and utility levels obtained from the counterfactual simulation for Spain without WWI as described in Section 4 and $\left\{\sigma^1_{nn|r}, \sigma^1_{rr|n}, u^1_{nr|r}\right\}$ are obtained from the fitted model as described and estimated in Section 4. The results represent the decomposed results from the couterfactual comparison in Row (2) of Panel A of Table 3.

I Additional tables

Table. A.5. Regression Results: Event Study on Belligerent Sectoral Exports I

	Exports (Value)		
	(1)	(2)	(3)
War Period × Sector = Books	-0.0641 (0.0783)	-0.1183 (0.1666)	-0.1154 (0.1390)
War Period × Sector = Ceramics	-0.0280 (0.1195)	-0.0519 (0.1871)	-0.0780 (0.1791)
War Period × Sector = Chemicals	0.5472* (0.3094)	0.6098*** (0.2269)	0.5782** (0.2625)
War Period × Sector = Construction	-0.0965 (0.2133)	-0.1724 (0.2127)	-0.0223 (0.1927)
War Period × Sector = Decoration	0.9878*** (0.0718)	1.184** (0.5652)	1.245*** (0.4558)
War Period × Sector = Electricity	0.3231*** (0.0903)	0.5665*** (0.2091)	0.6373** (0.3011)
War Period × Sector = Food	0.2104 (0.1414)	0.1873*** (0.0701)	0.1634* (0.0951)
War Period × Sector = Forrest	-0.3512*** (0.0736)	-0.1829 (0.3355)	-0.0531 (0.3673)
War Period × Sector = Furniture	0.1017 (0.1767)	0.0873 (0.1525)	0.0063 (0.1988)
War Period × Sector = Garments	0.9378*** (0.3113)	0.8903** (0.3804)	0.9717*** (0.2990)
War Period × Sector = Glass	0.3393*** (0.0817)	0.3104* (0.1772)	0.3738* (0.1931)
War Period × Sector = Gold	-0.4479*** (0.0848)	-0.3956* (0.2117)	-0.0607 (0.1444)
War Period × Sector = Leather	1.482*** (0.0732)	1.368** (0.5329)	1.536*** (0.5491)
War Period × Sector = Metallurgy	-0.0023 (0.5717)	0.1213 (0.6505)	0.1755 (0.7238)
War Period × Sector = MetalWorks	0.0470 (0.3080)	-0.0038 (0.2332)	0.0923 (0.2586)
War Period × Sector = Mines	-0.2246* (0.1227)	-0.2188 (0.2379)	-0.2129 (0.2147)
War Period × Sector = Other	0.1419 (0.1660)	0.2017 (0.1308)	0.2319 (0.1547)
War Period × Sector = Paper	-0.4212 (0.6106)	-0.4654 (0.3268)	-0.4700 (0.3765)
War Period × Sector = PublicIndustry	-4.433*** (0.0726)	-4.397*** (1.255)	-1.591* (0.8529)
War Period × Sector = Textiles	0.7245*** (0.1608)	0.7617*** (0.2321)	0.7419*** (0.1476)
War Period × Sector = Tobacco	2.147*** (0.0706)	1.723** (0.8450)	1.864** (0.9063)
War Period × Sector = Transport	0.5031** (0.2152)	0.1470 (0.1938)	-0.1267 (0.1046)
War Period × Sector = Wood	-0.1806* (0.0924)	-0.1865* (0.1125)	-0.1532 (0.1379)
Standard-Errors	Product	Destination	Destination-Product
Observations	80,153	80,150	79,920
Pseudo R^2	0.37166	0.66054	0.87407
Product fixed effects	✓	✓	
Year fixed effects	✓	✓	✓
Destination fixed effects		✓	
Destination-Product fixed effects			✓

Notes: Table shows the regressions results for the event study design described in Equation (5). In Columns (1)-(3), observations are values of exports (in pesetas) at the product-destination level for a given year. War Period is a dummy variable that takes the value of 1 for the duration of the war, i.e. 1914-1918. The omitted baseline sector is agriculture for all specifications. Three different specifications are reported: One with product and year fixed effects in the first column, a second with product, year and destination fixed effects and finally a third with interacted product-destination and year fixed effects. The regressions are estimated by PPML using the fixpois command of the fixest package in R. The source data are the digitized product-destination level trade statistics. More information on data construction can be obtained in the online appendix. In parantheses (heteroskedasticity) robust standard errors are being reported: *** for 1 percent significance; ** for 5 percent significance; * for 10 percent significance.

Table. A.6. Regression Results: Event Study on Belligerent Sectoral Exports II

	Exports (Value)		
	(1)	(2)	(3)
Belligerent	2.049*** (0.1689)		
War Period × Belligerent	0.4035* (0.2428)	0.2985 (0.1929)	0.2461* (0.1356)
War Period × Sector = Books	-0.0028 (0.3375)	-0.0436 (0.3290)	-0.0156 (0.1410)
War Period × Sector = Ceramics	0.0192 (0.2632)	0.0260 (0.2581)	0.0085 (0.1387)
War Period × Sector = Chemicals	0.3438* (0.1769)	0.4120** (0.1726)	0.3669*** (0.1249)
War Period × Sector = Construction	-0.0831 (0.2224)	-0.1076 (0.2235)	-0.0012 (0.1471)
War Period × Sector = Decoration	0.7229 (0.4900)	0.8025 (0.5496)	0.7040 (0.5151)
War Period × Sector = Electricity	0.3200 (0.4553)	0.3559 (0.5371)	0.6704* (0.3855)
War Period × Sector = Food	0.1518 (0.1711)	0.1481 (0.1487)	0.1211 (0.1082)
War Period × Sector = Forrest	-0.3993 (0.3718)	-0.2793 (0.3149)	-0.0158 (0.2550)
War Period × Sector = Furniture	0.1090 (0.2043)	0.1236 (0.2063)	0.0020 (0.1398)
War Period × Sector = Garments	0.0908 (0.1845)	-0.0034 (0.1904)	0.0661 (0.1146)
War Period × Sector = Glass	0.2117 (0.2838)	0.1508 (0.2733)	0.2099 (0.1780)
War Period × Sector = Gold	-0.0269 (0.4735)	-0.3080 (0.5196)	0.0314 (0.4351)
War Period × Sector = Leather	0.1957 (0.3398)	0.0245 (0.3985)	-0.0390 (0.2981)
War Period × Sector = Metallurgy	-0.7535 (0.8463)	-0.6450 (0.7634)	-0.4937 (0.7774)
War Period × Sector = MetalWorks	-0.2146 (0.2701)	-0.2055 (0.2117)	-0.1884 (0.1841)
War Period × Sector = Mines	-0.2395 (0.3215)	-0.1981 (0.2371)	-0.1627 (0.1391)
War Period × Sector = Other	0.1719 (0.1857)	0.2105 (0.1814)	0.3106** (0.1302)
War Period × Sector = Paper	-0.5526 (0.3865)	-0.5536 (0.3843)	-0.5692 (0.3684)
War Period × Sector = PublicIndustry	-4.501*** (1.277)	-4.938*** (1.383)	-0.2436 (1.179)
War Period × Sector = Textiles	0.3861* (0.2080)	0.3985** (0.2012)	0.3855*** (0.1418)
War Period × Sector = Tobacco	0.1948 (0.5225)	-0.1903 (0.6719)	-0.2222 (0.4242)
War Period × Sector = Transport	-0.8635** (0.4048)	-0.4548 (0.4039)	-0.5236** (0.2231)
War Period × Sector = Wood	-0.0518 (0.2114)	-0.0642 (0.1784)	-0.0012 (0.1297)
Belligerent × Sector = Books	-2.381*** (0.4094)	-2.589*** (0.3570)	
Belligerent × Sector = Ceramics	-1.839*** (0.3142)	-1.727*** (0.3230)	
Belligerent × Sector = Chemicals	-0.7845*** (0.2591)	-0.7638*** (0.2290)	
Belligerent × Sector = Construction	-2.365*** (0.3171)	-2.489*** (0.2932)	
Belligerent × Sector = Decoration	-1.307 (0.8647)	-1.838** (0.8941)	
Belligerent × Sector = Electricity	-0.9831** (0.5014)	-1.106** (0.5449)	
Belligerent × Sector = Food	0.0958 (0.2445)	-0.1070 (0.2099)	
Belligerent × Sector = Forrest	-1.360* (0.7617)	-0.7607 (0.6976)	
Belligerent × Sector = Furniture	0.2470 (0.3369)	0.1258 (0.2526)	
Belligerent × Sector = Garments	-0.0810 (0.4286)	-0.3025 (0.3976)	
Belligerent × Sector = Glass	-0.1480 (0.8409)	-0.4063 (0.8062)	
Belligerent × Sector = Gold	0.5775 (0.4792)	0.9312* (0.4826)	
Belligerent × Sector = Leather	0.0170 (0.9661)	-0.0738 (0.9231)	
Belligerent × Sector = Metallurgy	-2.253** (0.8927)	-1.702** (0.8534)	
Belligerent × Sector = MetalWorks	-1.604*** (0.4287)	-0.9888*** (0.3787)	
Belligerent × Sector = Mines	-2.544*** (0.3007)	-1.978*** (0.2127)	
Belligerent × Sector = Other	-1.322*** (0.2834)	-1.105*** (0.2499)	
Belligerent × Sector = Paper	-2.573*** (0.5938)	-2.621*** (0.5602)	
Belligerent × Sector = PublicIndustry	-4.743*** (0.9674)	-5.163*** (1.038)	
Belligerent × Sector = Textiles	-0.5276 (0.3284)	-0.6262** (0.3002)	
Belligerent × Sector = Tobacco	-1.570* (0.8065)	-1.995** (0.8325)	
Belligerent × Sector = Transport	1.356*** (0.3833)	0.9205** (0.3677)	
Belligerent × Sector = Wood	0.0671 (0.3436)	0.0072 (0.2251)	
War Period × Belligerent × Sector = Books	-0.3825 (0.5973)	-0.3859 (0.5149)	-0.4341 (0.3521)
War Period × Belligerent × Sector = Ceramics	-0.1552 (0.5689)	-0.1794 (0.5760)	-0.1749 (0.4190)
War Period × Belligerent × Sector = Chemicals	0.8262* (0.4303)	0.7580** (0.3770)	0.7982** (0.3524)
War Period × Belligerent × Sector = Construction	0.2978 (0.5313)	0.5123 (0.5009)	0.6182* (0.3162)
War Period × Belligerent × Sector = Decoration	1.197 (1.248)	1.077 (1.274)	1.155 (1.336)
War Period × Belligerent × Sector = Electricity	0.0713 (0.6816)	0.3267 (0.7208)	-0.0820 (0.6371)
War Period × Belligerent × Sector = Food	0.1643 (0.3313)	0.1417 (0.3019)	0.1536 (0.2300)
War Period × Belligerent × Sector = Forrest	0.3829 (0.8404)	0.2847 (0.8239)	-0.0495 (0.7061)
War Period × Belligerent × Sector = Furniture	-0.0415 (0.4626)	-0.0963 (0.3756)	0.0046 (0.3327)
War Period × Belligerent × Sector = Garments	1.564*** (0.5131)	1.722*** (0.4658)	1.632*** (0.4382)
War Period × Belligerent × Sector = Glass	0.2927 (0.9716)	0.4907 (0.8949)	0.4762 (0.8873)
War Period × Belligerent × Sector = Gold	-0.4985 (0.6270)	-0.0315 (0.5750)	-0.2444 (0.4845)
War Period × Belligerent × Sector = Leather	1.796 (1.195)	2.106* (1.121)	2.204* (1.136)
War Period × Belligerent × Sector = Metallurgy	2.288** (0.9711)	2.216** (0.9518)	2.007** (0.9241)
War Period × Belligerent × Sector = MetalWorks	0.5281 (0.5615)	0.7327 (0.4840)	0.9247** (0.4579)
War Period × Belligerent × Sector = Mines	0.3043 (0.4720)	0.2123 (0.3517)	0.1589 (0.2297)
War Period × Belligerent × Sector = Other	0.0005 (0.4426)	-0.0126 (0.4183)	-0.1717 (0.3561)
War Period × Belligerent × Sector = Paper	1.664** (0.7098)	1.658** (0.6647)	1.685** (0.6570)
War Period × Belligerent × Sector = PublicIndustry	0.6260 (1.503)	1.185 (1.555)	-3.553** (1.398)
War Period × Belligerent × Sector = Textiles	1.045** (0.4254)	1.041*** (0.3897)	0.9815*** (0.3416)
War Period × Belligerent × Sector = Tobacco	3.460*** (1.278)	3.868*** (1.316)	3.907*** (1.261)
War Period × Belligerent × Sector = Transport	0.6397 (0.5999)	0.3015 (0.5706)	0.3076 (0.4537)
War Period × Belligerent × Sector = Wood	-0.3595 (0.4678)	-0.3461 (0.3309)	-0.4224* (0.2284)
Observations	80,143	80,143	79,914
Pseudo R^2	0.49221	0.68012	0.87923
Product fixed effects	✓	✓	
Year fixed effects	✓	✓	✓
Destination fixed effects		✓	
Destination-Product fixed effects			✓

