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

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December 2021

Abstract

How does domestic factor mobility shape the welfare effects of trade? To study this, I employ an event-study design to show that during WWI a large trade shock caused uneven labor reallocation, wage and price growth across Spanish provinces. Employing a fully estimated spatial equilibrium model featuring imperfect spatial and sectoral labor mobility, I show that during WWI increases in consumer prices offset nominal income gains. Afterwards, the effects of persistent labor reallocation increased welfare by 2.93 pc. Industrial centers benefited from sectoral reallocation, while spatial flows disseminated gains across provinces. Lowering the spatial mobility frictions decreases countervailing price effects.

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

Keywords: Gains from Trade, Labor Mobility, Economic Geography

*For their comments, I am grateful to Konrad Adler, Treb Allen, Andy Bernard, Emily Blanchard, Toni Braun, Albert Carreras, Thomas Chaney, Kerem Coşar, Klaus Desmet, Chris Edmond, Patrick Fève, Jim Feyrer, Sharat Ganapati, Christian Hellwig, Rob Johnson, Brian Kovak, Tim Lee, Thierry Mayer, Rory McGee, Martí Mestieri, Nina Pavcnik, Franck Portier, B Ravikumar, Vincent Rebeyrol, Juan Rubio-Ramírez, Mohammed Saleh, Chris Snyder, François de Soyres, Bob Staiger, Robert Ulbricht, Nikolaus Wolf as well as seminar and workshop participants in many places. I also want to thank Javier Silvestre for sharing his data on internal migration in Spain and Julio Martinez-Galarraga for sharing their data on consumer prices as well as providing helpful comments. Finally, I acknowledge financial support via ERC grant No 337272-FiNet. All remaining errors are my own. The views expressed herein are those of the author and not necessarily those of the Federal Reserve Bank of Atlanta or the Federal Reserve System.

1 Introduction

In recent years, a rapidly growing empirical literature has documented the uneven incidence and effect of trade shocks across local labor markets within countries (Autor et al., 2016; Topalova, 2010; Kovak, 2013; Dix-Carneiro and Kovak, 2017; Jaravel and Sager, 2019; McCaig and Pavcnik, 2018). These studies have emphasized the distributional consequences of uneven trade shocks on employment, wages and consumer prices across locations and occupations. However, they often employ a regression-based approach that implicitly treats individual labor markets as independent observations. This abstracts from the rich network structure that - via labor mobility across sectors and space - connects local labor markets and determines how shocks affect factor allocation and consumer prices in general equilibrium. While some studies have incorporated this feature[1], important questions remain unanswered: What is the implication of spatially uneven shocks across connected local labor markets? What is the qualitative role of labor reallocation in determining the gains from trade? And what is the relative quantitative importance of sectoral compared to spatial mobility?

In this paper, I explore how local labor markets that are connected via imperfect labor mobility shape the aggregate welfare consequences of trade shocks with uneven incidence. I argue that when labor mobility is impeded by sectoral and spatial mobility frictions, the uneven incidence of a trade shock across local labor markets matters. On the one hand, improvements in allocative efficiency may arise and *increase* gains from trade. On the other hand, the uneven incidence of a trade shock across connected local labor markets might cause heightened competition for a limited pool of workers, inducing only limited reallocation of labor, and thus *limit* gains from trade.

To illustrate these opposing effects of uneven trade shocks, consider a stylized example of a simple economy with two local labor markets (i, j). 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.[2] Let ρ_i and ρ_j be the elasticity of labor demand with regard to demand shifts, and ψ_{ii} and ψ_{ij} be the own-wage and cross-wage elasticity of labor supply, respectively. Now, consider a (small) demand shift in both i and j ($d \ln e_i > 0, d \ln e_j > 0$), and

[1] Monte et al. (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 et al. (2019) characterize the dynamic evolution of the spatial equilibrium incorporating migration linkages. Adao et al. (2019) revisit the implications of the 'China shock' employing a reduced-form system that takes general equilibrium feedback into account.

[2] For simplicity I 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 do not exceed in magnitude the indirect effects on labor supply.

solving for wage and employment changes that satisfy labor market clearing in both i and j, we obtain,[3]

$$d \ln w_i = \alpha_1 d \ln e_i + \alpha_2 d \ln e_j \qquad d \ln \ell_i = \beta_1 d \ln e_i + \beta_2 d \ln e_j$$

where $\alpha_1 \propto \rho_i$, $\alpha_2 \propto \psi_{ij}\rho_j$. Furthermore, β_1 and β_2 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 and cross-wage elasticity of labor supply. The reduced-form system clarifies the role of uneven shocks: First, given the assumptions above, both α_1 and β_1 are positive, implying that the *direct effect* of an increase in local demand is to increase wages and labor allocations. If a demand shock disproportionately affects higher productivity sectors or locations, then *efficiency gains arise*. Second, α_2 is positive and β_2 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, 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 together with only *limited efficiency gains* might be the result.[4]

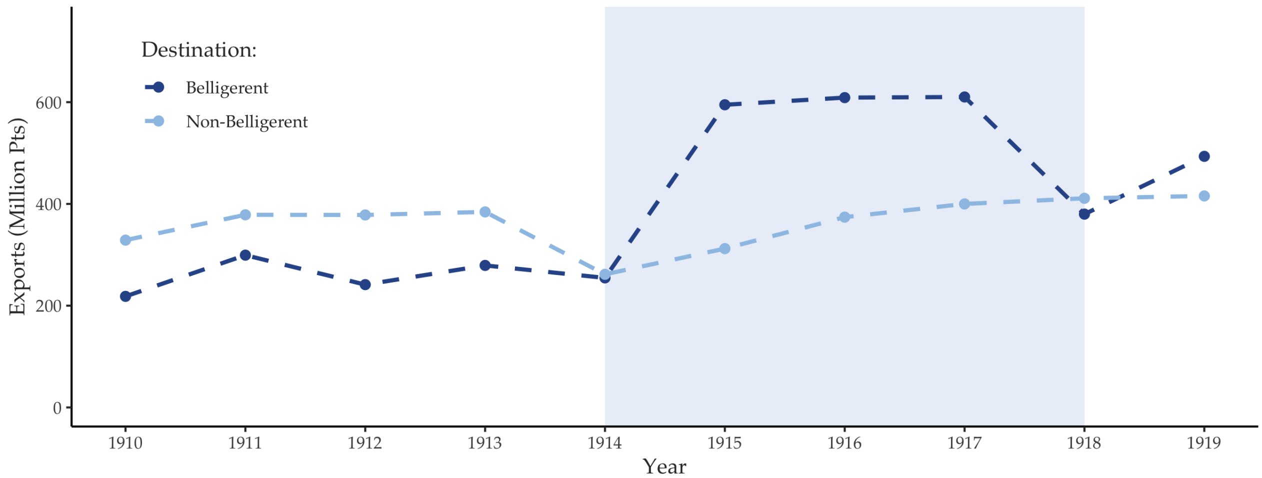
In practice, studying the effect of a trade shock across connected labor markets is challenging for two distinct reasons. First, without knowledge about the connectedness of labor markets, it is difficult to disentangle the direct and the indirect effect, especially when a shock is correlated across local labor markets. Therefore, it is crucial to model and estimate the linkages between local labor markets in a sufficiently rich, yet tractable way. Second, observed changes in wages and employment might be driven by unobserved productivity improvements that could be correlated with an observed trade shock. To disentangle the impact of demand shocks from other confounders, an exogenous trade shock is needed that affects local labor markets in an observably uneven manner.

To overcome these challenges and study the effects of trade shocks across connected local labor markets, this study combines three different elements: First, I examine a natural experiment, where a plausibly exogenous trade shock with discernible spatial and sectoral asymmetries affects a country with highly segmented local labor markets. The reduced-

[3] Derivations can be found in the online appendix Section B.1

[4] The online appendix Section B.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 and cross-wage labor supply elasticities is feasible.

Figure 1: Aggregate Trade Levels



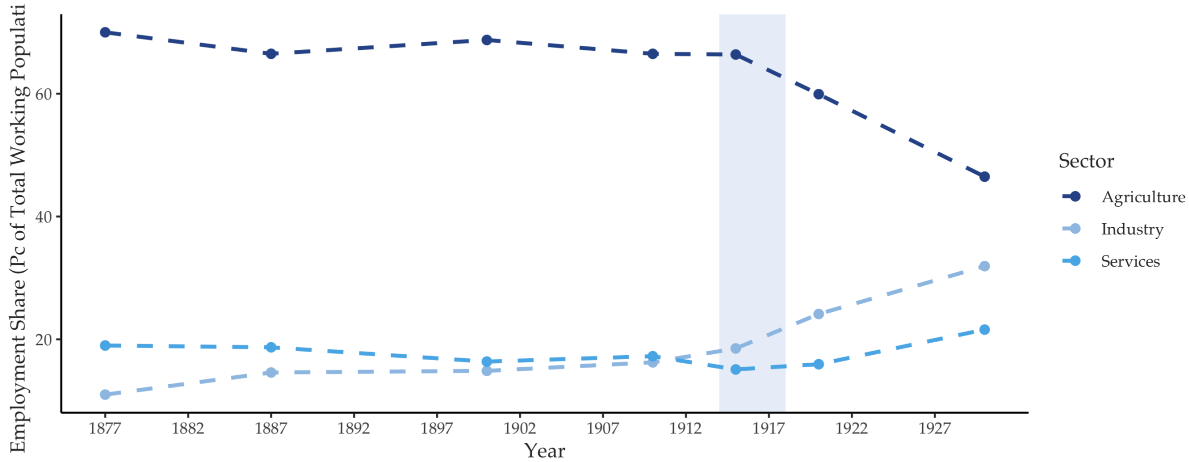
Notes: Aggregate exports (in million pesetas) by whether destination country is belligerent. Belligerent countries are primary belligerent countries where trade was not disrupted by the frontline itself, i.e. i.e. France, Italy and the United Kingdom. The non-belligerent countries exclude the United States and other later participants of WWI. The blue shaded area indicates the period of WWI. The source data are the digitized product-destination level trade statistics.

form evidence illustrates how an international trade shock that affects closely connected local labor markets can cause localized wage pressure that feeds into consumer prices, but also reallocation of factors towards high productivity industries. Second, I develop and estimate an economic geography model where local labor markets are connected. The worker faces a reallocation choice subject to switching costs that impede both spatial and sectoral mobility. This creates a tractable labor supply system that links local labor markets. I furthermore show how the historical setting can be used to estimate the model. Third, I show that changes in labor flows across space and sectors can be used as a sufficient statistic to measure and decompose gains from trade taking spatial and sectoral labor reallocation into account. This methodology cleanly distinguishes between improvements in the worker's current local labor market - cross-sectional welfare improvements - and improvements in the worker's option value to relocate to other local labor markets - dynamic gains from trade. Simulating WWI shock under different degrees of (spatial) labor market segmentation allows me to quantify the sensitivity of gains from trade to factor immobility.

At the heart of this study is the analysis of a historical natural experiment: An international trade demand shock to the Spanish economy that was caused by the participation of Spain's key trading partners in the first World War (1914-1918). Spain, however, remained neutral throughout this period, but was indirectly affected via trade linkages.[5] This unique historical episode features a plausibly exogenous and large trade shock (cp. Figure 1), with highly uneven incidence across sectors and across space. Spain at the time was marked by a

[5]The shock was caused by circumstances external to the Spanish economy, specifically reduced industrial capacity due to the large-scale mobilization required for the war effort as well as heightened war needs in belligerent countries, particularly France, while Spain remained neutral throughout the conflict.

Figure 2: Aggregate Composition of the Economy



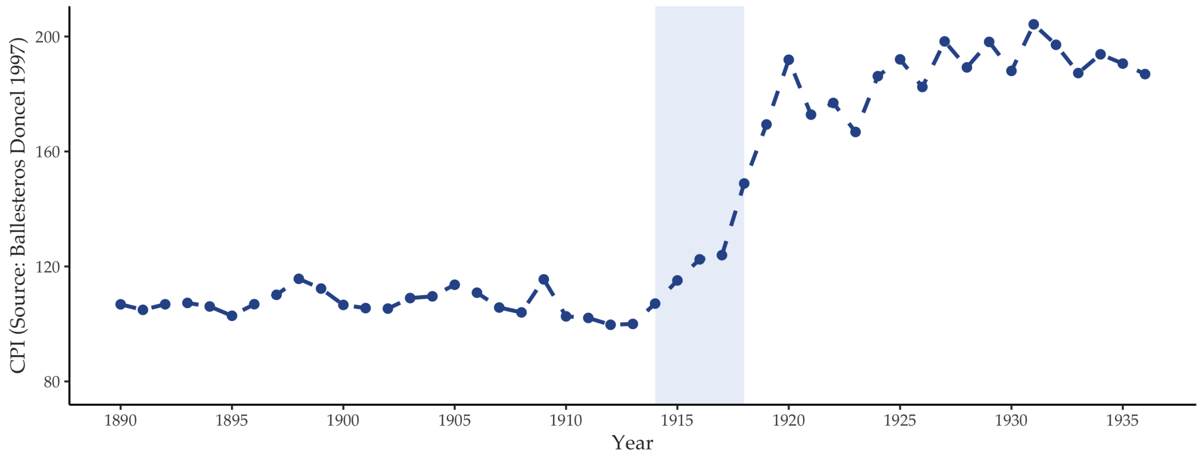
Notes: Primary (agriculture), secondary (industry/manufacturing) and tertiary (services) share of total employment in Spain between 1877-1930. Data series is constructed from census data, using the calculations in Harrison (1978) for the years 1877-1900, and follows own calculations for the period between 1900-1930. The blue shaded area indicates the period of WWI. Further information on how a consistent data series is constructed from census data is provided in the online appendix.

high degree labor market segmentation, however, despite that the trade shock induced sectoral reallocation (cp. Figure 2), causing at the same time a dramatic increase in consumer prices (cp. Figure 3). A detailed analysis of this period is only possible, because of a unique spatial panel that brings together for the first time hand-collected data on trade records, detailed employment surveys across all Spanish provinces, as well as data on consumer prices, covering the period between 1910-1920.

