Spoils of war: Trade shocks & segmented labor markets in Spain during WWI*

Simon Fuchs (Atlanta Fed)

April 2021

Abstract

How does intra-national factor mobility shape the welfare effects of a trade shock? I provide evidence that during WWI, a demand shock emanated from belligerent countries and affected neutral Spain. Within Spain, labor predominantly reallocated locally while the most affected provinces experienced drastic increases in wages and consumer prices. Embedding imperfect labor mobility in an economic geography model, I show that external demand shocks can improve allocative efficiency, but asymmetric shocks cause localized increases in wages and consumer prices instead of reallocation. Adjusting an aggregate gains of trade formula to take domestic reallocation into account more than triples the estimated welfare 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 Cosar, Klaus Desmet, Chris Edmond, Patrick Feve, Jim Feyrer, Sharat Ganapati, Christian Hellwig, Rob Johnson, Brian Kovak, Tim Lee, Thierry Mayer, Rory McGee, Marti Mestieri, Nina Pavcnik, Franck Portier, B Ravikumar, Vincent Rebeyrol, Juan Rubio-Ramirez, Mohammed Saleh, Chris Snyder, Francois 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

How important is the mobility of factors within countries to understand the economic and welfare consequences of a trade shock? In recent years, a rapidly growing literature has documented the heterogeneous 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). This literature has emphasized the distributional consequences of trade shocks across locations and occupations, but their findings raise the question to what extent the uneven incidence of trade shocks within countries determines the aggregate welfare consequences of international trade.

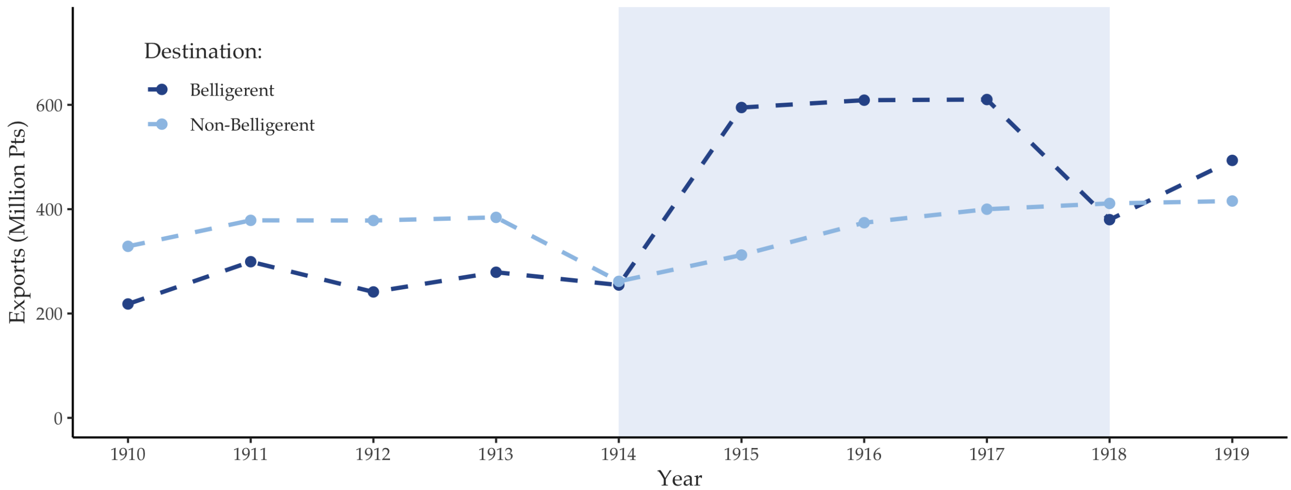
In this paper, I provide new theory and evidence to characterize how domestic labor reallocation frictions shape the economic and welfare consequences of international trade shocks. I argue that under imperfect factor mobility, an external demand shock can improve alloactive efficiency, but asymmetric 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. Empirically, I provide evidence from a plausibly exogenous trade demand shock with discernible spatial and sectoral asymmetries, affecting a country with highly segmented labor markets - a unique setting to study the implications of imperfect factor mobility.

I begin by 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[1], while Spain remained neutral throughout the conflict. I first examine trade data and show that the shock originated in belligerent countries, was large - increasing aggregate exports by 40pc - and sectorally asymmetric. I then examine the shock's impact on wages, labor allocations and consumer prices. First, by analyzing wage data across provinces and sectors, I show that the shock induced a spatial and sectoral gradient, with provinces closer to France and whose specialization was better aligned with the trade shock exhibiting larger wage increases. In contrast, labor reallocation was highly localized. Second, I show that localized labor competition further exacerbated wage pressure, with provinces that are closely located to other provinces that benefited from the trade shock, experiencing substantially larger wage increases. Finally, consumer price levels grew overall, but in particular in locations closer to the French border and locations that featured more favorable sectoral specialization.

To rationalize the empirical findings, I embed imperfect labor mobility in an otherwise standard economic geography model and show that the model implies that the wage response of a local labor market depends on whether closely connected labor markets are also affected. Consistent with the empirical evidence, changes in external demand that affect tightly linked local labor markets simultaneously will result in more intense competition for a limited pool of workers and

[1] 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.

Figure 1: Aggregate Trade levels



***Notes*:** This figure compares aggregate export levels in constant pre-war prices between destination countries that participated in WWI and those that did not. To adjust for additional spatial disruptions of the frontline the belligerent countries are made up only of the primary participants of WWI, i.e. France, Italy and the United Kingdom. The non-belligerent countries exclude the United States and other later participants of WWI. Data is not available for the years between 1910 and 1914 therefore a trend line is imputed. The blue shaded area indicates the period of WWI. The source data are the digitized product-destination level trade statistics.

therefore in a more severe localized wage and price response combined with relatively less labor re-allocation.

To characterize the welfare implications of a trade shock under imperfect labor mobility, I extend the sufficient statistic approach to gains from trade 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 welfare formula only requires (weighted) changes in domestic wages across local labor markets as a sufficient statistic to account for changes in the prices of domestically produced goods and how they reflect allocative efficiency of the distribution of labor. The weights needed are intuitive: The welfare impact of wage changes in each location depends on the direct benefit of higher nominal income - captured by the population weight - and the indirect effect of higher consumer prices which in turn depends on how important production of that location is in the domestic consumption basket across all locations. The latter weight can be constructed from domestic trade data. The aggregate welfare consequences then depend on both aggregate changes in trade openness and domestic changes in the allocation of factors and their implication for consumer prices of (domestic) tradables and non-tradables. The net aggregate effect depends on whether changes in external demand induce sufficient aggregate and domestic reallocative gains to compensate for any countervailing price effects.

Applying the welfare formula on the observed data shows that controlling for the domestic distribution of economic activity can change the overall conclusion about welfare gains, with the non-adjusted formula indicating a modest increase of less than 1 percent, while the augmented formula indicates gains of up to 3 percent. This points towards the importance of reallocative domestic gains that are due to the external demand shock. However, substantial countervailing consumer price effects also indicate that the welfare gains remain limited due to the lack of factor mobility. The fully estimated model can be used to simulate Spain in the absence of the WWI trade shock. This counterfactual shows that the observed welfare effects can be attributed in their entirety to the WWI trade shock.

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). What remains unexplored in this literature is the interaction between internal labor adjustments and shock asymmetry. This paper fills this gap by providing both reduced-form evidence from a natural experiment as well as novel theory regarding the welfare effects under shock asymmetry and reallocation frictions.

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). This paper contributes by characterizing gains from trade taking into account the imperfect reallocation of factors across domestic local labor markets and highlighting that data on regional employment and wages can be used to construct a sufficient statistic to do so.

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.

Outline. The remainder of the paper is structured as follows. Section 2 discusses the historical background, describing both the situation in Spain before the War and during the War. Section 3 describes the various data sources as well as the construction of the data set that underlies most of the analysis. Section 4 gives reduced form evidence on the trade shock and its effect local labor markets. Section 5 describes the theoretical model that can rationalize the empirical findings. Section 6 first introduces the sufficient statistic approach towards quantifying welfare gains under imperfect factor mobility, then quantifies the gains with raw data before estimating the model and comparing gains to a simulated 'no-war' counterfactual. Finally, section 7 concludes.

2 Historical background

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

As a result, at the beginning of the 20th century, the industrial sector barely continued to expand and Spain remained at a low level of industrial development. According to census data, in 1900 roughly 70pc of the working population worked in agriculture and only 12.5pc worked in industrial/manufacturing sectors. 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.

In terms of the spatial distribution of the population, most of the population was still concen-

Figure 2: Spatial distribution of manufacturing employment

***Notes*:** The map depicts total manufacturing and mining employment across all Spanish provinces in 1910 (excluding Canary Islands and North African possessions).

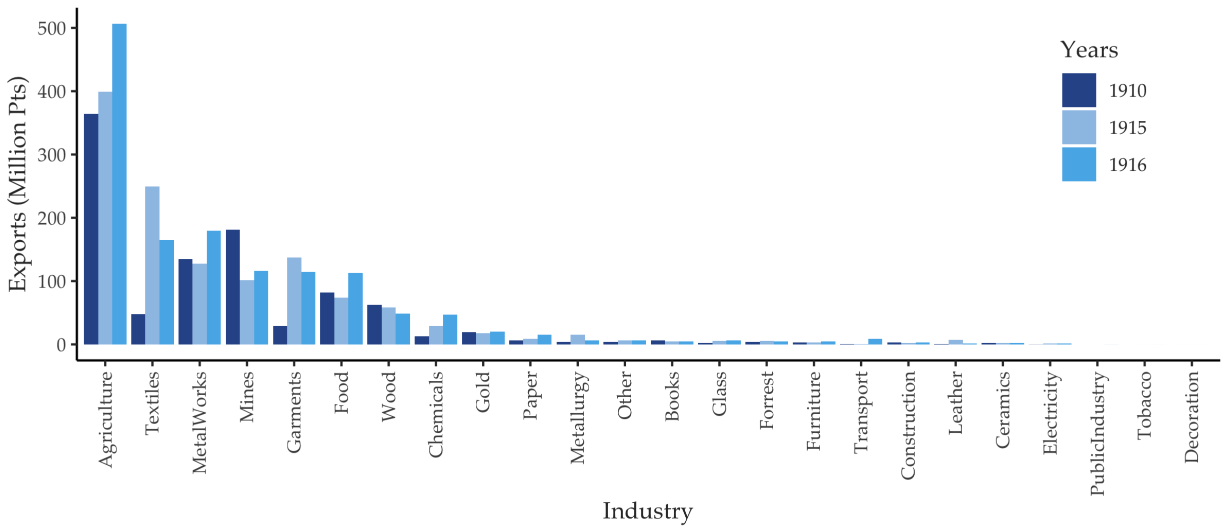
trated in predominantly rural and agricultural areas such as Andalucia[2] or Castilla y Leon.[3] However, looking beyond the larger regional aggregation and looking at individual provinces, it is precisely such major urban centers such as Oviedo, Valencia, Bilbao, Madrid and Barcelona that increasingly attracted and concentrated the Spanish population. The provinces that contained these urban centers tended to concentrate most of the industrial activity as can be seen by the map in figure 2 indicating the spatial distribution of manufacturing employment. While internal migration was perennially low, with net migration amounting to less than 5pc of the population before 1920, the two largest cities, Barcelona and Madrid, tended to nevertheless attract a large share of agricultural workers from other provinces, making them unique magnets for migrants around 1900 (Silvestre et al., 2015).

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. Be-

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

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

Figure 3: Sectoral export composition (1910, 1915, 1916)



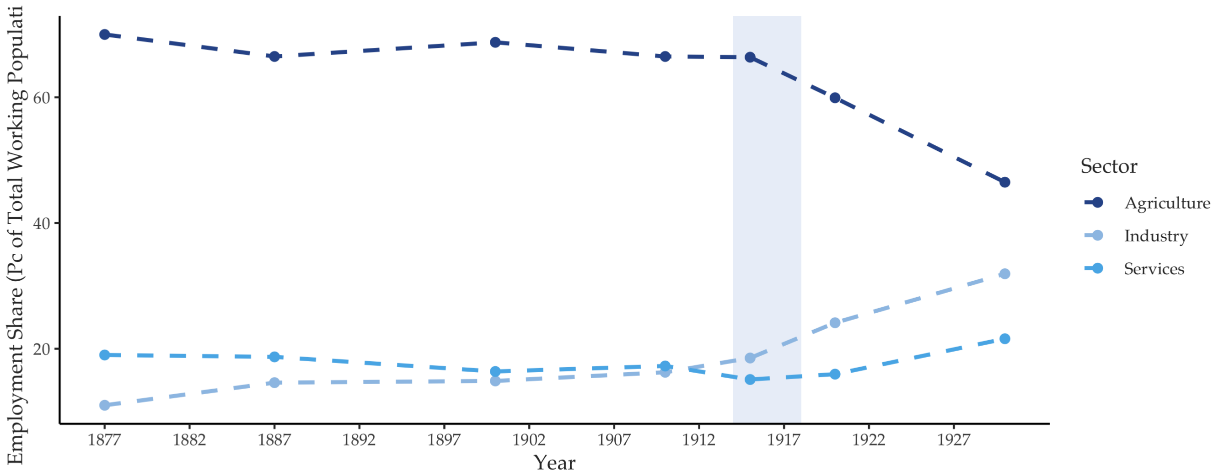
***Notes*:** This figure reports the aggregate export composition in sectoral terms. The product level trade has been aggregated to sector-level trade data to match the level of aggregation of the labor market panel. The total value of exports for each section in 1910 as well as the mean exports for 1915/1916 is reported. The source data are the digitized product-destination level trade statistics.

cause 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.

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. Most of the exports were raw materials or agricultural products consistent with the low developmental status of Spain at the time as depicted in figure 3. 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. In summary, it can be stated that at the beginning of the 20th century Spain was a predominantly agricultural economy with a low level of industrial activity and while there was some rural urban migration, there was in general little dynamism towards further industrialization.

The Spanish economy and World War I. The First World War began on 28 July 1914, with the allied powers spearheaded by France, the British Empire, Russia, and later on the United States, fighting the central powers, composed of the German Empire, Austria-Hungary, the Ottoman Empire, and other co-belligerents. The consensus is that a conflict limited in terms of duration and extent was expected, but instead, it would become one of the largest wars in history, spreading across all major populated continents and only ending four years later on 11

Figure 4: Aggregate composition of the economy



***Notes*:** This figure reports the employment share across the primary, secondary and tertiary sector of the economy. The data series is obtained from Harrison (1978) for the years 1877-1900 and follows my 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.

November 1918.