Notes: The Table shows the regressions results for the event study design described in Equation (4). In Columns (1)-(3), observations are values of exports (in pesetas) at the product-destination level for a given year. Belligerent Destination is a dummy that takes the value of 1 for the primary belligerent countries where trade was not disrupted by the frontline itself, i.e. i.e. France, Italy and the United Kingdom. The non-belligerent countries exclude the United States and other later participants of WWI. War Period is a dummy variable that takes the value of 1 for the duration of the war, i.e. 1914-1918. The omitted baseline sector is agriculture for all specifications. Three different specifications are reported: One with product and year fixed effects in the first column, a second with product, year and destination fixed effects and finally a third with interacted product-destination and year fixed effects. The regressions are estimated by PPML using the fixpois command of the fixest package in R. The source data are the digitized product-destination level trade statistics. More

Table. A.7. Results: Mobility Cost Estimation Sectoral Parameters

Sector	μ_{rs}
Agriculture	0.100000
Books	0.000602
Ceramics	0.001049
Chemicals	0.000497
Construction	0.000665
Decoration	0.000840
Electricity	0.001233
Food	0.000434
Forrest	0.000933
Furniture	0.000507
Garments	0.000468
Glass	0.000433
Leather	0.000568
Metallurgy	0.000519
MetalWorks	0.000476
Mines	0.001111
Other	0.001362
Paper	0.000488
Public	0.000871
PublicIndustry	0.001265
Textiles	0.000551
Tobacco	0.000665
Transport	0.000644
Wood	0.000549

Notes: Table reports the sectoral results of the joint estimation. The column indicates the sectoral switching costs. The estimation procedure minimizes the distance between observed labor allocations in 1920 and the predicted labor allocations from the economic geography model across all province-sectors, i.e.

$$\eta_{i,s}(\boldsymbol{\beta}) = L_{i,s}^{1920} - \widehat{L}_{i,s}^{1920}$$

Labor allocations are generated by feeding the average export levels for 1915 and 1916 into the model, and solving a fixed point problem that solves for the labor allocations, wages, prices and rental rates that solve the equilibrium coniditions and are consistent with rational expectation. The resulting flows are then given by the solution to the following fixed point problem,

$$\widehat{L}_{i,s}^{1920} = \sum_{n,r} \sigma_{ni,rs}^{1914 \to 1920} \left(\mathbf{w}^{\text{WWI}} \left(\widehat{L}_{i,s}^{1920} \right) \right) L_{n,r}^{1914}$$

The problem is being solved in MATLAB using the lsqnonlin solver to obtain the complete solution $\boldsymbol{\beta} = (\mu_{ag,1}, \ldots, \mu_{ag,n}, \mu_2, \ldots, \mu_S)$. This table presents the sectoral switching cost only. The data being used draws on trade statistics, census data, and the salarios publication as discussed in 4.

Table. A.8. Results: Mobility Cost Estimation Geographical Parameters

Province	β_n	ζ_n	$\mu_{ag,n}$	Province	β_n	ζ_n	$\mu_{ag,n}$
Alava	0.03	0.09	0.57	Lerida	0.45	0.52	0.80
Albacete	0.82	0.74	0.00	Logrono	0.09	0.41	0.22
Alicante	0.56	2.13	0.19	Lugo	0.18	0.08	0.26
Almeria	0.10	0.12	0.28	Madrid	0.08	1.95	0.95
Avila	0.20	0.26	0.12	Malaga	0.15	0.96	0.16
Badajoz	0.82	0.81	0.16	Murcia	1.11	5.04	0.00
Baleares	0.03	0.01	0.91	Navarra	0.10	0.13	0.60
Barcelona	1.00	102.75	0.87	Orense	0.10	0.04	0.29
Burgos	0.21	0.28	0.00	Oviedo	1.46	3.54	0.46
Caceres	0.81	0.47	0.01	Palencia	0.14	0.27	0.24
Cadiz	0.05	0.33	0.97	Pontevedra	0.04	0.09	0.42
Castellon	0.13	0.08	0.48	Salamanca	0.26	0.15	0.36
Ciudad Real	0.37	0.18	0.37	Santander	0.06	0.29	0.53
Cordoba	0.19	0.35	0.54	Segovia	0.11	0.06	0.39
Coruna	0.30	1.82	0.31	Sevilla	0.31	2.86	0.36
Cuenca	0.44	0.38	0.00	Soria	0.18	0.08	0.01
Gerona	0.41	2.89	0.38	Tarragona	0.09	0.12	0.72
Granada	0.21	0.40	0.00	Teruel	0.35	0.18	0.29
Guadalajara	0.20	0.09	0.00	Toledo	0.56	0.59	0.00
Guipuzcoa	0.14	6.52	0.25	Valencia	0.33	0.95	0.48
Huelva	0.21	0.57	0.00	Valladolid	0.10	0.17	0.58
Huesca	0.34	0.65	0.00	Vizcaya	0.02	0.32	0.71
Jaen	0.10	0.09	0.40	Zamora	0.27	0.11	0.00
Leon	0.32	0.20	0.22	Zaragoza	0.20	0.35	0.82

Notes: Table reports the sectoral results of the joint estimation. The Columns (1) through (3) indicate the estimated parameter values. The estimation procedure minimizes the distance between observed labor allocations in 1920 and the predicted labor allocations from the economic geography model across all province-sectors, i.e.

$$\eta_{i,s}(\boldsymbol{\beta}) = L_{i,s}^{1920} - \widehat{L}_{i,s}^{1920}$$

Labor allocations are generated by feeding the average export levels for 1915 and 1916 into the model, and solving a fixed point problem that solves for the labor allocations, wages, prices and rental rates that solve the equilibrium coniditions and are consistent with rational expectation. The resulting flows are then given by the solution to the following fixed point problem,

$$\widehat{L}_{i,s}^{1920} = \sum_{n,r} \sigma_{ni,rs}^{1914\to1920}\left(\mathbf{w}^{\mathrm{WWI}}\left(\widehat{L}_{i,s}^{1920}\right)\right) L_{n,r}^{1914}$$

The problem is being solved in MATLAB using the lsqnonlin solver to obtain the complete solution $\boldsymbol{\beta} = (\mu_{ag,1},\ldots,\mu_{ag,n},\mu_2,\ldots,\mu_S)$. This table presents the parameters pertaining to geographical switching cost as well as the agricultural switching costs, which is assumed to vary by province. In the left column the amenity shifters associated with the different provinces are reported. Barcelona is normalized to 1, with the other provinces being expressed relatively to Barcelona. The second column reports the location-specific spatial mobility shifter ζ_n as in the following specification of the spatial mobility cost: $\mu_{ij} = \zeta_i^1 \times \zeta \times distance_{ij}^{\zeta^2}$. In Column (3), the agricultural out-migration cost is being reported. The data being used draws on trade statistics, census data, and the salarios publication as discussed in 4.

J Quantitative Model: Multi-Sector Model with Trade Imbalances and Reallocation

In this section of the online appendix, I report detailed derivations for the quantitative model, allowing for multiple sectors, reallocation across sectors and space, as well as trade deficits.

J.1 Setting

Let there be a number of locations within a country $n, i, j, h \in \mathbb{D} = \{1, \ldots, N^D\}$. Let there be also a number of foreign locations $k, l, m \in \mathbb{F} = \{1, \ldots, N^F\}$. Domestic locations are heterogeneous in their exogenously fixed housing supply, H_i, and their geographical location relative to one another. The only factor of production is labor. In each location production occurs across multiple sectors $r, s, t \in \mathbb{S} = \{1, \ldots, S\}$. There are only two periods and the initial distribution of workers across locations $[\ell_{n,r}]_{\forall(n,r)\in\mathbb{D}\times\mathbb{S}}$, is given, while the distribution of workers in the second period, $[\ell'_{n,r}]_{\forall(n,r)\in\mathbb{D}\times\mathbb{S}}$, is endogenously determined.

J.2 Domestic Preferences

Workers residing in location i consume a Cobb-Douglas aggregate of housing and a consumption bundle:

$$U_n = (C_n)^{1-\delta} (R_n)^{\delta}$$

where δ is the expenditure share on housing. C_n is a Cobb-Douglas aggregate over sector-specific CES aggregates of origin-differentiated goods of both domestic and foreign origin:

$$C_n = \prod_{s=1}^{S} \left(C_{n,r}\right)^{\alpha_r}$$

$$C_{n,r} = \left(\sum_{i=1}^{N^D} C_{ni,r}^{\frac{\sigma_r - 1}{\sigma_r}} + \sum_{l=1}^{N^F} C_{nl,r}^{\frac{\sigma_r - 1}{\sigma_r}} \right)^{\frac{\sigma_r}{\sigma_r - 1}}$$

where $\sigma > 1$ is the elasticity of substitution. The indirect utility and the optimal price index of this problem is given by,

$$u_{n,r} = \frac{\rho_n e_{n,r} \bar{d}}{p_n^{(1-\delta)} r_n^{\delta}}, \quad p_n = \prod_{r=1}^{S} \left(p_{n,r}\right)^{\alpha_r} \quad \sum_{r=1}^{S} \alpha_r = 1$$

$$p_{n,r} = \left[\sum_{i=1}^{N^D} \left(p_{ni,r}\right)^{1-\sigma_r} + \sum_{l=1}^{N^F} \left(p_{nl,r}\right)^{1-\sigma_r} \right]^{\frac{1}{1-\sigma_r}}$$

where $e_{n,r}$ represents the disposable income of a representative worker in n. Notice that the ideal price index is adjusted to account for the fact that trade is balanced domestically, but not externally, which induces a wedge between domestic and foreign goods in the price index. Applying Roy's identity, demand in location n for the good produced in location i is given by,

$$q_{ni,r}\left(\boldsymbol{p}_{n,r}\right) = \frac{\left(p_{ni,r}\right)^{-\sigma_r}}{\sum_{j=1}^{N^D} \left(p_{nj,r}\right)^{1-\sigma_r} + \sum_{k=1}^{N^F} \left(p_{nk,r}\right)^{1-\sigma_r}} (1-\delta)\, \alpha_r \sum_{r=1}^{S} e_{n,r}$$

where $\boldsymbol{p}_n$ refers to the vector of prices in location n of the goods produced in all other locations. Similarly, demand in location n for the good produced in location l is given by,

$$q_{nl,r}\left(\boldsymbol{p}_{n,r}\right) = \frac{\left(p_{nl,r}\right)^{-\sigma_r}}{\sum_{j=1}^{N^D} \left(p_{nj,r}\right)^{1-\sigma_r} + \sum_{k=1}^{N^F} \left(p_{nk,r}\right)^{1-\sigma_r}} (1-\delta)\, \alpha_r \sum_{r=1}^{S} e_{n,r}$$

J.3 Foreign Preferences

Households in foreign locations l spend a fixed endowment e_l across domestic locations. They consume a Cobb-Douglas aggregate over sector-specific CES aggregates of origin-differentiated goods across domestic locations:

$$C_l = \prod_{s=1}^{S} \left(C_{l,r}\right)^{\alpha_{l,r}}$$

$$C_{l,r} = \left(\sum_{i=1}^{N^D} C_{li,r}^{\frac{\sigma_r - 1}{\sigma_r}} \right)^{\frac{\sigma_r}{\sigma_r - 1}}$$

where $\sigma_r > 1$ is the elasticity of substitution. The indirect utility and the optimal price index that households derive from consuming across domestic locations is given by

$$u_l = \frac{e_l}{\prod_{r=1}^{S} \left(p_n^r\right)^{\alpha_{l,r}}}, \quad \sum_{r=1}^{S} \alpha_{l,r} = 1 \tag{34}$$

$$p_{l,r} = \left(\sum_{i=1}^{N^D} \left(p_{li,r}\right)^{1-\sigma_r} \right)^{\frac{1}{1-\sigma_r}}$$

where e_l represents the endowment of workers in location l. Applying Roy's identity, demand in location l for the good produced in location i is given by,

$$q_{li,r}\left(\boldsymbol{p}_{l,r}\right) = \frac{p_{li,r}^{-\sigma_r}}{\sum_{j=1}^{N^D} p_{lj,r}^{1-\sigma_r}} \alpha_{l,r} e_l$$

where $\boldsymbol{p}_l$ refers to the vector of prices in location l of the goods produced in all other locations.

J.4 Production

Goods are produced only with labor and production is characterized by a constant returns to scale production technology, i.e.

$$q_{i,r} = z_{i,r} \ell_{i,r}$$

where z_i denotes a productivity shifter in location i and ℓ_i denotes the number of workers employed there. Goods can be traded between locations within and between countries, but transport is subject to iceberg variable trade costs, implying that delivering a unit of any good from location n to location i requires shipping $\tau_{ni} \geq 1$ units of the good. Therefore, the price that a representative worker faces in location i for any good from location $n$is given by,

$$p_{ni,r} = \tau_{ni} mc_{i,r} = \frac{\tau_{ni} w_{i,r}}{z_{i,r}}$$

where z_i captures as before the productivity of a given location and iceberg variable trade costs satisfy $\tau_{ni} > 1$ and $\tau_{nn} = 1$, that is we normalize trade costs within a location to 1.