I begin by examining the historical evidence: First, I establish the exogeneity of the shock. I examine the historical trade records and show that an increase in exports is associated with demand factors in belligerent countries that coincide with the outbreak of the war. This export shock was marked by sectoral asymmetry and the composition was in line with products that would have been needed for the sustained war effort. Second, I then examine the shock's impact on wages, labor allocations and consumer prices. The shock was highly uneven across space and sectors, and its direct effect induced limited spatial labor reallocation, but highly uneven wage and price growth. I also show that indirect exposure to the trade shock further exacerbated wage pressure: Provinces that are more closely located to other provinces that were heavily affected by the trade shock, experienced additional wage and price pressure.

The presence of indirect effects points towards the importance of spatial linkages across goods and factor markets. In order to quantify the welfare effects of a trade shock in the presence of such linkages, this paper takes an explicitly structural approach. I incorporate imperfect labor mobility across space and sectors in an otherwise standard economic geography model. The challenge is to develop a framework for labor mobility that is sufficiently rich to capture the details of how segmented labor markets interact, both characterizing

Figure 3: Evolution of the Spanish CPI



Notes: Consumer price index according to Ballesteros Doncel (1997) between 1890 and 1936. Normalized to 100 in 1913. Blue-shaded area indicates WWI period.

the flows between sectors and across space, but still remains tractable to be empirically estimated. The key innovation is to rely on a sequential formulation of the workers' relocation choice that separates spatial from sectoral adjustments and thus models complex interactions across space and sectors in a tractable way.

To characterize the welfare implications of a trade shock under imperfect labor mobility, I extend the sufficient statistic approach by Arkolakis et al. (2012) and Ossa (2015) and derive a closed-form formula for the gains from trade that takes domestic re-allocation into account. The model implies an inverse and invertible relationship between the share of workers that remain in a location or sector and the spatial or sectoral ex-ante expected utility associated with the reallocation choice.[6] Therefore, observing the change in the share of workers that remain across comparative statics is a sufficient statistic from which commonly used aggregate welfare measures can be constructed. The sequential choice implies a separability between spatial and sectoral mobility which in turn allows us to decompose and attribute welfare changes to changes in sectoral and spatial mobility. This methodology allows for a sharp decomposition of welfare improvements into different qualitative channel: Improvements in the current local labor market to which the worker is attached signify cross-sectional static gains. Increases in sectoral mobility pin down increases in the option-value of sectoral relocation, while increases in spatial mobility are associated with increases in the option-value of spatial relocation. These latter two channels are associated with the worker's mobility choice and constitute dynamic gains.

[6] Conceptually this approach is related to the notion that (conditional) choice probabilities are informative of choice-specific value functions, as is commonly used in the estimation of the dynamic discrete choice models (Hotz and Miller, 1993). In this setting, remain shares are directly related to the option-value of the worker's mobility choice. This option-value of the reallocation choice is related to what McFadden (1977) termed the social surplus function which is a commonly used welfare measure.

To implement the welfare analysis two ingredients are needed: First, this approach requires knowledge of labor flows in the shocked and non-shocked counterfactual scenario, which in turn requires a fully estimated model to simulate the counterfactual scenario. Second, the welfare formula requires estimates of the spatial and sectoral labor supply elasticities as well as the trade elasticity to be constructed. A large part of this study is therefore dedicated to exploiting the historical setting to obtain credible estimates of key elasticities and to fully calibrate the model, including a detailed effort to estimate mobility frictions across space and sectors.

The estimation of the model proceeds in four steps. In a first step, I derive from the model a structural reduced-form that traces out nominal income gains as a function of the spatial exposure to the WWI shock. Implementing this regression design allows me to estimate domestric trade costs. In a second step, I invert the model to location-sector specific fundamentals which correspond to market-share shifters. The sensitivity of these market share shifters with regard to (exogenous) changes in the input cost pins down the trade elasticity. I exploit the differential impact of the trade shock across locations and sectors to isolate wage changes and thereby identify the trade elasticity. I then turn towards estimating the parameters that determine labor flows in the model. Typically, the estimation of mobility frictions would require data on flows of workers across space and sectors. However, in historical settings this is rarely available. In this setting, the census provides additional data on the stock of residents dissected by their place of birth in 1920 and 1930. I begin by exploiting this information to estimate a (spatial) gravity regression, which identifies the spatial decay of migration flows as well as the average out-migration share across all provinces. In order to estimate sectoral switching costs and labor supply elasticities, I fit the model to changes in labor allocations at the province-sector level from before to after the war. A challenge is that migration decisions were made during the war based on wage dynamics that are not directly observable at the province-sector level. To overcome this, I invert the model to back out baseline productivities and then feed in the observed aggregate WWI trade shock to simulate - conditional on a guess for the migration frictions that are being estimated - labor flows and wages that solve the labor market equilibrium conditions across all province-sector units. The frictions are being estimated by minimizing the distance of the simulated labor allocations and the observed labor allocations just after the war.

As a result of the estimation I obtain predicted sectoral and spatial labor flows that are consistent with the observed changes in province-sector specific labor allocation. Both sectoral and spatial frictions are highly prohibitive. However, the implied reallocation strongly suggest that spatial frictions dominate sectoral adjustment frictions, with 76 percent of the adjustment happening across sectors within provinces, rather than between provinces.

With the fully estimated model in hand, it is possible to quantify and decompose the welfare effects of the WWI shock across Spain. To do so, I first simulate labor flows in the non-shocked scenario, by using the calibrated model to simulate the sectoral and spatial reallocation if external trade and productivity would have remained at the 1914 level. With the labor flows in the shocked and non-shocked scenarion, the welfare effects can be quantified. This is done both for the scenario where the labor market clearing wage (and therefore the prices of domestic tradeables and non-tradeables) is generated feeding in the WWI shock and for the scenario where the WWI shock just dissipated and export levels level off to a lower post-war export scenario. This exercise allows us to examine the dynamics of the gains from trade from a temporary trade shock: While the shock persisted increases in consumer prices entirely offset any gains from trade. After the shock dissipated, the reallocational gains increased welfare by 2.93 percent, however the gains were highly uneven across provinces. Lowering the spatial segmentation, increases reallocative gains and decreases offsetting price effects.

In a final step, I trace out the welfare effects for different degrees of (spatial) labor market segmentation. By varying the spatial mobility cost and recalculating the labor flows in both the shocked and non-shocked scenario I can trace out the relationship between labor market segmentation and gains from trade. Not surprisingly, as labor markets become more integrated the gains from trade increase. However, the exercise shines a role on the qualitative and quantitative importance of spatial mobility. Interestingly, the marginal gains are equally shared between increases in reallocation and lessened countervailing price pressure. 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.

Related literature. My paper is related to a number of different strands of research. First, there is a long-standing literature in international trade examining the implications of a lack of factor mobility, going back at least to the canonical analysis using the specific factor model (Jones, 1971; Mayer, 1974; Mussa, 1974, 1982). Mussa (1982) in particular pointed out that factor immobility leads to differential income gains across sectors with different factor endowments. More specifically related to labor adjustments, a number of papers have further examined the interaction between dynamic labor adjustments and external trade shocks with Matsuyama (1992) developing a first tractable analysis, and with a more recent set of papers exploring the phenomenon quantitatively (Tombe and Zhu, 2019; Kambourov, 2009; Artuc et al., 2007; Dix-Carneiro, 2010; Dix-Carneiro and Kovak, 2017; Kovak, 2013; Caliendo et al., 2015; Fajgelbaum and Redding, 2014; Fan, 2019; Adao et al., 2019; Monte et al., 2018; Caliendo et al., 2019). What is less explored in this literature is the interaction between connected local labor markets, uneven shock incidence and consumer prices.[7] This paper fills this gap by providing both reduced-form evidence from a unique historical natural experiment as well as a complete quantitative analysis of the interaction between labor market segmentation, uneven trade shocks and consumer prices.

Second, my paper contributes to the literature on characterizing gains of trade using sufficient statistics. Recent contributions sought to extend the initial work (Arkolakis et al., 2012) to allow for multiple sectors with different trade elasticities (Ossa, 2015), or workers with heterogeneous productivities across sectors (Galle et al., 2017; Kim and Vogel, 2020; Lee, 2020). This paper contributes to this literature by characterizing gains from trade taking into account the imperfect reallocation of workers across domestic local labor markets[8] and highlighting that data on labor flows can be used to construct a sufficient statistic to do so.[9]

Third, the paper adds to the literature on Spanish economic history by showing that the WWI shock had an important impact on the Spanish economy by reallocating factors across space and sectors to provide the preconditions for an economic take-off in the 1920s. As such it is a middle ground between two opposing views in the literature. The traditional view, represented by Roldan and Delgado (1973), interprets the war as a large turning point for economic development. The modern view, represented by Prados de la Escosura (2016) emphasises that the shock actually decreased real GDP and instead he points towards the 1920s as a much more important decade for Spain's development. My analysis provides a middle ground between these two opposing views, pointing towards substantial reallocation and nominal income gains, but tracing out substantial countervailing price effects that are driven by reallocation costs in the labor market, leading to positive but somewhat modest welfare gains despite a historically large demand shock to the Spanish economy.

[7]While the literature generally does not focus on the interaction between local labor markets, the studies by Helm (2020); Adao et al. (2019) are notable exceptions. In Helm (2020), the author exploits employment spillovers between local labor markets to estimate agglomeration effects. In Adao et al. (2019), the authors revisit the reduced-form analysis of Autor et al. (2013), but introduce an estimation framework that explicitly takes labor market linkages and general equilibrium responses into account. Indeed the stylized model in the next Section can be seen as a simplified version of their framework, but the focus of their analysis abstracts from efficiency gains and how those are conditioned by the uneveness of the shock.

[8]Kim and Vogel (2020) conduct a similar analysis, taking the imperfect reallocation of workers into account when calculating the welfare effect of the China shock across US labor markets. However, by abstracting from bilateral reallocation in their setting, they cannot capture the rich interactions between closely connected labor markets that is the centerpiece of this study. In their empirical implementation, they furthermore abstract from the impact on consumer prices.

[9]The paper is also related and adds to a growing literature characterising the welfare implications of factor misallocation, going back at least to Harberger's initial analysis (Harberger, 1964), with Baqaee and Farhi (2020) offering a characterisation of the effect of microeconomic shocks in inefficient economies, Hornbeck and Rotemberg (2019) studying the implications of misallocation on the welfare effect of transportation improvements in the US historical context and Zarate (2021) doing so in an urban contemporary context.

Outline. The remainder of the paper is structured as follows. Section 2 describes the historical background and the various data sources as well as the construction of the data set that underlies most of the analysis. Section 3 gives reduced form evidence on the trade shock and its effect local labor markets. Section 4 describes the theoretical model, the estimation of the model as well as the welfare quantification. Finally, Section 5 concludes.

2 Data and Historical Background

Before turning towards the empirical analysis, this section will provide background on the historical context and the key data sources that underlie the analysis. I will first describe key features of the Spanish economy just before the outbreak of WWI, focusing in particular on the spatial and sectoral organization of the Spanish economy, external trade and the segmentation of domestic labor markets. I will then proceed by introducing the historical spatial dataset that will be used in the rest of the paper.

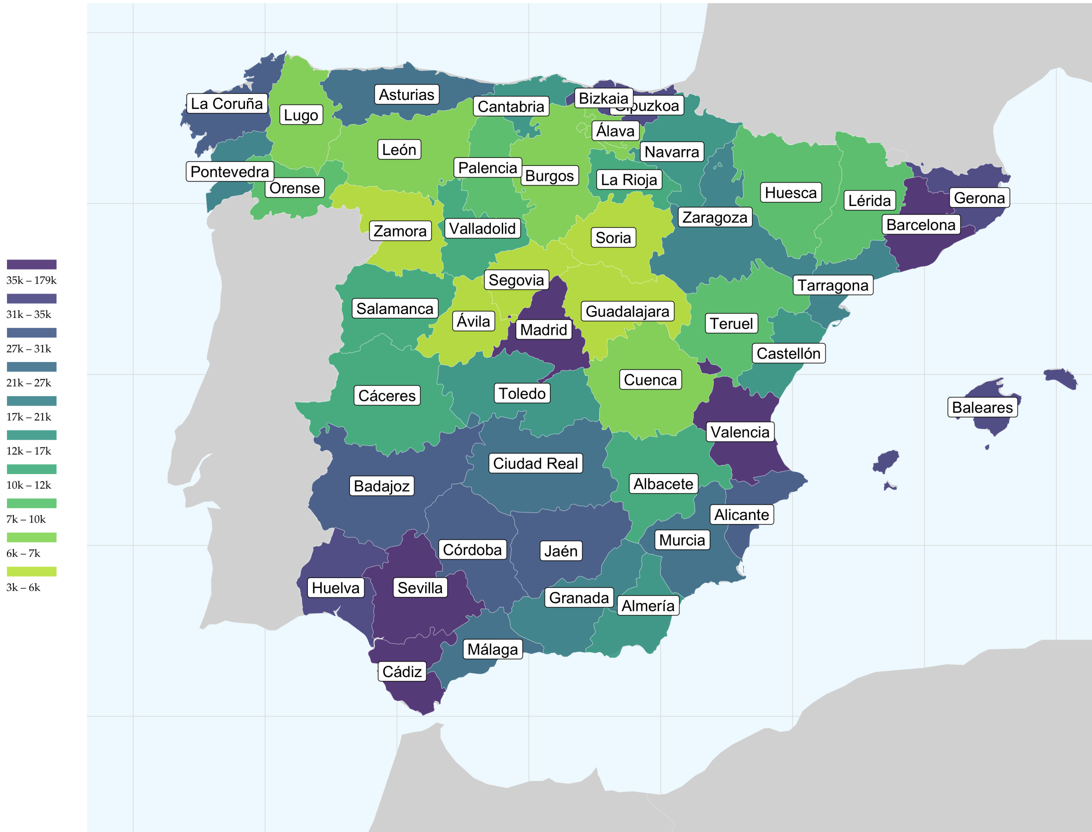
2.1 The Spanish economy at the beginning of the 20th century.