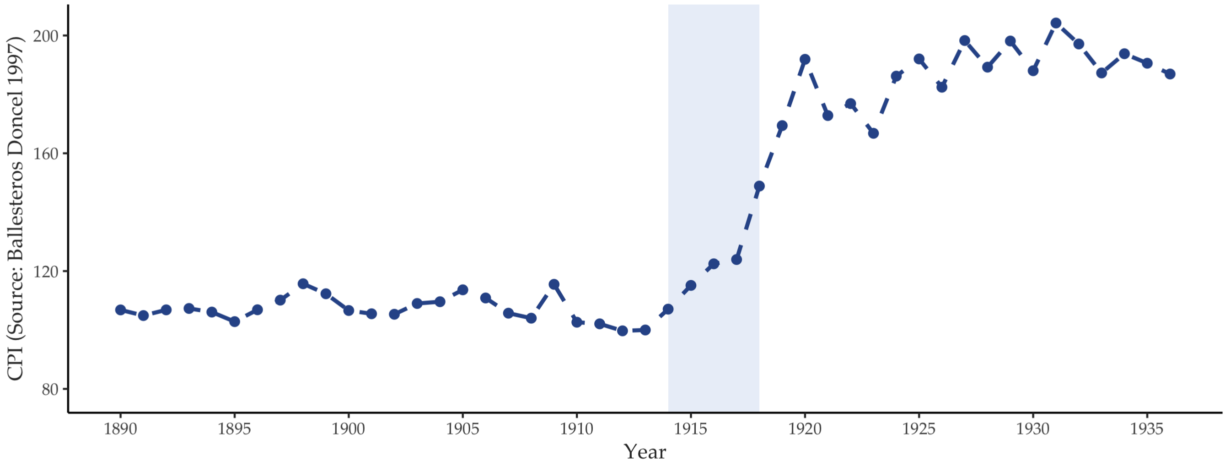
At the onset of the war Spanish society was divided into two opposing camps, with liberal fractions supporting the allied powers, and the remainder of the population supporting the central powers. However, participation in the war itself was not considered feasible (Harrison, 1978), so Spain remained neutral throughout the war.

As indicated by Tafunell and Carreras (2018) the impact of WWI on the Spanish economy was dominated by the impact of WWI on Spanish external trade. Spanish exports increased dramatically during the period, with aggregate exports increasing by 40pc. The surveys by the Instituto de Reformas Sociales (Instituto de Reformas Sociales, 1916) provides detailed information on the experience of Spanish manufacturers: The war brought about opportunities to provide war materials to the belligerent nations. This spawned increased demand for textiles, garments, chemicals, and the heavy metal industry. This shift in demand is reflected in the export statistics as can be seen in figure 3. It also induced dramatic changes in the structure of the Spanish economy, with employment in the manufacturing sector and in the service sector expanding, as can be seen in figure 4. These dramatic changes in demand and factor reallocation also brought about a rapid increase in consumer prices with the consumer prices approximately doubling throughout the period as can be seen in figure 5.

3 Data

To examine the impact of WWI on both trade flows and internal factor markets, I have assembled a unique dataset that provides disaggregated information on the distribution of economic activity

Figure 5: Evolution of the Spanish CPI



***Notes*:** This figure shows the estimated price index according to the work by Ballesteros Doncel (1997) with the blue shaded area indicating the WWI period. The series is normalized to 100 in 1913.

across regions and sectors, both before, during, and after WWI. This dataset allows me for the first time to analyze the impact of the trade shock taking both external trade and internal labor reallocations into account.

I construct a new regionally disaggregated dataset for Spain between 1910-1920 that covers information on wages, employed workers, prices and exports across local labor markets. In order to do so I rely on six principal sources of separate data.[4] First, 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[5] and 48 different provinces.[6] 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

[4]See the appendix for further information on data sources and construction.

[5]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.

[6]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.

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).

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

Third, 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.[7]

Fourth, 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 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.

[7]The correspondence table is available in the online appendix.

Fifth, 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.

Sixth, 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 and further added maritime linkages between important ports in France and Spain. Again using the Dijkstra's algorithm, I can obtain the shortest distance along this transportation network between provincial capitals in Spain and Paris.

Finally, 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 Boletins of the Instituto de Reformas Sociales. 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.

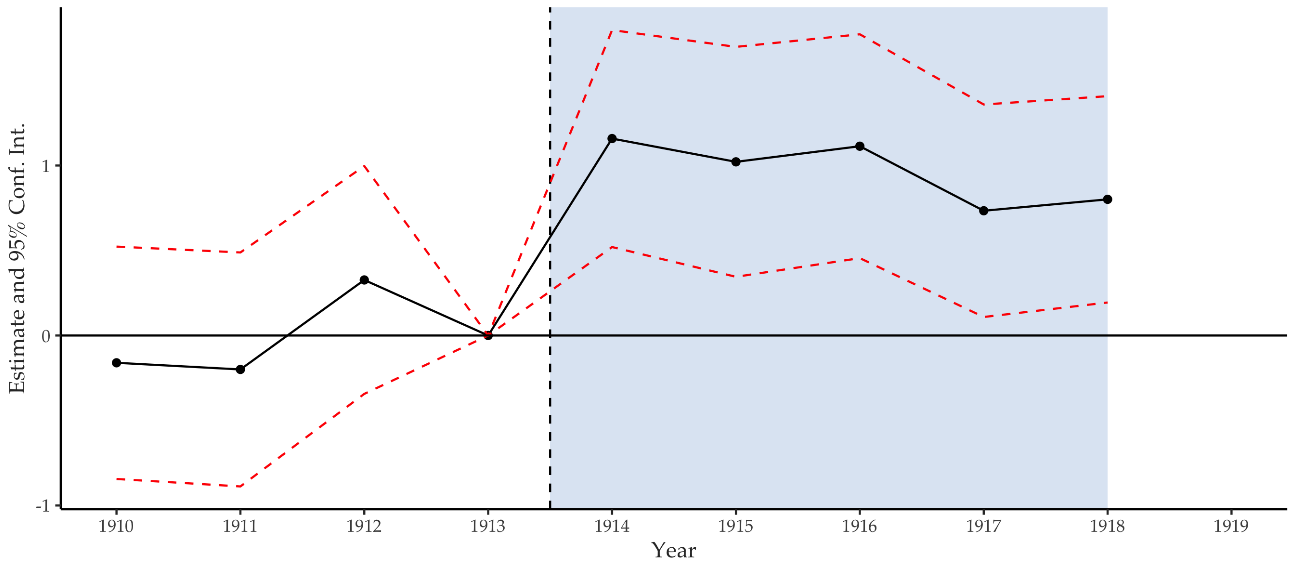
4 Reduced-form evidence

In this section, I provide reduced-form evidence on the origin and characteristics of the trade shock and its implications for industry, wage and price dynamics within Spain.

Fact 1: WWI trade shock was driven by belligerent demand. 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.[8] 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

[8] 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: Event study on exports: Estimate for belligerent destinations



***Notes*:** This figure reports the estimated coefficient on the dummy variable that indicates that a destination country is a belligerent country. The depicted coefficient responds to δ_t in the regression equation above. The red dotted lines indicated 95pc confidence intervals. The blue shaded area indicates the period of WWI. The source data are the digitized product-destination level trade statistics. Detailed construction on the source and construction of this data can be found in the online appendix.

analyze the export data taken from the annual export statistics. Specifically, I run the following event study specification:

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

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 δ_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 specification. 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 improve-

Table 1: Regression results: Event study on belligerent exports

	Exports (Value)		
	(1)	(2)	(3)
Belligerent × Year = 1910	-0.1970* (0.1096)	-0.2356 (0.3568)	-0.0144 (0.1696)
Belligerent × Year = 1911	-0.0516 (0.1398)	-0.1605 (0.3487)	0.1144 (0.1660)
Belligerent × Year = 1912	-0.1904* (0.0974)	-0.1997 (0.3511)	-0.1152 (0.1569)
Belligerent × Year = 1914	0.2649** (0.1238)	0.3267 (0.3419)	0.2197 (0.1493)
Belligerent × Year = 1915	1.058*** (0.2470)	1.159*** (0.3256)	0.9258*** (0.1827)
Belligerent × Year = 1916	0.9330*** (0.1917)	1.022*** (0.3451)	0.6710*** (0.1574)
Belligerent × Year = 1917	1.013*** (0.1993)	1.113*** (0.3359)	0.7110*** (0.1586)
Belligerent × Year = 1918	0.6607*** (0.2232)	0.7338** (0.3189)	0.4703** (0.2020)
Belligerent × Year = 1919	0.6684*** (0.1670)	0.8010*** (0.3096)	0.3726** (0.1472)
Standard-Errors	Product	Product×Year	Product×Year
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: 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 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.

ments 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 increased by almost 1 log point throughout the period, an effect that given the specification is plausibly driven by changes in export demand in these locations.

Fact 2: The trade shock was asymmetric 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 3. However, it is not clear whether these changes in sectoral trade flows are driven by plausibly exogenous demand shifts or by confounding domestic industry trends. In order to isolate the demand-side effects of war participation, I propose a simple regression that compares Spanish exports towards belligerent and non-belligerent countries, before and after the war, sector by sector, i.e.

$$\log\left(X_{i,p,t}\right) = \sum_{s} \theta_s^1 \times \mathrm{WWI}_t \times \mathrm{Belligerent}_i + \beta_1 \times \mathrm{WWI}_t \times \mathrm{Belligerent}_i \qquad (2)$$
$$+ \beta_2 \times \mathrm{WWI}_t + \beta_3 \times \mathrm{Belligerent}_i + \mu_{i,p} + \mu_t + \varepsilon_{i,p,t}$$

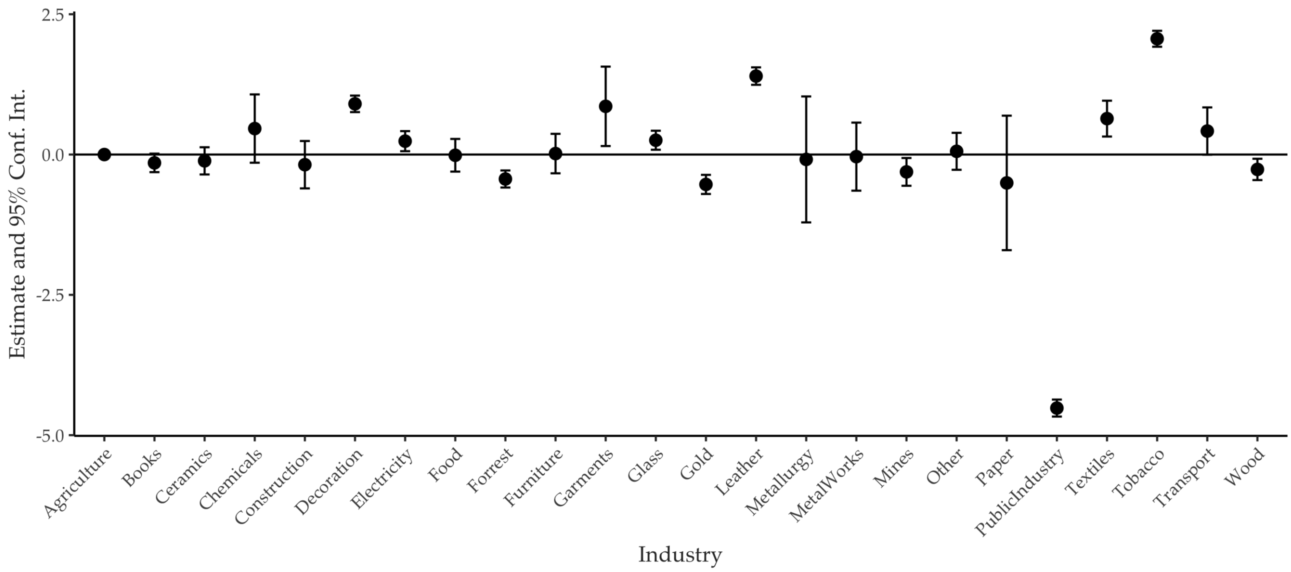
where - as before - $\mathrm{Belligerent}_{i,t}$ is a dummy that takes a value of 1 for countries that participated actively in WWI throughout the war, WWI_t is a dummy that takes a value of 1 for the years in which the war took place. I include both the levels and the interactions of the dummy variables 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 8 in the appendix. As in the previous subsection, I present results with different sets of fixed effects. Column (1) is the most parsimonious specification with only product and year fixed effects. Concerns about the heterogeneity of export composition across destination countries and product categories interacting with product-specific trends is alleviated by introducing 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.

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

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

Figure 7: Event study on exports: Estimate by sector



***Notes*:** This 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.

determine local shock exposure. The figure 7 depicts the estimated coefficients and their 95 percent intervals. Detailed regression results can be found in table 7. 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 3 above.

Fact 3: The shock impacted wages, labor allocations, and prices asymmetrically.

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 Instituto de Reformas Sociales (Gomez-Tello et al., 2018). 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, $\text{Local Shock}_{\,i,s}$, 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 $\text{Spatial Shock}_{\,i,s}$ 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,

$$\begin{aligned}
\begin{pmatrix} \log\left(w_{r,s,c,t}\right) \\ \log\left(\ell_{r,s,c,t}\right) \end{pmatrix} = \sum_{t\neq 1913} & \delta_t \times \log \text{ DistanceParis}_{\,r} + \beta_1 \times \text{WWI}_t \times \text{ Local Shock}_{r,s} \\
& + \beta_2 \times \text{WWI}_t \times \text{ Spatial Shock}_{r,s} + \beta_3 \times \text{WWI}_t \times \text{ Shock}_{r,s} \\
& + \beta_4 \times \text{WWI}_t + \beta_5 \times \text{ Local Shock}_{r,s} + \beta_6 \times \text{ Shock}_{r,s} \\
& + \beta_7 \times \text{ Spatial Shock}_{r,s} + \mu_r + \mu_{c,s} + \varepsilon_{r,s,c,t}
\end{aligned} \tag{6}$$

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,

$$\begin{aligned}
\log\left(p_{i,p,u,m,t}\right) = \sum_{t\neq 1913} & \delta_t \times \log \text{ DistanceParis}_{\,r} + \beta_1 \times \text{WWI}_t \times \text{ Local Shock}_r \\
& + \beta_2 \times \text{WWI}_t \times \text{ Spatial Shock}_r + \beta_3 \times \text{WWI}_t + \beta_4 \times \text{ Local Shock}_r \\
& + \beta_5 \times \text{ Spatial Shock}_r + \mu_{i,u} + \mu_{p,m} + \mu_t + \mu_{u,p} + \varepsilon_{i,s,r,m,t}
\end{aligned} \tag{7}$$

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 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

Table 2: Regression results: Event study on wages, labor allocations and prices

	log(Wage)		log(Labor)		log(Prices)	
	(1)	(2)	(3)	(4)	(5)	(6)
log(dist) × Year = 1908	-0.0215*** (0.0023)	-0.0223*** (0.0023)	-0.0729*** (0.0131)	-0.0801*** (0.0111)		
log(dist) × Year = 1909	-0.0001 (0.0022)	-0.0009 (0.0021)	-0.0683*** (0.0127)	-0.0745*** (0.0105)		
log(dist) × Year = 1910	-0.0029 (0.0020)	-0.0034* (0.0019)	-0.0235** (0.0117)	-0.0274*** (0.0096)	-0.0032 (0.0357)	-0.0036 (0.0350)
log(dist) × Year = 1911	-0.0053** (0.0021)	-0.0059*** (0.0021)	0.0018 (0.0118)	-0.0006 (0.0097)	-0.0232 (0.0342)	-0.0230 (0.0336)
log(dist) × Year = 1912	0.0014 (0.0021)	0.0010 (0.0020)	0.0125 (0.0117)	0.0112 (0.0095)	-0.0010 (0.0355)	0.0015 (0.0348)
log(dist) × Year = 1914	-0.0003 (0.0020)	-0.0010 (0.0019)	0.0025 (0.0118)	0.0025 (0.0097)	0.0304 (0.0334)	0.0309 (0.0326)
log(dist) × Year = 1915	-0.1076*** (0.0347)	-0.1049*** (0.0321)	-0.0058 (0.2108)	0.0279 (0.1687)	-0.0575* (0.0338)	-0.0635* (0.0332)
log(dist) × Year = 1916	-0.1051*** (0.0347)	-0.1027*** (0.0321)	-0.0096 (0.2110)	0.0246 (0.1691)	-0.0787** (0.0324)	-0.0832*** (0.0315)
log(dist) × Year = 1917	-0.0941*** (0.0347)	-0.0916*** (0.0320)	0.0040 (0.2110)	0.0379 (0.1689)	-0.0382 (0.0326)	-0.0378 (0.0318)
log(dist) × Year = 1918	-0.0808** (0.0347)	-0.0780** (0.0321)	0.0213 (0.2110)	0.0562 (0.1690)	-0.0755** (0.0372)	-0.0783** (0.0363)
War Period	0.2577 (0.2818)	0.2335 (0.2612)	-1.075 (1.735)	-1.265 (1.389)		
Local Shock	-0.0995 (0.3235)	-0.1633 (0.2777)	-6.004*** (2.041)	-6.229*** (1.215)		
Spatial Shock	0.7488* (0.3953)	0.6941* (0.3716)	9.958*** (2.426)	9.683*** (1.615)		
War Period × Shock	0.0639*** (0.0147)	0.0670*** (0.0119)	0.2772*** (0.0899)	0.2874*** (0.0602)		
War Period × Local Shock	0.8869*** (0.1016)	0.8867*** (0.0969)	1.773*** (0.5968)	1.742*** (0.4833)	3.105** (1.349)	3.323** (1.377)
War Period × Spatial Shock	0.5835*** (0.0893)	0.5848*** (0.0846)	0.9333* (0.4807)	0.8125** (0.3799)	-1.682** (0.6763)	-1.508** (0.6648)
R^2	0.73771	0.76171	0.46207	0.62884	0.93310	0.93732
Observations	6,454	6,454	6,700	6,700	32,147	32,147
Pseudo R^2	0.92948	0.99613	0.14544	0.23249	0.87187	0.89287
Ind fixed effects	✓		✓			
Type fixed effects	✓		✓			
Province fixed effects	✓	✓	✓	✓		
Type×Ind 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*:** The table shows the regressions results for the event study design described in equation (6). Six different specifications are reported with different combinations of industry, province and worker type fixed effects. The variables Shock, Local Shock and Spatial Shock correspond to Shock $_{i,s}$, Local Shock $_{i,s}$ and Spatial Shock $_{i,s}$ respectively. The regressions are estimated by using the feols command of the fixest package in R. The source data are the yearly wage survey released by the Spanish government. Additional information on data digitization and construction is available in the online appendix.