J.5 Expenditure Shares

In this model we have three different types of expenditures. I first derive the expenditure shares of domestic locations on domestic varieties for a given sector r,

$$\begin{aligned}\frac{s_{ni,r}}{(1-\delta)} &= \frac{p_{ni,r}q_{ni,r}\left(\boldsymbol{p}_n\right)}{\sum_{s=1}^{S}\sum_{j=1}^{N^D}p_{nj,s}q_{nj,s}\left(\boldsymbol{p}_n\right)+\sum_{s=1}^{S}\sum_{k=1}^{N^F}p_{nk,s}q_{nk,s}\left(\boldsymbol{p}_n\right)}\\ &= \frac{x_{ni,r}\left(\boldsymbol{p}_n\right)}{\sum_{s=1}^{S}\sum_{j=1}^{N^D}x_{nj,s}\left(\boldsymbol{p}_n\right)+\sum_{s=1}^{S}\sum_{k=1}^{N^F}x_{nk,s}\left(\boldsymbol{p}_n\right)}\\ &= \frac{\frac{1}{d}p_{ni,r}^{1-\sigma}}{\sum_{j=1}^{N^D}\frac{1}{d}\left(p_{nj,r}\right)^{1-\sigma_r}+\sum_{k=1}^{N^F}\left(p_{nk,r}\right)^{1-\sigma_r}}\alpha_r\end{aligned}$$

where $\boldsymbol{p}_n$ represents the price vector across locations and sectors. We can similarly derive expenditure shares of domestic locations on foreign varieties for a given sector r,

$$\begin{aligned}\frac{s_{nl,r}}{(1-\delta)} &= \frac{p_{nl,r}q_{nl,r}\left(\boldsymbol{p}_n\right)}{\sum_{s=1}^{S}\sum_{j=1}^{N^D}p_{nj,s}q_{nj,s}\left(\boldsymbol{p}_n\right)+\sum_{s=1}^{S}\sum_{k=1}^{N^F}p_{nk,s}q_{nk,s}\left(\boldsymbol{p}_n\right)}\\ &= \frac{x_{nl,r}\left(\boldsymbol{p}_n\right)}{\sum_{s=1}^{S}\sum_{j=1}^{N^D}x_{nj,s}\left(\boldsymbol{p}_n\right)+\sum_{s=1}^{S}\sum_{k=1}^{N^F}x_{nk,s}\left(\boldsymbol{p}_n\right)}\\ &= \frac{p_{nl,r}^{1-\sigma}}{\sum_{j=1}^{N^D}\frac{1}{d}\left(p_{nj,r}\right)^{1-\sigma_r}+\sum_{k=1}^{N^F}\left(p_{nk,r}\right)^{1-\sigma_r}}\alpha_r\end{aligned}$$

Finally, I can derive expenditure shares of foreign locations on domestic varieties,

$$s_{li,r} = \frac{p_{li,r}q_{li,r}\left(\boldsymbol{p}_n\right)}{\sum_{j=1}^{N^D}p_{lj,r}q_{lj,r}\left(\boldsymbol{p}_l\right)} = \frac{x_{li,r}\left(\boldsymbol{p}_l\right)}{\sum_{j=1}^{N^D}x_{lj,r}\left(\boldsymbol{p}_l\right)} = \frac{p_{li,r}^{1-\sigma_r}}{\sum_{j=1}^{N^D}p_{lj,r}^{1-\sigma_r}}\alpha_{l,r} \tag{35}$$

For convenience we can also define the domestic expenditure share of domestic locations and foreign expenditure share of domestic locations,

$$\begin{aligned}\frac{s_{nD,r}}{(1-\delta)} &= \frac{\sum_{i=1}^{N^D}p_{ni,r}q_{ni,r}\left(\boldsymbol{p}_n\right)}{\sum_{s=1}^{S}\sum_{j=1}^{N^D}p_{nj,s}q_{nj,s}\left(\boldsymbol{p}_n\right)+\sum_{s=1}^{S}\sum_{k=1}^{N^F}p_{nk,s}q_{nk,s}\left(\boldsymbol{p}_n\right)} && (36)\\ &= \frac{\sum_{i=1}^{N^D}x_{ni,r}\left(\boldsymbol{p}_n\right)}{\sum_{s=1}^{S}\sum_{j=1}^{N^D}x_{nj,s}\left(\boldsymbol{p}_n\right)+\sum_{s=1}^{S}\sum_{k=1}^{N^F}x_{nk,s}\left(\boldsymbol{p}_n\right)} && (37)\\ &= \frac{\left(p_{nD,r}\right)^{1-\sigma_r}}{\sum_{j=1}^{N^D}\frac{1}{d}\left(p_{nj,r}\right)^{1-\sigma_r}+\sum_{k=1}^{N^F}\left(p_{nk,r}\right)^{1-\sigma_r}}\alpha_r && (38)\end{aligned}$$

$$\begin{aligned}\frac{s_{nF,r}}{(1-\delta)} &= \frac{\sum_{\ell=1}^{N^F}p_{nl,r}q_{nl,r}\left(\boldsymbol{p}_n\right)}{\sum_{s=1}^{S}\sum_{j=1}^{N^D}p_{nj,s}q_{nj,s}\left(\boldsymbol{p}_n\right)+\sum_{s=1}^{S}\sum_{k=1}^{N^F}p_{nk,s}q_{nk,s}\left(\boldsymbol{p}_n\right)} && (39)\\ &= \frac{\sum_{l=1}^{N^F}x_{nl,r}\left(\boldsymbol{p}_n\right)}{\sum_{s=1}^{S}\sum_{j=1}^{N^D}x_{nj,s}\left(\boldsymbol{p}_n\right)+\sum_{s=1}^{S}\sum_{k=1}^{N^F}x_{nk,s}\left(\boldsymbol{p}_n\right)} && (40)\\ &= \frac{\left(p_{nF,r}\right)^{1-\sigma_r}}{\sum_{j=1}^{N^D}\frac{1}{d}\left(p_{nj,r}\right)^{1-\sigma_r}+\sum_{k=1}^{N^F}\left(p_{nk,r}\right)^{1-\sigma_r}}\alpha_r && (41)\end{aligned}$$

where in the final equality of both equations we have used a definition for the domestic and foreign sector specific price index respectively, i.e.

$$\left(p_{nD,r}\right)^{1-\sigma_r} \equiv \sum_{i=1}^{N^D} p_{ni,r}^{1-\sigma_r}$$

$$\left(p_{nF,r}\right)^{1-\sigma_r} \equiv \sum_{l=1}^{N^F} p_{nl,r}^{1-\sigma_r}$$

I assume that expenditure on land in each location is redistributed lump sum to the workers residing in that location. Total disposable income can then be written as,

$$e_{n,s}\ell_{n,s} = w_{n,s}\ell_{n,s} + \delta e_{n,s}\ell_{n,s} = \frac{w_{n,s}\ell_{n,s}}{1-\delta} \tag{42}$$

J.6 Static Equilibrium

In this subsection I characterize the static equilibrium which is the equilibrium taking the labor allocations as given. This definition of the equilibrium is appropriate for the first period while for the second period labor allocations are determined endogenously and an extended equilibrium definition will be provided below that uses the static equilibrium definition as a building block.

Definition of the Static Equilibrium Conditional on the measure of workers in each location, $[\ell_{n,r}]_{\forall(n,r)\in\mathbb{D}\times\mathbb{S}}$, foreign endowments, $[e_l]_{\forall l\in\mathbb{F}}$, the national external trade deficit $\bar{d}$, a fixed domestic housing supply, $[H_n]_{\forall n\in\mathbb{D}}$, a fixed assignment of producitivities across domestic locations, $[z_{n,r}]_{\forall(n,r)\in\mathbb{D}\times\mathbb{S}}$ and marginal costs across foreign locations, $[mc_{l,r}]_{\forall(l,r)\in\mathbb{F}\times\mathbb{S}}$, as well as a specification of the domestic geography of the economy, $[\tau_{ni}]_{\forall(n,i)\in\mathbb{D}x\mathbb{D}}$ and the foreign geography of the economy, $[\tau_{nl},\tau_{ln}]_{\forall(n,l)\in\mathbb{D}x\mathbb{F},\forall(l,n)\in\mathbb{F}x\mathbb{D}}$, the equilibrium in the first period is a set of prices $[p_{ni,r},p_{nl,r}]_{\forall(n,i,r)\in\mathbb{D}x\mathbb{D}\times\mathbb{S},\forall(n,l,r)\in\mathbb{D}x\mathbb{F}\times\mathbb{S}}$, housing rental rates $[r_n]_{n\in\mathbb{D}}$, wages in each domestic location-sector $[w_{n,r}]_{\forall(n,r)\in\mathbb{D}\times\mathbb{S}}$, as well as the foreign and domestic expenditure shares of domestic locations, $[s_{ni,r},s_{nl,r}]_{\forall(n,i,r)\in\mathbb{D}x\mathbb{D}\times\mathbb{S},\forall(n,l,r)\in\mathbb{D}x\mathbb{F}\times\mathbb{S}}$, and the expenditure of foreign locations on domestic varieties, $[s_{ln,r}]_{\forall(l,n,r)\in\mathbb{F}x\mathbb{D}\times\mathbb{S}}$ such that

1. Given domestic and foreign prices in domestic locations, $[p_{ni,r},p_{nl,r}]_{\forall(n,i,r)\in\mathbb{D}x\mathbb{D}\times\mathbb{S},\forall(n,l,r)\in\mathbb{D}x\mathbb{F}\times\mathbb{S}}$ as well as domestic prices in foreign locations $[p_{ln,r}]_{\forall(l,n,r)\in\mathbb{F}x\mathbb{D}\times\mathbb{S}}$, wages in each domestic location $[w_{n,r}]_{\forall(n,r)\in\mathbb{D}\times\mathbb{S}}$, and the assumption that expenditure on land is locally redistributed lump sum which defines the disposable income as in (42), the domestic and foreign households choose expenditure shares to maximize their respective utility (34) subject to their budget constraint, with the respective expenditure shares being given by,

$$s_{ni,r} = \alpha_r(1-\delta)\frac{p_{ni,r}^{1-\sigma_r}}{\sum_{i=1}^{N^D}\frac{1}{\bar{d}}\left(p_{ni,r}\right)^{1-\sigma_r} + \sum_{l=1}^{N^F}\left(p_{nl,r}\right)^{1-\sigma_r}}$$

$$s_{nl,r} = \alpha_r(1-\delta)\frac{p_{nl,r}^{1-\sigma_r}}{\sum_{i=1}^{N^D}\frac{1}{\bar{d}}\left(p_{ni,r}\right)^{1-\sigma_r} + \sum_{l=1}^{N^F}\left(p_{nl,r}\right)^{1-\sigma_r}}$$

$$s_{li,r} = \alpha_{l,r}\frac{\left(p_{li,r}\right)^{1-\sigma_r}}{\sum_{j=1}^{N^D}\left(p_{lj,r}\right)^{1-\sigma_r}}$$

2. Firms optimize their profits via marginal cost pricing, such that domestic and foreign prices are given by,

$$p_{ni,r} = \frac{\tau_{ni}w_{i,r}}{z_{i,r}}$$

$$p_{nl,r} = \tau_{nl}mc_{nl,r}$$

3. In each domestic location the labor income equals expenditure on goods produced in that location with expenditures originating both from domestic and foreign locations:

$$w_{i,r}\ell_{i,r} = \sum_{n=1}^{N^D} s_{ni,r}\left(\sum_{r=1}^{S} e_{n,r}\ell_{n,r}\right) + \sum_{l=1}^{N^F} s_{li,r}e_l$$

4. Trade is balanced domestically, but unbalanced externally,

$$\bar{d}\left(\sum_{r=1}^{S} e_{n,r}\ell_{n,r}\right) = \sum_{r=1}^{S}\left(\sum_{i=1}^{N} s_{ni,r}\left(\sum_{r=1}^{S} e_{n,r}\ell_{n,r}\right) + \sum_{l=1}^{N^F} s_{nl,r}\left(\bar{d}e_n\ell_n\right)\right)$$

5. Housing market clears

$$H_n r_n = \delta\left(\sum_{r=1}^{S} e_{n,r}\right)$$

J.7 Labor Reallocation

Between the first and second period, workers can reallocate between domestic locations to respond to changes in factor returns. The initial allocation of workers across locations is given, $[\ell_{n,s}]_{\forall(n,s)\in\mathbb{D}\times\mathbb{S}}$, but the allocation of workers in the second period is determined by their endogenous reallocation choice across sectors and locations. Recall that the indirect utility of a worker in a given location n and in a given sector is given by,

$$u_{n,r} = \frac{\rho_n e'_{n,r}\bar{d}'}{\left(p'_n\right)^{1-\delta}\left(r'_n\right)^{\delta}}$$

