The cost of trade disruptions at different stages of development*

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Abstract

We study the impact of trade disruptions at different stages of development in a two-country, three-sector model of Spain and the UK from 1850 to 2000. In our model, the impact of trade disruptions depends on trade openness and the productivity gap between the countries. A trade collapse today (more openness, less gap) that is comparable to the Inter-War Trade Collapse of a century ago decreases the capital stock threefold (12% instead of 4%) and lifetime consumption fourfold (1.58% instead of 0.37%). We highlight the importance of capital accumulation in amplifying the cost of trade disruptions. Furthermore, we find that the Inter-War Trade Collapse promoted Spanish industrialization, while the opposite would be true today.

Keywords: Trade disruption, International Trade, Structural transformation, Industrialization.
JEL Codes: F11, F12, N10, N60.

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1 Introduction

After the period of increased globalization and trade known as the Second Wave of Globalization (Baldwin and Martin, 1999), there are indications that we are now experiencing a new era of significant trade disruptions. This paper examines how the potential consequences of such disruptions differ depending on the countries' development stage. Specifically, countries that are still in the process of catching up to the technological frontier have a different composition of output and trade from those with higher levels of development. Given these differences, it is reasonable to anticipate that the effects of trade disruptions will vary.

There have been significant trade disruptions throughout history occurring after periods of expanding trade. One such episode was the Inter-War Trade Collapse (IWTC) that marked the end of the First Wave of Globalization from the mid-19th century to 1913. This event was followed by the Second Wave of Globalization, which we have experienced since the end of World War II. Spain and the UK provide an illustrative example of the evolution of trade and growth during those historical episodes. The UK is regarded as the technological frontier, while Spain initially lagged far behind in productivity. However, through an intense process of structural transformation, Spain caught up to the frontier. At the time of the IWTC, Spain's GDP per capita was well below that of the UK, and trade barriers were significant. Today, productivity and output composition in Spain are similar to that of the UK, and trade integration is profound (or it was before Brexit).

This paper presents a quantitative model that assesses the impact of trade disruptions in various developmental stages. To illustrate our point, we compare the effects of trade disruptions during the period of IWTC, characterized by significant disparities in productivity and limited trade integration, with a hypothetical disruption at the start of the 21st century. Additionally, we complement our theoretical analysis with comprehensive trade data dating back to 1850, which enables us to track the evolution of bilateral trade patterns during episodes of increased globalization.

Our paper makes several contributions. Firstly, we provide a detailed analysis of the composition of bilateral trade flows between Spain and the UK, starting from 1850. We achieve this by digitizing and categorizing information obtained from historical customs data from the "General Ledger of the Foreign Trade of Spain with its Overseas Possessions and Foreign Powers" for the years 1849-1855 and "General Statistical Report of the Foreign Trade of Spain with its Overseas Possessions and Foreign Powers" for the years 1856 and after. We manually assign each of these trade flows to SITC Rev.1 categories, enabling us to observe changes in trade patterns associated with structural transformation during a period of 150 years in Spain. We use this data to discipline the analysis of our research question.

Secondly, we develop a dynamic general equilibrium two-country model of trade and structural transformation. In this model, households accumulate capital and have Stone-Geary preferences over agriculture (modeled as a necessity), manufacturing, and services. Only intermediate goods are traded, with agriculture and services trade occurring "à la Armington" (Armington, 1969): one domestic and one foreign variety produced with constant returns to scale. On the other hand, manufacturing trade occurs "à la Krugman" (Krugman, 1980): many differentiated varieties produced with increasing returns to scale. This modelling choice is motivated by the patterns we document regarding increased trade in manufacturing varieties.

We calibrate the model using key moments of the Spanish economy in 1850 and 2000, and in addition we match the trend of exports to GDP in Spain, and GDP per working-age population in both Spain and the UK, from 1850 to 2000. Then, we validate our calibrated model by examining non-targeted moments along the transition path. The model accurately predicts the declining agricultural sector, moderate increase in the manufacturing sector, and secular increase in the services sector in Spain. It also captures the evolution of the capital stock and investment; Spain transitioned from investing 5 percent of GDP to investing 25 percent. Furthermore, the model reasonably explains the observed behavior of relative prices in Spain and the structural transformation in the UK from 1850 to 2000. On the trade side, the model correctly predicts the changes in the number of varieties that Spain imports and exports, as well as the shares of imports and exports that are accounted for by agriculture and manufacturing. Furthermore, the model replicates Spain's trade deficit in manufacturing from 1850 until the latter part of the 20th century.

Our paper's third contribution is a comparison of the effects of a trade disruption similar to the IWTC and a hypothetical trade collapse in the present day. We conduct two exercises to make this comparison. First, we compare the benchmark economy experiencing the IWTC to a counterfactual where the trade disruption did not occur. In the second exercise, we compare the benchmark economy with a low trade cost after 2000 to a counterfactual where a trade collapse similar to the IWTC occurs at the beginning of the 21st century. We make sure that the relative change in iceberg trade costs is comparable in both counterfactuals. Our findings reveal that during the IWTC, Spanish capital stock fell by 4 percent at its lowest point, while it would fall by up to three times as much today, at 12 percent. The decline in consumption follows a similar pattern, with manufacturing experiencing the greatest fall. We find that the drop on permanent consumption during the IWTC was 0.37% but it would be four times as high today, at 1.58%. These results imply that a trade collapse today would be considerably more costly than the IWTC in terms of output and household welfare.

Furthermore, we show that capital accumulation plays a crucial role to understand the effects of a trade collapse. To illustrate its importance, we compare the welfare losses of our benchmark model to a static version of the model without capital. We find that welfare costs in the static model are about half of those in the benchmark.

After presenting our main findings through the aforementioned counterfactuals, we investigate the underlying economic rationale for the difference in outcomes between the two episodes. In the first exercise, Spain's productivity is distant from UK's and initial trade costs are high. In the second exercise, the productivity gap and trade costs are relatively small. By conducting several numerical exercises, we demonstrate that the larger the gap between a country's productivity and the technological frontier, and the more open the economy, the more significant the negative impact of trade disruptions. Consequently, the IWTC is expected to be more costly for Spain because of its larger distance to the technological frontier. A trade collapse today is also expected to have a more significant impact because Spain's trade is now more open. Our two exercises indicate that the latter effect is quantitatively more significant for Spain. An essential implication of this study is that trade disruptions would be highly expensive for a country that is in the early stages of development and has a high degree of openness to trade with countries at the technological frontier. This is precisely the case of several countries today.

Furthermore, our main quantitative results show that during the IWTC there is an increase in the number of Spanish manufacturing varieties, and the opposite would happen today. When the technological gap between two countries is large (IWTC), the richer country has a comparative advantage in producing manufacturing goods, and the poorer country has a comparative advantage in the production of agriculture. In this case, the poorer country produces and exports agricultural goods and imports manufacturing goods. An increase in trade costs can foster industrialization of the poorer country, following a pattern of import-substitution. As trade becomes more costly, it increases the number of varieties produced domestically, leading to a rise in manufacturing output. By contrast, when both countries are rich (today), they engage in intra-industry trade by exchanging different varieties of manufacturing goods. In this case, an increase in trade barriers leads to a reduction in the manufacturing goods in both countries.