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.

5 The impact of trade under segmented labor markets

To rationalize the direct and indirect effect of the shock on wages, labor allocations and consumer prices, this section introduces a simple Armington model that features trade between domestic and foreign locations as well as labor reallocation between domestic locations. I will show that the model implies that a key determinant of wage and price dynamics is the spatial incidence of an external demand shock, with shocks that are more concentrated across space, creating labor market congestion effects that induce wage and price appreciation and less re-allocation. I will then argue in the next section that the degree of factor re-allocation can be crucial to understand and quantify the gains from trade.

Setting. Let there be a number of locations within a country $n, i, j \in \mathbb{D} = \left\{1, \ldots, N^D\right\}$. Let there be also a number of foreign locations $k, l \in \mathbb{F} = \left\{1, \ldots, N^F\right\}$. 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. There are only two periods and the initial distribution of workers across locations $[\ell_n]_{\forall n \in \mathbb{D}}$, is given, while the distribution of workers in the second period, $[\ell'_n]_{\forall n \in \mathbb{D}}$, is endogenously determined.

Preferences. Workers residing in location n 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 CES aggregate of origin differentiated goods of both domestic and foreign origin. The indirect utility and the optimal price index of this problem is given by,

$$u_n = \frac{\rho_n e_n}{p_n^{(1-\delta)} r_n^{\delta}} \qquad p_n = \left[\sum_{i=1}^{N^D} p_{ni}^{1-\sigma} + \sum_{l=1}^{N^F} p_{nl}^{1-\sigma}\right]^{\frac{1}{1-\sigma}} \tag{8}$$

where e_n represents the disposable income of a representative worker in n, p_n corresponds to the CES ideal price index, r_n is the rental rate of housing, and ρ_n is a location-specific amenity shifter that can be used to rationalize observed variations in population shares across locations. Applying Roy's identity, demand in location n for goods produced in domestic locations i and foreign locations l are given by,

$$q_{ni}(\boldsymbol{p}_n) = \frac{p_{ni}^{-\sigma}}{\sum_{j=1}^{N^D} p_{nj}^{1-\sigma} + \sum_{k=1}^{N^F} p_{nk}^{1-\sigma}} (1-\delta) e_n \qquad q_{nl}(\boldsymbol{p}_n) = \frac{p_{nl}^{-\sigma}}{\sum_{j=1}^{N^D} p_{nj}^{1-\sigma} + \sum_{k=1}^{N^F} p_{nk}^{1-\sigma}} (1-\delta) e_n$$

where $\boldsymbol{p}_n$ refers to the price vector for goods available in location $n$and produced in all other locations. Households in foreign locations l spend a fixed endowment e_l across domestic locations. They consume a CES aggregate of origin-differentiated goods across domestic locations. The indirect utility and the optimal price index that households derive from consuming across domestic locations is given by,

$$u_l = \frac{e_l}{p_l} \qquad p_l = \left[\sum_{i=1}^{N^D} p_{li}^{1-\sigma}\right]^{\frac{1}{1-\sigma}}$$

where $\sigma > 1$ is the elasticity of substitution and 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,

$$q_{li}\left(\boldsymbol{p}_l\right) = \frac{p_{li}^{-\sigma}}{\sum_{i=1}^{N^D} p_{li}^{1-\sigma}} e_l$$

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

Reallocation choice. Between the first and second period, workers can reallocate between domestic locations and sectors to respond to changes in factor returns. The initial allocation of workers across locations is given, $[\ell_i]_{\forall i}$, but the allocation of workers in the second period is determined by their endogenous decision making. I specify the reallocation choice using a stochastic choice that arises from a random utility model. The utility that an individual (ω) derives from moving from location n to location i can be expressed in terms of the indirect utility of being in that place in the next period, i.e. u_i', multiplied by an individual specific realization of a stochastic location-specific preference shock κ_i and adjusted by variable migration cost μ_{ni}, i.e.

$$v_{ni}'\left(\omega\right) \equiv \frac{u_i'}{\mu_{ni}} \times \kappa_i\left(\omega\right) = v_{ni} \times \kappa_i\left(\omega\right)$$

where the iceberg (variable) migration costs satisfy $\mu_{ni} \geq 1$ and $\mu_{nn} = 1$, that we assume the absence of migration costs if the worker remains in its current location. I assume that the preference shock κ_j is distributed identically and independently according an extreme value type II or Frechet distribution with a dispersion parameter γ. By the properties of the Frechet distribution, we can write the choice probabilities as,

$$\sigma_{ni}' = \frac{\left(v_{ni}'\right)^{\gamma}}{\left(\Omega_n'\right)^{\gamma}} \qquad \left(\Omega_n'\right)^{\gamma} \equiv \sum_{j=1}^{N^D}\left(v_{nj}'\right)^{\gamma}$$

where the denominator summarizes the options of the worker initially located in location n.

Production. Goods are produced only utilizing labor and production is characterized by a constant returns to scale production technology, i.e. $q_i = z_i \ell_i$, 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,

$$p_{ni} = \tau_{ni} mc_i = \frac{\tau_{ni} w_i}{z_i} \tag{9}$$

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 $mc_i = w_i/z_i$ is the marginal cost of production in location i.

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

$$w_i \ell_i = \sum_{i=1}^{N^D} s_{ni} e_n \ell_n + \sum_{l=1}^{N^F} s_{li} e_l \tag{10}$$

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

$$e_n \ell_n = \sum_{i=1}^{N^D} s_{ni} e_n \ell_n + \sum_{l=1}^{N^F} s_{nl} e_n \ell_n$$

where expenditure shares s_{ni}, s_{nl}, s_{li} follow from the characterization of foreign and domestic demand. Third, total expenditure on housing services has to equal the total returns to housing for each period,

$$H_n r_n = \delta e_n$$

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. Labor market clearing 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,

$$\ell_i^{'} = \sum_{n=1}^{N} \sigma_{ni}^{'} \ell_n \tag{11}$$

The impact of a trade shock on wages and prices. Finally, I will show that the model can rationalize the empirical findings of the previous section. In particular, the direct effect on wages and consumer prices and the indirect effect via labor market linkages. To do so I derive a comparative static that characterizes wage and price changes as a function of a foreign demand shock. In order to characterize the general equilibrium adjustments in closed-form I derive a first-order approximation of the equilibrium conditions as in Kleinman et al. (2020). Detailed derivations are provided in the appendix. Consider a small shock to foreign endowments, $\mathrm{d}\ln e_l \neq 0$, but assume that trade frictions and productivity shocks remain unaffected ($\mathrm{dln}\,\tau_{ni} = 0$, $\mathrm{dln}\,z_h = 0$). The short-run effect[9] on wages can be written as,

$$\left[\frac{\partial \ln w_i}{\partial \ln e_l}\right]_{il} = \left[\frac{\partial \ln p_i}{\partial \ln e_l}\right]_{il} = \underbrace{(1-\gamma)\left[\frac{s_{li}e_l}{y_i} + \frac{1}{y_i}\sum_j s_{ji} \times y_j \times \left(\frac{s_{lj}e_l}{y_j}\right) + \dots\right]_i}_{\text{Direct Effect}} + \tag{12}$$

$$\underbrace{\gamma \sum_h n_{ih}\left[\frac{s_{lh}e_h}{y_h} + \frac{1}{y_h}\sum_j s_{jh} \times y_j \times \left(\frac{s_{lj}e_l}{y_j}\right) + ...\right]_i + \dots}_{\text{Indirect Effect (Labor Market Spillovers)}}$$

where the first term is the direct effect on wages stemming from direct and indirect demand effects in the goods market. The second term is an indirect effect, where n_{ih} is a measure of the direct and indirect connectedness between local labor market i and h and depends on labor flows between the two locations, which themselves depend on the strength of the bilateral reallocation frictions. The qualitative direction of the direct effect depends on the elasticity of labor supply (γ). The more elastic the labor supply, the smaller the direct effect of the shock, as additional increases in demand attract a sufficient number of workers to limit wage appreciation. The indirect effect determines to what extent increases in labor demand in location h affect the across domestic local labor markets thus making it more difficult to attract workers to location i. The expression weights labor demand shocks by n_{ih} which measures the exposure of labor market i to labor demand shocks in h via the indirect linkages across all other labor markets. 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.

6 Quantifying GFT under imperfect labor mobility

I turn towards quantifying the gains from trade under imperfect labor mobility. To do so I will present expressions for the welfare gains from trade using a sufficient statistic approach. I begin by first presenting the formula for the simple one sector model of the previous section before extending the formula for the more general multi-sector case with trade deficits. I then apply

[9] In the sense that consumption allocations are fixed. Subsection A.1 appendix derives the full characterization allowing allocations to adjust.

the formula to measure the impact of the WWI trade shock on Spanish welfare by first applying the expression to raw data, before finally fully estimating the model and comparing the welfare numbers to a simulation where Spain did not experience a trade shock.

6.1 GFT in the simple model

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 Ossa (2015) and derive a closed-form formula for the gains from trade that takes domestic re-allocation into account. The expression measures changes 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. Specifically, it is an expression for ex-ante expected aggregate welfare in the second period, when the geographical location of a worker in period one is not known and subject to an additional discrete choice problem as in Redding (2012). Detailed derivations are available in the appendix A.2. Change in aggregate welfare is then given by,

$$\left(\frac{\mathcal{W}^1}{\mathcal{W}^0}\right) = \underbrace{\left(\frac{s_D^{1'}}{s_D^{0'}}\right)^{-\frac{(1-\delta)}{\sigma-1}}}_{\text{Aggregate Gains}} \underbrace{\prod_{n=1}^{N^D} \left(\frac{r_n^{1'}}{r_n^{0'}}\right)^{-\delta\pi'_n} \left(\frac{w_n^{1'}}{w_n^{0'}}\right)^{\pi'_n-\alpha'_n}}_{\text{Reallocative Gains}} \tag{13}$$

where $\alpha'_n \equiv s_D \sum_m \pi'_m s_{mn}$ represents the importance of individual locations from a production perspective whereas π'_n measures the population weight. The expression is empirically convenient and theoretically intuitive. The first term represents the aggregate gains and depends on changes in trade openness as in Arkolakis et al. (2012). The second term measures changes in allocative efficiency: A temporary external demand shock reallocates labor across domestic labor markets therefore changing the spatial wage dispersion. This changes both the distribution and aggregate level of nominal income as well as the cost of domestically produced goods. The impact on nominal incomes can be measured using population weights, while the effect on consumer prices depends on the importance of individual location in the production network. The take-away is that as soon as we incorporate imperfect factor mobility, allocative efficiency can change as factors are being re-allocated domestically. Additionally, changes in (spatial) wage dispersion can be a convenient sufficient statistic to empirically measure this. Notice that only three sources of data are needed to estimate gains from trade taking domestic factor allocation into account: First, international trade data to pin down the change in the trade openness of the domestic economy. Second, domestic regional labor market data on wages and population shares across locations. Third, data on internal trade flows to determine the importance of individual location in the domestic trade network.

6.2 GFT with multiple sectors and trade deficits

The previous section derived an intuitive closed-form expression for the gains from trade in the simple one-sector model with imperfect labor mobility. The WWI trade shock, however, was not only asymmetric across space, but also across sectors. This section then extends the baseline model to incorporate multiple sectors by introducing multi-sectoral production and trade, as well as a convenient and parsimonious description of sectoral and spatial reallocation. To account for changes in trade deficits, I also incorporate exogenous trade deficits into the model and show its implications for measured gains from trade.

Setting. Let there be a number of locations within a country $n, i, j, h \in \mathbb{D} = \left\{1, \ldots, N^D\right\}$. Let there be also a number of foreign locations $k, l, m \in \mathbb{F} = \left\{1, \ldots, N^F\right\}$. 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: $U_n = (C_n)^{1-\delta} H_n^{\delta}$ 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,

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

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. Applying Roy's identity gives marshallian demand.

Reallocation choice. As in the baseline model, between the first and second period, workers can reallocate between domestic local labor markets to respond to changes in factor returns. In this setting, 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,

$$\sigma'_{ni,rs} = \sigma'_{ni|r}\sigma'_{rs|i} \tag{14}$$

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,

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

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

$$\sigma'_{ni|r} = \frac{\left(v'_{ni|r}\right)^{\gamma}}{\left(\Omega'_{n,r}\right)^{\gamma}} \tag{15}$$

where $\gamma$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[10] 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.

[10]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 $\Pi'_{i,r} \equiv (\sum_t (w'_{it}/\mu_{rt})^{\nu})^{1/\nu}$, multiplied by a stochastic location-specific preference shock κ_i, and adjusted by variable geographical migration cost, μ_{ni}, i.e.

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

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. As before, goods can be traded subject to an iceberg transport cost.