I specify the reallocation choice using in terms of a stochastic sequential choice. Individuals first make a geographical relocation choice from location n to location i and subsequently a sectoral reloction choice moving from an initial sector r to another sector s. The introduction of extreme value distributed preference shocks allow us to write down the problem in closed form. Specifically, a worker first draws a location-specific preference shock κ_i, that is Frechet distributed with dispersion parameter γ. She then makes her geographical reallocation choice, forming expectations over, but prior to uncovering, the sector-specific preference shock ι_s, that will be drawn after the geographical reallocation choice is made from a Frechet distributed with dispersion parameter ν. Both the geographical reallocation choice and the sectoral reallocation choice is subject to variable geographical and sectoral migration cost, μ_{ni} and μ_{rs} respectively. The properties of the Frechet distribution and the sequencing of the reallocation choice imply that labor flows between location n and location i and between sector r and s take on a multiplicatively separable form,

$$\sigma'_{ni,rs} = \sigma'_{ni|r}\sigma'_{rs|i}$$

where $\sigma_{ni|r}$ is the share of workers that originate from sector r in location n and reallocate to location i, and where $\sigma_{rs|i}$ is the share of workers that conditional on having chosen location i and choose to relocate from sector r to sector s. I present the solution to the problem by solving backwards. First, conditional on having chosen location i the indirect utility relocating from sector $r$to $s$is given by,

$$v'_{rs|i} = \frac{u'_{i,s}}{\mu_{rs}} \times \iota_s$$

where I assume that the preference shocks ι_s are distributed identically and independently according an extreme value type II or Frechet distribution. Their cumulative distribution function is respectively given by,

$$F_{\kappa}\left(\iota_s\right) = e^{(-\iota_s)^{-\nu}} \qquad \nu > 1$$

and where the iceberg (variable) sectoral migration costs satisfy $\mu_{rs} \geq 1$ and $\mu_{rr} = 1$, that is staying in your initial sector is costless. Conditional on having chosen location $i$the properties of the Frechet distribution allow us to write in closed form the probability of relocating from sector r to sector s as,

$$\sigma'_{rs|i} = \frac{(w'_{is|r})^{\nu}}{\left(\Pi'_{i,r}\right)^{\nu}}$$

where $w'_{is|r} \equiv w'_{is}/\mu_{rs}$ and $\Pi'_{i,r} \equiv \left(\sum_t (w'_{it|r})^{\nu}\right)^{1/\nu}$ represents the option value of a worker conditional on having chosen location i and being initially attached to sector r. Prior to making the sectoral relocation choice, the worker makes a geographical choice. In a first step the worker therefore compares the different option values across geographical locations. The expected ex-ante utility, i.e. prior to observing and forming expectations over the sectoral preference shocks, that an individual derives from moving from location n to location i can be expressed in terms of the option value of being in that location-sector $\Pi'_{i,r} \equiv \left(\sum_t (w'_{it}/\mu_{rt})^{\nu}\right)^{1/\nu}$, multiplied by a stochastic location-specific preference shock κ_i, a stochastic sector-specific preference shock ι_s, and adjusted by variable geographical migration cost, μ_{ni}, i.e.

$$v'_{ni|r} \equiv \frac{\delta}{\mu_{ni}} \frac{\rho_i \Pi'_{i|r}}{\left(p'_i\right)^{1-\delta} \left(r'_i\right)^{\delta}} \times \kappa_i$$

where I assume that the preference shocks ι_s are distributed identically and independently according an extreme value type II or Frechet distribution. Their cumulative distribution function is respectively given by,

$$F_{\kappa}\left(\iota_s\right) = e^{(-\kappa_i)^{-\gamma}} \qquad \gamma > 1$$

and where the iceberg (variable) geographical migration costs satisfy $\mu_{ni} \geq 1$ and $\mu_{nn} = 1$, that is we assume the absence of migration costs if the worker remains in its current location. Given the properties of the Frechet distribution the geographical reallocation share takes on the following closed form form expression,

$$\sigma'_{ni|r} = \frac{\left(v'_{ni|r}\right)^{\gamma}}{\left(\Omega'_{n,r}\right)^{\gamma}}$$

where analogously to the option value of the sectoral choice, $\left(\Omega'_{n,r}\right)^{\gamma} \equiv \sum_j \left(v'_{nj|r}\right)^{\gamma}$ represents the option value of the geographical choice. The indirect utility depends on earnings, price indices and rental rates in the destination location. I assume that expenditure on land in each location is redistributed lump sum to the workers residing in that location. Total disposable income can then be written as,

$$e'_{n,s}\ell'_{n,s} = w'_{n,s}\ell'_{n,s} + \delta e'_{n,s}\ell'_{n,s} = \frac{w'_{n,s}\ell'_{n,s}}{1-\delta}$$

Wages are pinned down by a labor market clearing condition: In each domestic location the labor income equals expenditure on goods produced in that location with expenditures originating both from domestic and foreign locations:

$$w'_i\ell'_i = \sum_{i=1}^{N^D} s'_{ni} e'_n \ell'_n + \sum_{l=1}^{N^F} s'_{li} e'_l \tag{43}$$

I can then define the land market clearing condition that implies that the equilibrium land can be determined from the condition that total housing expenditure has to equal land income,

$$r_n = \frac{\delta e_n}{H_n} = \frac{\delta}{1-\delta} \frac{w_n \ell_n}{H_n} \tag{44}$$

Finally, it will be instructive to see the forces that pin down the changes in reallocation shares. Totally differentiating geographical mobility we obtain,

$$d\sigma'_{ni|r} = \gamma \frac{\left(v'_{ni|r}\right)^{\gamma}}{\sum_{j=1}^{N^D}\left(v'_{nj|r}\right)^{\gamma}} \frac{dv'_{ni|r}}{v'_{ni|r}} - \gamma \sum_{h=1}^{N^D} \frac{\left(v'_{ni|r}\right)^{\gamma}}{\sum_{j=1}^{N^D}\left(v'_{nj|r}\right)^{\gamma}} \frac{\left(v'_{nh|r}\right)^{\gamma}}{\sum_{j=1}^{N^D}\left(v'_{nj|r}\right)^{\gamma}} \frac{dv'_{nh|r}}{v'_{nh|r}}$$

$$\frac{d\sigma'_{ni|r}}{\sigma'_{ni|r}} = \gamma \frac{dv'_{ni|r}}{v'_{ni|r}} - \gamma \sum_{h=1}^{N^D} \frac{\left(v'_{nh|r}\right)^{\gamma}}{\sum_{j=1}^{N^D}\left(v'_{nj|r}\right)^{\gamma}} \frac{dv'_{nh|r}}{v'_{nh|r}}$$

$$\frac{d\sigma'_{ni|r}}{\sigma'_{ni|r}} = \gamma \frac{dv'_{ni|r}}{v'_{ni|r}} - \gamma \sum_{h=1}^{N^D} \sigma'_{nh|r} \frac{dv'_{nh|r}}{v'_{nh|r}} \tag{45}$$

which summarizes the overall effect on labor reallocation shares as a combination between the change in the attractiveness of the destination location i compared to the change in the attractiveness of all other locations. Similarly, totally differentiating sectoral flows, we obtain,

$$d\sigma'_{rs|i} = \nu \frac{\left(w'_{is|r}\right)^{\nu}}{\sum_{t=1}^{S}(w'_{itr})^{\nu}} \frac{dw'_{is|r}}{w'_{is|r}} - \nu \sum_{t=1}^{S} \frac{\left(w'_{is|r}\right)^{\nu}}{\sum_{t=1}^{S}(w'_{itr})^{\nu}} \frac{\left(w'_{it|r}\right)^{\nu}}{\sum_{t=1}^{S}(w'_{itr})^{\nu}} \frac{dw'_{it|r}}{w'_{it|r}}$$

$$\frac{d\sigma'_{rs|i}}{\sigma'_{rs|i}} = \nu \frac{dw'_{is|r}}{w'_{is|r}} - \nu \sum_{t=1}^{S} \frac{\left(w'_{it|r}\right)^{\nu}}{\sum_{t=1}^{S}(w'_{itr})^{\nu}} \frac{dw'_{it|r}}{w'_{it|r}}$$

$$\frac{d\sigma'_{rs|i}}{\sigma'_{rs|i}} = \nu \frac{dw'_{is|r}}{w'_{is|r}} - \nu \sum_{t=1}^{S} \sigma'_{rt|i} \frac{dw'_{it|r}}{w'_{it|r}}$$

which summarizes the overall effect on sectoral labor reallocation shares as a combination between the change in the attractiveness of the destination sector s compared to changes in the attractiveness of all other sectors.

J.8 Dynamic Equilibrium

In this subsection I characterize the general equilibrium which extends the static equilibrium above to allow for the endogenous allocation of labor across space. This definition of the equilibrium is appropriate for the second period: It extends the definition of the static equilibrium by allowing for an endogenous labor reallocation choice given the initial labor allocations in the previous period.

Definition of the Dynamic Equilibrium Conditional on the measure of workers in each location in the first period, $[\ell_{n,r}]_{\forall(n,r)\in\mathbb{D}\times\mathbb{S}}$, and for the second period, foreign endowments, $[e'_l]_{\forall l\in\mathbb{F}}$, the national external trade deficit $\bar{d}'$, a fixed domestic housing supply, $[H'_n]_{\forall n\in\mathbb{D}}$, an fixed assignment of producivities across domestic locations, $[z'_n]_{\forall n\in\mathbb{D}}$ and marginal costs across foreign locations, $[mc'_{l,r}]_{\forall(l,r)\in\mathbb{F}\times\mathbb{S}}$, as well as a specification of the domestic geography of the economy, $[\tau'_{ni}]_{\forall(n,i)\in\mathbb{D}x\mathbb{D}}$ and the foreign geography of the economy, $[\tau'_{nl},\tau'_{ln}]_{\forall(n,l)\in\mathbb{D}x\mathbb{F},\forall(l,n)\in\mathbb{F}x\mathbb{D}}$, the equilibrium in the first period is a set of prices $[p'_{ni,r},p'_{nl,r},p'_{ln,r}]$, housing rental rates $[r'_n]$, wages in each domestic location $[w'_{n,r}]_{\forall(n,r)\in\mathbb{D}\times\mathbb{S}}$, the measure of workers in each location, $[\ell'_n]_{\forall n\in\mathbb{D}}$, as well as the foreign and domestic expenditure shares of domestic locations, $[s'_{ni,r},s'_{nl,r}]_{\forall(n,i,r)\in\mathbb{D}x\mathbb{D}\times\mathbb{S},\forall(n,l,r)\in\mathbb{D}x\mathbb{F}\times\mathbb{S}}$, and the expenditure of foreign locations on domestic varieties, $[s'_{ln,r}]_{\forall(l,n,r)\in\mathbb{F}x\mathbb{D}\times\mathbb{S}}$, and the reallocation shares of workers across the domestic economy,$[\sigma'_{ni}]_{\forall(n,i)\in\mathbb{D}x\mathbb{D}}$, such that,

1. Given domestic and foreign prices in domestic locations, $[p'_{ni,r},p'_{nl,r}]_{\forall(n,i,r)\in\mathbb{D}x\mathbb{D}\times\mathbb{S},\forall(n,l,r)\in\mathbb{D}x\mathbb{F}\times\mathbb{S}}$, wages in each domestic location $[w'_{n,r}]_{\forall(n,r)\in\mathbb{D}\times\mathbb{S}}$, and the assumption that expenditure on land is locally redistributed lump sum which defines the disposable income as in (42), the domestic household chooses optimally where to relocate, such that,

$$\sigma'_{ni,rs} = \sigma'_{ni|r}\sigma'_{rs|i}$$

$$\sigma'_{ni|r} = \frac{\left(v'_{ni|r}\right)^{\nu}}{\sum_j \left(v'_{nj|r}\right)^{\nu}} \qquad \sigma'_{rs|i} = \frac{(w'_{is}/\mu_{rs})^{\gamma}}{\sum_t (w'_{it}/\mu_{rt})^{\gamma}}$$

2. Given domestic and foreign prices in domestic locations, $[p'_{ni,r},p'_{nl,r}]_{\forall(n,i,r)\in\mathbb{D}x\mathbb{D}\times\mathbb{S},\forall(n,l,r)\in\mathbb{D}x\mathbb{F}\times\mathbb{S}}$ as well as domestic prices in foreign locations $[p'_{ln,r}]_{\forall(l,n,r)\in\mathbb{F}x\mathbb{D}\times\mathbb{S}}$, wages in each domestic location $[w'_{n,r}]_{\forall(n,r)\in\mathbb{D}\times\mathbb{S}}$, and the assumption that expenditure on land is locally redistributed lump sum which defines the disposable income as in (42), the domestic and foreign households choose expenditure shares to maximize their respective utility (34) subject to their budget constraint, with the respective expenditure shares being given by,

$$s'_{ni,r} = \alpha_r (1-\delta) \frac{\left(p'_{ni,r}\right)^{1-\sigma_r}}{\sum_{i=1}^{N^D} \frac{1}{d} \left(p'_{ni,r}\right)^{1-\sigma_r} + \sum_{l=1}^{N^F} \left(p'_{nl,r}\right)^{1-\sigma_r}}$$

$$s'_{nl,r} = \alpha_r (1-\delta) \frac{\left(p'_{nl,r}\right)^{1-\sigma_r}}{\sum_{i=1}^{N^D} \frac{1}{d} \left(p'_{ni,r}\right)^{1-\sigma_r} + \sum_{l=1}^{N^F} \left(p'_{nl,r}\right)^{1-\sigma_r}}$$

$$s'_{li,r} = \alpha_{l,r} \frac{\left(p'_{li,r}\right)^{1-\sigma_r}}{\sum_{j=1}^{N^D}\left(p'_{lj,r}\right)^{1-\sigma_r}}$$