It is important to note that, while trade barriers can increase industrialization in the poorer country, they are still detrimental to welfare. The key feature explaining this outcome is that, for the poorer country, the marginal utility of having access to one more variety is very large, and the loss of access to a foreign variety triggers the country to substitute by producing more domestic varieties at a large cost.

Finally, we demonstrate that our main findings hold under many alternative calibrations of the model. We highlight the following two: first, we assume sector-neutral productivities in our benchmark exercises but acknowledge that sector-specific productivities are crucial for some studies. To address this, we perform a robustness exercise where we calibrate sector-specific productivities to match the evolution of value-added shares by sector. Second, our benchmark exercises assume weak complementarity between consumption goods by sector. However, Herrendorf, Rogerson, and Valentinyi (2013) suggests that stronger complementarity is necessary to explain structural transformation when looking at value-added per sector, at least for the United States after World War II. To test the sensitivity of our results to this assumption, we redo our benchmark exercises in a model with stronger complementarity between consumption goods by sector. Our main findings regarding the impact of trade disruptions remain robust to these alternative specifications.

Related literature: Our paper shares a methodological approach with several papers that build structural models to analyze the impact of a trade collapse. Steinberg (2019) and McGrattan and Waddle (2020) build structural models to analyze the impact of Brexit. Steinberg (2020) analyzes the impact of a potential termination of NAFTA. In a similar vein, our paper contributes to a growing literature that assesses the impact of trade policy changes in dynamic models with factor accumulation. Ravikumar, Santacreu, and Sposi (2019) study trade liberalizations in a model with capital accumulation and find large dynamic gains. Perri and Quadrini (2007) analyze the impact of the trade collapse in Italy during the Great Depression. They find that the trade collapse was a major cause of the economic downturn and emphasize its impact on investment. Crucini and Kahn (1996, 2007) argue that the global tariff war during Great Depression contributed to a fall in international output and investment because of its persistence and impact on capital accumulation. Alessandria and Choi (2007, 2014), Ruhl and Willis (2017), and Brooks and Pujolas (2018) focus on capital accumulation and firm creation. Kehoe, Ruhl, and Steinberg (2018) build a model of structural transformation and trade but focus on the US economy from 1992 to 2012.

The process of structural transformation has been widely studied since Kuznets (1973), with Kongsamut, Rebelo, and Xie (2001) showing how to rationalize structural transformation by introducing non-homothetic preferences, and Ngai and Pissarides (2007) doing so with differential productivity growth by sector. See Herrendorf, Rogerson, and Valentinyi (2014) for a thorough overview of the literature.[1]

The recent literature linking trade and structural transformation, which began with seminal contributions by Matsuyama (1992) and Echevarria (1995), has usually been confined

[1] Buera and Kaboski (2012) pioneered the introduction of sophisticated services into the analysis. Following Buera and Kaboski (2009) and Dennis and Iscan (2009), there has been a surge in the literature testing the model against observed historical patterns in the data. Some examples of this literature include Boppart (2014), Comin, Mestieri, and Lashkari (2021), and García-Santana, Pijoan-Mas, and Villacorta (2021).

to the analysis of a single open economy. Stokey (2001), Desmet and Parente (2012), and Ferreira, Pessôa, and dos Santos (2016) focus on the role of trade during the Industrial Revolution in England. Teignier (2018) builds a two-sector, small open economy model with capital accumulation to compare the cases of Great Britain and South Korea. Uy, Yi, and Zhang (2013) build a two-country, three-sector model with trade as in Eaton and Kortum (2002) without capital accumulation to also study South Korea's case.[2] Apart from the technical differences (we build a two-country, three-sector model with capital accumulation and trade in varieties à la Krugman, and we focus on the bilateral relationship between Spain and the UK), what most distinguishes our paper is that we study the impact of trade disruptions at different stages of the development process. That is, our longer time horizon allows us to validate our model against both key macro and trade patterns observed for Spain from 1850 to 2000 and make comparisons across different stages of the development process. Furthermore, our emphasis on the rise in the number of varieties in manufacturing complements Kehoe and Ruhl (2013), who argue that the extensive margin growth of least-traded varieties is brought about by structural change and moves little in response to business cycles.

In our model, we capture the IWTC through a rise in trade iceberg costs. This approach is supported by findings in Jacks, Meissner, and Novy (2008). They derive a micro-founded measure to estimate trade costs (e.g., tariffs, transportation costs, and other frictions that dampen trade) from 1870 to 2000 for France, the United States, and the UK. They find that the rise in trade costs explains the entire inter-war trade collapse.

Finally, the pattern of a country catching up to the technology frontier, as Spain did during the Second Wave of Globalization, is ubiquitous in the data as reported in Parente and Prescott (1994). All the cases the paper analyzes (Japan, South Korea, France, Germany, Taiwan) happened during the Second Wave of Globalization, but the analysis did not focus on the role of trade. Instead, we focus on the role that trade and its evolution played during periods of trade growth.

2 Data

This section provides a description of the data used, which starts in 1849-1850. First, we compute GDP per working age population (WAP) for Spain and the UK from 1850 to 2000. We use GDP data provided in Maddison Project (2013), expressed in Geary-Khamis dollars.

While WAP data from the World Bank's World Development Indicators is available from

[2] Betts, Giri, and Verma (2017) perform an analysis similar to Uy, Yi, and Zhang (2013), but in their model trade happens à la Armington.

1960, data from other sources is used to estimate WAP for years before 1960. Specifically, data from the Spanish *Instituto Nacional de Estadística* is used for Spain, while data from the 2020 edition of *Population estimates for the UK and constituent countries by sex and age; historical time series* (Office for National Statistics, 2020; 1911-1960) and a report on historical British labor statistics published in 1971 by the UK Office of Employment and Productivity (Department of Labour and Productivity, 1971; pre-1911) are used for the UK.[3]

GDP per WAP for Spain and the UK is presented in solid lines in Figure 1a. Since we focus on long-run trends, we also present the GDP estimates using the Hodrick-Prescott filter (after Hodrick and Prescott, 1997, the dashed lines in the figure). In 1850, Spain's GDP per WAP was significantly lower than that of the UK, but caught up rapidly during the second wave of globalization.

Figure 1b illustrates the evolution of Spanish exports to GDP, with the solid line representing the raw data and the dashed line representing the trend. The corresponding figure for imports to GDP is presented in Appendix A, Figure 17a, which has a similar pattern. The trade volume grew during the first and second waves of globalization, but underwent a significant decline during the Inter-War Trade Collapse (IWTC). The Historical National Accounts dataset from Prados de la Escosura (2015) is the source of this data, which is only available for Spain.