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,

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

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

$$\bar{d}\left(\sum_{r=1}^{S} e_{n,r}\ell_{n,r}\right) = \sum_{r=1}^{S}\left(\sum_{i=1}^{N} s_{ni,r}\left(\sum_{r=1}^{S} e_{n,r}\ell_{n,r}\right) + \sum_{l=1}^{N^F} s_{nl,r}\left(\bar{d}e_n\ell_n\right)\right) \tag{17}$$

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

$$H_n r_n = \delta\left(\sum_{r=1}^{S} e_{n,r}\right) \tag{18}$$

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. Labor market clearing 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**,**

$$\ell'_{i,s} = \sum_{r=1}^{S}\sum_{n=1}^{N} \sigma_{ni,rs}\ell_{n,r} \tag{19}$$

Gains from trade. To characterize the gains from trade taking multiple sectors and trade deficits into account, I derive a closed-form expression, again mirroring the sufficient statistic approach by Arkolakis et al. (2012) and particularly, building on the multi-sector expression by Ossa (2015). Detailed derivations are available in the appendix A.3. Change in aggregate welfare is then given by,

$$\left(\frac{\mathcal{W}^1}{\mathcal{W}^0}\right) = \underbrace{\left(\frac{\bar{d}^1}{\bar{d}^0}\right)}_{\text{Deficit Adjustment}} \underbrace{\prod_{s=1}^{S}\left(\frac{s_D^1}{s_D^0}\right)^{\frac{(1-\delta)}{\sigma_r-1}}}_{\text{Aggregate Gains}} \underbrace{\prod_{n=1}^{N^D}\left(\frac{r_n^1}{r_n^0}\right)^{-\delta\sum_r \pi'_{n,r}} \prod_{r=1}^{S}\left(\frac{w_{n,r}^1}{w_{n,r}^0}\right)^{\pi'_{n,r}-\alpha_{n,r}}}_{\text{Reallocative Gains}} \tag{20}$$

where $\alpha'_{n,r} \equiv \sum_r s_{D,r} \sum_m \pi'_{m,r} s_{mi,r}$ represents the importance of individual locations from a production perspective whereas $\pi'_{n,r}$ measures the population weight in sector-location (n, r). The first term is novel and corresponds to an adjustment due to changes in trade deficits. The second term measures aggregates gains and depends on sector-specific changes in trade openness as in Ossa (2015). The final term measures changes in allocative efficiency and has the same interpretation as above. Again, only three sources of data are needed: International trade data, domestic (sector-specific) trade data and regional labor market data.

6.3 Quantifying GFT for the WWI Shock

I will now turn towards quantifying the gains from trade using the closed-form expressions introduced above. In a first step, I will implement the evaluation using the observed raw data. One might argue that not all of the observed changes in labor allocations, wages and prices are due to the WWI trade shock and that therefore quantifying directly using raw data might misrepresent the gains from trade. To tackle these concerns, in a second step, I fully estimate the quantitative model and simulate as a counterfactual the Spanish economy in the absence of WWI.

6.3.1 GFT using raw data

As a first step, I quantify the gains from trade using raw data directly. Recall, that in order to do so three different sources of data are needed: International trade data, domestic trade flows, and regional labor market data. Additionally, to quantify aggregate gains from trade, an estimate of the elasticity of substitution is needed. While international trade data and regional labor market data is readily available, domestic trade flows are not. I therefore begin by implementing a procedure that allows me to back out the domestic trade flows that rationalize the observed spatial distribution of economic activity in the baseline period. To do so an estimate of the domestic distance elasticity is necessary which I will estimate using the heterogeneous domestic wage response to the WWI trade shock. Finally, I use the structure of the model and the WWI trade shock to obtain an estimate of the elasticity of substitution. With data and parameters in hand, the welfare formula can be directly implemented.

Table 3: Results: Nonlinear GMM Estimation of Distance Elasticity

	Wage (1)
δ	733.5 (1,235.1)
θ	-1.769*** (0.5228)
log(dist)	-0.0949 (0.0790)
Observations	1,102
Pseudo R^2	0.14170
Worker Type×Year fixed effects	✓

***Notes*:** The table reports the results of estimating equation (21).

Estimating domestic trade costs. The procedure to back out domestic trade flows proceeds in two steps. 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 (10) 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 account, i.e.[11]

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

where in the final step we can empirically approximate the hypothetical market shares with the observed labor share of that location and trade costs are approximated with the inverse of distance along the transportation network and where $\pi_n = \ell_n/\bar{\ell}$ is the share of workers in a given location, θ is the domestic trade elasticity. 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 4. Empirically, I estimate the following nonlinear event study,

$$\log\left(w_{r,s,c,t}\right) = \sum_{t\neq 1914} \delta_t \times \left(\frac{dist_{lr}^{\theta}\pi_i}{\sum_{n=1}^{N^D} dist_{ln}^{\theta}\pi_n} \right) + \mu_{r,c} + \varepsilon_{r,s,c,t} \tag{21}$$

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

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.

Backing out trade flows. The second step in backing out domestic trade flows requires labor market data and imposes the equilibrium structural of the structural model. Specifically, I obtain factor prices adjusted to the demand curvature that corresponds destination fixed effects in a gravity specification. Combining the market clearing condition (16) and the balanced trade condition (17) 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 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 3. I use the shortest distance along the railroad graph between Spanish provincial capitals and furthermore add France as an additional location, where the distance to France is the shortest distance to Paris across railroad and maritime linkages. 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. $s_{ni,s} = (p_{is,t})^{-\epsilon_s} \tau_{ni}^{-\epsilon_s} \left(\sum_{k=1}^{N^D} \tau_{nk}^{-\epsilon_s} \left(p_{ks,t}\right)^{-\epsilon_s} \right)^{-1}$.

Table 4: Results table: Price regressions

	log(Price_eps)	
	Naive OLS	2SLS
	(1)	(2)
log(Wage)	-0.7557*** (0.0978)	1.582** (0.6599)
R^2	0.96824	0.94799
Observations	2,182	2,180
F-test (1st stage)		19.555
Pseudo R^2	0.88467	0.75818
Industry×Worker Type×Province fixed effects	✓	✓
Year×Industry fixed effects	✓	✓

***Notes*:** This table reports the results of the second stage for estimating the structural equation 22. The first stage predicts the endogenous variables $\log w_{ist}$, denoting (log) wage changes between 1920 and 1914 at the province-sector-level and the results of the first stage are reported in the appendix table 9. The regressions are estimated by using the feols command of the fixest package in R. The source data are the yearly wage survey released by the Spanish government. Additional information on data digitization and construction is available in the online appendix.

Estimating the elasticity of substitution. The final ingredient necessary to quantify gains from trade is an estimate of the elasticity of substitution. The estimation proceeds in two steps. In a first step I use the same procedure as in the previous subsection to obtain market share shifters. In the 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.

$$\epsilon \log p_{i,r,t} = \mu_{i,r} + \mu_{r,t} + \epsilon \log w_{i,r,t} - \log z_{i,r,t} \tag{22}$$

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

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 4 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. The first stages are reported separately in table 9 in the appendix and are sufficiently strong.

A 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.

Gains from trade using raw data. In the final step, I use the Spanish trade data to obtain changes in the aggregate trade openness, the labor market panel to obtain population weights, the wage data to calculate labor market specific wage changes between 1914 and 1920 and the backed out domestic trade flows to calculate $\alpha_{n,s}$. To compute welfare results I use an elasticity of substitution of $\sigma = 2.5$. In table 6 I report the results. Compared to the aggregate welfare gains formula, accounting for changes in domestic labor markets adjusts welfare conclusion and magnifies the welfare gains tenfold. The reallocative gains, which is the impact on nominal income subtracting increases in housing cost and consumer prices, is substantial and increases the welfare gains in this period by an additional 3 percentage points.

6.3.2 GFT in the simulated counterfactual

As noted before, one might argue that not all of the observed changes in labor allocations, wages and prices are due to the WWI trade shock and that therefore quantifying directly using raw data might misrepresent the gains from trade. To tackle these concerns, I fully calibrate the quantitative model by estimating the full set of geographical and sectoral reallocation frictions. I then simulate the Spanish economy in the absence of the WWI trade shock and use the counterfactual welfare changes to determine secular welfare changes in the economy that would have taken place even in the absence of the shock.

Estimation of geographical reallocation frictions. I begin by estimating geographical reallocation frictions. To do so, I rely on data that shows the decennial change in the number of workers who live in a certain province but were born in another province, that is $BAP^t_{i,j}$ for a worker who was born in province i but now lives in province j. 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 3 - 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. Using the closed forms from the previous section I can construct the model equivalent of this moment. The (estimated) stock of workers born in province i and currently residing in province k is given by,

$$\widehat{BAP}_{i,k,1930} = \sum_{n,s} \sigma_{nk,s}(\mathbf{v}_{n,s,1930}) \times \pi^{1920}_{i,s} \times S \times BAP^{1920}_{i,n}$$

where $\widehat{BAP}_{i,k,1930}$ refers to the simulated stock of workers born in province i and currently residing in province k, $\pi^{1920}_{j,r}$ refers to the industry share of industry r in province j in 1920 and where the closed form for the share of flows between province j and province k originating from sector s is given by equation (15). Implicitly, this is assuming that there is no sorting across industries of different groups of inhabitants, which in the absence on additional information is a necessary assumption. The geographical switching cost is calibrated as a function of distance that is $\mu_{ij} = \zeta^1_i \times distance^{\zeta^2}_{ij}$, where $distance_{ij}$ is the shortest distance across railroad and maritime travelling routes from the province capital in i to the province capital in j in km. The structural estimation chooses the parameter vector $\boldsymbol{\beta} = (\zeta^1_1, \ldots, \zeta^I_1, \rho_1, \ldots, \rho^I, \zeta^2, \nu, \gamma, \mu_1, \ldots, \mu_S)$ to match the observed moments, that is minimizing the error between imputed and observed quantities of workers born in another province,

$$\hat{\boldsymbol{\beta}} = \arg\min_{\beta \in B} \boldsymbol{\eta}\left(BAP_{1930}, \boldsymbol{\beta}\right)' \boldsymbol{\eta}\left(BAP_{1930}, \boldsymbol{\beta}\right)$$

Table 5: Results: Mobility cost estimation

Parameter	Value
γ_1	0.72
$\zeta_2 \times \nu$	2.19
ν	3.70
Spatial Share	0.07

***Notes*:** This table reports the results of the migration cost estimation. 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. In the right column the sectoral switching cost parameter μ_s is reported as well as the key elasticities pinning down spatial migration cost $\mu_{ij} = \zeta_i^1 \times distance_{ij}^{\zeta^2}$. Geographical switching cost is presented in table 11 while sectoral switching cost is presented in table 10.

where $\boldsymbol{\eta}$ is the stacked vector of structural errors, $\eta_{i,j} = BAP_{i,j,1930} - \widehat{BAP}_{i,j,1930}$. The origin varying scalar, ζ_i^1, determines the out-province migration share. Conditional on moving out of a province, the distance between the origin province and the destination province is informative about how geographical frictions affect migration flows and thus determines the distance elasticity, ζ^2. The incoming migration to specific provinces above and beyond what is justified by wage differences informs the province specific amenities, ρ_i. The responsiveness of in migration to dispersion in wages across sectors within a given province pins down the local supply elasticity, γ, while the response to dispersion of imputed indirect utilities across provinces informs the estimation of the spatial migration elasticity, ν.

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 overcome this limitation I propose to use the estimated labor demand model together with sectoral trade data from 1915 to simulate the market clearing wages in the presence of the World War shock. I proceed by first using the 1914 data to impute the residual productivities, $\{z_{i,s}^{1914}\}$, and then feed in the trade shock to back out the simulated market clearing sectoral wage vectors, $\hat{\mathbf{w}}_s^{1915}$. Using these sectoral wage vectors as expected wages, and calibrating the spatial friction to the estimated values from the previous section, I use the closed forms to match the observed changes in employment size between 1914 and 1920,

$$\widehat{L}_{i,s}^{1920} = \sum_{n,r} \sigma_{ni,rs}^{1914\to 1920} \left(\mathbf{v}_{n,s,1930}, \mathbf{w}^{1915}\right) L_{n,r}^{1914}$$

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 $\sigma_{ni,rs}^{1914\to 1920}\left(\mathbf{v}_{n,s,1930}, \mathbf{w}^{1915}\right)$ is the closed form for migration flows between province n to province i and sector r to sector s.[12] The optimization problem is then given by,

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

where $\boldsymbol{\eta}$ is the stacked vector of structural errors, $\eta_{i,s}(\boldsymbol{\beta}) = L_{i,s}^{1920} - \widehat{L}_{i,s}^{1920}$. In the quantitative model presented in the previous section, I introduced a general set of sector-to-sector bilateral switching costs (i.e. μ_{rs}). The relatively aggregated nature of the data makes the estimation of the full set of parameters infeasible. Instead, I estimate a destination specific adjustment costs in the spirit of Kambourov (2009) for all sectors except for agriculture which has an origin 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 $\boldsymbol{\beta} = (\mu_{agriculture}, \mu_2, \ldots, \mu_S, \gamma)$ to minimize the distance between the observed and the estimated employment size of each sector-province observation. With spatial frictions being calibrated, 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 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 approximately 7 percent of the population reallocating spatially during the fitted period which is a gross measure. This is consistent with reported decennial net internal migration of 2.8 percent between 1911 and 1920 (Silvestre, 2005). Conditional on migrating distance is an important determinant with the distance elasticity given by $\zeta_2 \times \nu = 2.2$. 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 model is fitted to match both provincial population numbers and aggregate sectoral num-

[12] Recall that,

$$\sigma_{ij,rs}^{1914\to1920}\left(\mathbf{v}_{n,s,1930}, \mathbf{w}^{1915}\right) = \sigma_{ij|r}^{1914\to1920}\sigma_{j,s|r}^{1914\to1920}$$

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

Table 6: Gains from trade: Totals and decomposition

Type	ACR Gains	Housing Cost	Income	Prices	Total	Deficit	Total (with Deficit)
Raw	0.82	-23.96	70.61	-43.98	3.49	-0.79	2.70
Cfl	-0.06	-1.52	-0.00	-0.00	-1.58	0.00	-1.58

***Notes*:** This table reports the welfare decomposition using equation 20. The table presents the results for two different welfare calculations. In the first line, I report the raw results. In the second line, I report the results from the 'no-war' counterfactual scenario.

bers. The model is sufficiently saturated to fit the observed data well on these dimension as can be seen by figures 8 and 9 in the appendix. These figures compare the predicted sectoral and provincial employment numbers to the observed data in 1920.

Spain without WWI. Having quantified the model, I can now conduct counterfactual analyses. One might be concerned that examining the raw data confounds the effects of the WWI trade shock with secular trends in allocative efficiency. To address this concern, I simulate the Spanish economy in the absence of the WWI trade shock and examine the welfare changes in the absence of the shock. The simulation uses the calibrated model to examine the implications for reallocation if the economy stays at the same level external trade flows and baseline productivities as in 1914, but allows for additional endogenous reallocation of the workers and endogenous adjustment of prices, rental rates, domestic trade flows and wages. In the following, I compare the counterfactual 1920 wages and labor densities with the observed state of the economy in 1920.

Before turning towards the welfare implications, I analyze the counterfactual patterns of economic activity, across both space and sectors. The sectoral composition is strikingly different between the counterfactual scenario and the data as shown in figure 11. There is high degree of reallocation from the agricultural sector towards the manufacturing sector in general, with industries that are affected by the trade shock growing the most. Spatially, there are very small differences in regional growth between the two scenarios, consistent with the finding that most of the adjustment is due to within provincial reallocation rather than between provincial allocation.

Finally, in table 6, I report the welfare results using equation 20 as before for the raw data. Keeping external trade fixed implies that deficit remains unchanged and therefore has no impact on welfare in this scenario. Furthermore, what I call ACR gains and corresponds to the aggregate sufficient statistic approach is small in this scenario and is only driven by the differential sorting of labor across locations with slightly different domestic trade shares. Housing costs also respond to this natural internal migration. Consistent with the lack of differential pre-trends in the reduced-form analysis, the structural counterfactual indicates that in the absence of WWI I find little change taking place, allowing us to attribute the brunt of the change in the observed scenario to the external trade shock.