3. Firms optimize their profits via marginal cost pricing, such that domestic and foreign prices are given by,

$$p'_{ni,r} = \frac{\tau_{ni} w'_{i,r}}{z'_{i,r}}$$

$$p'_{nl,r} = \tau_{nl} mc'_{nl,r}$$

4. In each domestic location the labor income equals expenditure on goods produced in that location with expenditures originating both from domestic and foreign locations:

$$w'_{i,r}\ell'_{i,r} = \sum_{n=1}^{N^D} s'_{ni,r}\left(\sum_{r=1}^{S} e'_{n,r}\ell'_{n,r}\right) + \sum_{l=1}^{N^F} s'_{li,r} e'_l$$

5. Trade is balanced domestically, but unbalanced externally,

$$\bar{d}'\left(\sum_{r=1}^{S} e'_{n,r}\ell'_{n,r}\right) = \sum_{r=1}^{S}\left(\sum_{i=1}^{N} s'_{ni,r}\left(\sum_{r=1}^{S} e'_{n,r}\ell'_{n,r}\right) + \sum_{l=1}^{N^F} s'_{nl,r}\left(\bar{d}' e'_n \ell'_n\right)\right)$$

6. The labor market clearing condition requires that the measure of workers in the second period is equal to all the incoming labor flows, i.e.

$$\ell'_{i,s} = \sum_{r=1}^{S}\sum_{n=1}^{N} \sigma_{ni,rs}\ell_{n,r}$$

7. Housing market clears

$$H_n r'_n = \delta\left(\sum_{r=1}^{S} e'_{n,r}\right)$$

J.9 Aggregate Welfare

In this subsection, I will derive an expression for the change in aggregate welfare **across** all domestic locations in the second period, taking into account the endogenous reallocation of workers and how the reallocation itself depends on the initial allocation of workers in the first period. In order to do so, I proceed in two steps: In a first step I will assume that rather than the initial allocation of workers in the first period being fixed, it instead by thought of as a separate allocation problem, where ex-ante homogenous household make a choice where they would like to be located in the first period. Following the convention in the literature, I stipulate this as a discrete optimization problem where households receive location-specific extreme value distributed preference shock that gives rise to and matches the observed allocation of workers across space as in Redding (2012). In a second step the household then faces a second subsequent location choice problem that mirrors the re-allocation problem in section (J.7). This way of characterizing the problem allows me to derive a closed-form expression for the expected utility in the second period of a hypothetical aggregate household that incorporates the dependence of the economy on the initial allocation of labor in the first period and takes migration costs explicitly into account.

The welfare expression that corresponds to the first step, and expresses the value of being able to choose any of the domestic location by summing up over the migration value of each one location, that is,

$$\mathscr{W} \equiv E\left(\Omega_{n,r}\right) = \delta\left[\sum_{n=1}^{N^D}\sum_{r=1}^{S}\left(\tilde{\rho}_{n,r}\Omega_{n,r}\right)^{\epsilon}\right]^{1/\epsilon}$$

where $\delta = \Gamma\left(\frac{\epsilon}{\epsilon-1}\right)$ and $\Gamma(\cdot)$ is the gamma function and we impose $\epsilon > 1$ to obtain a finite value for the expected utility. Additionally, $\tilde{\rho}$ corresponds to an amenity shifter that is chosen to exactly fit the distribution of the population across space. Following Redding (2012), I use this measure of expected utility as a proxy for aggregate welfare. Conditional on the initial allocation, workers face a reallocation choice subject to switching costs and a new set of independently drawn extreme value distributed preferences shocks as stated above and as before Ω'_n corresponds to the expected utility of that choice,

$$\Omega'_{n,r} = \tilde{\delta}\left[\sum_{j=1}^{N^D}\left(v'_{nj|r}\right)^{\gamma}\right]^{1/\gamma}$$

where again $\delta = \Gamma\left(\frac{\gamma}{\gamma-1}\right)$ and $\Gamma(\cdot)$ is the gamma function and we impose $\gamma > 1$ to obtain a finite value for the expected utility. Totally differentiating the welfare expression, we obtain,

$$\begin{aligned}\frac{d\mathscr{W}'}{\mathscr{W}'} &= \sum_{n=1}^{N^D}\sum_{r=1}^{S}\frac{d\Omega'_{n,r}}{\Omega'_{n,r}} \times \frac{\left(\tilde{\rho}_{n,r}\Omega_{n,r}\right)^{\epsilon}}{\sum_{n=1}^{N^D}\sum_{r=1}^{S}\left(\tilde{\rho}_{n,r}\Omega_{n,r}\right)^{\epsilon}} \\ &= \sum_{n=1}^{N^D}\sum_{r=1}^{S}\frac{d\Omega'_{n,r}}{\Omega'_{n,r}} \times \pi_{i,r}\end{aligned}$$

where $\pi_{i,r} = \frac{\ell_{i,r}}{\sum_i \sum_r \ell_{i,r}}$ is the population share observed in the data in the baseline period. Integrating, we obtain,

$$\begin{aligned}\int_{\mathscr{W}^0}^{\mathscr{W}^1}\frac{d\mathscr{W}'}{\mathscr{W}'} &= \sum_{n=1}^{N^D}\sum_{r=1}^{S}\pi_{i,r} \times \int_{\Omega^0_{n,r}}^{\Omega^1_{n,r}}\frac{d\Omega'_{n,r}}{\Omega'_{n,r}} \\ \ln\left(\frac{\mathscr{W}^1}{\mathscr{W}^0}\right) &= \sum_{n=1}^{N^D}\sum_{r=1}^{S}\pi_{n,r}\ln\left(\frac{\Omega^1_{n,r}}{\Omega^0_{n,r}}\right) \\ \left(\frac{\mathscr{W}^1}{\mathscr{W}^0}\right) &= \prod_{n=1}^{N^D}\prod_{r=1}^{S}\left(\frac{\Omega^1_{n,r}}{\Omega^0_{n,r}}\right)^{\pi_{n,r}}\end{aligned}$$

From we can construct an expression for changes in the option value $\Omega_{n,r}$,

$$\hat{\Omega}_{n,r} = \hat{v}_{nn|r}\left(\hat{\sigma}_{nn|r}\right)^{-\frac{1}{\gamma}}$$

which only depends on the

$$\hat{v}_{nn|r} = \hat{\tilde{\delta}}_n \hat{\Pi}_{n|r}$$

which only depends on the

$$\hat{\Pi}_{n,r} = \hat{w}_{nr|r}\left(\hat{\sigma}_{rr|i}\right)^{-\frac{1}{\nu}}$$

$$\hat{\Omega}_{n,r} = \hat{u}_{nr|r}\left(\hat{\sigma}_{rr|i}\right)^{-\frac{1}{\nu}}\left(\hat{\sigma}_{nn|r}\right)^{-\frac{1}{\gamma}}$$

$$\left(\frac{\mathscr{W}^1}{\mathscr{W}^0}\right) = \prod_{n=1}^{N^D}\prod_{r=1}^{S}\left(\underbrace{\left(\frac{\sigma^1_{nn|r}}{\sigma^0_{nn|r}}\right)^{-\frac{1}{\gamma}}}_{\text{Spatial Flows}}\underbrace{\left(\frac{\sigma^1_{rr|n}}{\sigma^0_{rr|n}}\right)^{-\frac{1}{\nu}}}_{\text{Sectoral Flows}}\frac{u^1_{nr|r}}{u^0_{nr|r}}\right)^{\pi_{n,r}}$$

where $\sigma^1_{nn|r}$ represents the share of workers initially located in province n and working sector r and deciding to remain in that province, while $\sigma^1_{rr|n}$ represents the share of workers who in the second period will be located in province n, were initially attached to sector $r$and decide to remain in sector r. Intuitively, if more workers decide to either change their sector or their location, then this is informative about the option value of a spatial or sectoral change to have increased, relative to the remain option. In other words, the remain share (to the power of the negative inverse of the labor supply elasticity) is proportional to changes in the option-value and therefore a sufficient statistic for welfare changes that arise due to the ability of the worker being able to reallocate. This approach is intimately related to the argument that conditional choice probabilities can be used to infer continuation values in dynamic discrete choice problems (Hotz and Miller, 1993). Even though, it is here stated in the context of two period model, the approach is much more general and a similar expression for welfare can be derived for multi-period or infinite horizon models. The final term represents cross-sectional improvements in the indirect utility of workers across locations. This term can be constructed using the tools by Arkolakis, Costinot and Rodriguez-Clare (2012) and Ossa (2015). Starting from the expenditure shares, we can solve for sectoral price indices,

$$p_{n,r} = p_{ni,r}\left(\frac{s_{ni,r}}{\alpha_r\left(1-\delta\right)}\right)^{\frac{1}{\sigma_r-1}}$$

constructing aggregate price indices,

$$\begin{aligned} p_n &= \prod_{r=1}^{S}\left(p_{n,r}\right)^{\alpha_r} \\ &= \prod_{r=1}^{S}\left(p_{ni,r}\left(\frac{s_{ni,r}}{\alpha_r\left(1-\delta\right)}\right)^{\frac{1}{\sigma_r-1}}\right)^{\alpha_r} \\ &= \prod_{r=1}^{S}\left(\left(w_{n,r}\right)^{\alpha_r}\left(\frac{s_{nn,r}}{\alpha_r\left(1-\delta\right)}\right)^{\frac{\alpha_r}{\sigma_r-1}}\right) \end{aligned}$$

rewriting this in changes,

$$\hat{p}_n = \prod_{r=1}^{S}\left(\left(\hat{w}_{n,r}\right)^{\alpha_r}\left(\hat{s}_{nn,r}\right)^{\frac{\alpha_r}{\sigma_r-1}}\right)$$

noticing that utility in changes can be written as,

$$\hat{u}_{n,r} = \hat{e}_{n,r}\hat{\hat{d}}\hat{p}_n^{(\delta-1)}\hat{r}_n^{-\delta},$$

and substituting, we obtain,

$$\hat{u}_{n,r} = \hat{e}_{n,r}\hat{d}\hat{r}_n^{-\delta}\prod_{r=1}^{S}\left(\left(\hat{w}_{n,r}\right)^{(\delta-1)\alpha_r}\left(\hat{s}_{nn,r}\right)^{\frac{(\delta-1)\alpha_r}{\sigma_r-1}}\right)$$

$$\hat{u}_{n,r} = \hat{w}_{n,r}\hat{d}\hat{r}_n^{-\delta}\prod_{r=1}^{S}\left(\left(\hat{w}_{n,r}\right)^{(\delta-1)\alpha_r}\left(\hat{s}_{nn,r}\right)^{\frac{(\delta-1)\alpha_r}{\sigma_r-1}}\right)$$

$$\hat{u}_{n,r} = \frac{\left(\hat{w}_{n,r}\right)^{\delta}}{\left(\hat{r}_n\right)^{\delta}}\frac{\left(\hat{w}_{n,r}\right)^{(1-\delta)}}{\prod_{r=1}^{S}\left(\hat{w}_{n,r}\right)^{(1-\delta)\alpha_r}}\prod_{r=1}^{S}\left(\hat{s}_{nn,r}\right)^{\frac{(\delta-1)\alpha_r}{\sigma_r-1}}$$

substituting into above formula gives us the expression in the main text,

$$\left(\frac{\mathscr{W}^1}{\mathscr{W}^0}\right) = \prod_{n=1}^{N^D}\prod_{r=1}^{S}\left(\underbrace{\left(\frac{\sigma^1_{nn|r}}{\sigma^0_{nn|r}}\right)^{-\frac{1}{\gamma}}}_{\text{Spatial Flows}}\underbrace{\left(\frac{\sigma^1_{rr|n}}{\sigma^0_{rr|n}}\right)^{-\frac{1}{\nu}}}_{\text{Sectoral Flows}}\underbrace{\left(\frac{r^1_n}{r^0_n}\right)^{-\delta}}_{\text{Housing Cost}}\underbrace{\prod_{t=1}^{S}\left(\frac{s^1_{nn,t}}{s^0_{nn,t}}\right)^{-\frac{(1-\delta)\alpha_t}{\sigma_t-1}}}_{\text{ACR Gains}}\right)^{\pi_{n,r}}$$