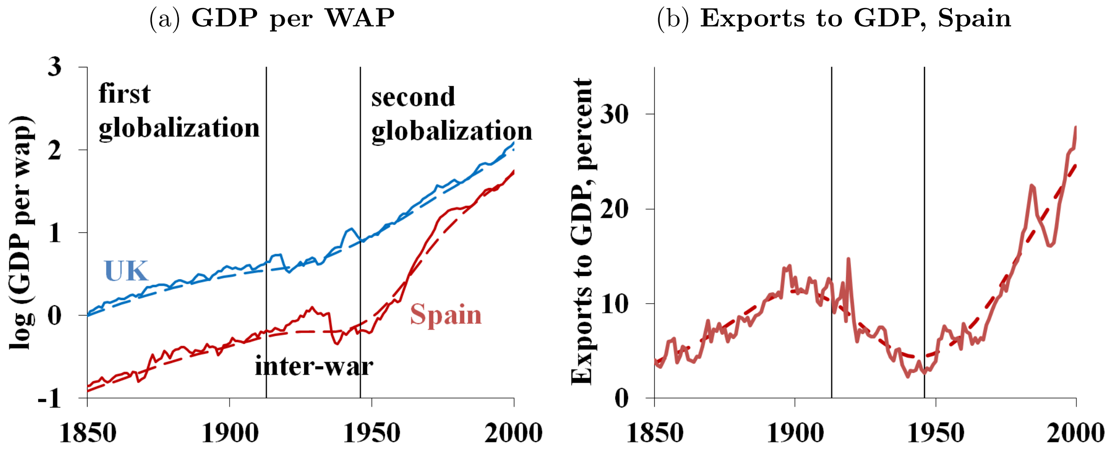
Figure 2a illustrates that the share of value added in agriculture decreased over time in Spain, while services experienced the opposite trend. Significantly, manufacturing increased to approximately 25 percent of GDP and remained at that level during the second wave of globalization, experiencing a slight decline after the 1990s.[4] Another crucial empirical observation for the Spanish economy is the progression of investment as a percentage of GDP, as depicted in Figure 2b. Starting from a low level of around 5 percent of GDP in 1850, investment consistently increased over time to exceed 20 percent by 2000. Figure 2c shows that the Spanish capital-to-GDP ratio follows a similar trend. The data source for these figures is also Prados de la Escosura (2015).

Finally, we examine the historical bilateral trade patterns between Spain and the UK from 1850 to 2000. Our analysis involves the digitization of trade data between Spain and Great Britain for years between 1849 and 1913 from the statistical publications of the Spanish Customs Agency. Specifically, we use the "General Ledger of the Foreign Trade of Spain

[3]For Spain, WAP estimates cover years 1857, 1860, 1877, 1887, 1900, 1910, 1920, 1930, 1940, 1950, and 1960. For the UK, WAP estimates cover years 1851, 1861, 1871, 1881, 1891, 1901, 1911, 1921, 1931, 1941, 1951, and 1960. For the remaining years, we linearly interpolate.

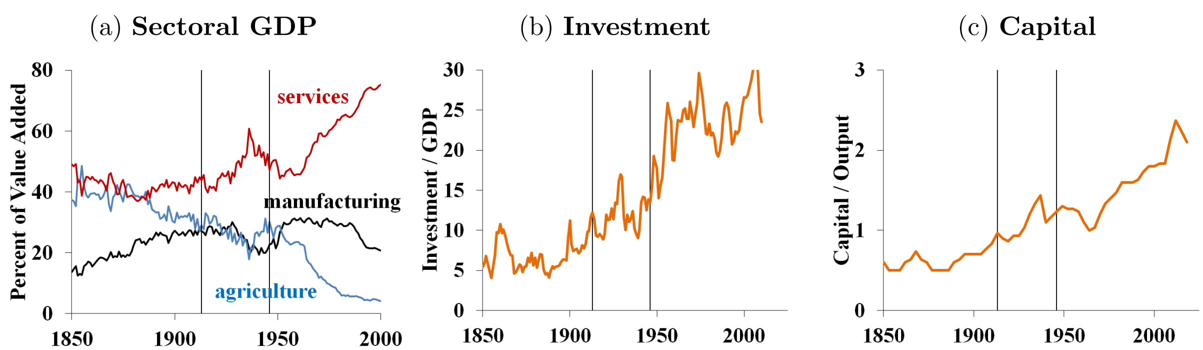
[4]It is important to note that we combine construction with services, and in Appendix B, we demonstrate that the key takeaways remain unchanged if we instead combine construction with manufacturing.

Figure 1: GDP and exports



Notes: Figure 1a plots GDP per working-age person (WAP) for both Spain (red line) and the UK (blue line) from 1850 to 2000. Sources: Maddison Project (2013), World Bank's World Development Indicators, National Statistics Institute, Office for National Statistics (2020), and a report on historical British labor statistics published in 1971 by the UK Office of Employment and Productivity (Department of Labour and Productivity, 1971). Figure 1b plots Spain's exports to GDP from 1850 to 2000. Source: Historical National Accounts dataset from Prados de la Escosura (2015). In both figures, the solid lines are the raw data. The dashed lines are the trends computed using the HP filter with a penalty parameter of 100.

Figure 2: Sectoral GDP, investment, and capital in Spain



Notes: Figure 2a plots value-added shares by sector for Spain (1850-2000). Figure 2b plots investment as a percentage of GDP for Spain (1850-2000). Figure 2c plots the capital-to-GDP ratio for Spain (1850-2000). Source: Prados de la Escosura (2015).

with its Overseas Possessions and Foreign Powers" for the years 1849-1855, and the "General Statistical Report of the Foreign Trade of Spain with its Overseas Possessions and Foreign Powers" for the years 1856 and after.[5] The trade patterns after 1962 are directly reported

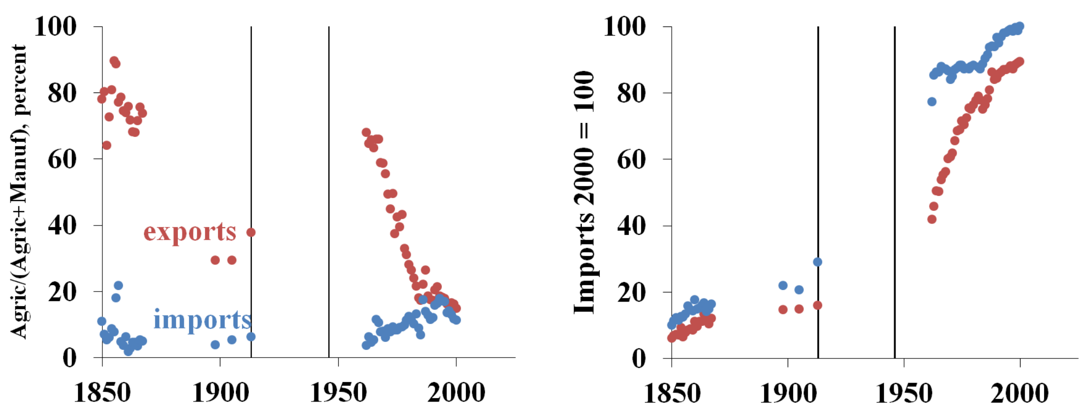
[5]Original, in Spanish: "Cuadro General del Comercio Exterior de España con sus Posesiones Ultramarinas y Potencias Estrangeras," Dirección General de Aduanas de España (1849–1855); and "Estadística General del Comercio Exterior de España con sus Posesiones Ultramarinas y Potencias Extranjeras," Dirección

in SITC Rev. 1 4-digit categories. To have a consistent measure of trade patterns for the entire period, we manually assign each ledger prior to 1962 to the 4-digit SITC Rev. 1 code that provides the best match.[6]

We present findings on the trade composition of agriculture and manufacturing, as well as the number of traded varieties, based on the data we have compiled. It is worth noting that neither the historical accounts nor the SITC Rev. 1 data provide information on trade in services. Figure 3a illustrates Spain's share of agricultural exports (red dots) and imports (blue dots). Our observations reveal that Spain did not import many agricultural goods during the time frame under study. However, the proportion of Spain's agricultural exports was significant at the beginning of both the first and second waves of globalization, reaching about 80 percent in 1850 and 70 percent in 1960. By the end of these periods, these figures had dropped to around 30 percent in 1900 and 20 percent in 2000.