7 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 asymmetric 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 and showed that this framework implies that the wage response of a local labor market depends on whether closely connected labor markets are also affected. Consistent with the empirical evidence, changes in external demand that affect tightly linked local labor markets simultaneously result in more intense competition for a limited pool of workers and therefore in a more severe localized wage and price response combined with relatively less labor re-allocation.

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 Ossa (2015) and derive a closed-form formula for the gains from trade that takes domestic re-allocation into account. Changes in allocative efficiency can be measured by including an index of spatial wage dispersion. Gains from trade can then be readily computed using external and internal trade data as well as regional labor market data.

I finally use this formula to quantify the effects of the WWI trade shock, first on the raw data, then controlling for the counterfactual welfare changes implied by a 'no-war' simulation using the fully estimated model. Applying the welfare formula on the observed data shows that controlling for the domestic distribution of economic activity can change the overall conclusion about welfare gains, with the non-adjusted formula indicating a modest increase of less than 1 percent, while the augmented formula indicates gains of up to 3 percent. The counterfactual simulation indicates that the observed welfare effects can be attributed in their entirety to the WWI trade shock.

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. Regional labor market data in combination with aggregated trade data offers an empirically convenient way to do so.

References

Treb Allen and Dave Donaldson. Persistence and Path Dependence in the Spatial Economy. NBER Working Papers 28059, National Bureau of Economic Research, Inc, November 2020. URL https://ideas.repec.org/p/nbr/nberwo/28059.html.

Costas Arkolakis, Arnaud Costinot, and Andres Rodriguez-Clare. New Trade Models, Same Old Gains? *American Economic Review*, 102(1):94–130, February 2012. URL https://ideas.repec.org/a/aea/aecrev/v102y2012i1p94-130.html.

Erhan Artuc, Shubham Chaudhuri, and John McLaren. Trade Shocks and Labor Adjustment: A Structural Empirical Approach. NBER Working Papers 13465, National Bureau of Economic Research, Inc, October 2007. URL https://ideas.repec.org/p/nbr/nberwo/13465.html.

David H. Autor, David Dorn, and Gordon H. Hanson. The china syndrome: Local labor market effects of import competition in the united states. *American Economic Review*, 103(6):2121–68, October 2013. doi: 10.1257/aer.103.6.2121. URL https://www.aeaweb.org/articles?id=10.1257/aer.103.6.2121.

David H. Autor, David Dorn, and Gordon H. Hanson. The china shock: Learning from labor-market adjustment to large changes in trade. *Annual Review of Economics*, 8(1):205–240, 2016. doi: 10.1146/annurev-economics-080315-015041. URL https://doi.org/10.1146/annurev-economics-080315-015041.

Esmeralda Ballesteros Doncel. Una estimación del coste de la vida en españa, 1861–1936. *Revista de Historia Económica*, 15(2):363–395, 1997.

Lorenzo Caliendo, Maximiliano Dvorkin, and Fernando Parro. The impact of trade on labor market dynamics. Working Paper 21149, National Bureau of Economic Research, May 2015. URL http://www.nber.org/papers/w21149.

Rafael Dix-Carneiro. Trade Liberalization and Labor Market Dynamics. Working Papers 1273, Princeton University, Department of Economics, Center for Economic Policy Studies., November 2010. URL https://ideas.repec.org/p/pri/cepsud/212dix-carneiro.pdf.html.

Rafael Dix-Carneiro and Brian K. Kovak. Trade liberalization and regional dynamics. *American Economic Review*, 107(10):2908–46, October 2017. doi: 10.1257/aer.20161214. URL http://www.aeaweb.org/articles?id=10.1257/aer.20161214.

Pablo Fajgelbaum and Stephen J. Redding. External Integration, Structural Transformation and Economic Development: Evidence from Argentina 1870-1914. NBER Working Papers 20217, National Bureau of Economic Research, Inc, June 2014. URL https://ideas.repec.org/p/nbr/nberwo/20217.html.

Jingting Fan. Internal geography, labor mobility, and the distributional impacts of trade. *American Economic Journal: Macroeconomics*, 11(3):252–88, July 2019. doi: 10.1257/mac.20150055. URL https://www.aeaweb.org/articles?id=10.1257/mac.20150055.

Simon Galle, Andres Rodriguez-Clare, and Moises Yi. Slicing the Pie: Quantifying the Aggregate and Distributional Effects of Trade. NBER Working Papers 23737, National Bureau of Economic Research, Inc, August 2017. URL https://ideas.repec.org/p/nbr/nberwo/23737.html.

Alicia Gomez-Tello, Alfonso Diez-Minguela, Julio Martinez-Galarraga, and Daniel A. Tirado-Fabregat. Regional prices in early twentieth-century Spain: A country-product-dummy approach. Documentos de Trabajo (DT-AEHE) 1802, February 2018. URL https://ideas.repec.org/p/ahe/dtaehe/1802.html.

J. Harrison. *An Economic History of Modern Spain*. Manchester University Press, 1978. ISBN 9780719007040. URL https://books.google.com/books?id=1hfpAAAAIAAJ.

Ines Helm. National Industry Trade Shocks, Local Labour Markets, and Agglomeration Spillovers. *Review of Economic Studies*, 87(3):1399–1431, 2020. URL https://ideas.repec.org/a/oup/restud/v87y2020i3p1399-1431..html.

L. Instituto de Reformas Sociales. *Informes de los Inspectores del Trabajo sobre la Influencia de la Guerra Europea en las Industrias Espanolas*. 1916. URL https://books.google.com/books?id=z1cPAQAAIAAJ.

L. Instituto Nacional de Prevision Social. *Clasificacion general de industrias, oficios y comercios*. Madrid, 2 edition, 1930. 006583.

Ronald W. Jones. *A three-factor model in theory, trade, and history*, pages 3–21. North-Holland Publishing, Amsterdam, 1971. ISBN 0720430518; 0444100946. URL https://contentstore.cla.co.uk/secure/link?id=f87eeec4-3916-e811-80cd-005056af4099.

Gueorgui Kambourov. Labour Market Regulations and the Sectoral Reallocation of Workers: The Case of Trade Reforms. *Review of Economic Studies*, 76(4):1321–1358, 2009. URL https://ideas.repec.org/a/oup/restud/v76y2009i4p1321-1358.html.

Benny Kleinman, Ernest Liu, and Stephen J. Redding. International Friends and Enemies. NBER Working Papers 27587, National Bureau of Economic Research, Inc, July 2020. URL https://ideas.repec.org/p/nbr/nberwo/27587.html.

Brian K. Kovak. Regional effects of trade reform: What is the correct measure of liberalization? *American Economic Review*, 103(5):1960–76, August 2013. doi: 10.1257/aer.103.5.1960. URL http://www.aeaweb.org/articles?id=10.1257/aer.103.5.1960.

Kiminori Matsuyama. A Simple Model of Sectoral Adjustment. *The Review of Economic Studies*, 59(2):375–387, 02 1992. ISSN 0034-6527. doi: 10.2307/2297959. URL https://doi.org/10.2307/2297959.

Wolfgang Mayer. Short-run and long-run equilibrium for a small open economy. *Journal of Political Economy*, 82(5):955–67, 1974. URL https://EconPapers.repec.org/RePEc:ucp:jpolec:v:82:y:1974:i:5:p:955-67.

Comercio e Industria Ministerio de Trabajo. *Estadística de los salarios y jornadas de trabajo referida al período 1914-1925*. Number v. 1914-1930 in Estadística de los salarios y jornadas de trabajo referida al período 1914-1925. Sobrinos de sucesora de M. Minuesa de los Ríos, M. Servet, 1927. URL https://books.google.fr/books?id=TJ1CAAAAIAAJ.

Michael Mussa. Tariffs and the distribution of income: The importance of factor specificity, substitutability, and intensity in the short and long run. *Journal of Political Economy*, 82(6):1191–1203, 1974. URL https://EconPapers.repec.org/RePEc:ucp:jpolec:v:82:y:1974:i:6:p:1191-1203.

Michael Mussa. Imperfect factor mobility and the distribution of income. *Journal of International Economics*, 12(1):125 – 141, 1982. ISSN 0022-1996. doi: https://doi.org/10.1016/0022-1996(82)90080-0. URL http://www.sciencedirect.com/science/article/pii/0022199682900800.

J. Nadal. *El fracaso de la revolución industrial en España, 1814-1913*. Ariel historia. Editorial Ariel, 1975. ISBN 9788434465053. URL https://books.google.com/books?id=xqAYSxmeIJMC.

Ralph Ossa. Why trade matters after all. *Journal of International Economics*, 97(2):266–277, 2015. doi: 10.1016/j.jinteco.2015.07. URL https://ideas.repec.org/a/eee/inecon/v97y2015i2p266-277.html.

L. Prados de la Escosura. Spains Historical National Accounts: Expenditure and Output, 1850-2015. Working Papers 0103, European Historical Economics Society (EHES), September 2016. URL https://ideas.repec.org/p/hes/wpaper/0103.html.

L. Prados de la Escosura. *Spanish Economic Growth, 1850–2015*. Palgrave Studies in Economic History. Springer International Publishing, 2017. ISBN 9783319580425. URL https://books.google.com/books?id=Jho0DwAAQBAJ.

Stephen J. Redding. Goods Trade, Factor Mobility and Welfare. NBER Working Papers 18008, National Bureau of Economic Research, Inc, April 2012. URL https://ideas.repec.org/p/nbr/nberwo/18008.html.

S. Roldan and J.L.G. Delgado. *La formación de la sociedad capitalista en España, 1914-1920*. Number v. 2 in Publicaciones del Fondo para la Investigación Económica y Social de la Confederación Española de Cajas de Ahorros: Fondo para la Investigación Económica y Social. Confederacion Española de Cajas de Ahorro, 1973. URL https://books.google.com/books?id=SG7iXwAACAAJ.

J. M. C. Santos Silva and Silvana Tenreyro. The Log of Gravity. *The Review of Economics and Statistics*, 88(4):641–658, November 2006. URL https://ideas.repec.org/a/tpr/restat/v88y2006i4p641-658.html.

Javier Silvestre. Internal migrations in spain, 1877-1930. *European Review of Economic History*, 9(2):233–265, 2005. ISSN 13614916, 14740044. URL http://www.jstor.org/stable/41378422.

Javier Silvestre, Maria Isabel Ayuda, and Vicente Pinilla. The occupational attainment of migrants and natives in barcelona, 1930. *The Economic History Review*, 68(3):985–1015, 2015. ISSN 1468-0289. doi: 10.1111/ehr.12090. URL http://dx.doi.org/10.1111/ehr.12090.

X. Tafunell and A. Carreras. *Entre el imperio y la globalización: Historia económica de la España contemporánea*. Crítica/Historia del Mundo Moderno. Grupo Planeta, 2018. ISBN 9788491990369. URL https://books.google.com/books?id=uJVlDwAAQBAJ.

Trevor Tombe and Xiaodong Zhu. Trade, Migration, and Productivity: A Quantitative Analysis of China. *American Economic Review*, 109(5):1843–1872, May 2019. URL https://ideas.repec.org/a/aea/aecrev/v109y2019i5p1843-72.html.

Petia Topalova. Factor immobility and regional impacts of trade liberalization: Evidence on poverty from india. *American Economic Journal: Applied Economics*, 2(4):1–41, October 2010. doi: 10.1257/app.2.4.1. URL https://www.aeaweb.org/articles?id=10.1257/app.2.4.1.

Nikolaus Wolf. Was Germany Ever United? Evidence from Intra- and International Trade, 1885-1933. *The Journal of Economic History*, 69(03):846–881, September 2009.

A Additional derivations

This section provides additional derivations. Subsection A.1 provides comprehensive derivations for the comparative statics result regarding the impact of a trade shock on wages and prices. Subsection A.2 provides the derivations to obtain the welfare expression in the simple model and A.3 provides the derivation for the welfare expression in the extended model.

A.1 The impact of a trade shock on wages and prices

I derive a first-order approximation of the equilibrium conditions as in Kleinman et al. (2020). Detailed derivations are provided in the online appendix. Differentiating the labor market clearing condition (11) and combining with the differentiated condition for reallocation shares (14) we obtain,

$$d\ln \ell_i' = \gamma \sum_{n=1}^{N^D} \omega_{in} \times d\ln v_{ni} - \gamma \sum_{n=1}^{N^D} \omega_{in} \times \sum_{h=1}^{N^D} \sigma_{nh} d\ln v_{nh}$$

where $\omega_{ni} \equiv \sigma_{ni}\frac{\ell_n}{\ell_i'}$ is a weight that reflects the importance of labor flows originating in location n for employment dynamics in location i. Simplifying and assuming migration costs to be constant across time, $d\ln \mu_{nh} = 0$, we can derive changes in labor supply in matrix notation,

$$\mathrm{d}\ln \mathbf{l}' = -\gamma\Omega \mathrm{d}\ln \mathbf{w} \tag{23}$$

where $\gamma\Omega$ is matrix of partial elasticities of labor supply where $\boldsymbol{\Omega} \equiv \left[\left(\sum_{n=1}^{N} \omega_{in}\sigma_{nh} - 1_{i=h}\right)\right]_{ih}$. Similarly, differentiating the goods market clearing condition (10) and considering a small shock to foreign endowments, $\mathrm{d}\ln e_l \neq 0$, but assuming that trade frictions and productivity shocks remain unaffected ($\mathrm{dln}\, \tau_{ni} = 0$, $\mathrm{dln}\, z_h = 0$). We can obtain,

$$\begin{aligned}\mathrm{d}\ln w_i + \mathrm{d}\ln \ell_i = &\sum_{n=1}^{N^D} t_{in}\left(\mathrm{d}\ln w_n + \mathrm{d}\ln \ell_n\right) + \theta\left(\sum_{n=1}^{N^D} m_{in}\mathrm{d}\ln w_n\right) \\ &+ \theta\left(\sum_{n=1}^{N^D} m_{in}^f \mathrm{d}\ln w_n\right) + \sum_{h=1}^{N^D} t_{il}^f \mathrm{d}\ln e_l\end{aligned}$$

where $t_{in} = \frac{s_{ni}w_n\ell_n}{w_i\ell_i}$, $t_{in}^f = \frac{s_{li}e_l}{w_i\ell_i}$, $m_{in} = \sum_{h=1}^{N^D} t_{ih}s_{hn} - 1_{n=i}$, and $m_{in}^f = \sum_{l=1}^{N^F}\left(t_{il}^f s_{lh} - 1_{h=i}\right)$ which in matrix representation is given by,

$$\mathrm{d}\ln \mathbf{w} + \mathrm{d}\ln \mathbf{l} = \mathbf{T}\mathrm{d}\ln \mathbf{w} + \mathbf{T}\mathrm{d}\ln \mathbf{l} + \theta\mathbf{M}(\mathrm{d}\ln \mathbf{w}) + \theta\mathbf{M}^{\mathbf{F}}(\mathrm{d}\ln \mathbf{w}) + \mathbf{T}^F \mathrm{d}\ln \mathbf{e} \tag{24}$$