At the beginning of the 20th century, Spain remained at a relatively low level of industrial development.[10] According to census data, in 1900 roughly 70pc of the working population worked in agriculture and only 12.5pc worked in manufacturing. Industrialization only proceeded slowly, with the industrial sector only growing marginally in total employment by 3pc, adding a little bit less than 40,000 jobs nation-wide 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.

Spatial distribution of economic activity. In terms of the spatial distribution of the population, most of the population was still concentrated in predominantly rural and agricul-

[10] 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 are more advanced in terms of their industrialization (Harrison, 1978).

Figure 4: 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.

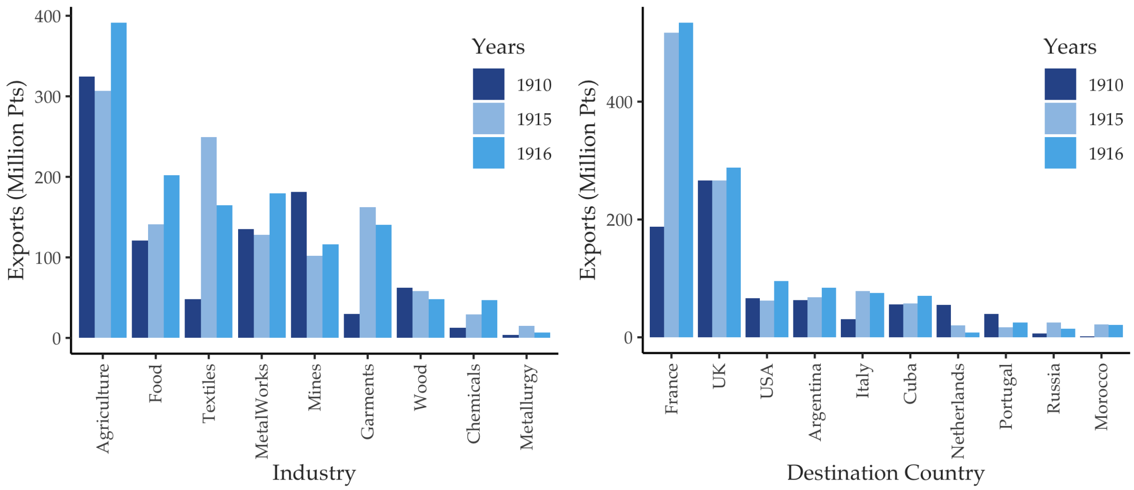
tural areas such as Andalucía[11] or Castilla y León.[12] Major urban centers such as Oviedo, Valencia, Bilbao, Madrid and Barcelona concentrate most of the industrial activity as can be seen by the map in Figure 4 indicating the spatial distribution of manufacturing employment. The industrial structure of those urban centers was heterogeneous. For example, Barcelona was highly specialized in the cotton textile industry, while Valencia specialized in garments. Because of natural endowments mining and associated downstream industries dominated Oviedo and Jaen. The Basque country had an early advantage in the heavy metal industries, featuring numerous Martin-Siemens open-hearth furnaces for steel production as well as other fixed installations.

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 5pc the

[11] 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

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

Figure 5: 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.

population at a decennial rate (Silvestre, 2005). Explanations focus mainly on an insufficient release of agricultural works 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.[13] 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.

External markets. 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 5). 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 5. 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.

2.2 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

[13]For a complete discussion and references of demand-based and supply-based explanation see Section 2 in Silvestre (2005).

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.[14]

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[15] and 48 different provinces.[16] 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

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

[15]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.

[16]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.

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.[17]

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.

[17]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 13 - 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.

3 WWI Trade Shock and its Effect on Spanish Workers

Having introduced the historical background and data, this section then turns towards examining the impact of WWI on Spanish local labor markets. A particular focus is to examine both how the shock directly affected local labor markets, but also how linkages between local labor markets create indirect exposure and determines wage and employment adjustments. The analysis proceeds in three steps: First, I examine detailed trade records to establish that the increase in exports was entirely driven by an increase in beliggerent demand. I then examine the heterogeneity of the trade shock across sectors, before finally turning towards establishing the impact it had across local labor markets on wages, employment levels and consumer prices.

Table 1: Belligerent Export Destinations

	Exports (Value)		
	(1)	(2)	(3)
Belligerent Destination × Year=1910	-0.1970 (0.2652)	-0.2356 (0.2950)	-0.0144 (0.1269)
Belligerent Destination × Year=1911	-0.0516 (0.3124)	-0.1605 (0.2895)	0.1144 (0.1306)
Belligerent Destination × Year=1912	-0.1904 (0.2619)	-0.1997 (0.2869)	-0.1152 (0.1261)
Belligerent Destination × Year=1914	0.2649 (0.2608)	0.3267 (0.2787)	0.2197* (0.1163)
Belligerent Destination × Year=1915	1.058*** (0.2718)	1.159*** (0.2693)	0.9258*** (0.1427)
Belligerent Destination × Year=1916	0.9330*** (0.2685)	1.022*** (0.2753)	0.6710*** (0.1247)
Belligerent Destination × Year=1917	1.013*** (0.2817)	1.113*** (0.2781)	0.7110*** (0.1585)
Belligerent Destination × Year=1918	0.6607*** (0.2553)	0.7338*** (0.2653)	0.4703*** (0.1483)
Belligerent Destination × 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			✓

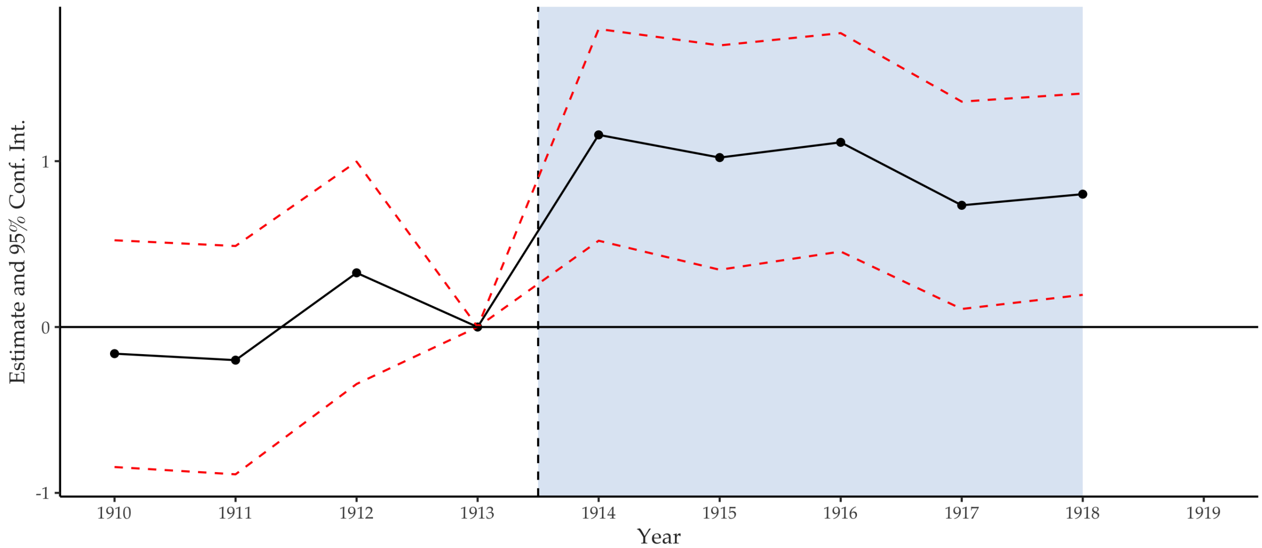
Notes: Observations are values of exports (in pesetas) at the product-destination level for a given year. Belligerent Destination is a dummy that takes the value of 1 for the primary belligerent countries where trade was not disrupted by the frontline itself, i.e. i.e. France, Italy and the United Kingdom. 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 (1). 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.

3.1 Fact 1: WWI trade shock was driven by belligerent demand.

In a first step, I examine the WWI trade shock through the lense of the trade records. The export shock was large from an aggregate point of view. In 1915 aggregate exports increased by 40pc compared to 1914 and stayed at a high level for as long as the war lasted.[18] 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:

[18] 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 has further increased the price.

Figure 6: 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 responds to β_t in the regression Equation above. The red dotted lines indicate 95pc 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.

$$\log\left(X_{i,p,t}\right) = \sum_{t \neq 1913} \beta_t \times \text{Belligerent}_i + \mu_{i,p} + \mu_{t,p} + \varepsilon_{i,p,t} \tag{1}$$

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, $\text{Belligerent}_{i,t}$ 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. The regressions results are reported in Table 1. The table presents three specifications. Column (1) shows the more parsimonious specification and only controls for product, year and destination country fixed effects. One might be concerned that the effect captured by the belligerent dummy is affected by how differential export composition to belligerent countries interacts with product-level export time-varying effects - which very well might be driven by Spanish improvements in productivity rather than destination-specific demand factors. In Column (2) I therefore control for interacted product-year fixed effect to capture possible time-varying differences in Spanish productivity and in Column (3) I control for both interacted product-year as well as product-destination fixed effects, capturing additionally baseline heterogeneity in the export composition across destination countries. All specifications are being estimated using ppml to address concerns about bias from heteroskedasticity and zeros in the data (Silva and Tenreyro, 2006).

In all specifications, I find a significant and large increase in exports to belligerent countries. The absence of differential pre-trends provides support for the identifying assumption that belligerent countries were on similar pre-trends to non-belligerent countries prior to WWI. For Column (2) - the regression specification that most closely traces the aggregate effect of the shock - I present the estimated coefficients and their 95pc confidence interval in Figure 6. On average, exports to belligerent countries approximately tripled ($\exp(1.1) \approx 3$) during the period, an effect that given the specification is plausibly driven by changes in export demand in these locations.

3.2 Fact 2: The trade shock was uneven across sectors.

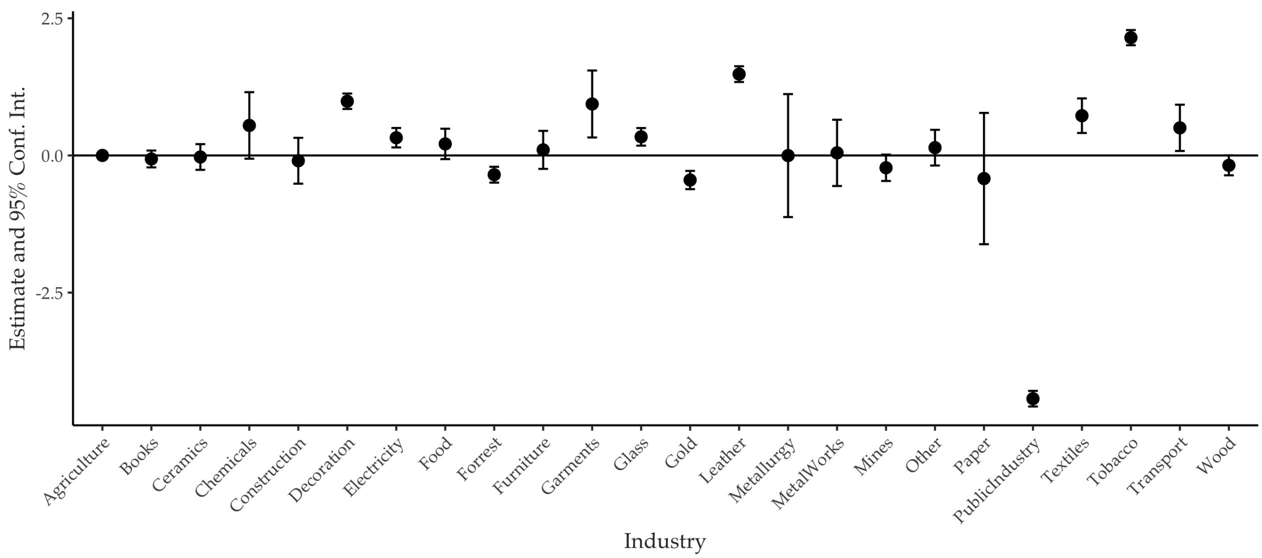
In a second step, I inspect the sector-specific dynamics in the export data. As was previously shown, the raw data strongly indicates a shift away from primary goods towards manufactured goods, as is evident in Figure 5. However, it is not clear whether these changes in sectoral trade flows are driven 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.

$$\begin{aligned} \log\left(X_{i,p,t}\right) = & \sum_s \theta_s^1 \times \text{WWI}_t \times \text{Belligerent}_i + \beta_1 \times \text{WWI}_t \times \text{Belligerent}_i + \\ & \beta_2 \times \text{WWI}_t + \beta_3 \times \text{Belligerent}_i + \mu_{i,p} + \mu_t + \varepsilon_{i,p,t} \end{aligned} \tag{2}$$

where - as before - $\text{Belligerent}_{i,t}$ 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 control for heterogeneity in the export composition across destination countries, while μ_t represents a year fixed effect that controls for aggregate shocks.