J.10 Trade Imbalances

To reflect the change in trade deficits in the analysis, I incorporate exogenous trade imbalances as in Dekle, Eaton, and Kortum (2007) and Caliendo and Parro 2015. However, instead of an additive formulation, I instead model trade balances as a multiplicative scalar that adjusts the disposable income available to the representative agent. Furthermore, I distinguish between domestic and external trade, and while external trade might be unbalanced, domestic trade is assumed to be balanced. Consider the domestic and external trade balance condition separately. As before, trade is balanced domestically, implying that domestic income is equal to domestic expenditure,

$$d_1 y_n = \sum_{r=1}^{S} \left(\sum_{i=1}^{N} s_{ni,r} y_n \right)$$

where d_1 is defined as the fraction of income that is being derived from domestic sales and y_n denotes the disposable income, such that,

$$y_n = \sum_{r=1}^{S} e_{n,r} \ell_{n,r}$$

Externally, trade is possibly unbalanced, such that expenditures on foreign goods might be below or above income derived from foreign goods, i.e.

$$(1 - d_1)\, y_n = d_2 \times \sum_{r=1}^{S} \sum_{l=1}^{N^F} s_{nl,r} y_n$$

where the left hand side denotes income derived from foreign sales and the right hand side denotes expenditures on foreign goods. As before, d_1, is the fraction of income that is being derived domestically. On the right hand side, d_2 is the proportion of foreign income that is being expended on foreign goods. where d_2 is defined as,

$$d_2 = \frac{\sum_{l=1}^{N^F} \sum_{r=1}^{S} X_{nl.r}}{\sum_{l=1}^{N^F} \sum_{r=1}^{S} X_{ln,r}}$$

To derive the total price index, combine,

$$y_n = \sum_{r=1}^{S} \sum_{i=1}^{N} s_{ni,r} y_n + d_2 \times \sum_{r=1}^{S} \sum_{l=1}^{N^F} s_{nl,r} y_n$$

Dividing by income and noticing that $s_{ni,r} = \left(p_{ni,r}\right)^{1-\sigma_r} p_{n,r}^{\sigma_r - 1}$, we obtain,

$$p_{n,r}^{1-\sigma} = \sum_{i=1}^{N^D} p_{ni,r}^{1-\sigma} + d_2 \sum_{l=1}^{N^F} p_{nl,r}^{1-\sigma}$$

which allows us to express the price index in terms of the weighted domestic and external prices, i.e.

$$p_{n,r} = \left(\sum_{i=1}^{N^D} p_{ni,r}^{1-\sigma} + d_2 \sum_{l=1}^{N^F} p_{nl,r}^{1-\sigma} \right)^{\frac{1}{1-\sigma}}$$

This implies that the indirect utility and the optimal price index of this problem is given by,

$$u_{n,r} = \frac{\rho_n e_{n,r}}{p_n^{(1-\delta)} r_n^{\delta}}, \quad p_n = \prod_{r=1}^{S} \left(p_{n,r}\right)^{\alpha_r} \quad p_{n,r} = \left[\sum_{i=1}^{N^D} \left(p_{ni,r}\right)^{1-\sigma_r} + d_2 \sum_{l=1}^{N^F} \left(p_{nl,r}\right)^{1-\sigma_r} \right]^{\frac{1}{1-\sigma_r}}$$

Combining and factoring out the trade imbalance term we obtain,

$$u_{n,r} = d_2^{-\sum_r \frac{(1-\delta)\alpha_r}{1-\sigma_r}} \frac{\rho_n e_{n,r}}{r_n^{\delta} \prod_{r=1}^{S} \left(\left(\sum_{i=1}^{N^D} \frac{1}{d_2} p_{ni}^{1-\sigma_r} + \sum_{l=1}^{N^F} p_{nl}^{1-\sigma_r} \right)^{\frac{(1-\delta)\alpha_r}{1-\sigma_r}} \right)}$$

Following the same derivations as before,

$$\left(\frac{\mathscr{W}^1}{\mathscr{W}^0} \right) = \underbrace{\left(\frac{d_2^1}{d_2^0} \right)^{-\sum_r \frac{(1-\delta)\alpha_r}{1-\sigma_r}}}_{\text{Deficit Adjustment}} \prod_{n=1}^{N^D} \prod_{r=1}^{S} \left(\underbrace{\left(\frac{\sigma_{nn|r}^1}{\sigma_{nn|r}^0} \right)^{-\frac{1}{\gamma}}}_{\text{Spatial Flows}} \underbrace{\left(\frac{\sigma_{rr|n}^1}{\sigma_{rr|n}^0} \right)^{-\frac{1}{\nu}}}_{\text{Sectoral Flows}} \underbrace{\left(\frac{\tilde{r}_n^1}{\tilde{r}_n^0} \right)^{-\delta}}_{\text{Housing Cost}} \underbrace{\prod_{t=1}^{S} \left(\frac{\tilde{s}_{nn,t}^1}{\tilde{s}_{nn,t}^0} \right)^{-\frac{(1-\delta)\alpha_t}{\sigma_t - 1}}}_{\text{ACR Gains}} \right)^{\pi_{n,r}}$$

J.11 Deriving an Empirical Specification to estimate the Distance Elasticity

This subsection shows how the model in this section can be used to derive an empirical specification as used in the reduced form section in the paper. Specifically, we derive the impact of an increase in foreign expenditures on domestic locations taking domestic trade cost into account. I start with the goods market clearing condition,

$$w_{i,r}\ell_{i,r} = \sum_{n=1}^{N^D} s_{ni,r}\left(\sum_{r=1}^{S} e_{n,r}\ell_{n,r}\right) + \sum_{l=1}^{N^F} s_{li,r}e_l$$

considering the case where only foreign expenditures vary, $d\ln e_l \neq 0$, totally differentating, I obtain,

$$\frac{dy_{i,r}}{y_{i,r}} = \sum_{l=1}^{N^F} \frac{s_{li,r}e_l}{y_{i,r}}\frac{de_l}{e_l}$$

which represents the impcat of changes in foreign expenditures on local income as a weighted sum over percentage changes in foreign expenditures, where the weights are given by the share of revenue that is due to foreign expenditures, $\frac{s_{li}e_l}{y_{i,r}}$. Since data on region specific exports to foreign locations is not available, I will use the structural of the model to recover a representation of region-specific export shares that depends on the share of a location in national employment and its geographical location vis-a-vis the destination market only. In order to derive this, define the hypothetical market share of a location in the absence of domestic frictions as,

$$\tilde{s}_{i,r} = \alpha_r \frac{p_{i,r}^{1-\sigma_{,r}}}{\sum_{n=1}^{N^D} p_{n,r}^{1-\sigma_{,r}}}$$

Notice that I can now derive the deviation from this hypothetical market share that is due to trade costs, as,

$$\begin{aligned}
\frac{s_{li,r}}{\tilde{s}_{i,r}} &= \left(\frac{\alpha_{l,r}}{\alpha_r}\right)\left(\frac{p_{li,r}}{p_{i,r}}\right)^{1-\sigma_{,r}} \times \left(\frac{\sum_{n=1}^{N^D} p_{ln,r}^{1-\sigma}}{\sum_{n=1}^{N^D} p_{n,r}^{1-\sigma}}\right)^{-1} \\
&= \left(\frac{\alpha_{l,r}}{\alpha_r}\right)(\tau_{li})^{1-\sigma} \times \left(\frac{\sum_{n=1}^{N^D} p_{ln,r}^{1-\sigma}}{\sum_{n=1}^{N^D} p_{n,r}^{1-\sigma}}\right)^{-1} \\
&= \left(\frac{\alpha_{l,r}}{\alpha_r}\right)(\tau_{li})^{1-\sigma} \times \left(\sum_{n=1}^{N^D} \frac{p_{ln,r}^{1-\sigma}}{\sum_{n=1}^{N^D} p_{n,r}^{1-\sigma}}\right)^{-1} \\
&= \left(\frac{\alpha_{l,r}}{\alpha_r}\right)(\tau_{li})^{1-\sigma} \times \left(\sum_{n=1}^{N^D} \tau_{ln}^{1-\sigma}\frac{p_{n,r}^{1-\sigma}}{\sum_{n=1}^{N^D} p_{n,r}^{1-\sigma}}\right)^{-1} \\
&= \left(\frac{\alpha_{l,r}}{\alpha_r}\right)(\tau_{li})^{1-\sigma} \times \left(\sum_{n=1}^{N^D} \tau_{ln}^{1-\sigma}\tilde{s}_{n,r}\right)^{-1}
\end{aligned}$$

Returning to the expression for the differentiated market clearing condition, I have,

$$\begin{aligned}
\frac{dy_{i,r}}{y_{i,r}} &= \sum_{l=1}^{N^F} \frac{s_{li,r}e_l}{y_{i,r}}\frac{de_l}{e_l} \\
&= \sum_{l=1}^{N^F} \frac{e_l}{y_{i,r}}\tilde{s}_{i,r}\frac{s_{li,r}}{\tilde{s}_{i,r}}\frac{de_l}{e_l}
\end{aligned}$$

substituting from above,

$$\frac{dy_{i,r}}{y_{i,r}} = \sum_{l=1}^{N^F} \frac{e_l}{y_{i,r}}\left(\left(\frac{\alpha_{l,r}}{\alpha_r}\right)\frac{(\tau_{li})^{1-\sigma}\tilde{s}_{i,r}}{\sum_{n=1}^{N^D} \tau_{ln}^{1-\sigma}\tilde{s}_{n,r}}\right)\frac{de_l}{e_l}$$

where we can empirically approximate the hypothetical market shares with the observed labor share of that location and trade costs are approximated with the inverse of distance along the transportation network. This gives,

$$d\ln y_{i,r} \approx \sum_{l=1}^{N^F} \frac{e_l}{y_{i,r}} \left(\frac{dist_{li}^{-1}\pi_{i,r}}{\sum_{n=1}^{N^D} dist_{ln}^{-1}\pi_{n,r}} \right) d\ln e_l$$

where $\pi_{ir} = \ell_{ir}/\bar{\ell}_r$ is the share of workers in a given location and where $\frac{e_l}{y_{i,r}}$ can be readily constructed from data. Similar in spirit to Autor, Dorn and Hanson (2013) I define a trade shock exposure variable,

$$TE_{i,r} \equiv \sum_{l=1}^{N^F} \frac{e_l}{y_{i,r}} \left(\frac{dist_{li}^{-1}\pi_{i,r}}{\sum_{n=1}^{N^D} dist_{ln}^{-1}\pi_{n,r}} \right) \Delta\ln e_l$$

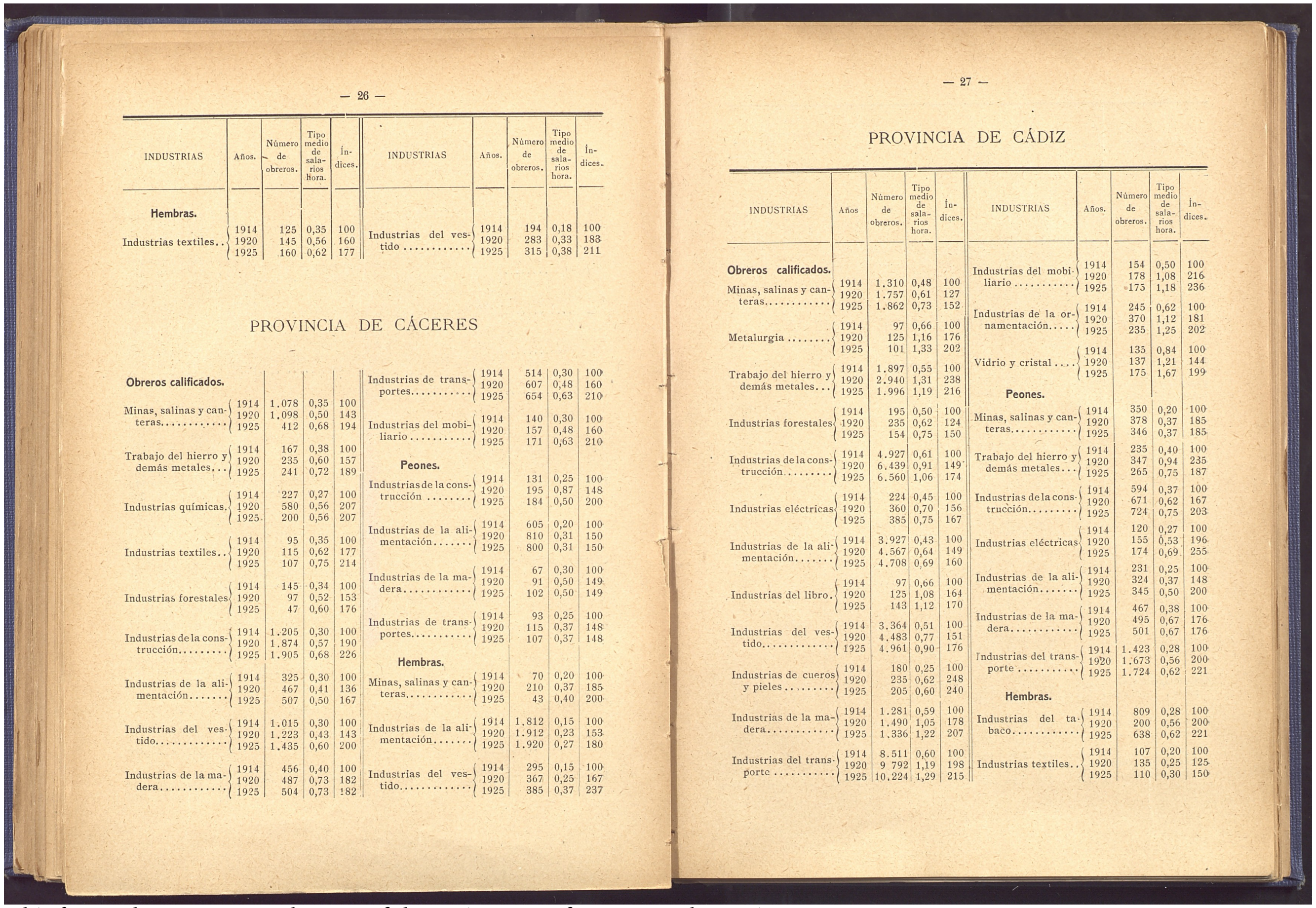
As an approximation of the labor market dynamics, I will use the geographical mobility model from section J.7 to derive an empirical specification that exploits observable geographical distance, but incorporating trade exposure that is driven by sectoral specialization. For this purpose we take an average across the sectoral trade exposure measures,

$$TE_i \equiv \sum_r \pi_{r|i} TE_{i,r}$$

K Details on Data Sources

I have assembled a unique dataset that provides disaggregated information on the distribution of economic activity across regions and sectors, consumer prices, factor reallocation and external trade for the period between 1910-1920. The dataset draws on multiple historical sources some of which were digitized specifically for this projects, others (such as the migration and price data) had been previoulsy digitized, but were matched to the other data sources to give a comprehensive view of the evolution of the Spanish economy during that period. In this section I will introduce the different data series that are contained in the dataset, present their sources, describe the digitization effort and how they were matched together into one cohesive dataset.