Figure 3: Trade between Spain and the UK

(a) **Share of agriculture** (b) **Number of traded varieties**



Notes: Figure 3a plots exports (imports) of agriculture as a share of agriculture plus manufacturing exports (imports) for Spain with the UK. Analogously, Figure 3b plots the number of traded varieties, measured by the count number of non-empty, non-agricultural SITC codes each year. Sources: "General Ledger of the Foreign Trade of Spain with its Overseas Possessions and Foreign Powers" for the years 1849-1855 and "General Statistical Report of the Foreign Trade of Spain with its Overseas Possessions and Foreign Powers" for the years 1856 and after.

To examine the number of varieties traded between Spain and other countries, we counted the non-empty, non-agricultural SITC codes for each year. The resulting series is shown in Figure 3b. Our analysis reveals a steady rise in the number of traded varieties over time. Notably, the number of varieties imported (represented by the blue dots) exceeds the number of varieties exported (represented by the red dots).

General de Aduanas de España (1856–1867,1898,1905,1913), respectively.

[6]In some instances, when the categories in the ledgers are less specific than the 4-digit SITC categories, 3-digit codes are used or customized categories are created by combining two or more 4-digit categories.

The general trend for Spain over the course of this extensive period of time is that of a nation closing the technological gap with its more advanced trading partner. As Spain goes through a typical structural transformation, it experiences significant shifts in its trade patterns. Our goal is to construct a model that examines the interplay between the different stages of development and trade patterns, and to use this model to assess the effects of trade disruptions at various stages of the development process.

3 Model

Based on the discussion in the previous section, we develop a two-country model with trade, capital accumulation, and Stone-Geary preferences (after Stone, 1954; and Geary, 1950) over agriculture, manufacturing, and services. The final agricultural good is only used for consumption. Its production uses one type of domestic and one type of foreign intermediates, and trade happens à la Armington (1969). The intermediate agricultural good is produced using land and labor. The final manufacturing good can be either consumed or used for capital accumulation. Its production uses many domestic and foreign intermediates, combined with a Dixit and Stiglitz (1977) aggregator, and trade happens à la Krugman (1980). The producers of intermediate manufacturing varieties operate in a monopolistically competitive environment, have an increasing returns to scale technology, and use capital and labor as inputs. Finally, the services good is also used for consumption only. Its production uses one type of domestic and one type of foreign intermediates, and again trade happens à la Armington (1969). The intermediate services good is produced using capital and labor. All markets operate under perfect competition, except the differentiated varieties in manufacturing, which operate under monopolistic competition with free entry. We incorporate differentiated varieties into only manufacturing and none of the other sectors because we have data to calibrate parameters related to manufacturing varieties but not the other sectors.

Each country's productivity changes over time, and it is sector neutral. As in Kongsamut, Rebelo, and Xie (2001), with Stone-Geary preferences and sector neutral productivity growth, our model generates an evolution of sectoral GDP that is roughly consistent with the data. This is in contrast to Ngai and Pissarides (2007), who show that allowing for differential productivity per sector generates structural change in the model that is consistent with the data. Our benchmark model is simpler along this dimension. Nevertheless, in Appendices C, we perform robustness exercises with sector-specific productivities. The results from the robustness exercises do not alter the conclusions of our paper.

Finally, we assume that trade in both countries is subject to the same iceberg transportation cost across sectors and trade balances every period. Even with iceberg costs that are the same across sectors, we show that our model generates observed patterns in the composition of trade by sector. The assumption about balanced trade is motivated by the empirical observation that Spain's trade was almost balanced in most years between 1850 and 2000, which we show in Figure 17b in Appendix A.

3.1 Households

We start by describing the problem of the household in country h (with the household in country f facing an analogous problem, with appropriate changes to f and h). The household maximizes the discounted flow of utilities by choosing consumption of agriculture, $c_{a,h,t}$, consumption of manufacturing, $c_{m,h,t}$, consumption of services, $c_{s,h,t}$, and next period assets, $a_{h,t+1}$. The problem is given by

$$\max_{c_{a,h,t},c_{m,h,t},c_{s,h,t},a_{h,t+1}} \sum_{t=0}^{\infty} \beta^t \frac{(\mu_a(c_{a,h,t}-\bar{c}_a)^{\epsilon}+\mu_m(c_{m,h,t})^{\epsilon}+\mu_s(c_{s,h,t})^{\epsilon})^{\frac{1-\sigma}{\epsilon}}}{1-\sigma}$$

$$\text{subject to:} \tag{1}$$

$$\begin{aligned} & p_{a,h,t}c_{a,h,t}+p_{m,h,t}(c_{m,h,t}+a_{h,t+1}-(1-\delta)a_{h,t})+p_{s,h,t}c_{s,h,t} \\ =& r^K_{h,t}a_{h,t}+w_{h,t}+r^L_{h,t}L_{h,t}+\pi_{h,t}, \end{aligned}$$

where $p_{a,h,t}$ is the price of agriculture, $p_{m,h,t}$ is the price of manufacturing, $p_{s,h,t}$ is the price of services, $r^K_{h,t}$ is the return on savings, $w_{h,t}$ is the wage rate, $r^L_{h,t}$ is the return on land, $\pi_{h,t}$ is the sum of all the profits that all firms in the three sectors make (in equilibrium, these profits are zero), and $L_{h,t}$ is land. The parameters governing the household problem are the following: β is the discount factor, δ is the depreciation rate of capital, σ governs the intertemporal elasticity of substitution, ϵ determines the elasticity of substitution across sectors, and μ_a, μ_m, and μ_s determine the expenditure on agriculture, manufacturing, and services, respectively. Finally, within-period utility exhibits preferences of the Stone-Geary form, where $\bar{c}_a$ is the minimum consumption requirement for agriculture, making it a necessity.

3.2 Production of agriculture

The agricultural sector consists of final producers selling the final good, a CES aggregate of domestic and foreign intermediates, to households, and intermediate producers selling both domestically and abroad. We now discuss the problems for the producers in country h (with the producers in country f facing an analogous problem, with appropriate changes to f and h).

The final agricultural good firm produces $y_{a,h,t}$ units of the good for price $p_{a,h,t}$ combining $x_{a,h,h,t}$ units bought from intermediate producer in h for price $q_{a,h,h,t}$ and $x_{a,h,f,t}$ units from intermediate producer in f for price $q_{a,h,f,t}$. The problem is given by

$$\begin{aligned} \max_{y_{a,h,t},x_{a,h,h,t},x_{a,h,f,t}} \quad & p_{a,h,t}y_{a,h,t} - q_{a,h,h,t}x_{a,h,h,t} - q_{a,h,f,t}x_{a,h,f,t} \\ \text{s.t.} \quad & y_{a,h,t} = \left(\nu_a x_{a,h,h,t}^{\rho_a} + (1-\nu_a)x_{a,h,f,t}^{\rho_a}\right)^{1/\rho_a}, \end{aligned} \tag{2}$$

where parameter ν_a is a measure of the home bias in agricultural consumption and ρ_a governs the agricultural trade elasticity.