Combining labor supply (23) and labor demand (24) and we can obtain a combined equilibrium condition that entails that the wage response solves the following fixed point problem,

$$\mathrm{d}\ln\mathbf{w} = (\mathbf{U}\Omega)\,\mathrm{d}\ln\mathbf{w} + \mathbf{W}\mathrm{d}\ln\mathbf{e}$$

where $\mathbf{W} \equiv (\mathbf{I}-\mathbf{V})^{-1}\mathbf{T}^{F}$ measures the exposure to foreign expenditure shocks and $\mathbf{U} \equiv -(\mathbf{I}-\mathbf{V})^{-1}(\mathbf{I}-\mathbf{T})$ measures the extent to which additional labor adjustments can lower the local wage pressure, and where $\boldsymbol{\Omega} \equiv \left[(n_{ih} - 1_{i=h})\right]_{ih}$. This can be solved for the wage response,

$$\mathrm{d}\ln\mathbf{w} = \mathbf{Z}\mathrm{d}\ln\mathbf{e}$$

where $\mathbf{Z} \equiv (\mathbf{I}-\mathbf{U}\boldsymbol{\Omega})^{-1}\, W$ which adjusts the direct response of the foreign expenditure shock for labor market linkages. Note that we can write this expression in terms of total wage changes as a response to all expenditure changes in matrix notation using the Neumann series,

$$\Delta\ln\mathbf{w} = \mathbf{W}\Delta\ln\mathbf{e} + \sum_{k=1}^{\infty}(\mathbf{U}\boldsymbol{\Omega})^{k}\times\mathbf{W}\times\Delta\mathrm{d}\ln\mathbf{e}$$

To build some intuition for the result, let us focus on the simpler case where we abstract from substitution patterns in the goods market and assume that expenditure shares are fixed. In this case we have,

$$(\mathbf{I}-\mathbf{T})\,\mathrm{d}\ln\mathbf{w} + (\mathbf{I}-\mathbf{T})\,\mathrm{d}\ln\mathbf{l} = \mathbf{T}^{F}\mathrm{d}\ln\mathbf{e}$$

which we can solve for the response of labor and wages in terms of foreign expenditure shocks,

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

Substituting for the endogenous labor supply response and solving out for the overall effect on wages, we obtain,

$$\mathrm{d}\ln\mathbf{w} = (\mathbf{I}-\gamma\Omega)^{-1}(\mathbf{I}-\mathbf{T})^{-1}\,\mathbf{T}^{F}\mathrm{d}\ln\mathbf{e}$$

To illustrate this result, we can re-express the Leontief inverse in a Neumann series and obtain an expression for the elasticity of wages with regard country-specific expenditure shocks,

$$\left[\frac{\partial \ln w_i}{\partial \ln e_l}\right]_{il} = (1-\gamma)\left[\frac{s_{li}e_l}{y_i} + \frac{1}{y_i}\sum_j s_{ji} \times y_j \times \left(\frac{s_{lj}e_l}{y_j}\right) + ...\right]_i \tag{25}$$

$$+\gamma \sum_h \left[\frac{s_{lh}e_h}{y_h} + \frac{1}{y_h}\sum_j s_{jh} \times y_j \times \left(\frac{s_{lj}e_l}{y_j}\right) + ...\right]_i \sum_{n=1}^{N} \omega_{in}\sigma_{nh} + ...$$

$$= (1-\gamma)\left[\frac{s_{li}e_l}{y_i} + \frac{1}{y_i}\sum_j s_{ji} \times y_j \times \left(\frac{s_{lj}e_l}{y_j}\right) + ...\right]_i + \tag{26}$$

$$\gamma \sum_h n_{ih}\left[\frac{s_{lh}e_h}{y_h} + \frac{1}{y_h}\sum_j s_{jh} \times y_j \times \left(\frac{s_{lj}e_l}{y_j}\right) + ...\right]_i + ... \tag{27}$$

which implies that the impact of foreign demand shock on local wages can be written as the direct impact on the local labor market as well as the indirect impact on other labor markets where the appropriate weights are given by the labor market linkages. This corresponds to the main expression in the paper.

A.2 Aggregate welfare in the simple model

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. Specifically, I will derive an expression for ex-ante expected aggregate welfare in the second period, when the geographical location of a worker in period one is not known. 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 be 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 (**??**). 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,

$$\mathcal{W}' \equiv E\left(\Omega_n'\right) = \delta \left[\sum_{n=1}^{N^D} \left(\tilde{\rho}_n \Omega_n'\right)^{\epsilon}\right]^{1/\epsilon}$$

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. Totally differentiating the welfare expression, we obtain,

$$\begin{aligned} d\ln\mathcal{W} &= \sum_{n=1}^{N^D} d\ln\Omega_n \times \frac{\tilde{\rho}_n\Omega_n^{\epsilon}}{\sum_{n=1}^{N^D}\left(\tilde{\rho}_n\Omega_n\right)^{\epsilon}} \\ &= \sum_{n=1}^{N^D} d\ln\Omega_n \times \pi_i \end{aligned}$$

where $\pi_i = \frac{\ell_i}{\sum_i \ell_i}$ is the population share observed in the data in the baseline period. Integrating, we obtain,

$$\left(\frac{\mathcal{W}^1}{\mathcal{W}^0}\right) = \prod_{n=1}^{N^D}\left(\frac{\Omega_n^1}{\Omega_n^0}\right)^{\pi_i} \quad = \prod_{n=1}^{N^D}\left(\prod_{m=1}^{N^D}\left(\frac{v_{nm}^1}{v_{nm}^0}\right)^{\sigma_{nm}}\right)^{\pi_n} = \prod_{m=1}^{N^D}\left(\frac{u_m^1}{u_m^0}\right)^{\pi_m'} \tag{28}$$

where in the first I substituted for the expression for changes of the option values (**??**) and in the second step I simplified the expression assuming that migration costs are time-invariant, $d\ln\mu_{ni} = 0$. This formula expressses aggregate welfare changes as a power index of the population weighted utility changes in each domestic location. We can similarly derive an expression for the change of indirect utility in each location. Totally differentiating indirect utility,

$$\mathrm{d}\ln u_n = \mathrm{d}\ln w_n - \delta\mathrm{d}\ln r_n - (1-\delta)\left(\sum_{i=1}^{N^D} s_{ni}\mathrm{d}\ln p_{ni} + \sum_{l=1}^{N^F} s_{nl}\mathrm{d}\ln p_{nl}\right) \tag{29}$$

which expresses changes in the indirect utility in location $n$as the sum of a direct income effect $\mathrm{d}\ln w_n$ net changes in the price index. Changes in the price index in turn depend on changes in prices of domestic and foreign varieties as well as the rental rate of housing, where δ is the housing expenditure share that weights the relative importance of housing cost vis-a-vis good consumption. The constant elasticity of demand system implies for foreign expenditure shares,

$$\mathrm{d}\ln s_{nl} - \mathrm{d}\ln s_{nD} = -(\sigma-1)\left(\mathrm{d}\ln p_{nl} - \mathrm{d}\ln p_{nD}\right)$$

where $\mathrm{d}\ln p_{nD}$ refers to (log) changes in the domestic price index and $\mathrm{d}\ln s_{nD}$ refers to (log) changes in the domestic expenditure share. This can be solved for $\mathrm{d}\ln p_{nl}$ and substituted into the expression for changes of indirect utility (29) . Simplifying and integrating we finally obtain,

$$\left(\frac{u_n^1}{u_n^0}\right) = \left(\frac{w_n^1}{w_n^0}\right)\left(\frac{r_n^1}{r_n^0}\right)^{-\delta}\left(\frac{s_D^1}{s_D^0}\right)^{-\frac{(1-\delta)}{\sigma-1}}\prod_{i=1}^{N^D}\left(\frac{w_i^1}{w_i^0}\right)^{-(1-\delta)s_{ni}}$$

Combining this with the expression for aggregate welfare changes (28) we obtain,

$$\left(\frac{\mathcal{W}^1}{\mathcal{W}^0}\right) = \left(\frac{s_D^{1\prime}}{s_D^{0\prime}}\right)^{-\frac{(1-\delta)}{\sigma-1}}\prod_{n=1}^{N^D}\left(\frac{r_n^{1\prime}}{r_n^{0\prime}}\right)^{-\delta\pi_n^\prime}\left(\frac{w_n^{1\prime}}{w_n^{0\prime}}\right)^{\pi_n^\prime-\alpha_n^\prime}$$

which corresponds to the main expression in the paper.

A.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 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 $\delta = \Gamma\left(\frac{\gamma}{\gamma-1}\right)$ and $\Gamma(\cdot)$ is the gamma function and we impose $\gamma > 1$ to obtain a finite value for the expected utility. 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 $\pi_{i,r} = \frac{\ell_{i,r}}{\sum_i\sum_r \ell_{i,r}}$ is the population share observed in the data in the baseline period. Furthermore, substituting the expression for changes of the option values (**??**) and assuming that migration costs are time-invariant, $d\ln\mu_{ni} = 0$, we obtain,

$$\left(\frac{\mathcal{W}^1}{\mathcal{W}^0}\right) = \prod_{n=1}^{N^D}\prod_{r=1}^{S}\left(\frac{u_{n,r}^1}{u_{n,r}^0}\right)^{\pi_{n,r}^\prime} \tag{30}$$

where $\pi_i^\prime = \frac{\ell_i^\prime}{\sum_i \ell_i^\prime}$ is the population share observed in the data in the shifted period. This expressses aggregate welfare changes as a power index of the population weighted utility changes in each domestic location. We can similarly derive an expression for the change of indirect utility in each location. Totally differentiating indirect utility,

$$\mathrm{d}\ln u_{n,r} = \mathrm{d}\ln w_{n,r} + \mathrm{d}\ln \bar{d} - \delta \mathrm{d}\ln r_n - (1-\delta)\left(\sum_{r=1}^{S}\sum_{i=1}^{N^D} s_{ni,r}\mathrm{d}\ln p_{ni,r} + \sum_{r=1}^{S}\sum_{l=1}^{N^F} s_{nl,r}\mathrm{d}\ln p_{nl,r}\right) \quad (31)$$

which expresses changes in the indirect utility in location $n$as the sum of a direct income effect $\mathrm{d}\ln w_n$ net changes in the price index. Changes in the price index in turn depend on changes in prices of domestic and foreign varieties as well as the rental rate of housing, where δ is the housing expenditure share that weights the relative importance of housing cost vis-a-vis good consumption. The constant elasticity of demand system implies for foreign expenditure shares,

$$\mathrm{d}\ln s_{nl,r} - \mathrm{d}\ln s_{nD,r} = -(\sigma_r - 1)\left(\mathrm{d}\ln p_{nl,r} - \mathrm{d}\ln p_{nD,r}\right)$$

where $\mathrm{d}\ln p_{nD,r}$ refers to (log) changes in the domestic sector-specific price index and $\mathrm{d}\ln s_{nD}$ refers to (log) changes in the domestic sector-specific expenditure share. This can be solved for $\mathrm{d}\ln p_{nl}$ and substituted into the expression for changes of indirect utility (31). Simplifying and integrating we finally obtain,

$$\left(\frac{u^1_{n,r}}{u^0_{n,r}}\right) = \left(\frac{w^1_{n,r}}{w^0_{n,r}}\right)\left(\frac{\bar{d}^1}{\bar{d}^0}\right)\left(\frac{r^1_n}{r^0_n}\right)^{-\delta}\prod_{r=1}^{S}\left(\frac{s^1_{D,r}}{s^0_{D,r}}\right)^{-\frac{(1-\delta)}{\sigma_r-1}}\prod_{r=1}^{S}\prod_{i=1}^{N^D}\left(\frac{w^1_{i,r}}{w^0_{i,r}}\right)^{-(1-\delta)s_{nD,r}s_{ni,r}}$$

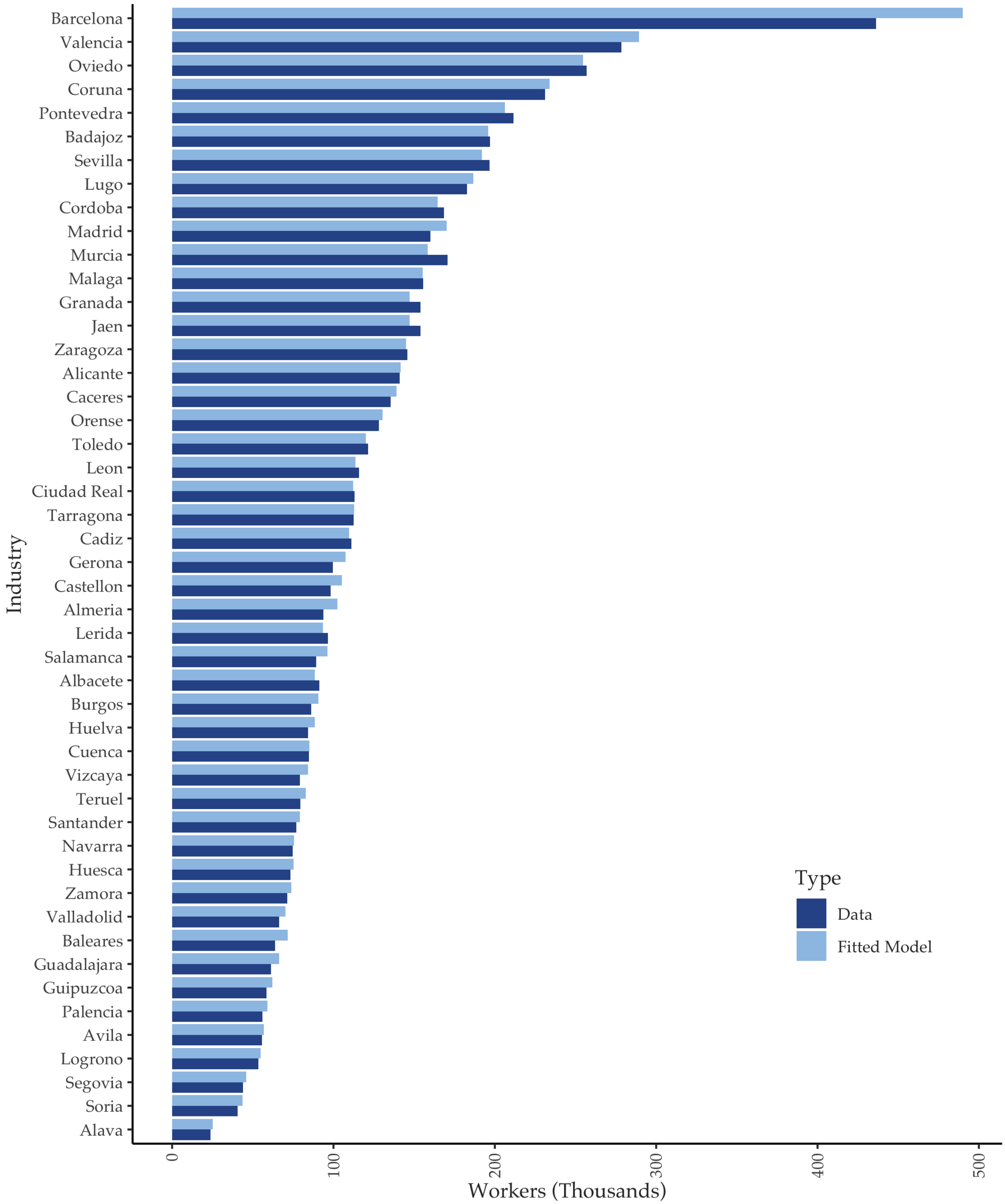
Combining this with the expression for aggregate welfare changes (30) we obtain,

$$\left(\frac{\mathcal{W}^1}{\mathcal{W}^0}\right) = \left(\frac{\bar{d}^1}{\bar{d}^0}\right)\prod_{s=1}^{S}\left(\frac{s^1_D}{s^0_D}\right)^{\frac{(1-\delta)}{\sigma_r-1}}\prod_{n=1}^{N^D}\left(\frac{r^1_i}{r^0_i}\right)^{-\delta\sum_r \pi'_{i,r}}\prod_{r=1}^{S}\left(\frac{w^1_{n,r}}{w^0_{n,r}}\right)^{\pi'_{n,r}-\alpha_{n,r}} \quad (32)$$

which corresponds to the main expression in the paper.