The results for this regression are reported in Table 9 in the online appendix. As in the previous subsection, I present results with different sets of fixed effects. Column (1)

Figure 7: Sectoral Heterogeneity of the Trade Shock



Notes: Figure shows the sector-specific shifts in export demand as estimated in Equation (3). 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.

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

$$\log\left(X_{i,p,t}\right) = \sum_{s} \theta_s^2 \times \mathrm{WWI}_t + \beta_1 \times \mathrm{WWI}_t + \mu_{i,p} + \mu_t + \varepsilon_{i,p,t} \tag{3}$$

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 7 depicts the estimated coefficients and their 95 percent intervals. Detailed regression results can be found in Table 8. 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 5 above.

3.3 Fact 3: The shock impacted wages, labor allocations, and prices directly and indirectly.

In a third step, 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 of 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. Specifically, I am constructing the following three measures:

$$\text{Shock}_{i,s} \equiv \theta_s^2 \qquad \text{Local Shock}_{i,s} \equiv \sum_{r \neq s} \pi_{r|i}^{1914} \text{Shock}_{i,s} \tag{4}$$

$$\text{Spatial Shock}_{i,s} \equiv \sum_{j \neq i} \frac{1}{\text{dist}_{ij}} \text{Local Shock}_{j,s} \tag{5}$$

where the first measures simply consitutes the log change in sector-level exports during WWI as estimated in the previous section. The second variable, Local Shock$_{i,s}$, 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 Spatial Shock$_{i,s}$ measures to what extent a sector is exposed to the trade demand shock via increased competition for labor via highly affected proximate provinces. I use these measures in a 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. For wages and labor allocations, I follow the following specification,

$$\begin{pmatrix} \log\left(w_{r,s,c,t}\right) \\ \log\left(\ell_{r,s,c,t}\right) \end{pmatrix} = \beta_1 \times \mathrm{WWI}_t \times \log \mathrm{DistanceParis}_r + \beta_2 \times \mathrm{WWI}_t \times \text{Local Shock}_{r,s} + \tag{6}$$
$$\beta_3 \times \mathrm{WWI}_t \times \text{Spatial Shock}_{r,s} + \beta_4 \times \mathrm{WWI}_t \times \text{Shock}_{r,s} +$$
$$\beta_5 \times \mathrm{WWI}_t + \beta_6 \times \text{Local Shock}_{r,s} + \beta_7 \times \text{Shock}_{r,s} +$$
$$\beta_8 \times \text{Spatial Shock}_{r,s} + \mu_r + \mu_{c,s} + \varepsilon_{r,s,c,t}$$

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. For consumer prices, I follow the slightly different specification,

$$\log\left(p_{i,p,u,m,t}\right) = \beta_1 \times \mathrm{WWI}_t \times \log \mathrm{DistanceParis}_{\,r} + \beta_2 \times \mathrm{WWI}_t \times \text{Local Shock}_r + \tag{7}$$
$$\beta_3 \times \mathrm{WWI}_t \times \text{Spatial Shock}_r + \beta_4 \times \mathrm{WWI}_t + \beta_5 \times \text{Local Shock}_r +$$
$$\beta_6 \times \text{Spatial Shock}_r + \mu_{i,u} + \mu_{p,m} + \mu_t + \mu_{u,p} + \varepsilon_{i,p,u,m,t}$$

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 variable 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.

Table 2 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

Table 2: 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 (6) and (7). 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 (4) and (5). Log distance to France is the shortest distance to Paris along the Spanish and French railroad network (as explained in Section 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 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.

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.

For wages, the distance coefficient - while sensitive towards controlling for cross-sectional heterogeneity across space - is negative throughout the specifications. Recall that the dataset is at the region level which reduces the spatial units to 8, making it more difficult to precisely estimate the distance effect. Nevertheless the coefficient while diminished remains significant for some of the war years, even in the most stringent specification. All three direct and indirect shock variables have significant and strong positive effects on wage growth in local labor markets. Furthermore, the indirect spatial shock variable is insignificant in the pre-period and conditional on controlling for province fixed effect so is the local shock variable, creating confidence that the the affected sectors do not exhibit differential pre-trends.

Regarding labor allocations, no spatial tilt can be detected, 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.

Concerning prices, across specifications the distance elasticity is (mostly) significantly negative indicating a spatial tilt in prices with provinces further south experiencing less of a price increase during the war years. Also, across specifications, the local shock exposure measure positively contributes to price increases, which is consistent with the interpretation that some of the localized wage gains passed through into consumer prices. Finally, maybe surprisingly, the sign on the spatial shock proxy is flipped. This might reflect the fact that increased labor demand in close-by provinces might diminish effective labor supply and therefore local consumption demand, possibly lowering consumer prices.

4 The Impact of Trade under Segmented Labor Markets

To rationalize the direct and indirect effect of the WWI shock across Spanish local labor markets and to evaluate the welfare implications of trade shocks given labor market linkages, this section embraces an explicitly structural approach. The section proceeds in three steps. First, I show how to embed imperfect labor mobility into an otherwise standard economic geography model, by introducing a tractable worker reallocation choice where mobility is impeded by sectoral and spatial mobility frictions. In this model, spatial and sectoral labor flows can be used as sufficient statistics to quantify and decompose gains from trade, taking domestic reallocation and associated *efficiency gains* into account. Second, I then proceed to estimate the model. The structure of the model together with the variation from the WWI shock is exploited to estimate labor supply and demand elasticities as well as the full set of sectoral and spatial mobility frictions. Third, I use the model to quantify gains from trade for the historical case, but also for counterfactual scenarios under different degrees of (spatial) labor market segmentation. This last exercise traces out the interaction between factor mobility and gains from trade.

4.1 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 et al., 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.[19]

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,

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

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

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

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,

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

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

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,

$$\sigma'_{ni,rs} = \sigma'_{ni|r}\sigma'_{rs|i} \tag{8}$$

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,

$$\sigma'_{rs|i} = \frac{(w'_{is|r})^{\nu}}{\left(\Pi'_{i,r}\right)^{\nu}} \tag{9}$$

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,

$$\sigma'_{ni|r} = \frac{\left(v'_{ni|r}\right)^{\gamma}}{(\Omega'_{n,r})^{\gamma}} \tag{10}$$

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[20] and where finally $\left(\Omega'_{n,r}\right)^{\gamma} \equiv \sum_j \left(v'_{nj|r}\right)^{\gamma}$ represents the option value of the 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,

$$p_{ni,r} = \tau_{ni} mc_{i,r} = \frac{\tau_{ni} w_{i,r}}{z_{i,r}} \tag{11}$$

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,

$$w_{i,r}\ell_{i,r} = \sum_{n=1}^{N^D} s_{ni,r}\left(\sum_{r=1}^{S} e_{n,r}\ell_{n,r}\right) + \sum_{l=1}^{N^F} s_{li,r} e_l \tag{12}$$

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

$$\left(\sum_{r=1}^{S} e_{n,r}\ell_{n,r}\right) = \sum_{r=1}^{S}\left(\sum_{i=1}^{N} s_{ni,r}\left(\sum_{r=1}^{S} e_{n,r}\ell_{n,r}\right) + \sum_{l=1}^{N^F} s_{nl,r}\left(\sum_{r=1}^{S} e_{n,r}\ell_{n,r}\right)\right) \tag{13}$$

[20]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.

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

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

$$H_n r_n = \delta \left(\sum_{r=1}^{S} e_{n,r} \ell_{n,r} \right) \tag{14}$$

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,

$$\ell_i' = \sum_n \sum_r \sigma_{ni|r} \ell_{n,r} \tag{15}$$

Sector-province labor market clearing is given by,

$$\ell_{i,s}' = \sum_{r=1}^{S} \sum_{n=1}^{N} \sigma_{ni,rs} \ell_{n,r} \tag{16}$$

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.

Gains from trade. 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). As welfare measure I focus on the ex-ante expected utility in the second period, but taking into account the initial allocation of workers in the first period. Given that this initial allocation arises from an EV1 allocation problem, this allows us to construct an aggregate welfare formula. The welfare expression then correponds to the expected utility for a worker across all possible locations and sectors:

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

where again $\delta = \Gamma\left(\frac{\epsilon}{\epsilon - 1}\right)$ and $\Gamma(\cdot)$ is the gamma function. Additionally, $\tilde{\rho}$ corresponds to an amenity shifter that is chosen to exactly fit the distribution of the population across space and sectors. Totally differentiating the welfare expression and integrating for small changes, we obtain,

$$\left(\frac{\mathcal{W}^1}{\mathcal{W}^0} \right) = \prod_{n=1}^{N^D} \prod_{r=1}^{S} \left(\frac{\Omega_{n,r}^1}{\Omega_{n,r}^0} \right)^{\pi_{n,r}}$$

where $\pi_{n,r} = \frac{\ell_{n,r}}{\sum_i \sum_r \ell_{i,r}}$ is the population share observed in the data in the baseline period. Inverting the Equations (10) and (9) and solving for the respective option-values, we construct an expression for changes in the option value in terms of labor reallocation shares,

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

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 observation that conditional choice probabilities can be used to infer continuation values in dynamic discrete choice problems (Hotz and Miller, 1993).[21] The final term represents cross-sectional improvements in the indirect utility of workers across locations. Following Arkolakis et al. (2012) and Ossa (2015), this term can be constructed as a function of trade shares, i.e.

$$\left(\frac{\mathcal{W}^1}{\mathcal{W}^0}\right) = \prod_{n=1}^{N^D} \prod_{r=1}^{S} \left(\underbrace{\left(\frac{\sigma^1_{nn|r}}{\sigma^0_{nn|r}}\right)^{-\frac{1}{\gamma}}}_{\text{Spatial Flows}} \underbrace{\left(\frac{\sigma^1_{rr|n}}{\sigma^0_{rr|n}}\right)^{-\frac{1}{\nu}}}_{\text{Sectoral Flows}} \underbrace{\left(\frac{r^1_n}{r^0_n}\right)^{-\delta}}_{\text{Housing Cost}} \underbrace{\prod_{t=1}^{S} \left(\frac{s^1_{nn,t}}{s^0_{nn,t}}\right)^{-\frac{(1-\delta)\alpha_t}{\sigma_t - 1}}}_{\text{ACR Gains}} \right)^{\pi_{n,r}} \tag{17}$$

where the final two terms capture the static gains in terms of 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.[22] 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 that arise due to spatial or sectoral reallocation - in a sense those are *dynamic gains from reallocation* - or alternatively via the more traditional channel of changes

[21] 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.

[22] The online appendix Section B.3 provides detailed derivations.

in trade openness.

4.2 Parameterization and Estimation

Next, I discuss the calibration of the model. 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 $\{\rho_n, \zeta_n, \mu_{agri,n}\}$, 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, $\{e_l, \alpha_{l,r}\}$. An overview of the full set of parameters and their respective calibration method is given in Table 3. This section discusses the calibration of the full set of parameters in four steps. In a first step, I exploit the spatial difference in exposure to the WWI shock to estimate domestic trade costs (4.2.1). In a second step, I utilize the differential impact of the trade shock across locations and sectors to estimate the elasticity of substitution (4.2.2). This step furthermore requires inverting the model to obtain the location-sector specific fundamentals, $\{z_{ni}\}$, that rationalize the equilibrium distribution of labor payments, as well as obtaining the sectoral expenditure shares. Finally, I turn towards estimating migration costs, first by estimating the geographical migration costs by estimating gravity regression to fit spatial mobility flows (4.2.3) and then by estimating the sectoral migration costs and labor supply elasticities jointly to fit the labor reallocation patterns during the WWI shock period (4.2.4). The fully estimated model can then be used to determine the labor flows to impute the spatial and sectoral flows consistent with the labor allocations during that period, as well as in the absence of the WWI shock.

4.2.1 Estimating domestic trade costs.

In a first step, I estimate domestic trade costs by examining the spatial incidence of the trade shock on wages across Spanish local labor markets. To do so I derive a structural reduced form from the model. Differentiating the goods market clearing condition (12) 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 ($\mathrm{d} \ln e_l \neq 0$) on domestic locations taking domestic trade costs into

Table 3: Parameter Values and Estimation Method

Panel A: Parameters Parameter	Value	Method
Utility function		
Elasticity of Substitution, σ	3.63	2SLS Estimation (Table 6)
Sectoral Expenditure Shares, α_r	-	Imputed
Housing Expenditure Share, δ	0.33	Imputed
Location-specific amenity shifter, ρ_n	See Table 11	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 4)
Mean Outgoing spatial migration cost shifter, ζ_n	2.80	Migration Gravity Results (Table 4)
Province-specific Outgoing spatial migration cost shifter, ζ_n	See Table 11	Match own-migration share in BAP data
Sector-specific dispersion parameter, ν	0.47	Jointly Estimated
Province-specific dispersion parameter, γ	7.65	Jointly Estimated
Agricultural out-migration cost, $\mu_{Agri,n}$	See Table 11	Jointly Estimated
Sectoral in-migration cost, μ_r	See Table 10	Jointly Estimated
Transport Cost		
Domestic distance elasticity, θ	-1.769	Reduced-form (Table 7)
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 $\left(\eta_{i,s} \equiv L_{i,s}^{1920} - \widehat{L}_{i,s}^{1920}\right)$	See Figure 9 for provincial employment fit See Figure 10 for sectoral employment fit

Notes: Table gives an overview of the parameterization and estimation of the model. Five parameters (Elasticity of substitution, spatial labor supply elasticity, migration distance elasticity, domestic distance elasticity) are separately estimated using reduced-form estimations and 2SLS. The remaining parameters are jointly estimated, matching the province-sector labor allocations before and after the war, as described in Subsection 4.2. Panel A lists the parameters, their estimated values and their estimation method. Panel B lists the moments for the joint estimation and references the Figures summarizing the aggregate fit.

account, i.e.[23]

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

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

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

of workers in a given location, θ is the domestic trade elasticity. The final expression can be compared to Autor et al. (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. Using the results from the theoretical model, we can now combine the reduced form event study design from above with the theoretical structure to estimate the distance elasticity. The regression is a structural equivalent of the empirical exercise in Subsection 3.1. Empirically, I estimate the following nonlinear event study,

$$\log\left(w_{r,s,c,t}\right) = \sum_{t \neq 1914} \beta_t \times \left(\frac{dist_{lr}^{\theta}\pi_i}{\sum_{n=1}^{N^D} dist_{ln}^{\theta}\pi_n}\right) + \mu_{r,c} + \varepsilon_{r,s,c,t} \tag{18}$$

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 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.