Given aggregate productivity, $Z_{h,t}$, the intermediate agricultural producer, chooses labor, $\ell_{a,h,t}$, and land, $L_{h,t}$, to maximize profits. The intermediate good is produced using a Cobb-Douglas technology with land share parameter α_a and is sold both to h, $x_{a,h,h,t}$, and to f, $x_{a,f,h,t}$. Because the production function is Cobb-Douglas, in equilibrium, intermediate agricultural producers make zero profits. The problem of the intermediate agricultural producer is given by

$$\begin{aligned} \max_{x_{a,h,h,t},x_{a,f,h,t},L_{h,t},\ell_{a,h,t}} \quad & q_{a,h,h,t}x_{a,h,h,t} + q_{a,f,h,t}x_{a,f,h,t} - r_{h,t}^M L_{h,t} - w_{h,t}\ell_{a,h,t} \\ \text{s.t.} \quad & x_{a,h,h,t} + (1+\tau_t)x_{a,f,h,t} = Z_{h,t}L_{h,t}^{\alpha_a}\ell_{a,h,t}^{1-\alpha_a}. \end{aligned} \tag{3}$$

Note that to ship one unit of the good to country f, the producer needs to ship $1+\tau_t$ units of the good. Hence, in equilibrium $q_{a,f,h,t} = q_{a,h,h,t}(1+\tau_t)$.

3.3 Production of manufacturing

The manufacturing sector is similar to the agricultural sector in that it consists of final producers selling the final good to households and intermediate producers selling both domestically and abroad.

The final manufacturing good firm produces $y_{m,h,t}$ units of the good for price $p_{m,h,t}$ by using as inputs intermediate goods from the $i \in N_h$ domestic producers (she purchases $x_{m,h,h,t}(i)$ units from producer i for price $q_{m,h,h,t}(i)$) and also from the $j \in N_f$ foreign producers (she purchases $x_{m,h,f,t}(j)$ units from producer j for price price $q_{m,h,f,t}(j)$). The problem is given by

$$
\begin{aligned}
&\max_{y_{m,h,t}, x_{m,h,h,t}(i), x_{m,h,f,t}(j)} \; p_{m,h,t} y_{m,h,t} - \int_{i \in N_h} q_{m,h,h,t}(i) x_{m,h,h,t}(i) di \\
&- \int_{j \in N_f} q_{m,h,f,t}(j) x_{m,h,f,t}(j) dj \\
&\text{s.t. } \; y_{m,h,t} = \left(\nu_m \int_{i \in N_h} x_{m,h,h,t}(i)^{\rho_m} di + (1 - \nu_m) \int_{j \in N_f} x_{m,h,f,t}(j)^{\rho_m} dj \right)^{1/\rho_m},
\end{aligned}
\tag{4}
$$

where parameter ν_m is a measure of the home bias in manufacturing consumption and ρ_m governs the manufacturing trade elasticity. The solution to this maximization problem gives demand functions for each intermediate variety that are taken into account by the producer when deciding how much to produce.

Intermediate manufacturing producer i chooses capital to rent, $k_{m,h,t}(i)$, and labor to hire, $\ell_{m,h,t}(i)$. The intermediate good is produced using a Cobb-Douglas technology with capital share parameter α_m and sold both to h, $x_{m,h,h,t}(i)$, and to f, $x_{m,f,h,t}(i)$. Operating this technology entails a fixed cost F_h, paid in units of final manufacturing good. We assume that no firm operates with negative profits, and hence, $\pi_{m,h,h,t}(i) \geq 0$. The problem of the intermediate manufacturing producer is thus given by

$$
\begin{aligned}
\pi_{m,h,h,t}(i) = &\max \left[\max_{q_{m,h,h,t}(i), q_{m,f,h,t}(i), k_{m,h,t}(i), \ell_{m,h,t}(i)} \begin{pmatrix} q_{m,h,h,t}(i) x_{m,h,h,t}(i) + q_{m,f,h,t}(i) x_{m,f,h,t}(i) \\ - w_{h,t} \ell_{m,h,t}(i) - r_{h,t} k_{m,h,t}(i) - p_{m,h,t} F_h \end{pmatrix}, 0 \right] \\
&\text{s.t. } \; x_{m,h,h,t}(i) + (1 + \tau_t) x_{m,f,h,t}(i) = k_{m,h,t}(i)^{\alpha_m} \left(Z_{h,t} \ell_{m,h,t}(i) \right)^{1 - \alpha_m},
\end{aligned}
\tag{5}
$$

where $x_{m,h,h,t}(i)$ and $x_{m,h,f,t}(i)$ are the demand functions taken as given.[7] In equilibrium, $q_{m,f,h,t}(i) = q_{m,h,h,t}(i)(1 + \tau_t)$.

3.4 Production of services

The service sector is very similar to the agricultural sector, with the difference that intermediate producers use capital rather than land to produce the good.

The final service good firm produces $y_{s,h,t}$ units of the good for price $p_{s,h,t}$ combining $x_{s,h,h,t}$ units bought from intermediate producer in h (with price $q_{s,h,h,t}$) and $x_{s,h,f,t}$ units

[7] We write productivity as raised to the $(1-\alpha_i)$ for manufacturing and services and as TFP for agriculture so that productivity is sector neutral in a balanced growth path without the non-homotheticities in the model. In agriculture, land is inelastic, whereas in manufacturing and services, capital will grow with productivity.

from intermediate producer in f (with price $q_{s,f,h,t}$). Their problem is given by

$$
\begin{aligned}
\max_{y_{s,h,t},x_{s,h,h,t},x_{s,h,f,t}} \quad & p_{s,h,t}y_{s,h,t} - q_{s,h,h,t}x_{s,h,h,t} - q_{s,h,f,t}x_{s,h,f,t} \\
\text{s.t.} \quad & y_{s,h,t} = \left(\nu_s x_{s,h,h,t}^{\rho_s} + (1-\nu_s)x_{s,h,f,t}^{\rho_s}\right)^{1/\rho_s},
\end{aligned} \tag{6}
$$

where the parameter ν_s is a measure of the home bias in services consumption and ρ_s governs the services trade elasticity.

The intermediate service producer chooses capital to rent, $k_{a,h,t}$, and labor to hire, $\ell_{a,h,t}$. The good is produced using a Cobb-Douglas technology with capital share parameter α_s and is sold to both h, $x_{s,h,h,t}$, and to f, $x_{s,f,h,t}$. The problem of the intermediate service producer is given by

$$
\begin{aligned}
\max_{x_{s,h,h,t},x_{s,f,h,t},k_{s,h,t},\ell_{s,h,t}} \quad & q_{s,h,h,t}x_{s,h,h,t} + q_{s,f,h,t}x_{s,f,h,t} - r_{h,t}^{K}k_{s,h,t} - w_{h,t}\ell_{s,h,t} \\
\text{s.t.} \quad & x_{s,h,h,t} + (1+\tau_t)x_{s,f,h,t} = k_{s,h,t}^{\alpha_s}\left(Z_{h,t}\ell_{s,h,t}\right)^{1-\alpha_s}.
\end{aligned} \tag{7}
$$

In equilibrium, $q_{s,f,h,t} = q_{s,h,h,t}(1+\tau_t)$.