Figure A.8. Example Page: Ministerio de Trabajo (1927)



INDUSTRIAS	Años.	Número de obreros.	Tipo medio de salarios hora.	Índices.
Hembras.				
Industrias textiles..	1914	125	0,35	100
	1920	145	0,56	160
	1925	160	0,62	177
Industrias del vestido	1914	194	0,18	100
	1920	283	0,33	183
	1925	315	0,38	211

PROVINCIA DE CÁCERES

INDUSTRIAS	Años.	Número de obreros.	Tipo medio de salarios hora.	Índices.
Obreros calificados.				
Minas, salinas y canteras............	1914	1.078	0,35	100
	1920	1.098	0,50	143
	1925	412	0,68	194
Trabajo del hierro y demás metales...	1914	167	0,38	100
	1920	235	0,60	157
	1925	241	0,72	189
Industrias químicas.	1914	227	0,27	100
	1920	580	0,56	207
	1925	200	0,56	207
Industrias textiles..	1914	95	0,35	100
	1920	115	0,62	177
	1925	107	0,75	214
Industrias forestales	1914	145	0,34	100
	1920	97	0,52	153
	1925	47	0,60	176
Industrias de la construcción.........	1914	1.205	0,30	100
	1920	1.874	0,57	190
	1925	1.905	0,68	226
Industrias de la alimentación.......	1914	325	0,30	100
	1920	467	0,41	136
	1925	507	0,50	167
Industrias del vestido.............	1914	1.015	0,30	100
	1920	1.223	0,43	143
	1925	1.435	0,60	200
Industrias de la madera............	1914	456	0,40	100
	1920	487	0,73	182
	1925	504	0,73	182
Industrias de transportes...........	1914	514	0,30	100
	1920	607	0,48	160
	1925	654	0,63	210
Industrias del mobiliario	1914	140	0,30	100
	1920	157	0,48	160
	1925	171	0,63	210
Peones.				
Industrias de la construcción	1914	131	0,25	100
	1920	195	0,87	148
	1925	184	0,50	200
Industrias de la alimentación.......	1914	605	0,20	100
	1920	810	0,31	150
	1925	800	0,31	150
Industrias de la madera............	1914	67	0,30	100
	1920	91	0,50	149
	1925	102	0,50	149
Industrias de transportes...........	1914	93	0,25	100
	1920	115	0,37	148
	1925	107	0,37	148
Hembras.				
Minas, salinas y canteras............	1914	70	0,20	100
	1920	210	0,37	185
	1925	43	0,40	200
Industrias de la alimentación.......	1914	1.812	0,15	100
	1920	1.912	0,23	153
	1925	1.920	0,27	180
Industrias del vestido.............	1914	295	0,15	100
	1920	367	0,25	167
	1925	385	0,37	237

PROVINCIA DE CÁDIZ

INDUSTRIAS	Años	Número de obreros.	Tipo medio de salarios hora.	Índices.
Obreros calificados.				
Minas, salinas y canteras............	1914	1.310	0,48	100
	1920	1.757	0,61	127
	1925	1.862	0,73	152
Metalurgia	1914	97	0,66	100
	1920	125	1,16	176
	1925	101	1,33	202
Trabajo del hierro y demás metales...	1914	1.897	0,55	100
	1920	2.940	1,31	238
	1925	1.996	1,19	216
Industrias forestales	1914	195	0,50	100
	1920	235	0,62	124
	1925	154	0,75	150
Industrias de la construcción.........	1914	4.927	0,61	100
	1920	6.439	0,91	149
	1925	6.560	1,06	174
Industrias eléctricas	1914	224	0,45	100
	1920	360	0,70	156
	1925	385	0,75	167
Industrias de la alimentación.......	1914	3.927	0,43	100
	1920	4.567	0,64	149
	1925	4.708	0,69	160
Industrias del libro.	1914	97	0,66	100
	1920	125	1,08	164
	1925	143	1,12	170
Industrias del vestido.............	1914	3.364	0,51	100
	1920	4.483	0,77	151
	1925	4.961	0,90	176
Industrias de cueros y pieles	1914	180	0,25	100
	1920	235	0,62	248
	1925	205	0,60	240
Industrias de la madera............	1914	1.281	0,59	100
	1920	1.490	1,05	178
	1925	1.336	1,22	207
Industrias del transporte	1914	8.511	0,60	100
	1920	9 792	1,19	198
	1925	10.224	1,29	215
Industrias del mobiliario	1914	154	0,50	100
	1920	178	1,08	216
	1925	175	1,18	236
Industrias de la ornamentación.....	1914	245	0,62	100
	1920	370	1,12	181
	1925	235	1,25	202
Vidrio y cristal	1914	135	0,84	100
	1920	137	1,21	144
	1925	175	1,67	199
Peones.				
Minas, salinas y canteras............	1914	350	0,20	100
	1920	378	0,37	185
	1925	346	0,37	185
Trabajo del hierro y demás metales...	1914	235	0,40	100
	1920	347	0,94	235
	1925	265	0,75	187
Industrias de la construcción.........	1914	594	0,37	100
	1920	671	0,62	167
	1925	724	0,75	203
Industrias eléctricas	1914	120	0,27	100
	1920	155	0,53	196
	1925	174	0,69	255
Industrias de la alimentación.......	1914	231	0,25	100
	1920	324	0,37	148
	1925	345	0,50	200
Industrias de la madera............	1914	467	0,38	100
	1920	495	0,67	176
	1925	501	0,67	176
Industrias del transporte	1914	1.423	0,28	100
	1920	1.673	0,56	200
	1925	1.724	0,62	221
Hembras.				
Industrias del tabaco............	1914	809	0,28	100
	1920	200	0,56	200
	1925	638	0,62	221
Industrias textiles..	1914	107	0,20	100
	1920	135	0,25	125
	1925	110	0,30	150

***Notes*:** This figure shows an example page of the main source for structural exercise.

K.1 Provincial Wage Data from Annual Reports of the Instituto para Reformes Sociales

Data on wages across provinces and sectors can be obtained at a yearly frequency from the annual publications of the Institute for Social Reforms (Instituto de Reformas Sociales, 1911, 1912, 1913, 1914, 1915, 1916, 1917, 1918, 1919, 1920, 1921). The publications contain information on workplace conditions collected through a large-scale effort to collect information on manufacturing workers across all provinces and industries. At the end of the decade, in 1920, the survey employed more than 80 full time investigators who dispatched more than 18.000 documents summarizing their reports from visits across all Spanish Regions. The publications summarize work hours, infractions of labor laws, and hourly wages. They also offer disaggregated information across industries and gender. For the purpose of this study, I digitzed the hourly wages of workers across regions and industries for the years between 1910-1920.

Table. A.9. Summary Statistics: Provincial Wages Panel Data

	Province	Male_1914	Male_1919	Female_1914	Female_1919	Male_Wage_1914	Male_Wage_1919	Female_Wage_1914	Female_Wage_1919
1	Madrid	10204	23409	1094	4454	2.88	4.30	1.40	2.13
2	Badajoz	630	4231	164	1412	2.75	2.98	1.00	0.90
3	Caceres	4807	3556	667	807	1.96	3.70	0.70	1.00
4	Ciudad_Real	10587		645		2.50		0.75	
5	Guadalajara	703		75		2.25		0.75	
6	Toledo	602		230		3.00		0.85	
7	Barcelona	57323	44791	61759	41259	4.34	7.11	2.01	3.41
8	Gerona	11455	6022	17606	6212	3.21	4.86	1.75	2.56
9	Lerida		4868		1754		3.94		1.86
10	Tarragona	4136	2868	6068	3818	2.84	5.84	1.40	3.33
11	Vizcaya	20391	10328	3173	3264	3.67	4.80	1.88	2.46
12	Alava	974	464	214	58	2.94	3.87	1.39	1.89
13	Guipuzcoa	7414		2493		3.44		1.59	
14	Logrono	2809	8230	3190	2342	2.40	3.87	1.42	1.85
15	Santander	4298	10687	1300	1080	3.16	5.23	1.58	2.72
16	Oviedo	14853	12421	4327	3307	3.00	6.00	1.75	2.00
17	Coruna	9388	10561	8701	9582	2.40	3.75	1.50	1.50
18	Leon	4807	3615	1029	865	2.50	3.75	1.25	1.25
19	Lugo	438	2321	14	593	2.50	3.00	0.75	1.73
20	Orense	503	360	4	22	2.50	4.00	1.50	1.50
21	Pontevedra	6006	5377	3774	2905	2.50	4.00	1.25	1.75
22	Granada	14155	7756	5626	1924	2.50	3.94	1.03	1.33
23	Almeria	1997	5279	390	1072	2.75	3.50	1.00	1.00
24	Cadiz	2448	11463	876	2042	3.00	2.88	1.87	1.55
25	Cordoba	15000	4443	890	1376	2.25	3.30	1.19	1.20
26	Huelva	24791	15138	1969	2148	2.86	3.51	1.26	1.55
27	Jaen	1437		4		2.50		1.25	
28	Malaga	23801	12303	8312	3545	3.30	3.50	1.09	1.75
29	Sevilla	9997	5997	11978	2586	3.10	3.96	1.57	1.83
30	Valencia	11799	12815	12745	22541	2.70	4.26	1.45	2.07
31	Albacete	838		616		2.50		1.20	
32	Alicante	12263	2388	11965	5311	2.40	4.04	1.25	1.91
33	Castellon	3280	1813	1884	3745	2.20	3.69	0.75	1.53
34	Cuenca	313	2477	8	2890	2.50	4.40	0.90	2.00
35	Murcia	10527	4785	3588	9058	2.55	3.05	1.20	1.56
36	Valladolid	3369	4568	1556	6253	3.00	4.00	1.00	1.25
37	Avila	192	1077	28	1214	2.50	3.50	0.75	1.50
38	Burgos	685	2821	133	3459	2.50	3.50	1.00	1.50
39	Palencia	1924	2849	344	3252	2.50	3.50	1.00	1.25
40	Salamanca	657	1839	67	2055	2.00	3.50	1.25	1.25
41	Segovia	4514	4470	621	4752	2.50	4.00	1.00	1.50
42	Zamora	762	1515	283	2332	2.50	3.50	1.00	1.25
43	Zaragoza	7135	9261	1865	11366	3.50	8.60	1.50	2.75
44	Huesca	1838	2841	41	3003	2.50	4.50	1.25	2.25
45	Navarra	5242	3418	1607	4162	3.00	4.00	1.10	1.50
46	Soria	438	266	1	310	2.75	3.75	1.50	1.00
47	Teruel	1589	1702	38	1786	3.00	4.00	1.00	1.50

K.2 Sector-Province Data from Salarios

I obtain information regarding the labor market from two related sources: First a comprehensive industry survey that reports labor quantities and wages across province-sector pairs and covers the years 1914, 1920, 1925 (Ministerio de Trabajo, 1927). This industry survey was published by the Ministry for Labor and Industry and is based on surveys conducted at all public firms and large private enterprises in cities that are larger than 20,000 inhabitants (Casanovas 2004). It covers 23 different industries[6] and 48 different provinces.

[6]The industries included are called: Books, Ceramics, Chemicals, Construction, Decoration, Electricity, Food, Forrest, Furniture, Garments, Glass, Leather, Metal Works, Metallurgy, Mines, Paper, Public, Public Industry, Textiles, Tobacco, Transport, Varias, Wood.