4.2.2 Estimating the elasticity of substitution.

I utilize 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 (12) and the balanced trade condition (13) we can obtain a system of equations in terms of prices only,

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

where $(p_{is,t})^{\epsilon_s}$ 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, $\left\{p_{is,t}^{\epsilon_s}\right\}$, as employed by Allen and Donaldson (2020).

Using the labor market data before and after the war - that is for 1914 and 1920 - and using the housing market data to construct disposable income across provinces, one can implement the inversion described in the previous paragraph. In the implementation, I first calculate the Cobb Douglas expenditure shares as the national income share of an industry out of aggregate labor income adjusted for aggregate trade flows. The procedure to obtain the housing expenditure share δ is described in Section 2. I use the shortest distance along the railroad graph between Spanish provincial capitals. I furthermore add France as an additional location, where the distance to France is the shortest distance to Paris across railroad and maritime linkages. As described in Section 2, other foreign exports are being combined and their distance corresponds to the combined railroad and maritime distance to the island of Cuba, mirroring the importance of the Latin American destination market in Spanish external trade.[24] The iceberg transport cost is calibrated to be, $\tau_{ij} = dist_{ij}^{\theta}$, calibrating the distance elasticity to the estimate for the domestic trade frictions from the previous section. To account for the influence of French exports, I include the total value of sectoral exports as additional demand into the spatial equilibrium. Once the vector of origin-prices is obtained, domestic expenditure shares can be calculated using the expression for spatial expenditure shares, i.e. $s_{ni,s} = (p_{is,t})^{-\epsilon_s} \tau_{ni}^{-\epsilon_s} \left(\sum_{k=1}^{N^D} \tau_{nk}^{-\epsilon_s} (p_{ks,t})^{-\epsilon_s}\right)^{-1}$.

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.

$$\epsilon \log p_{i,r,t} = \mu_{i,r} + \mu_{r,t} + \epsilon \log w_{i,r,t} - \log z_{i,r,t} \tag{19}$$

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

[24]In principle, the model can be extended to account for any number of destination countries. In practice, as long as there are no substantive differences between Spanish provinces in transportation cost to a foreign country, there differential geography will have little impact on the inversion procedure. Therefore, to a first order, assigning foreign trade to a distant common location is without loss of generality.

prices are only identified up-to-scale.

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 6 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. To overcome these problems, 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 (4) simply consitutes the log change in sector-level exports during WWI as estimated in the previous section. The second variable in Equation (4), 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 (5) 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.

Another natural concern using the aforementioned identification strategy is that industrialization might have induced differential productivity dynamics across provinces and sectors. However, the pre-trends presented in the reduced-form section is consistent with the historical narrative that the Spanish economy was practically speaking stagnant at the beginning of the 20th century and did not experience any trends that have the sort of spatial or sectoral bias to invalidate the identification strategy.

Columns (2) through (4) in Table 6 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 $\sigma = 3.63$.

Table 4: 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 (20). 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 (as explained in Section 2). 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 (as explained in Section 2). 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.

4.2.3 Estimation of geographical reallocation frictions.

To estimate geographical reallocation frictions, I exploit 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 measure can be constructed. The difference in this stock of foreign born workers, $BAP^t_{i,j} - S \times BAP_{i,j,t-1}$ - adjusted for survivability rate S as explained in Section 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,

$$\mu_{ni} = \zeta^1_n \times \zeta \times distance^{\zeta^2}_{ni}$$

where ζ^1_i 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.

$$\log \ell_{ni,t} = \gamma_n + \delta_i + \beta_1 \log \text{dist}_{ni} + \beta_2 \text{Stay}_{ni,t} + \epsilon_{ni,t} \tag{20}$$

where $\text{Stay}_{ni,t}$ takes on a value of 1 if the origin province is the same as the destination province. Table 4 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 $\beta_1 = \zeta_2 \times \nu \in [-1.434, -1.455]$.

4.2.4 Estimation of sectoral reallocation frictions.

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 (12) and the balanced trade condition (13) 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.

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

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 $\sigma_{ni,rs}^{1914\to 1920}\left(\mathbf{w}^{\text{WWI}}\left(\widehat{L}_{i,s}^{1920}\right)\right)$ is the closed form for migration flows between province n to province i and sector r to sector s.[25] The optimization problem is then given by,

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

[25]Recall that,

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

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.

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 $\boldsymbol{\beta} = (\mu_{ag,1}, \ldots, \mu_{ag,n}, \mu_2, \ldots, \mu_S, \nu, \gamma)$ 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 11 while sectoral switching cost is presented in Table 10. 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 reported in Table 3. 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). The values estimated here are not directly comparable to these estimates for two distinct reasons. First, the joint estimation fits migration elasticities conditional on sectoral and spatial switching costs. Second, the estimation procedure distinguishes between sectoral and spatial labor supply, with the net effect given by the composite of the two elasticities. The estimation finds relatively high spatial labor supply elasticities of around 7.65 - conditional on prohibitively high geographical migration cost - while finding a relatively low value for the sectoral labor supply elasticity of 0.47. The composite elasticity is at the upper range of literature estimates, but remains comparable. Interestingly, while migration patterns are very sensitive towards wage differences between provinces - conditional on migrating and distance - sectoral reallocation patterns seem to be less sensitive to wage differences. This mirrors the importance of sectoral switching costs and labor market frictions in determining sectoral reallocation.

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 9 and 10 in the appendix. These figures compare the predicted sectoral and provincial employment numbers to the observed data in 1920.

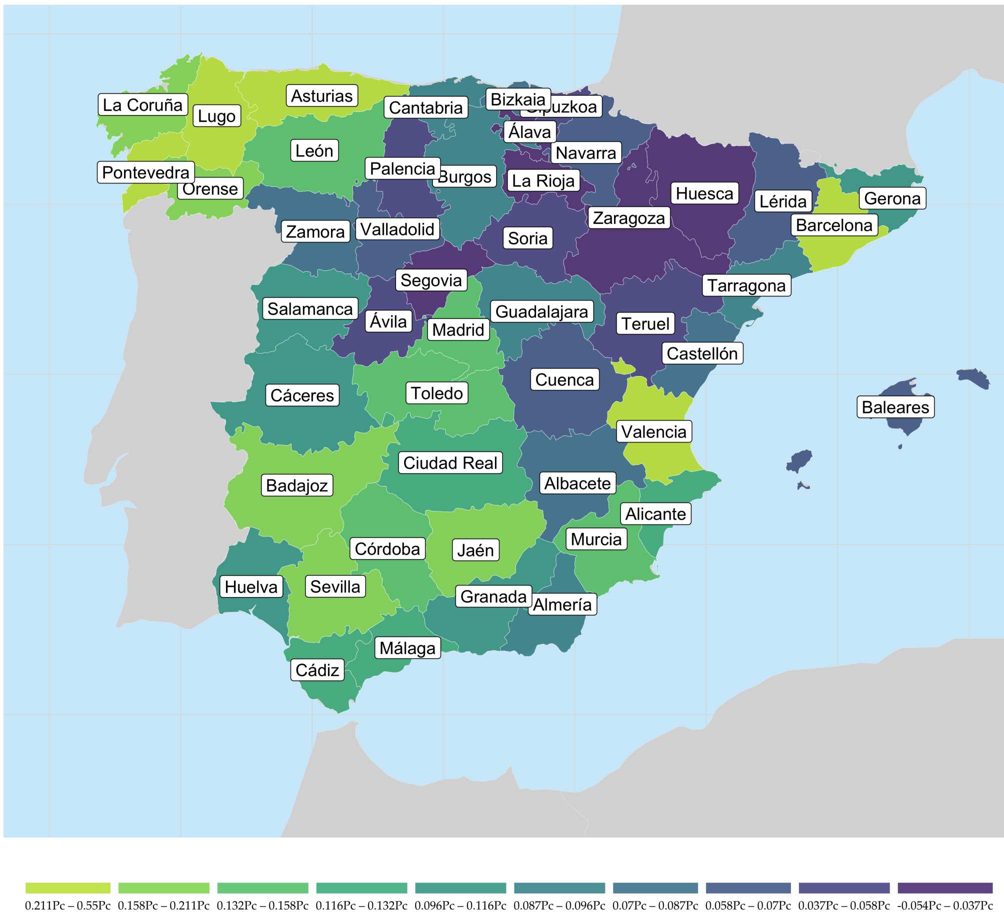
4.3 Quantifying the Welfare Effects for the WWI Shock

The previous Subsection 4.2 presented the estimation of the parameterized model. In order to fully quantyify and decompose the gains from trade using Equation (17), both the trade and labor flows in the shocked and non-shocked scenario are required, $\left\{\sigma^0_{nn|r}, \sigma^0_{rr|n}, s^0_{nn}, \sigma^1_{nn|r}, \sigma^1_{rr|n}, s^1_{nn}\right\}$, as well as market clearing wages and rental rates,$\{r^0_n, w^0_{nr}, r^1_n, w^1_{nr}\}$. 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.

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 of Subsection 4.2 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 (16), 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 12. There is high degree of reallocation from the agricultural sector towards the manufacturing sector in general, with industries that are affected by the trade

Figure 8: 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 (17), specifically,

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

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 4.3 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 4.2. The results represent the decomposed results from the couterfactual comparison in Row (2) of Panel A of Table 5.

shock growing the most. Spatially, there are very small differences in regional growth between the two scenarios (cp Figure 11), 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 labor flows, trade flows and prices for the shocked-scenario, $\left\{\sigma^1_{nn|r}, \sigma^1_{rr|n}, s^1_{nn,r}, r^1_n, w^1_{n,r}\right\}$. Labor flows are directly obtained from the fitted model from Subsection 4.2. 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 (16), as well as goods market clearing and housing market clearing, $\{s^1_{nn,r}, r^1_n, w^1_{n,r}\}$. 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. $\{s^2_{nn,r}, r^2_n, w^2_{n,r}\}$.

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 (17)[26], 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 5. 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. While the shock persisted increases in consumer prices entirely offset any gains from trade. After the shock dissipated, the reallocational gains increased welfare by 2.93 percent. Furthermore, in Figure 8, 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 14 in the online appendix, I plot the welfare contribution from spatial and sectoral mobility across provinces. Gains from improvements in the sec-

[26] In the online appendix Subsection (B.4) 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 5.

Table 5: Welfare and Simulation Results

Counterfactual Exercise	Dynamic Gains Spatial	Sectoral	ACR	Static Gains Rental	Wage	Deficit	Total
Panel A: Baseline Result							
(1a) External Trade fixed at 1914 level (WWI Comparison)	0.04	0.24	-0.89	0.02	-0.09	-7.70	-8.39
(1b) External Trade fixed at 1914 level (1920 Comparison)	0.04	0.24	-0.35	-0.32	5.64	-2.32	2.93
Panel B: More integrated Labor Markets							
(2a) Lowering Spatial Mobility Cost ($\zeta = 1.79$, WWI Comparison)	0.16	0.24	-0.84	0.03	-0.15	-7.70	-8.27
(2b) Lowering Spatial Mobility Cost ($\zeta = 1.79$, 1920 Comparison)	0.16	0.24	-0.65	-0.45	4.95	-2.32	1.91
Panel C: Less uneven Trade Shock							
(3a) Removing Spatial Bias in Trade Shock (WWI Comparison)	0.03	0.24	-0.81	0.03	-0.10	-7.70	-8.31
(3b) Removing Spatial Bias in Trade Shock (1920 Comparison)	0.03	0.24	-0.26	-0.31	5.62	-2.32	2.99
Panel D: Less uneven shock & More integrated Labor Market							
(4a) Removing Spatial Bias & Low Mob. Cost (WWI Comparison)	0.16	0.22	-0.87	0.07	-0.14	-7.70	-8.27
(4b) Removing Spatial Bias & Low Mob. Cost (1920 Comparison)	0.16	0.22	-0.67	-0.42	4.97	-2.32	1.92

Notes: Table reports the welfare decomposition using Equation (17) 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. Panel D combines the counterfactual experiment of Panel B and C.

toral 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 5 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. 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. However, the exercise shines a role on the qualitative and quantitative importance of spatial mobility. Interestingly, the marginal gains are equally shared between increases in reallocation and lessened countervailing price pressure. 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 provided new theory and evidence to characterize how domestic segmented labor markets shape the welfare consequences of trade. I argued that under imperfect factor mobility, an external demand shock can improve alloactive efficiency, but uneven shocks cause localized increases in wages and consumer prices instead of reallocation, therefore limiting the extent to which reallocative gains from trade can be realized.