3.5 Market clearing and feasibility

Finally, we write all the market clearing and feasibility conditions for this economy. We start with the final production of both agriculture and services. Note that all the production of the final good can only be consumed by the household of that country. Hence, $c_{a,h,t} = y_{a,h,t}$ and $c_{s,h,t} = y_{s,h,t}$. In the case of manufacturing, the final good can be consumed, used to pay the fixed cost to operate intermediate manufacturing varieties, or saved by the household. Hence, $c_{m,h,t} + F_h N_h + a_{h,t+1} - (1-\delta)a_{h,t} = y_{m,h,t}$.

We assume that there is free entry of intermediate manufacturing varieties, which means that $\pi_{m,h,t}(j) = 0$, an equation that is key to solving for the equilibrium number of varieties, N_h. Labor is used in all three sectors, implying that $\ell_{a,h,t} + \int_{i\in N_h}\ell_{m,h,t}(i)di + \ell_{s,h,t} = \ell_{h,t}$. Similarly, all the savings in the country are used by manufacturing or services, $\int_{i\in N_h}k_{m,h,t}(i)di + k_{s,h,t} = a_{h,t}$.

Finally, trade balances every period:

$$
\begin{aligned}
& q_{a,f,h,t}x_{a,f,h,t} + \int_{i\in N_h} q_{m,f,h,t}(i)x_{m,f,h,t}(i)di + q_{s,f,h,t}x_{s,f,h,t} \\
=& q_{a,h,f,t}x_{a,h,f,t} + \int_{i\in N_f} q_{m,h,f,t}(i)x_{m,h,f,t}(i)di + q_{s,h,f,t}x_{s,h,f,t}.
\end{aligned} \tag{8}
$$

4 Calibration and model validation

We calibrate the home country, h, to be Spain. Our paper's main focus is on the catching up country. Hence, we choose the foreign country, f, to look like the Spanish foreign sector. At the same time, our paper focuses on catching up to the industrial leader. Hence, we choose the foreign country to also look like the industrial leader in the 19th and early 20th century, the UK. We combine these two needs by setting the trade volume to match that of Spain and the foreign country's GDP and trade composition to match that of the UK. As a result, f is a scaled-up version of the UK that accounts for the overall Spanish foreign sector. Importantly, throughout the years of our exercise, the UK is not only one of Spain's main trading partners, but also its trade composition is similar to that of Spanish trade with other major trading partners.[8] Therefore, we do not view the treatment of the UK as a trading partner that encompasses the rest of the world from Spain's perspective as a major concern for our results.

The economy starts in 1850, and given the computational burden of the model, we assume a period is three years. The economy is calibrated such that in 1850, it is in a steady state.[9] When the economy starts, agents are informed of new trajectories in productivity and iceberg costs.[10]

The calibration exercise consists of two parts. First, we calibrate a number of parameters outside the model equilibrium. Then, we jointly calibrate a number of parameters so that the model matches aggregate moments in both 1850 and 2000, and also the entire evolution of GDP in Spain and the UK, and the evolution of Spain's exports to GDP from 1850 to 2000.[11] Although we discuss a relationship between each parameter and a moment, it is important to note that all parameters are estimated jointly because they also affect the other target moments.

We start by describing the parameters that are determined outside the model equilibrium. We set $\beta = 0.885$, which implies an annual interest rate of 4%. Following Herrendorf, Rogerson, and Valentinyi (2013), we take the approach of focusing on the final consumption expenditure and set $\epsilon = -0.176$, which implies an elasticity of substitution across goods of 0.85.[12] We set $\sigma = 1$ and $\delta = 0.129$, which imply an intertemporal elasticity of substitution

[8] Figures 23a and 23b in Appendix D show that the trade flows between Spain and the UK are representative of the overall flows for Spain.

[9] In Appendix E, we show that the target moments for 1850 change only slightly even if we assume the initial steady state year is 1835.

[10] To solve the model, we derive a non-linear system of equations using the first-order conditions and use the Newton-Raphson method. In Section 5, we discuss the role of perfect foresight.

[11] See Appendix F for details on how GDP is computed.

[12] In our model, final expenditure per sector and value-added per sector are very similar. Herrendorf, Rogerson, and Valentinyi (2013) point out that the parameter we use is appropriate to match the US

of 1 and an annual depreciation rate of 4.5%.

Table 1: **Parameters determined outside of the model equilibrium**

Parameter		Description	Value
β	Discount rate	Annual interest rate 4%	0.885
ϵ	Final goods elasticity parameter	Final goods elasticity = 0.85	-0.176
σ	Inverse of intertemporal elasticity	Intertemporal elasticity = 1	1.000
δ	Depreciation rate	Annual depreciation = 4.5%	0.129
α_a	Land share agriculture	Labor share agriculture = 39.8%	0.602
α_m	Capital share manufacturing	Labor share manufacturing = 69.1%	0.309
α_s	Capital share services	Labor share services = 68.5%	0.315
ρ_a	Production elasticity parameter: agriculture	Agriculture elasticity = 2.7	0.631
ρ_m	Production elasticity parameter: manufacturing	Manufacturing elasticity = 7.5	0.866
ρ_s	Production elasticity parameter: services	Services elasticity = 7.5	0.866
F_f	Fixed cost UK	Normalization	1.000
τ_T	Final iceberg	Normalization	0.000
L_f	Land UK	Normalization	1.000
L_h	Land Spain	Adamopoulos and Restuccia (2021)	1.502

Using labor compensation from the input-output tables from Spain in 2000, we compute sector-specific labor shares, which we use to calibrate the sector-specific land/capital shares: we estimate $\alpha_a = 0.602$, $\alpha_m = 0.309$, and $\alpha_s = 0.315$. We set $\rho_a = 0.631$ and $\rho_m = \rho_s = 0.866$, which imply an agricultural trade elasticity of 2.7 and a manufacturing and services trade elasticity of 7.5. We follow Bas et al. (2017) for the elasticity estimates for agriculture (1.08 to 2.71); similarly, they estimate an average trade elasticity (including agriculture) between 4.74 and 5.71. These estimates are on the lower end of what the literature uses as a trade elasticity. Anderson and van Wincoop (2003) summarize the range to be between 5 and 10. We choose 7.5 for the manufacturing elasticity because it is within the range of these estimates. We are not aware of good estimates for services trade. We choose to set it equal to 7.5 because estimates for the aggregate trade elasticity of modern rich economies are closer to the manufacturing elasticity than to the agricultural elasticity.

Next, we do three normalizations. First, we set the fixed cost of producing a variety in the UK to $F_f = 1$.[13] In our model, a change in this number would only change the measure of varieties in operation, but everything else scales up. Later on, we calibrate its Spanish counterpart to be consistent with the ratio of varieties observed in the data. Second, we normalize the final iceberg cost, $\tau_T = 0$, which gives a relative baseline for trade costs before

structural transformation when the model is calibrated to final expenditure, but that the parameter should approach negative infinity (preferences should be Leontief) when calibrated to the percentage of value-added. In Appendix G, we redo the exercise with $\epsilon = -10$ (implies an elasticity of substitution across goods of 0.09) and find that our welfare results are robust to the alternative specification.

[13] See Appendix H for how the model changes when we build it without varieties.