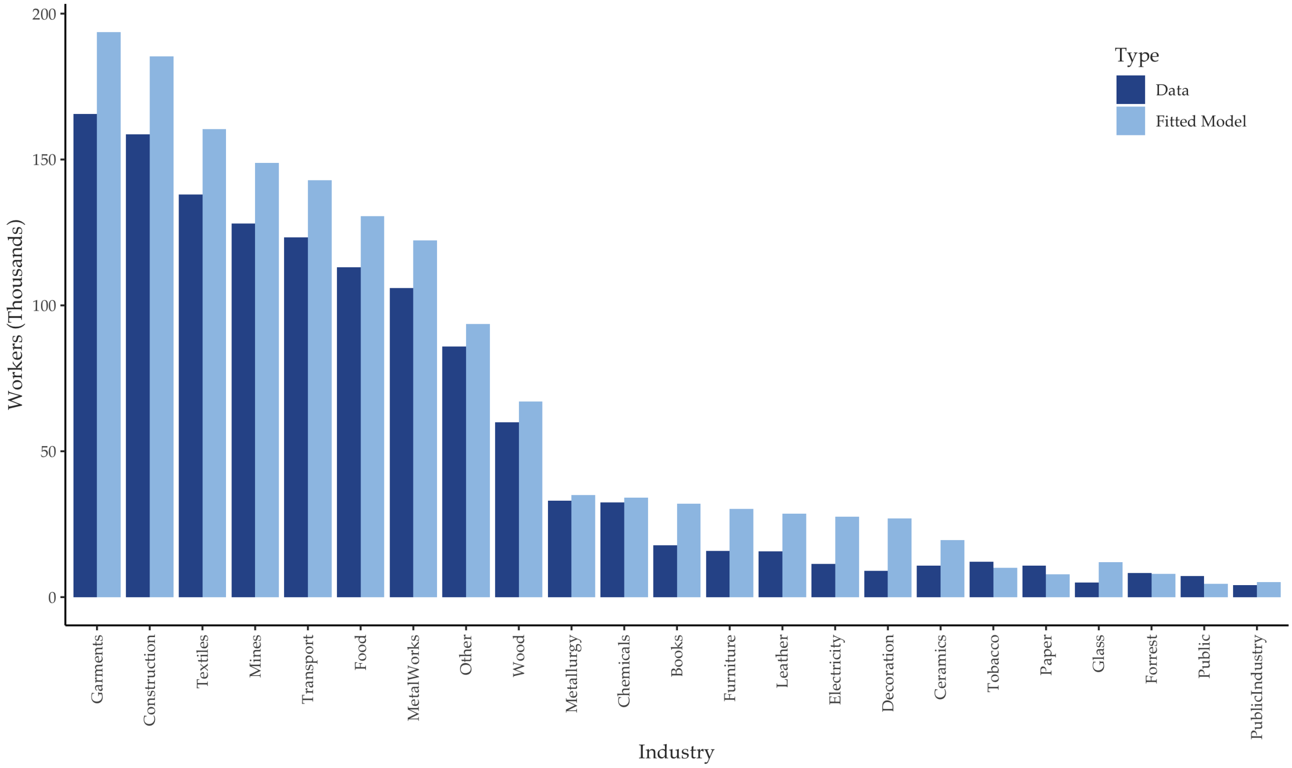
B Figures

Figure 8: Model Fit: Provincial Employment (1920 Data vs Fitted Model)



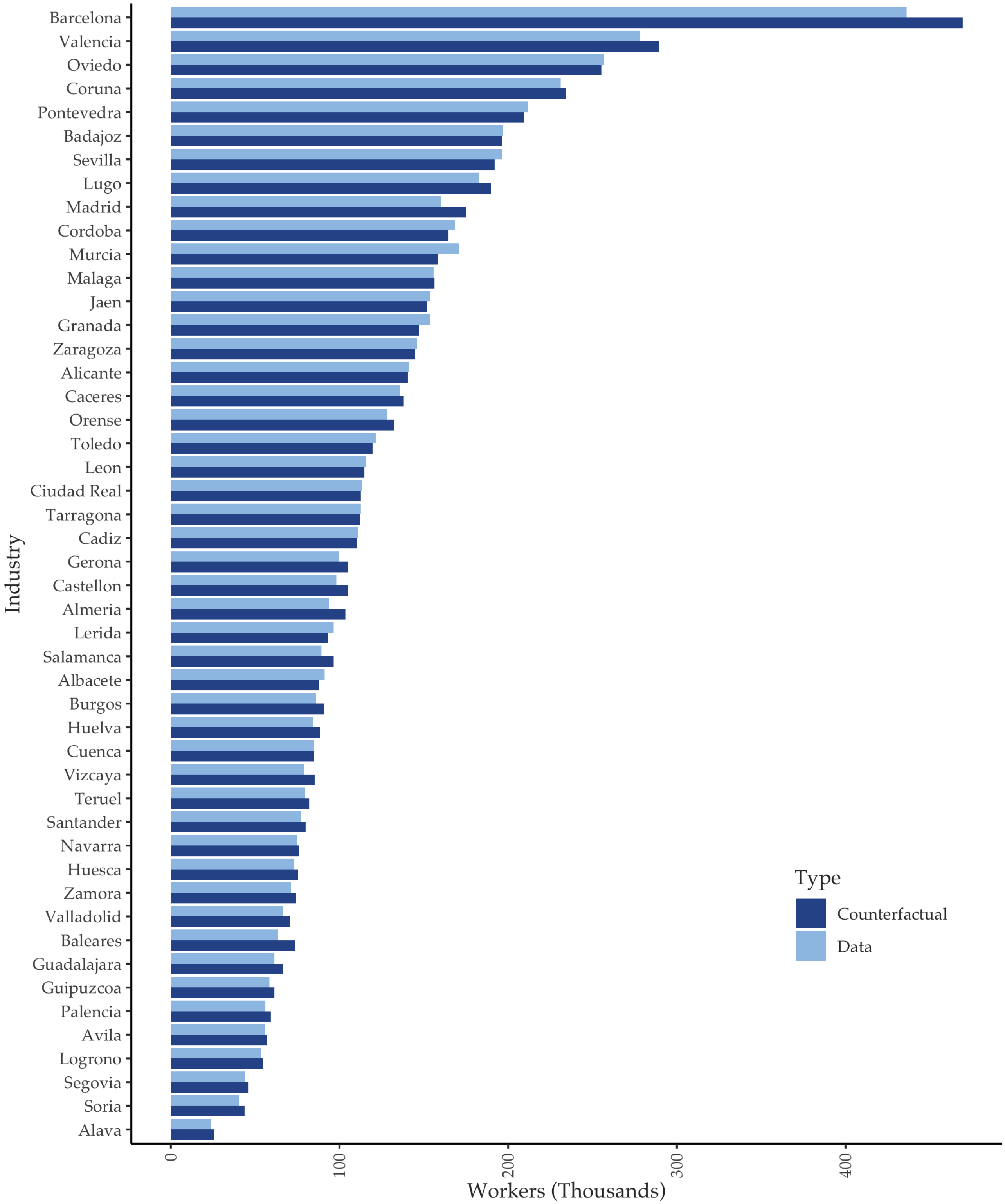
***Notes*:** This figure reports the provincial employment across manufacturing and agriculture and compares the observed data for 1920 with the fitted data from the model. The data source for the observed data is the salarios dataset. Additional details on data construction and sources can be found in the online appendix.

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



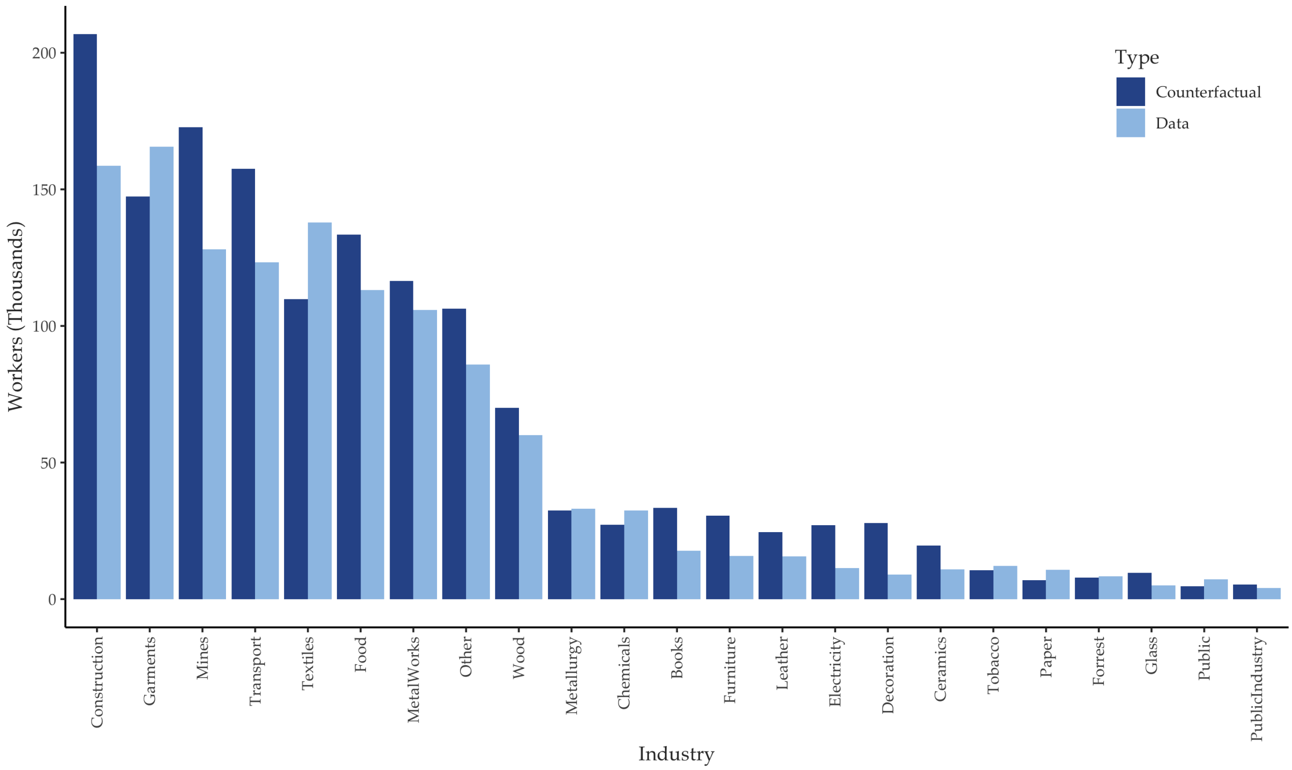
***Notes*:** This figure reports the sector employment across the manufacturing sector only and compares the observed data for 1920 with the fitted data from the model. The data source for the observed data is the salarios dataset. Additional details on data construction and sources can be found in the online appendix.

Figure 10: No WWI Cfl: Provincial Employment (1920 Data vs Cfl)



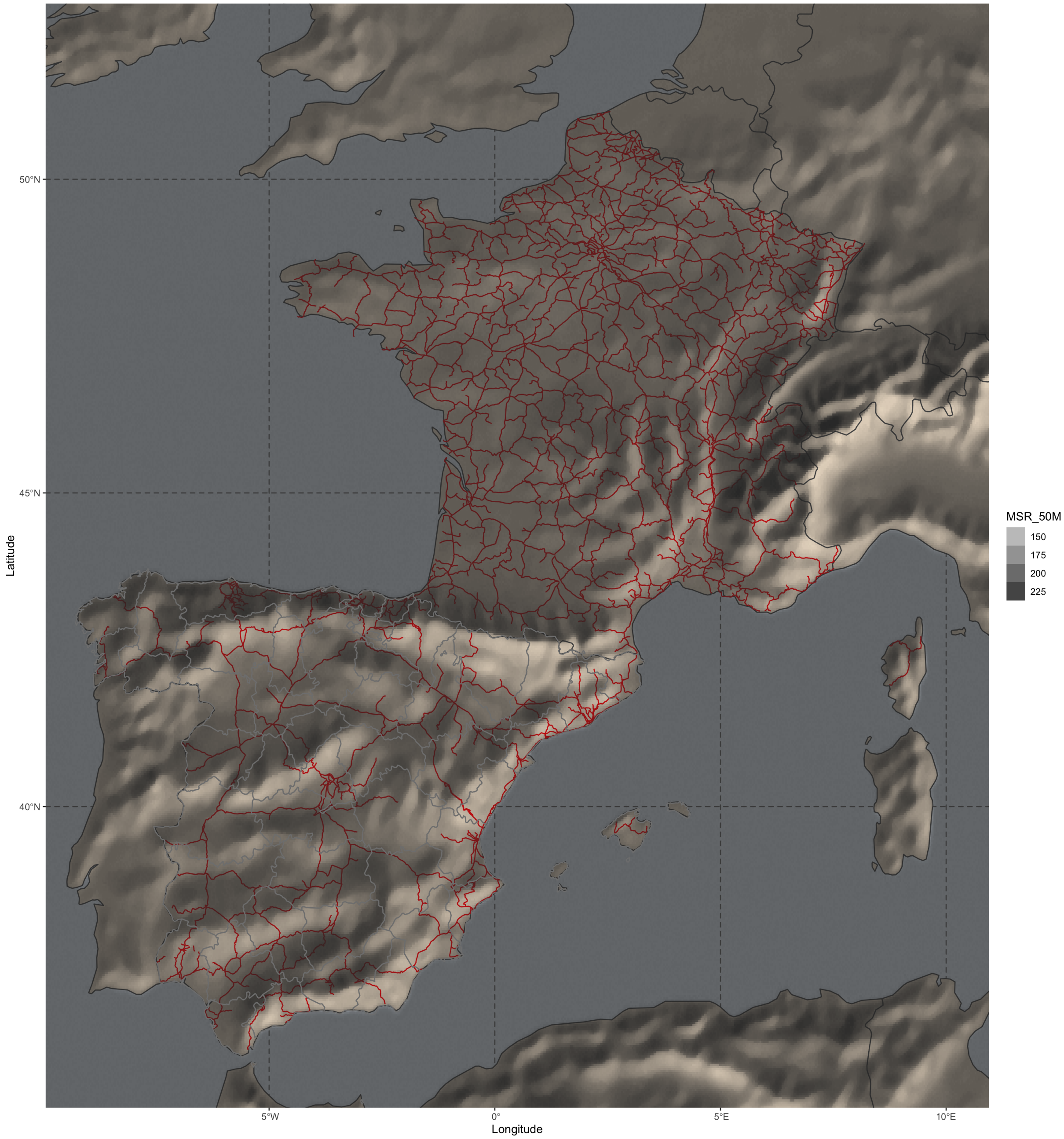
***Notes*:** This figure reports the provincial employment across manufacturing and agriculture and compares the observed data for 1920 with the counterfactual predictions of subsection 6.3.2. The data source for the observed data is the salarios dataset. Additional details on data construction and sources can be found in the online appendix.