Table. A.10. Summary Statistics: Salarios

	Province	wage_mean_1914	wage_mean_1920	labor_1914	labor_1920
1	Alava	0.31	0.64	2774	4107
2	Albacete	0.36	0.65	7897	10057
3	Alicante	0.37	0.71	24615	28456
4	Almeria	0.45	0.69	11908	11607
5	Avila	0.40	0.70	1250	1823
6	Badajoz	0.31	0.47	18296	20664
7	Baleares	0.35	0.64	24744	29143
8	Barcelona	0.46	0.87	259736	320564
9	Burgos	0.36	0.65	1760	2715
10	Caceres	0.26	0.44	8805	11217
11	Cadiz	0.49	0.87	33026	40604
12	Castellon	0.29	0.62	7518	9553
13	Ciudad_Real	0.36	0.63	12618	17545
14	Cordoba	0.36	0.67	25916	33933
15	Coruna	0.40	0.61	29602	30939
16	Cuenca	0.30	0.56	3304	4425
17	Gerona	0.41	0.68	24944	28370
18	Granada	0.37	0.55	12001	11907
19	Guadalajara			4557	4887
20	Guipuzcoa	0.48	0.76	19210	25172
21	Huelva	0.39	0.57	21945	20166
22	Huesca	0.38	0.71	6405	5213
23	Jaen	0.42	0.64	15500	14237
24	Leon	0.43	1.02	9084	11780
25	Lerida	0.41	0.70	6767	8667
26	Logrono	0.37	0.67	8244	8662
27	Lugo	0.32	0.44	3036	4017
28	Madrid	0.44	0.85	81107	93963
29	Malaga	0.45	0.68	19326	25444
30	Murcia	0.38	0.61	27005	29872
31	Navarra	0.39	0.75	8227	10240
32	Orense	0.32	0.50	2871	3784
33	Oviedo	0.46	1.37	42732	68770
34	Palencia	0.39	0.74	5886	8048
35	Pontevedra	0.38	0.62	16057	19262
36	Salamanca	0.30	0.58	12496	13389
37	Santander	0.44	0.87	15708	22859
38	Segovia	0.33	0.60	2881	3457
39	Sevilla	0.40	0.71	44966	63816
40	Soria	0.38	0.56	1393	2211
41	Tarragona	0.51	0.83	10977	13838
42	Teruel	0.37	0.96	4631	5845
43	Toledo	0.38	0.65	5458	8623
44	Valencia	0.31	0.72	67963	71027
45	Valladolid	0.39	0.66	10476	13815
46	Vizcaya	0.41	1.06	32956	42515
47	Zamora	0.31	0.62	1821	3160
48	Zaragoza	0.45	0.96	18443	27657

K.3 Export Data from Annual Export Statistics

Data on external trade for Spain from 1910-1920 can be obtained from the annual statistical publications of the Spanish customs agency (Dirección General de Aduanas, 1911, 1912, 1913, 1914, 1915, 1916, 1917, 1918, 1919, 1920, 1921). Each year the Spanish customs published two volumes, one containing information on imports and exports across all destination countries and divided by tariff groups - which can be seen as product groups - and the other containing information on imports and exports across tariff groups and reported by the processing custom location. For each observation quantities (typically in kilogram, liters or units) and values are being reported. To obtain overall export values, the Spanish customs agency employed a table of fixed unit prices that are reported alongside the export and import quantities. Overall the publications contains 383 tariff categories and 77 different destination countries.

Table. A.11. Summary Statistics: Exports (Million Pts)

	Industry	1910	1911	1912	1913	1914	1915	1916	1917	1918	1919
1	Agriculture	364	394	405	438	352	399	507	490	318	573
2	Books	6	6	7	9	6	5	5	5	4	5
3	Ceramics	2	3	3	3	2	2	3	2	2	2
4	Chemicals	13	18	21	16	15	29	47	51	44	40
5	Construction	3	3	4	4	3	3	3	2	2	2
6	Decoration	0	0	0	0	0	0	0	0	0	0
7	Electricity	0	0	1	1	0	1	1	1	1	1
8	Food	82	81	88	98	64	74	113	113	102	138
9	Forrest	4	3	4	7	3	5	4	4	2	3
10	Furniture	3	4	3	4	3	3	5	3	4	5
11	Garments	29	31	34	30	41	137	114	94	49	65
12	Glass	2	2	4	3	2	5	7	6	5	8
13	Gold	19	18	18	28	17	18	20	16	11	10
14	Leather	0	1	0	0	0	7	2	1	1	2
15	Metallurgy	4	4	22	1	6	15	7	5	1	0
16	MetalWorks	135	271	144	144	107	128	179	185	132	89
17	Mines	181	163	165	175	123	102	116	103	84	79
18	Other	4	4	4	4	4	6	6	6	8	10
19	Paper	7	64	7	7	6	9	15	11	11	10
20	PublicIndustry	0	0	7	0	0	0	0	0	0	0
21	Textiles	48	49	53	52	66	249	165	168	186	193
22	Tobacco	0	0	0	0	0	0	0	0	1	0
23	Transport	1	1	1	1	1	1	9	14	8	9
24	Wood	62	69	66	67	60	58	48	39	33	59

Table. A.12. Summary Statistics: Exports (Million Pts)

	dest_country	1910	1911	1912	1913	1914	1915	1916	1917	1918	1919
1	alemania	55	49	65	74	43	0	0	0	0	5
2	alhucemas	0	0	0	0	0	0	0	0	0	0
3	andorra	0	0	0	0	0	0	0	0	0	0
4	argelia	4	5	6	8	6	15	11	8	4	10
5	argentina	63	82	71	72	41	68	85	95	113	66
6	austria-hungria	5	3	8	8	5	0	0	0	0	2
7	belgica	33	103	49	45	21	0	0	0	1	87
8	bolivia	0	0	0	0	0	0	0	0	0	0
9	brasil	2	2	5	8	3	4	4	6	4	4
10	canarias	11	14	14	13	14	17	18	18	17	22
11	ceuta	2	3	2	3	5	6	8	9	9	10
12	chafarinas	0	0	0	0	0	0	0	0	0	0
13	chile	8	10	15	7	6	3	6	10	8	5
14	china	0	0	0	0	0	0	0	0	0	0
15	colombia	2	0	1	3	2	2	6	5	0	1
16	costa_rica	1	0	0	1	1	0	0	0	0	0
17	cuba	56	60	64	64	52	57	71	62	43	44
18	dinamarca	8	13	4	4	4	9	15	3	3	10
19	ecuador	1	1	1	1	1	2	2	0	0	0
20	egipto	0	0	0	1	0	2	8	2	2	2
21	estados_unidos	66	55	67	72	63	63	95	106	50	99
22	fernando_poo	1	2	2	2	2	3	3	3	4	3
23	filipinas	8	8	8	7	7	6	6	4	3	1
24	finlandia	0	0	0	1	0	0	0	0	0	0
25	francia	187	257	199	246	206	517	534	557	327	450
26	gibraltar	2	2	1	1	3	5	3	8	14	8
27	gran_bretana	261	299	252	229	231	263	285	202	168	205
28	grecia	0	0	0	0	0	1	12	2	38	33
29	guatemala	0	0	0	0	0	0	0	0	0	0
30	haiti	0		0	0	0	0	0	0	0	0
31	holanda	55	59	65	70	40	20	8	2	1	25
32	honduras	1	0	0	0	0	0	0	0	0	0
33	italia	31	42	43	33	49	78	75	54	53	44
34	japon	1	0	0	0	0	0	0	0	0	0
35	liberia	0	0			0	0	0	0	0	0
36	marruecos	2	6	6	9	0	0	0	0	0	0
37	marruecos__tanger_y_zona_internal	0				1	1	2	4	7	4
38	marruecos__zona_espanola	0				2	4	4	12	9	6
39	mejico	12	11	18	16	3	1	2	6	4	7
40	melilla	3	3	5	4	4	5	5	12	13	17
41	nicaragua	0	0	0	0	0	0	0	0	0	0
42	noruega	2	2	3	2	3	8	8	5	10	14
43	panama	4	13	9	3	4	4	6	6	4	6
44	penon_de_la_gomera	0	0	0	0	0	0	0	0	0	0
45	peru	1	0	1	2	1	1	2	1	1	2
46	portugal	40	44	32	31	14	17	25	27	29	14
47	posesiones_danesas_en_america	0	0	0	0	0	0	0	0	0	0
48	posesiones_francesas_en_africa	0	0	0	0	0	0	0	0	0	0
49	posesiones_francesas_en_america	0	0	0	0	0	0	0	0	0	0
50	posesiones_holandesas_en_america	0	0	0	0	0	0	0	0	0	0
51	posesiones_holandesas_en_asia	0		0	0						
52	posesiones_holandesas_en_oceania	0	0	0	0	1	0	0	0	0	0
53	posesiones_inglesas_en_africa	0	0	0	0	0	0	0	0	0	0
54	posesiones_inglesas_en_america	2	2	2	2	2	1	1	1	1	1
55	posesiones_inglesas_en_asia	1	2	1	1	1	2	2	1	0	1
56	posesiones_inglesas_en_europa	0	0	0	0	0	0	0	0	0	1
57	posesiones_inglesas_en_oceania	2	0	1	1	1	0	0	0	0	0
58	puerto_rico	3	4	3	3	3	2	2	3	1	2
59	rusia	7	5	7	8	6	25	14	3	0	0
60	salvador	0	0	0	0	0	0	0	0	0	0
61	santo_domingo	1	1	0	1	0	0	0	0	0	0
62	suecia	2	2	2	2	3	4	3	1	0	7
63	suiza	7	8	10	12	3	6	10	56	38	32
64	turquia	2	0	1	6	3	0	0	0	0	23
65	uruguay	10	12	10	10	6	12	13	11	17	11
66	venezuela	2	1	3	4	3	3	5	6	5	2
67	bulgaria		0	0	0	0	0	0	0	0	0
68	posesiones_danesas_en_asia		0								
69	posesiones_franceas_en_africa		0								
70	posesiones_franceas_en_america		0								
71	rumania		0	0	0	0	1	1	0	0	6
72	tunez		0	0	0	1	0	0	0	0	0
73	zanzibar		0	0							
74			0								
75	paraguay			1		0	0	0	0	0	0
76	posesiones_portueguesas_en_africa			0							
77	posesiones_portuguesas_en_africa			0		0	0	0	0	0	0

K.4 Correspondence between Tariff Groups and Industry Classifications

A separate publication by the institute for social reform contains a correspondence between industries and occupations (Instituto Nacional de Prevision Social, 1930) . Since occupations can be more easily mapped to the products in the export data, this information is particularly helpful in constructing the correspondence between sectors and product-level trade data. The complete correspondence between export products and sectors is available upon request.

K.5 Migration Data

I follow Silvestre (2005) and use the province level data on inhabitants that are Born in Another Province which is contained in the censuses. For 1920 and 1930 additional information is available listing not only the stock of migrants which were born in another province, but their origin province as well. The difference between 1930 and 1920 in the stock of migrants - adjusted for decennial survivability rates - is informative about net migration. In order to construct net migration, I follow (Silvestre, 2005) and use the decennial census survivability rate between 1921-1930, $S \equiv 0.86$. Net internal migration can be obtained by constructing the survivability adjusted change in stock of migrants, i.e.

$$\text{Internal migrations}_{1930,1920,i,j} = BAP_{i,j,1930} - S \times BAP_{i,j}^{1920}$$

where $BAP_{i,j}^{1920}$ refers to the stock of residents in i who were born in province j in 1920.

K.6 Consumer Price Data

The Boletins of the Instituto de Reformas Sociales contain detailed information on consumer prices of key agricultural and non-agricultural products across Spanish provinces throughout the decade. The data was previously used by Gomez-Tello et al. (2018) and I refer for detailed information to their paper.

K.7 Transportation Network

I georeferenced the Spanish railroad network in 1920. Then, using MATLAB's internal shortest path function, I obtain bilateral distances between provincial capitals along the shortest path of the railroad network. In order to obtain distances to Paris, I augmented the graph with the French railroad network and further added maritime linkages between important ports in France and Spain. Again using the shortest path functionality of MATLAB I can obtain the shortest distance along this transportation network between provincial capitals in Spain and Paris.

K.8 Census Data

I digitized data from four different census publications for 1900, 1910, 1920 and 1930 respectively Instituto Geográfico (1912, 1932, 1922). The census publication contain population data disaggregated by profession for each province of Spain between 1900-1930. Additionally the census publication in 1920 and 1930 contain data on the origin of residents in each province that were born in another province, which - as described before - I use to construct bilateral migration data in the spirit of (Silvestre, 2005).

As has been previously noted in the literature, the structure of the population censuses for Spain between 1900-1920 is not consistent, which makes it difficult to construct a consistent time series for sectoral labor shares across broadly defined categories (Erdozain Azpilicueta and Mikelarena Pena, 1999; Dovring, 2013). Particularly troublesome is an item called "jornaleros, braceros, peones, destajistas" (day-laborers, etc.) which in the 1900 census is subsumed in the agricultural category, but in the 1910 census listed separately. This category likely contains both agricultural workers and workers in other sectors of the economy. I follow Dovring (2013) and partition the category proportionately to agricultural and manufacturing sectors.