2000. As we discuss below, given $\tau_T = 0$, we calibrate the home bias parameters to target the observed volume of trade in the year 2000 and the evolution of τ_t to target the observed volume of total trade over time.[14] Third, we normalize UK's land, $L_f = 1$, and set Spain's land, $L_h = 1.502$ based on estimates from Adamopoulos and Restuccia (2021), who find that the potential output per unit of land is 287.4 international dollars for Spain, and 191.3 for the UK. Table 1 summarizes parameter estimates for this part of the calibration.

The second set of parameters are jointly determined in equilibrium. We calibrate the following parameters to target moments in 1850. We set the consumption floor for agriculture $\bar{c}_a = 0.682$ and manufacturing utility share parameter $\mu_m = 0.097$ to match the sectoral composition of Spanish GDP. Similarly, we set Spain's home bias agriculture $\nu_{h,a} = 0.845$ to match agricultural imports as a fraction of its total imports net of services imports (with the UK in the data) and the UK's home bias for agriculture $\nu_{f,a} = 0.662$ for Spain's exports counterpart.[15] We calibrate the remaining parameters to target moments in 2000. We set the agriculture utility share parameter $\mu_a = 0.029$ to match the percentage of agriculture in GDP. Given that the manufacturing utility share parameter μ_m has already been calibrated, μ_s is left as a residual to ensure that the sum of the three parameters is 1. We set Spain's home bias for manufacturing $\nu_{h,m} = 0.514$ to match Spanish exports over GDP in 2000 (we set its UK counterpart, $\nu_{f,m}$, to be the same value) and Spain's home bias for services $\nu_{h,s} = 0.575$ to target the fraction of Spanish exports in services (again setting its UK counterpart, $\nu_{f,s}$, to be the same value). Finally, we calibrate the fixed cost of operating a manufacturing variety in Spain, $F_h = 0.737$, to match the observed ratio of Spanish varieties over UK varieties in 2000. All these parameters are reported in Table 2. The last two columns of Table 2 show the values for the targeted moments in both the data and the model. In short, our calibration matches all the target moments.

[14] In this class of trade models, both home bias parameters and iceberg trade costs jointly determine trade volumes. In Appendix I, we redo all the main exercises without home bias and sector-specific trade costs. We find that the main results barely change.

[15] In our calibration, Spain's higher land endowment contributes to Spain's specialization in agriculture significantly while Spain's lower fixed cost of manufacturing mitigates it slightly. Suppose we take our baseline calibration with $L_h = 1.502$, set $L_h = L_f = 1$ while keeping the other parameters the same, and recompute the equilibrium. In that case, Spain's agricultural imports as a share of its total imports net of services in 1850 increases from 0.085 in the baseline model to 0.280. Therefore, decreasing Spain's land endowment to equalize it to that of the UK decreases Spain's specialization in agriculture. To illustrate this further, if we re-calibrate the model keeping $L_h = L_f = 1$, then Spain's home bias parameter $\nu_{h,a}$ increases from its baseline value of 0.845 to 0.870. In regards to the fixed costs, suppose we take our baseline calibration with $F_h = 0.737$, set $F_h = F_f = 1$ while keeping the other parameters the same, and recompute the equilibrium. In that case, Spain's agricultural imports as a share of its total imports net of services decreases from 0.085 in the baseline model to 0.068. Therefore, increasing Spain's fixed cost in manufacturing to equalize it to that of the UK increases Spain's specialization in agriculture slightly. To illustrate this further, if we re-calibrate the model keeping $F_h = F_f = 1$ and dropping the target moment related to F_h (Spain/UK varieties in 2000), then Spain's home bias parameter $\nu_{h,a}$ decreases from its baseline value of 0.845 to 0.833.

The last part of the calibration consists of jointly targeting three sequences of macroeconomic aggregates between 1850 and 2000 (Spanish exports over GDP, Spanish GDP per working-age population, and UK GDP per working-age population) using three series of parameters: (1) iceberg costs $\{\tau_t\}_{t=1850}^{2000}$; (2) Spanish productivities $\{Z_{h,t}\}_{t=1850}^{2000}$; and (3) UK productivities $\{Z_{f,t}\}_{t=1850}^{2000}$. In our model, we load all of the trade expansions and disruptions in iceberg costs. While this abstraction captures all changes to policies and technologies, it allows us to parsimoniously compare trade disruptions at different stages of development.

Table 2: **Parameters determined jointly in model equilibrium**

Parameter		**Value**	**Target**	**Year**	**Model**	**Data**
$\bar{c}_a$	Agri cons floor	0.682	% Agri in GDP	1850	*0.402*	*0.402*
μ_m	Manu utility share	0.097	% Manu in GDP	1850	*0.149*	*0.150*
$\nu_{h,a}$	Spain Agri home bias	0.845	Spain Agri Imp/(Imp: Agri+Manu)	1850	*0.085*	*0.085*
$\nu_{f,a}$	UK Agri home bias	0.662	Spain Agri Exp/(Exp: Agri+Manu)	1850	*0.778*	*0.778*
μ_a	Agri utility share	0.029	% Agri in GDP	2000	*0.040*	*0.040*
μ_s	Serv utility share	0.874	$1-\mu_a-\mu_m$	-	-	-
$\nu_{h,m}$	Spain manu home bias	0.514	Spain Exp/GDP	2000	*0.247*	*0.247*
$\nu_{f,m}$	UK manu home bias	0.514	$\nu_{f,m}=\nu_{h,m}$	-	-	-
$\nu_{f,s}$	UK serv home bias	0.575	Spain Serv Exp/ Tot Exp	2000	*0.310*	0.*310*
$\nu_{h,s}$	Spain serv home bias	0.575	$\nu_{h,s}=\nu_{f,s}$	-	-	-
F_h	Spain fixed cost	0.737	Spain/UK varieties	2000	*0.878*	*0.879*