I began by providing novel evidence from examining a historical natural experiment: An international trade demand shock to the Spanish economy that was caused by the participation of Spain's key trading partners in the first World War (1914-1918). The shock was large and caused by circumstances external to the Spanish economy, specifically an increase in belligerent demand for Spanish goods. I demonstrated that the adjustment of local wages and consumer prices exhibited a distinct spatial pattern that was driven by direct and indirect incidence of the shock. Labor adjustments were predominantly local.

To rationalize the empirical findings, I incorporated imperfect labor mobility in an otherwise standard economic geography model. By introducing a tractable worker reallocation choice where mobility is impeded by sectoral and spatial mobility frictions, the model allows for rich interactions between local labor markets and can trace out how an external demand shock affects connected local labor markets. To characterize the welfare effects of an external demand shock, I extend the sufficient statistic approach to gains from trade by Arkolakis et al. (2012) and derive a closed-form formula for the gains from trade that takes domestic re-allocation into account. In this model, spatial and sectoral labor flows can be used as sufficient statistics to quantify and decompose gains from trade, taking domestic reallocation and associated *efficiency gains* into account.

I use the structure of the model and the WWI shock to fully estimate the key parameters of the model, in particular, labor supply and trade elasticities as well as mobility frictions. Simulating the Spanish economy in the absence of the WWI shock allows me to recover counterfactual labor and trade flows that can be used to quantify and decompose the welfare gains from trade. Reallocation contributes positively towards the gains from trade and constitutes an additional dynamic component to it, but countervailing price effects were sufficiently high to offset these gains. Therefore, the WWI shock, at least in the short-run, did not positively affect Spanish welfare. In a final step, I simulate the gains from trade if Spain had had a more (spatially) integrated labor market. In that scenario, reallocational gains would have increase and the countervailing price effects decreased, illustrating the qualitative channel through which labor reallocation affects the gains from trade.

This paper emphasizes that to fully understand the welfare gains of an aggregate shock one needs to take into account the domestic disaggregated distribution of economic activity and in particular the reallocation of factors across domestic labor markets. Domestic reallocational flows can be a convenient sufficient statistic to augment an aggregate gains from trade analysis.

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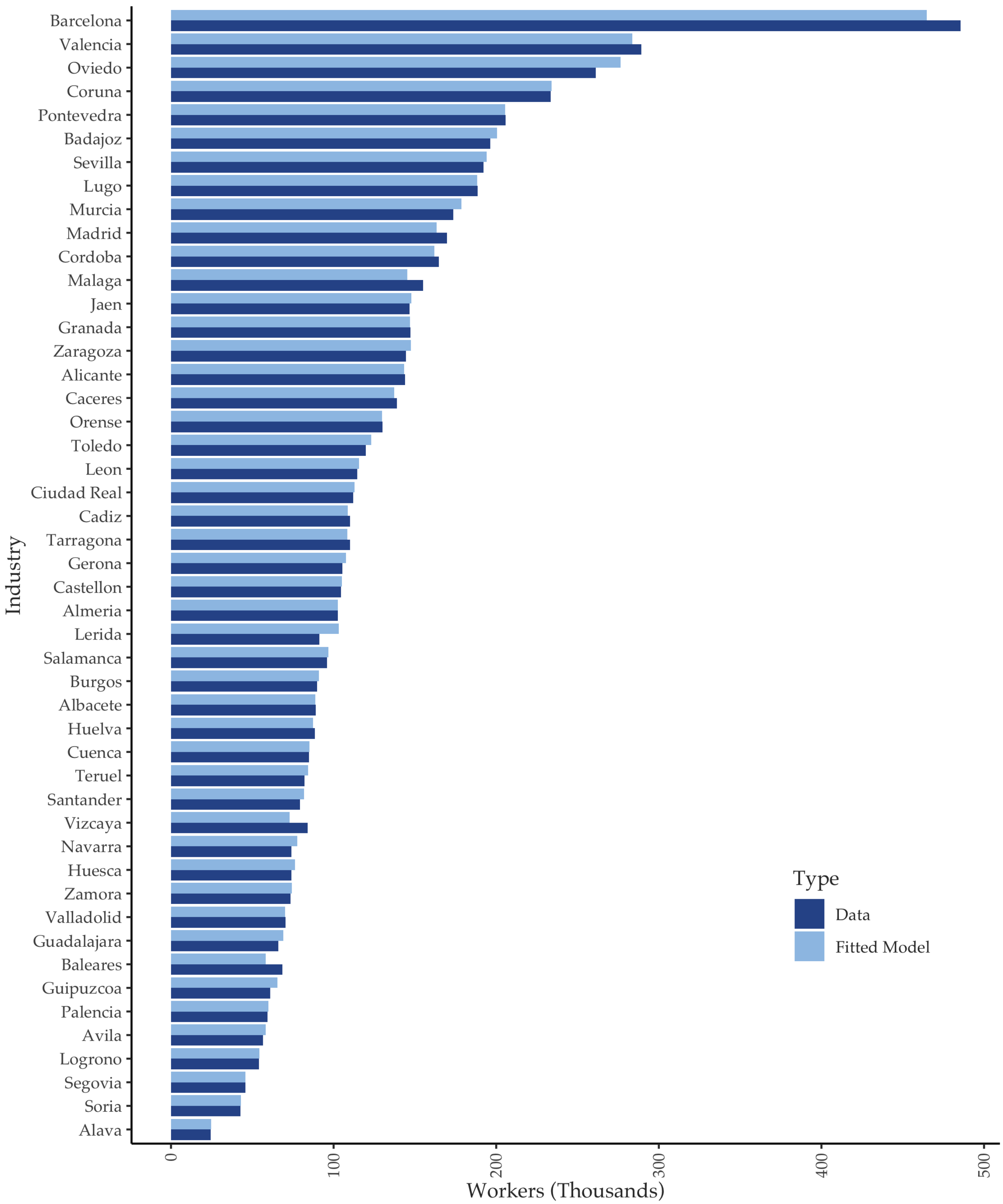
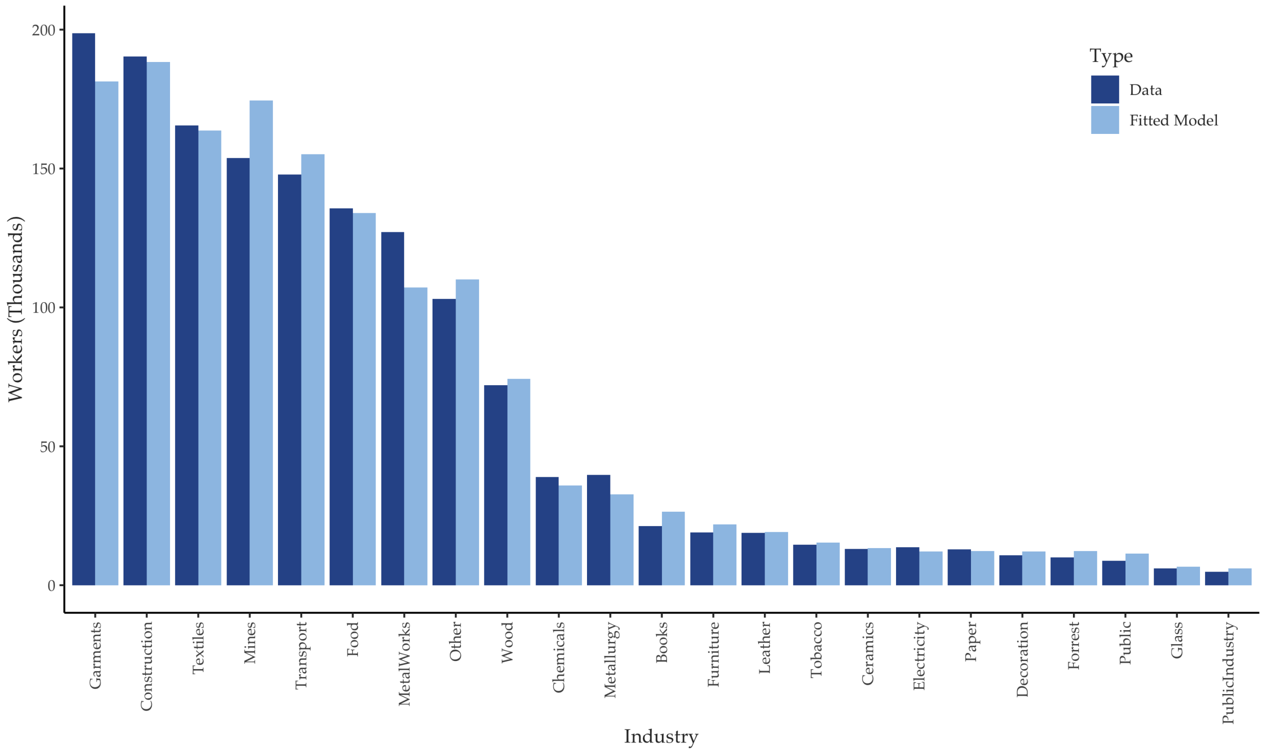
6 Figures

Figure 9: Model Fit: Provincial Employment (1920 Data vs Fitted Model)



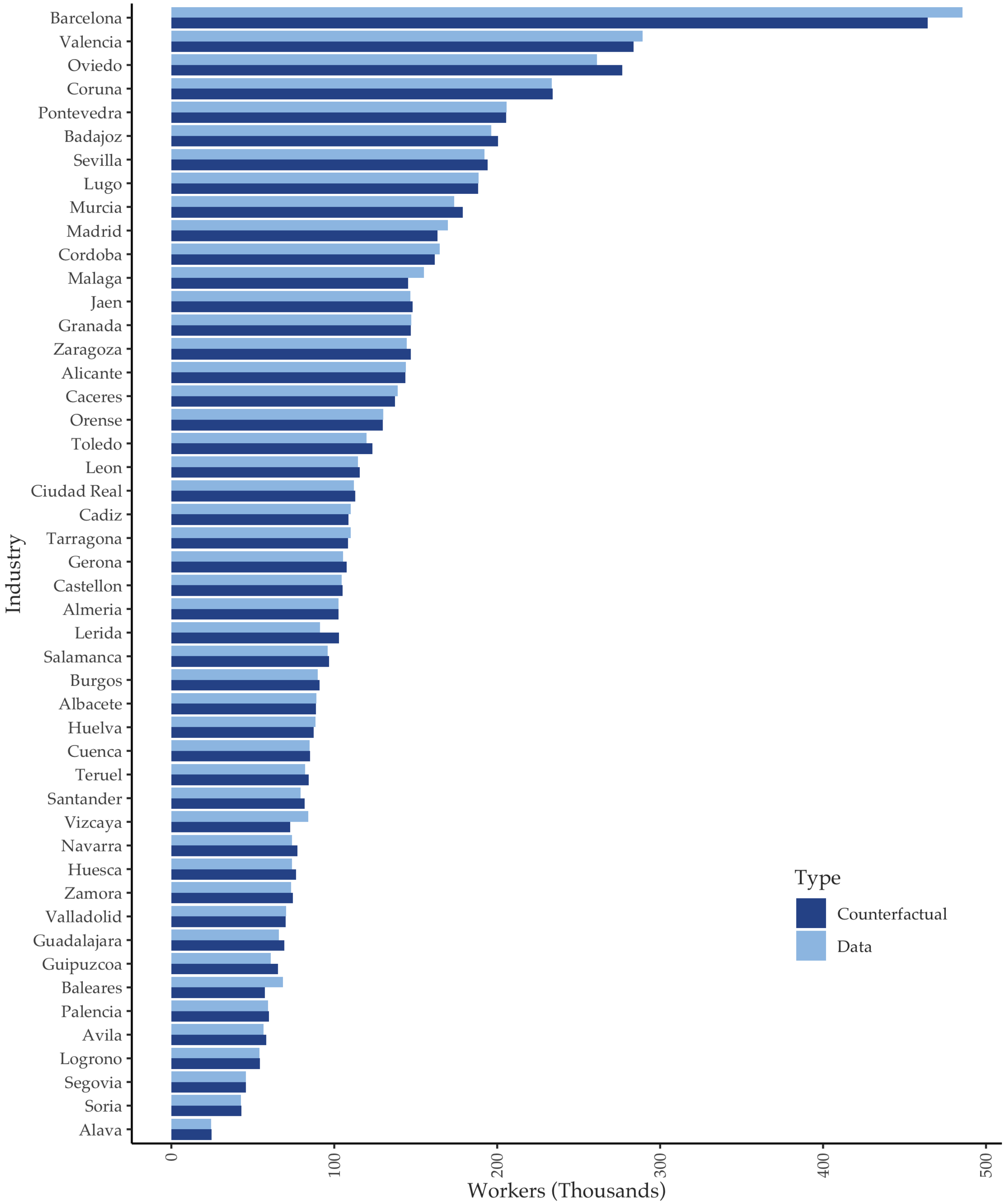
Notes: Figure reports the model fit of the joint estimation for provincial employment across manufacturing and agriculture. Observed data are employment levels for manufacturing and agriculture for each province, constructed from the salarios publication and the census. Fitted model are the labor allocations implied by the fully estimated dynamic model for 1920 and aggregated by province (as described in Section 4.2). Additional details on data construction and sources can be found in the online appendix.