Figure 11: No WWI Cfl: Sectoral Employment (1920 Data vs Cfl)



***Notes*:** This figure reports the sector employment for manufacturing only and compares the observed data for 1920 with the counterfactual predictions of subsection 6.3.2. The data source for the observed data is the salarios dataset. Additional details on data construction and sources can be found in the online appendix.

Figure 12: 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.

C Regression Tables

Table 7: Regression Results: Event Study on Belligerent Sectoral Exports I

	Exports (Value)		
	(1)	(2)	(3)
War Period × sectorfBooks	-0.1485* (0.0842)	-0.1868 (0.1638)	-0.1876 (0.1378)
War Period × sectorfCeramics	-0.1125 (0.1237)	-0.1206 (0.1805)	-0.1503 (0.1781)
War Period × sectorfChemicals	0.4627 (0.3105)	0.5411** (0.2279)	0.5059* (0.2619)
War Period × sectorfConstruction	-0.1809 (0.2154)	-0.2411 (0.2100)	-0.0946 (0.1918)
War Period × sectorfDecoration	0.9033*** (0.0750)	1.115** (0.5650)	1.172** (0.4553)
War Period × sectorfElectricity	0.2386*** (0.0912)	0.4978** (0.2053)	0.5651* (0.3005)
War Period × sectorfFood	-0.0131 (0.1485)	0.0355 (0.0923)	0.0151 (0.1097)
War Period × sectorfForrest	-0.4357*** (0.0775)	-0.2516 (0.3368)	-0.1254 (0.3669)
War Period × sectorfFurniture	0.0173 (0.1794)	0.0187 (0.1455)	-0.0659 (0.1980)
War Period × sectorfGarments	0.8590** (0.3610)	0.8169** (0.3813)	0.8534** (0.3447)
War Period × sectorfGlass	0.2549*** (0.0864)	0.2417 (0.1735)	0.3015 (0.1922)
War Period × sectorfGold	-0.5324*** (0.0869)	-0.4646** (0.2082)	-0.1329 (0.1432)
War Period × sectorfLeather	1.398*** (0.0793)	1.299** (0.5298)	1.464*** (0.5488)
War Period × sectorfMetallurgy	-0.0869 (0.5726)	0.0526 (0.6430)	0.1032 (0.7236)
War Period × sectorfMetalWorks	-0.0374 (0.3094)	-0.0724 (0.2271)	0.0200 (0.2580)
War Period × sectorfMines	-0.3091** (0.1262)	-0.2873 (0.2447)	-0.2852 (0.2139)
War Period × sectorfOther	0.0575 (0.1680)	0.1330 (0.1232)	0.1597 (0.1536)
War Period × sectorfPaper	-0.5056 (0.6113)	-0.5340 (0.3274)	-0.5423 (0.3760)
War Period × sectorfPublicIndustry	-4.517*** (0.0772)	-4.466*** (1.254)	-1.663* (0.8527)
War Period × sectorfTextiles	0.6401*** (0.1629)	0.6930*** (0.2287)	0.6697*** (0.1463)
War Period × sectorfTobacco	2.063*** (0.0725)	1.655** (0.8426)	1.792** (0.9060)
War Period × sectorfTransport	0.4184* (0.2150)	0.0780 (0.1882)	-0.1988* (0.1016)
War Period × sectorfWood	-0.2650*** (0.0969)	-0.2551** (0.1227)	-0.2255* (0.1366)
Standard-Errors	Product	Destination	Destination×Product
Observations	80,153	80,150	79,920
Pseudo R^2	0.37127	0.66018	0.87355
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 equation3. 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.

Table 8: Regression Results: Event Study on Belligerent Sectoral Exports II

	Exports (Value)		
	(1)	(2)	(3)
war	2.157*** (0.3498)		
War Period × war	0.4450*** (0.1193)	0.3606*** (0.1298)	0.3039** (0.1279)
War Period × sectorfBooks	-0.0660 (0.0948)	-0.0870 (0.1888)	-0.0620 (0.1453)
War Period × sectorfCeramics	-0.0441 (0.1287)	-0.0173 (0.2232)	-0.0378 (0.1883)
War Period × sectorfChemicals	0.2806 (0.2028)	0.3686 (0.2474)	0.3206* (0.1911)
War Period × sectorfConstruction	-0.1464 (0.2563)	-0.1509 (0.2536)	-0.0476 (0.2086)
War Period × sectorfDecoration	0.6597*** (0.0863)	0.7592 (0.7479)	0.6579 (0.5264)
War Period × sectorfElectricity	0.2567 (0.3117)	0.3125 (0.2241)	0.6241* (0.3679)
War Period × sectorfFood	-0.1064 (0.1622)	-0.0353 (0.1109)	-0.0546 (0.1173)
War Period × sectorfForrest	-0.4627 (0.3099)	-0.3226 (0.4264)	-0.0622 (0.4258)
War Period × sectorfFurniture	0.0457 (0.1082)	0.0803 (0.1921)	-0.0443 (0.1609)
War Period × sectorfGarments	0.0884 (0.1402)	0.0307 (0.1896)	0.0641 (0.1462)
War Period × sectorfGlass	0.1485 (0.1148)	0.1074 (0.2032)	0.1635 (0.1772)
War Period × sectorfGold	-0.0902 (0.1394)	-0.3517 (0.4784)	-0.0149 (0.4599)
War Period × sectorfLeather	0.1324 (0.0913)	-0.0191 (0.3682)	-0.0853 (0.3164)
War Period × sectorfMetallurgy	-0.8169 (0.8447)	-0.6881** (0.3123)	-0.5401 (0.6953)
War Period × sectorfMetalWorks	-0.2779 (0.2230)	-0.2488 (0.3636)	-0.2348 (0.2878)
War Period × sectorfMines	-0.3028** (0.1467)	-0.2414 (0.2918)	-0.2091 (0.2475)
War Period × sectorfOther	0.1087 (0.2032)	0.1672 (0.1636)	0.2643 (0.1712)
War Period × sectorfPaper	-0.6159 (0.7420)	-0.5968* (0.3259)	-0.6156 (0.3906)
War Period × sectorfPublicIndustry	-4.564*** (0.0872)	-4.982*** (1.354)	-0.2896 (1.044)
War Period × sectorfTextiles	0.3228*** (0.1250)	0.3550* (0.2051)	0.3392** (0.1479)
War Period × sectorfTobacco	0.1316 (0.0854)	-0.2341 (0.5415)	-0.2683 (0.5325)
War Period × sectorfTransport	-0.9269*** (0.2970)	-0.4985** (0.2085)	-0.5699** (0.2712)
War Period × sectorfWood	-0.1150 (0.1346)	-0.1075 (0.1244)	-0.0476 (0.1819)
war × sectorfBooks	-2.490*** (0.5671)	-2.635*** (0.5588)	
war × sectorfCeramics	-1.947*** (0.5745)	-1.774*** (0.4910)	
war × sectorfChemicals	-0.8931** (0.4111)	-0.8100*** (0.3022)	
war × sectorfConstruction	-2.474*** (0.6326)	-2.535*** (0.4092)	
war × sectorfDecoration	-1.415*** (0.3408)	-1.885*** (0.5523)	
war × sectorfElectricity	-1.092** (0.4732)	-1.152 (0.7256)	
war × sectorfFood	-0.3773 (0.4196)	-0.3935** (0.1940)	
war × sectorfForrest	-1.469 (1.236)	-0.8065** (0.3529)	
war × sectorfFurniture	0.1383 (0.3499)	0.0798 (0.2937)	
war × sectorfGarments	-0.3911 (0.5162)	-0.5617 (0.4409)	
war × sectorfGlass	-0.2567 (0.8971)	-0.4526 (0.4154)	
war × sectorfGold	0.4689 (0.7600)	0.8851* (0.5292)	
war × sectorfLeather	-0.0914 (0.3505)	-0.1204 (0.4995)	
war × sectorfMetallurgy	-2.362*** (0.6252)	-1.748 (1.155)	
war × sectorfMetalWorks	-1.713*** (0.5054)	-1.034*** (0.1590)	
war × sectorfMines	-2.653*** (0.5188)	-2.023*** (0.2557)	
war × sectorfOther	-1.430*** (0.4081)	-1.152*** (0.3292)	
war × sectorfPaper	-2.682*** (0.6753)	-2.668*** (0.4695)	
war × sectorfPublicIndustry	-4.852*** (0.3459)	-5.211*** (0.9802)	
war × sectorfTextiles	-0.6363 (0.4487)	-0.6726* (0.4028)	
war × sectorfTobacco	-1.678*** (0.3620)	-2.041*** (0.5737)	
war × sectorfTransport	1.248 (1.124)	0.8744** (0.3636)	
war × sectorfWood	-0.0416 (0.7172)	-0.0387 (0.1269)	
War Period × war × sectorfBooks	-0.4240*** (0.1224)	-0.4479* (0.2422)	-0.4918** (0.2166)
War Period × war × sectorfCeramics	-0.1967 (0.5636)	-0.2415 (0.2445)	-0.2327 (0.5691)
War Period × war × sectorfChemicals	0.7847* (0.4131)	0.6959*** (0.2541)	0.7404 (0.5810)
War Period × war × sectorfConstruction	0.2562 (0.5784)	0.4499 (0.3068)	0.5604 (0.3591)
War Period × war × sectorfDecoration	1.156*** (0.1154)	1.015 (0.7483)	1.097** (0.5383)
War Period × war × sectorfElectricity	0.0299 (0.6813)	0.2646 (0.2361)	-0.1397 (0.5607)
War Period × war × sectorfFood	0.3737* (0.1973)	0.2821** (0.1313)	0.2903 (0.2310)
War Period × war × sectorfForrest	0.3414 (1.117)	0.2226 (0.9125)	-0.1073 (0.8775)
War Period × war × sectorfFurniture	-0.0830 (0.5575)	-0.1585 (0.2657)	-0.0532 (0.4632)
War Period × war × sectorfGarments	1.577*** (0.3567)	1.681*** (0.1974)	1.615*** (0.3872)
War Period × war × sectorfGlass	0.2513 (0.5883)	0.4286* (0.2329)	0.4184 (0.4099)
War Period × war × sectorfGold	-0.5400*** (0.1400)	-0.0934 (0.4918)	-0.3023 (0.4883)
War Period × war × sectorfLeather	1.754*** (0.1202)	2.044*** (0.3772)	2.146*** (0.3353)
War Period × war × sectorfMetallurgy	2.246*** (0.7160)	2.153** (0.9972)	1.949* (0.9999)
War Period × war × sectorfMetalWorks	0.4866 (0.6550)	0.6706* (0.3494)	0.8669 (0.6257)
War Period × war × sectorfMines	0.2629 (0.2418)	0.1501 (0.2917)	0.1012 (0.3136)
War Period × war × sectorfOther	-0.0409 (0.3378)	-0.0747 (0.1867)	-0.2295 (0.3759)
War Period × war × sectorfPaper	1.623 (0.9987)	1.596*** (0.3095)	1.627*** (0.5349)
War Period × war × sectorfPublicIndustry	0.5846*** (0.1169)	1.124 (1.370)	-3.612*** (1.080)
War Period × war × sectorfTextiles	1.004*** (0.2017)	0.9789*** (0.2025)	0.9237*** (0.2683)
War Period × war × sectorfTobacco	3.418*** (0.1326)	3.807*** (0.5350)	3.849*** (0.5431)
War Period × war × sectorfTransport	0.5979** (0.2684)	0.2391 (0.2167)	0.2502 (0.2969)
War Period × war × sectorfWood	-0.4010** (0.1571)	-0.4082*** (0.1271)	-0.4802** (0.2135)
Standard-Errors	Product	Destination	Destination×Product
Observations	80,143	80,143	79,914
Pseudo R^2	0.49093	0.67890	0.87870
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 equation2. 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.

Table 9: Regression Results: Price Regressions First Stage

	log(Wage) (1)	log(Quantity) (2)
log(indirect_local+1)	0.0897*** (0.0284)	-0.0769** (0.0389)
log(indirect_spatial+1)	0.0225 (0.0282)	-0.0202 (0.0393)
log(direct+1)	0.1745** (0.0709)	0.0708 (0.1228)
i(var=log(dist),f=Yearf,ref=1914)	-0.1763*** (0.0292)	-0.0764* (0.0453)
R^2	0.96072	0.98776
Observations	2,153	2,153
Pseudo R^2	2.0312	1.2883
Industry×Worker Type×Province fixed effects	✓	✓
Year×Industry fixed effects	✓	✓

***Notes*:** This table reports the results of the first stage for estimating the structural equation 22. The first stage predicts the endogenous variables $\log w_{ist}$, denoting (log) wage changes between 1920 and 1914 at the province-sector-level. The variables export_shock, local_minus_ind_shock and shock correspond to Shock $_{i,s}$, Local Shock $_{i,s}$ and Spatial Shock $_{i,s}$ respectively. The regressions are estimated by using the feols command of the fixest package in R. The source data are the yearly wage survey released by the Spanish government. Additional information on data digitization and construction is available in the online appendix.

Table 10: Results: Mobility Cost Estimation Sectoral Parameters

Sector	μ_{rs}
Agriculture	0.01
Books	0.00
Ceramics	0.00
Chemicals	0.02
Construction	0.55
Decoration	0.00
Electricity	0.00
Food	0.33
Forrest	0.00
Furniture	0.00
Garments	0.50
Glass	0.00
Leather	0.00
Metallurgy	0.01
MetalWorks	0.21
Mines	0.50
Other	1.00
Paper	0.00
Public	0.00
PublicIndustry	0.00
Textiles	0.43
Tobacco	0.02
Transport	0.35
Wood	0.07

***Notes*:** This table reports the results of the migration cost estimation. The tables reports the sectoral switching costs across all 24 different sectors.

Table 11: Results: Mobility Cost Estimation Geographical Parameters

Province	β_n	ζ_n
Alava	0.33	0.08
Albacete	0.60	0.00
Alicante	0.76	0.01
Almeria	0.32	0.16
Avila	0.33	0.02
Badajoz	0.71	0.01
Baleares	0.09	0.00
Barcelona	1.00	1.00
Burgos	0.37	0.05
Caceres	0.88	0.00
Cadiz	0.35	0.15
Castellon	0.36	0.01
Ciudad Real	0.42	0.01
Cordoba	0.34	0.02
Coruna	0.45	0.09
Cuenca	0.48	0.02
Gerona	0.76	0.01
Granada	0.30	0.00
Guadalajara	0.18	0.00
Guipuzcoa	0.73	0.36
Huelva	0.40	0.00
Huesca	0.45	0.01
Jaen	0.09	0.00
Leon	0.29	0.02
Lerida	0.54	0.03
Logrono	0.48	0.11
Lugo	0.21	0.04
Madrid	0.54	0.88
Malaga	0.45	0.02
Murcia	1.00	0.05
Navarra	0.24	0.02
Orense	0.13	0.02
Oviedo	1.00	0.01
Palencia	0.31	0.02
Pontevedra	0.19	0.07
Salamanca	0.19	0.00
Santander	0.28	0.09
Segovia	0.29	0.00
Sevilla	0.59	0.06
Soria	0.37	0.01
Tarragona	0.29	0.01
Teruel	0.61	0.03
Toledo	0.24	0.00
Valencia	0.57	0.01
Valladolid	0.23	0.01
Vizcaya	0.36	0.12
Zamora	0.26	0.01
Zaragoza	0.37	0.00

***Notes*:** This table reports the results of the migration cost estimation. 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: $\mu_{ij} = \zeta_i^1 \times distance_{ij}^{\zeta^2}$.