Figure 10: Model Fit: Sectoral Employment (1920 Data vs Fitted Model)



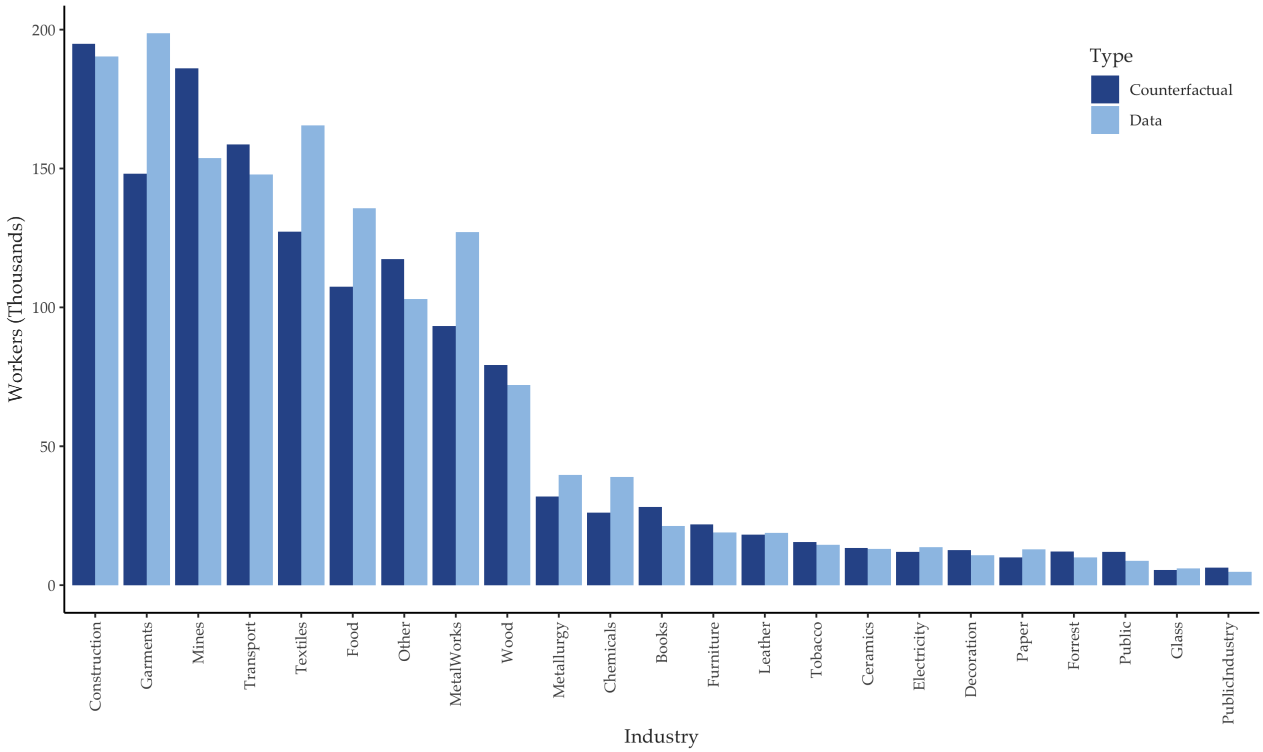
Notes: Figure reports the model fit of the joint estimation for sectoral employment across manufacturing and agriculture. Observed data are employment levels for manufacturing and agriculture for each sector, constructed from the salarios publication and the census. Fitted model are the labor allocations implied by the fully estimated dynamic model for 1920 and aggregated by sector (as described in Section 4.2). Additional details on data construction and sources can be found in the online appendix.

Figure 11: 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 4.2). Additional details on data construction and sources can be found in the online appendix.

Figure 12: 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 4.2). Additional details on data construction and sources can be found in the online appendix.

7 Regression Tables

Table 6: 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 (19). 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 (4.2). 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 (4) and (5). Log distance to France is the shortest distance to Paris along the Spanish and French railroad network (as explained in Section 2), originating from either provincial or region capital cities. The data sources for Column (1) through (4) is the salarios publication as described in Section 2. 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 7: GMM Estimation of Distance Elasticity

	(Log) Wages of Workers in Industry-Region pairs (1908-1919)	
	(1) OLS	(2) 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 (18). 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 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 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.

Online Appendix (not for publication)

In this online appendix I provide additional information on data sources as well as additional figures, tables and derivations. In Section A I provide additional information regarding the data sources being used. In Section B 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 C I include additional figures omitted from the main text. In Section D. Section E provides detailed derivations for the quantitative model. Finally, in Section F, I describe data construction and references for data sources.

A 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)

B Additional derivations

This Section provides additional derivations. Subsection B.1 provides additional derivation for the stylized two location setting in the introduction. Subsection B.2 generalizes this model to an arbitrary number of locations. Subsection B.3 derives the aggregate welfare formula. Finally, Subsection B.4 derives the aggregate welfare formula incorporating trade imbalances.

B.1 Stylized example: Uneven trade shocks

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

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

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

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

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

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

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,

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

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

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

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.

B.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,[27]

[27]Writing in short-form,

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

$$d\ln w_i = \underbrace{\frac{\rho_i}{(\psi_{ii}-\zeta_i)}d\ln e_i}_{\text{Direct Effect}} + \underbrace{\sum_j \frac{-\psi_{ij}}{(\psi_{ii}-\zeta_i)}\left(\frac{\rho_j}{(\psi_{jj}-\zeta_j)}\right)\mathrm{d}\ln e_j + \ldots}_{\text{Indirect Effect}} \tag{21}$$

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 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,

$$d\ln \ell_i = \psi_{ii} d\ln w_i + \sum_j \psi_{ij} d\ln w_j \tag{22}$$

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

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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 et al., 1962).

reduced-form expression for labor changes,

$$d \ln \ell_i \approx \underbrace{\frac{\psi_{ii}\rho_i}{(\psi_{ii} - \zeta_i)} d \ln e_i}_{\text{Direct Effect}} + \underbrace{\sum_j \frac{\psi_{ij}\rho_j}{(\psi_{jj} - \zeta_j)} d \ln e_j}_{\text{Indirect Effect}} \tag{23}$$

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

B.3 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,

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

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,

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

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,

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

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 (10) 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 (9) 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,

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

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 et al. (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,

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

B.4 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 $s_{ni,r} = (p_{ni,r})^{1-\sigma_r} \, p_{n,r}^{\sigma_r - 1}$, 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,

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

Combining and factoring out the trade imbalance term we obtain,

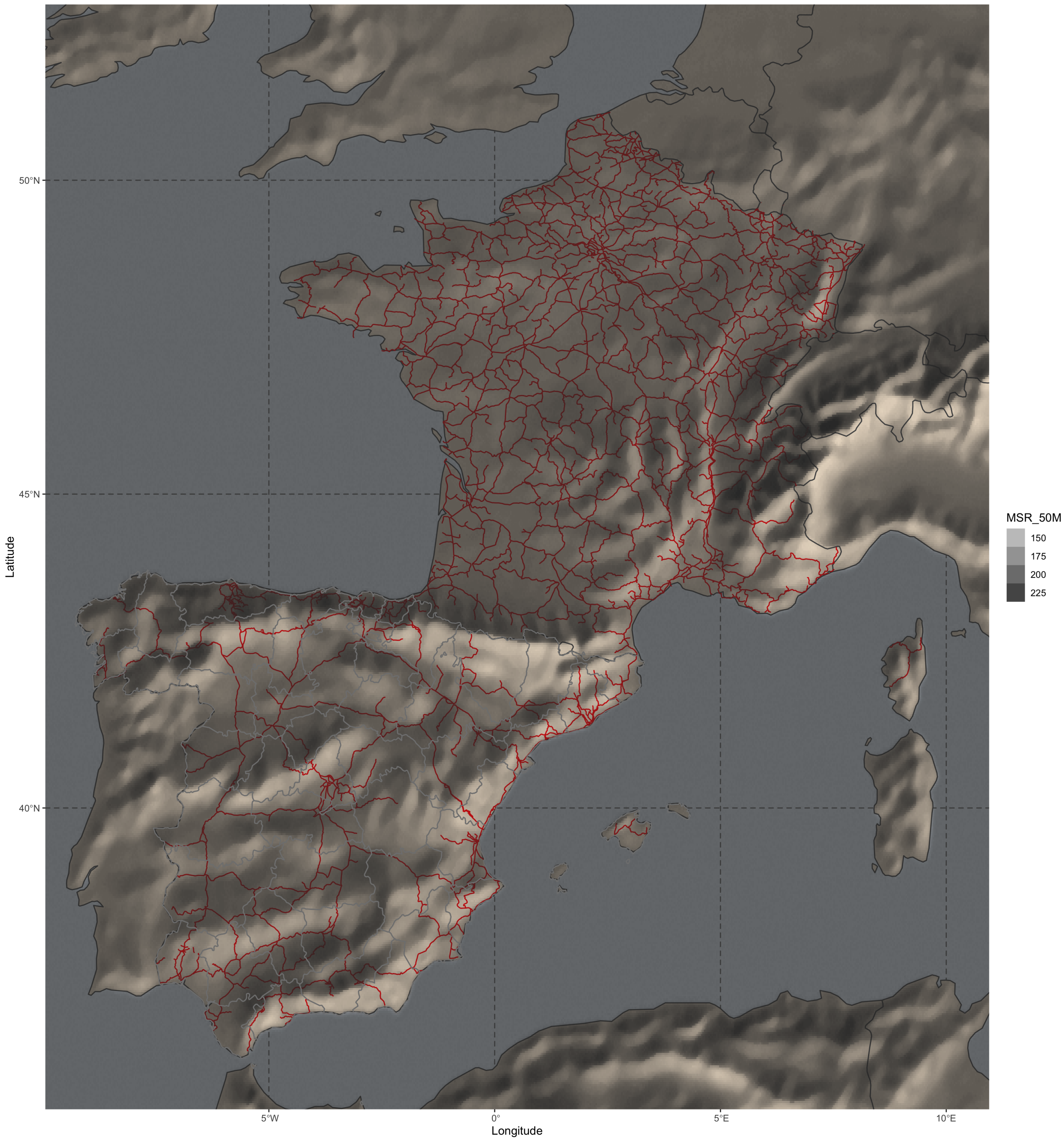
$$u_{n,r} = d_2^{-\sum_r \frac{(1-\delta)\alpha_r}{1-\sigma_r}} \frac{\rho_n e_{n,r}}{r_n^{\delta} \prod_{r=1}^{S} \left(\left(\sum_{i=1}^{N^D} \frac{1}{d_2} p_{ni}^{1-\sigma_r} + \sum_{l=1}^{N^F} p_{nl}^{1-\sigma_r} \right)^{\frac{(1-\delta)\alpha_r}{1-\sigma_r}} \right)}$$

Following the same derivations as before,

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

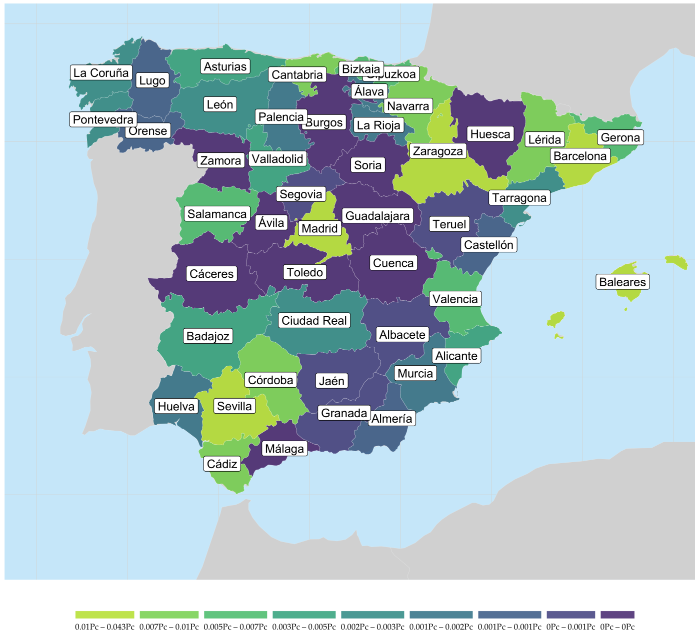
C Additional figures

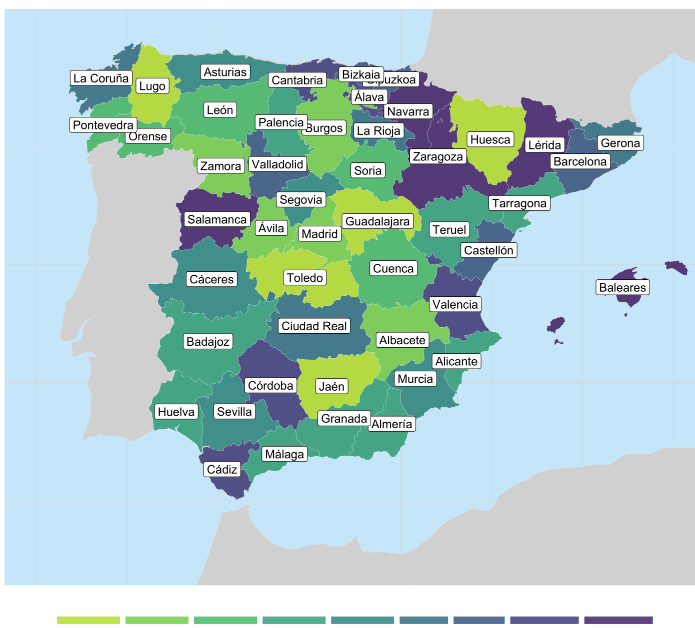
Figure 13: Railroad Network Spain/France 1910



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 14: 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 (17). 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.

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

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 4.3 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 4.2. The results represent the decomposed results from the couterfactual comparison in Row (2) of Panel A of Table 5.

D Additional tables

Table 8: 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 (3). 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 9: 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 (2). 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 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 10: Results: Mobility Cost Estimation Sectoral Parameters

Sector	μ_{rs}
Agriculture	0.10
Books	0.18
Ceramics	0.19
Chemicals	0.15
Construction	0.18
Decoration	0.14
Electricity	0.15
Food	0.18
Forrest	0.17
Furniture	0.15
Garments	0.17
Glass	0.11
Leather	0.15
Metallurgy	0.11
MetalWorks	0.13
Mines	0.32
Other	0.35
Paper	0.16
Public	0.24
PublicIndustry	0.14
Textiles	0.19
Tobacco	0.12
Transport	0.18
Wood	0.21

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 $\boldsymbol{\beta} = (\mu_{ag,1}, \ldots, \mu_{ag,n}, \mu_2, \ldots, \mu_S, \gamma)$. 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 4.2.

Table 11: Results: Mobility Cost Estimation Geographical Parameters

Province	β_n	ζ_n	$\mu_{ag,n}$	Province	β_n	ζ_n	$\mu_{ag,n}$
Alava	0.00	0.57	1.04	Lerida	0.16	0.51	0.80
Albacete	0.22	0.44	0.20	Logrono	0.02	0.60	0.60
Alicante	0.21	0.71	0.33	Lugo	0.10	0.23	0.50
Almeria	0.05	0.32	0.56	Madrid	0.02	1.51	1.13
Avila	0.05	0.25	0.01	Malaga	0.05	0.82	0.23
Badajoz	0.57	0.43	0.43	Murcia	0.59	0.70	0.35
Baleares	0.01	0.12	0.94	Navarra	0.04	0.33	0.94
Barcelona	1.00	13.31	0.88	Orense	0.06	0.15	0.58
Burgos	0.08	0.33	0.03	Oviedo	0.87	1.01	0.61
Caceres	0.43	0.35	0.24	Palencia	0.04	0.35	0.49
Cadiz	0.01	0.98	1.15	Pontevedra	0.02	0.45	0.60
Castellon	0.07	0.26	0.81	Salamanca	0.11	0.22	0.56
Ciudad Real	0.17	0.29	0.58	Santander	0.01	0.79	0.76
Cordoba	0.09	0.60	0.71	Segovia	0.03	0.19	0.58
Coruna	0.24	1.35	0.54	Sevilla	0.11	1.27	0.51
Cuenca	0.18	0.27	0.05	Soria	0.04	0.20	0.00
Gerona	0.21	1.48	0.60	Tarragona	0.05	0.45	0.94
Granada	0.13	0.45	0.38	Teruel	0.16	0.30	0.55
Guadalajara	0.06	0.19	0.02	Toledo	0.24	0.29	0.01
Guipuzcoa	0.03	3.55	0.37	Valencia	0.20	0.76	0.64
Huelva	0.05	0.68	0.36	Valladolid	0.03	0.37	0.79
Huesca	0.14	0.28	0.00	Vizcaya	0.00	1.24	0.83
Jaen	0.05	0.27	0.64	Zamora	0.09	0.17	0.30
Leon	0.13	0.28	0.38	Zaragoza	0.13	0.58	1.03

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,

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

The problem is being solved in MATLAB using the lsqnonlin solver to obtain the complete solution $\boldsymbol{\beta} = (\mu_{ag,1}, \ldots, \mu_{ag,n}, \mu_2, \ldots, \mu_S, \gamma)$. 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 4.2.

E 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.

E.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.

E.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:

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

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

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

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

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

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,

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

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,

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

E.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

$$u_l=\frac{e_l}{\prod_{r=1}^{S}\left(p_n^r\right)^{\alpha_{l,r}}},\quad\sum_{r=1}^{S}\alpha_{l,r}=1 \tag{24}$$

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

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.

E.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.

E.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,

$$s_{li,r} = \frac{p_{li,r} q_{li,r}\left(\boldsymbol{p}_n\right)}{\sum_{j=1}^{N^D} p_{lj,r} q_{lj,r}\left(\boldsymbol{p}_l\right)} = \frac{x_{li,r}\left(\boldsymbol{p}_l\right)}{\sum_{j=1}^{N^D} x_{lj,r}\left(\boldsymbol{p}_l\right)} = \frac{p_{li,r}^{1-\sigma_r}}{\sum_{j=1}^{N^D} p_{lj,r}^{1-\sigma_r}} \alpha_{l,r} \tag{25}$$

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

$$\frac{s_{nD,r}}{(1-\delta)} = \frac{\sum_{i=1}^{N^D} p_{ni,r} q_{ni,r}\left(\boldsymbol{p}_n\right)}{\sum_{s=1}^{S}\sum_{j=1}^{N^D} p_{nj,s} q_{nj,s}\left(\boldsymbol{p}_n\right) + \sum_{s=1}^{S}\sum_{k=1}^{N^F} p_{nk,s} q_{nk,s}\left(\boldsymbol{p}_n\right)} \tag{26}$$

$$= \frac{\sum_{i=1}^{N^D} x_{ni,r}\left(\boldsymbol{p}_n\right)}{\sum_{s=1}^{S}\sum_{j=1}^{N^D} x_{nj,s}\left(\boldsymbol{p}_n\right) + \sum_{s=1}^{S}\sum_{k=1}^{N^F} x_{nk,s}\left(\boldsymbol{p}_n\right)} \tag{27}$$

$$= \frac{\left(p_{nD,r}\right)^{1-\sigma_r}}{\sum_{j=1}^{N^D} \frac{1}{\bar{d}}\left(p_{nj,r}\right)^{1-\sigma_r} + \sum_{k=1}^{N^F}\left(p_{nk,r}\right)^{1-\sigma_r}}\alpha_r \tag{28}$$

$$\frac{s_{nF,r}}{(1-\delta)} = \frac{\sum_{\ell=1}^{N^F} p_{nl,r} q_{nl,r}\left(\boldsymbol{p}_n\right)}{\sum_{s=1}^{S}\sum_{j=1}^{N^D} p_{nj,s} q_{nj,s}\left(\boldsymbol{p}_n\right) + \sum_{s=1}^{S}\sum_{k=1}^{N^F} p_{nk,s} q_{nk,s}\left(\boldsymbol{p}_n\right)} \tag{29}$$

$$= \frac{\sum_{l=1}^{N^F} x_{nl,r}\left(\boldsymbol{p}_n\right)}{\sum_{s=1}^{S}\sum_{j=1}^{N^D} x_{nj,s}\left(\boldsymbol{p}_n\right) + \sum_{s=1}^{S}\sum_{k=1}^{N^F} x_{nk,s}\left(\boldsymbol{p}_n\right)} \tag{30}$$

$$= \frac{\left(p_{nF,r}\right)^{1-\sigma_r}}{\sum_{j=1}^{N^D} \frac{1}{\bar{d}}\left(p_{nj,r}\right)^{1-\sigma_r} + \sum_{k=1}^{N^F}\left(p_{nk,r}\right)^{1-\sigma_r}}\alpha_r \tag{31}$$

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,

$$e_{n,s}\ell_{n,s} = w_{n,s}\ell_{n,s} + \delta e_{n,s}\ell_{n,s} = \frac{w_{n,s}\ell_{n,s}}{1-\delta} \tag{32}$$

E.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 (32), the domestic and foreign households choose expenditure shares to maximize their respective utility (24) subject to their budget constraint, with the respective expenditure shares being given by,

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

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

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

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,

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

5. Trade is unbalanced externally,

6. Trade is balanced domestically, but unbalanced externally,

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

7. Housing market clears

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

E.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,

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

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:

$$w'_i\ell'_i = \sum_{i=1}^{N^D} s'_{ni}e'_n\ell'_n + \sum_{l=1}^{N^F} s'_{li}e'_l \tag{33}$$

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,

$$r_n = \frac{\delta e_n}{H_n} = \frac{\delta}{1-\delta}\frac{w_n\ell_n}{H_n} \tag{34}$$

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

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

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

$$\frac{d\sigma'_{ni|r}}{\sigma'_{ni|r}} = \gamma\frac{dv'_{ni|r}}{v'_{ni|r}} - \gamma\sum_{h=1}^{N^D}\sigma'_{nh|r}\frac{dv'_{nh|r}}{v'_{nh|r}} \tag{35}$$

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.

E.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 producitivities 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 (32), 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 (32), the domestic and foreign households choose expenditure shares to maximize their respective utility (24) subject to their bud-

get constraint, with the respective expenditure shares being given by,

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

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

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

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

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

E.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 (E.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,

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

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,

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

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,

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

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

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

which only depends on the

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

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

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

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 et al. (2012) and Ossa (2015). Starting from the expenditure shares, we can solve for sectoral price indices,

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

constructing aggregate price indices,

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

rewriting this in changes,

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

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,

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

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

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

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

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

E.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 $s_{ni,r} = (p_{ni,r})^{1-\sigma_r}\, p_{n,r}^{\sigma_r - 1}$, 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,

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

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,

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

E.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 et al. (2013) I define a trade shock exposure variable,

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

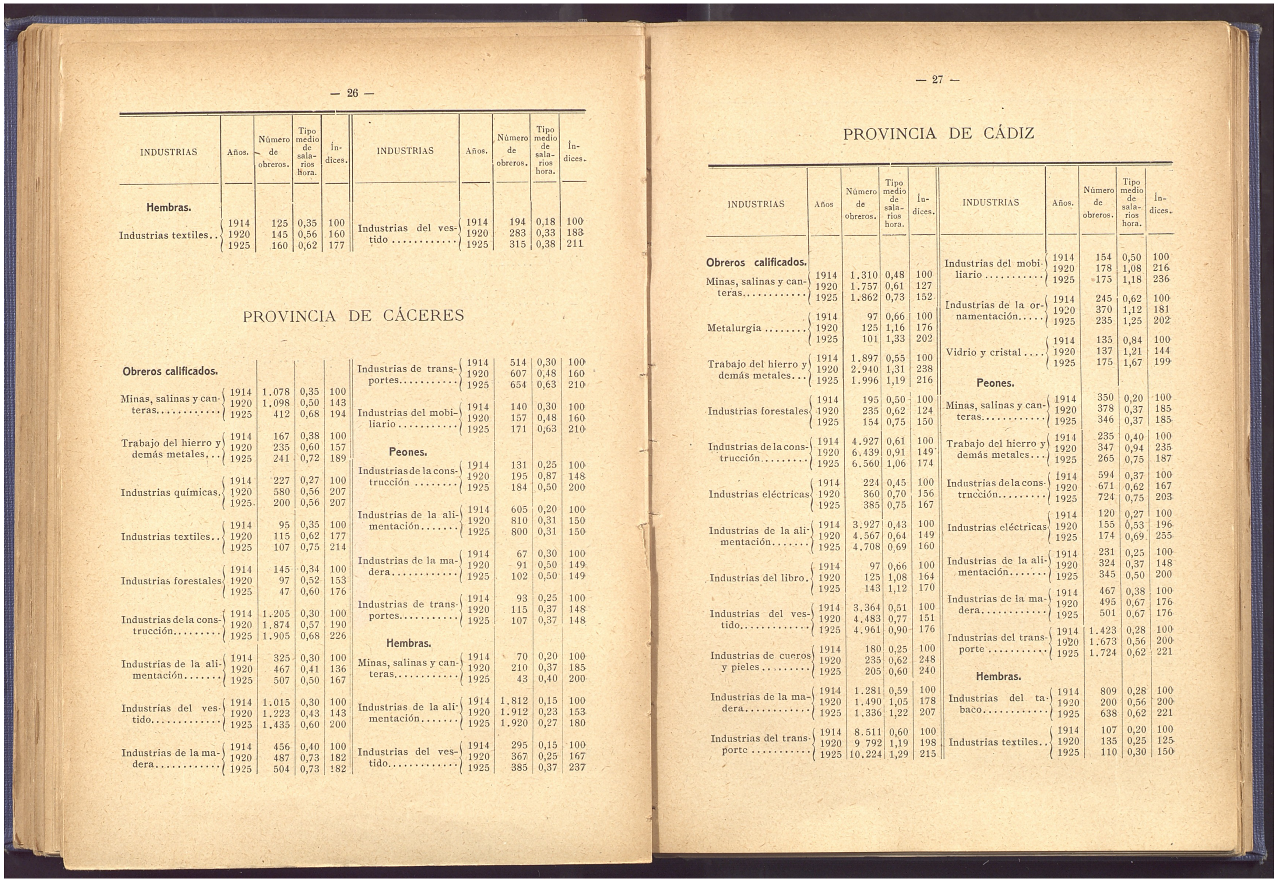
As an approximation of the labor market dynamics, I will use the geographical mobility model from section E.7 to derive an empirical specification that exploits observable geographical distance, but incorporating trade exposure that is driven by sectoral specialization. For this purpose we take an average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

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

F 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 15: Example Page: Ministerio de Trabajo (1927)



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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

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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.

F.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 12: 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

F.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[28] and 48 different provinces.

[28]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 13: 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

F.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 14: 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 15: 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
78	rio_de_oro			0		0	0	0	0	0	0
79	siam			0	0	0	0	0	0	0	0
80	zancibar			0							
81	espana				0						
82	marruecos__zona_francesa					10	16	16	9	7	11
83	monaco					0	0	0	0	0	0
84	montenegro					0	0	0	0	0	0
85	posesiones_danesas_en_europa					0	0	0	0	0	0
86	servia					0	0	0	0	0	1

F.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.

F.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.

F.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.

F.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.

F.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.