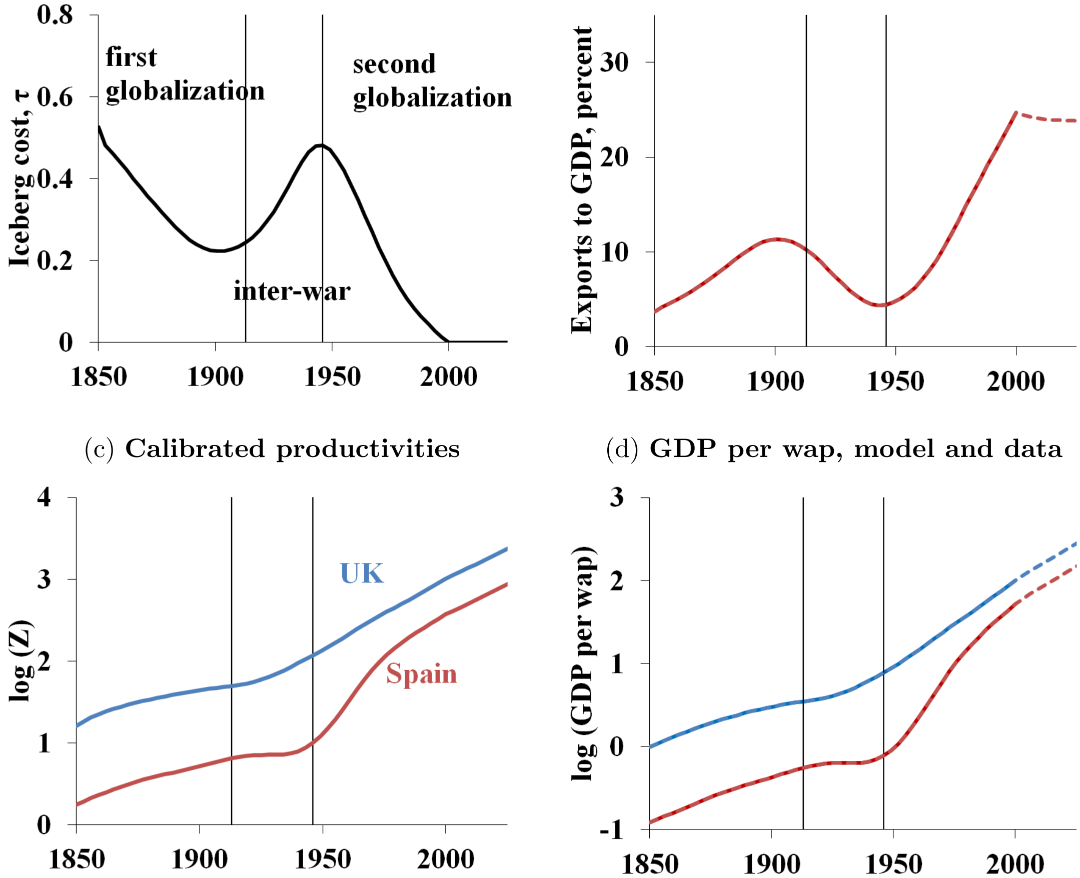
In Figure 4a, we plot the calibrated series for the iceberg cost, τ_t, since 1850. This series is calibrated such that the model matches the evolution of exports over GDP in Spain (Figure 4b). Note that Figure 4b has two series: a solid line, the trend data (as discussed in Section 2) and a dashed line, the predicted series by the model. Even with iceberg costs that are the same across sectors, below we show that our model generates observed patterns in the composition of trade by sector. Therefore, we do not view the abstraction from sector-specific iceberg costs as a major concern for our results.

In Figure 4c, we plot the calibrated productivity series, in red, for Spain, $Z_{h,t}$, and, in blue, for the UK, $Z_{f,t}$. Again, these series are calibrated such that the model matches the observed evolution of GDP per working-age population in Spain and the UK. This can be seen in Figure 4d. It has four series: two in red for Spain and two in blue for the UK. In both cases, the solid line is the trend data and the dashed line is the predicted series by the model. As was the case in Figure 4b, the dashed lines lie on top of each other because the model exactly matches the data. In Appendix J, we plot the evolution of export/GDP and GDP per working-age person under the following two cases: (1) constant iceberg costs (at their 1850 levels) while productivities evolve as depicted in Figure 4c and (2) constant productivities (at their 1850 levels) while iceberg costs evolve as depicted in Figure 4a. Quantitatively, the

Figure 4: Calibration of iceberg costs τ_t and productivity $Z_{i,t}$

(a) **Calibrated iceberg costs** (b) **Exports/GDP, model and data**

(c) **Calibrated productivities** (d) **GDP per wap, model and data**

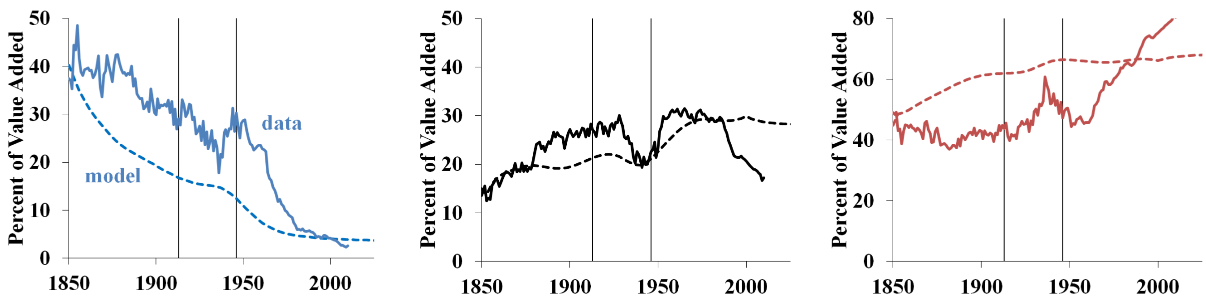


Notes: Figure 4a plots the calibrated series for the iceberg cost, τ_t. Figure 4b plots the evolution of exports over GDP for Spain in model (dashed line) and data (solid line). Figure 4c plots the calibrated productivity series for Spain, $Z_{h,t}$, in red, and for the UK, $Z_{f,t}$, in blue. Figure 4d plots GDP per working-age person (WAP) for Spain, $Z_{h,t}$, in red, and for the UK, $Z_{f,t}$, in blue, in both model (dashed line) and data (solid line).

impact of trade costs on GDP is small (Figures 30a and 30c) and the impact of productivity on exports/GDP is small (Figures 30b and 30d).

Model validation: We have calibrated the model to reproduce the composition of trade and output in 1850 and 2000 and to match the evolution of both GDP per working-age person in the two countries and the aggregate volume of trade from 1850 to 2000. However, we did not target the time series for the composition of output, total investment and capital, and composition of trade between 1850 and 2000. That is exactly the data of interest for us, which we use to validate the model.

Figure 5: Non-targeted moments: value-added shares in Spain



(a) **Value added, agri.** (b) **Value added, man.** (c) **Value added, ser.**

Notes: Figures 5a, 5b, and 5c plot the share of output accounted for by agriculture, manufacturing, and services both in the data (solid line, using the accounts from Prados de la Escosura, 2015) and the model (dashed line) for Spain.

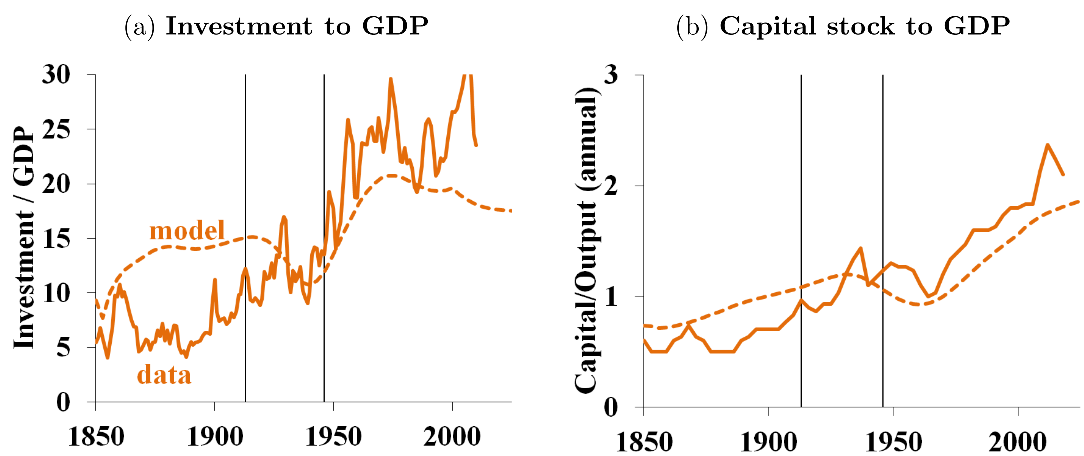
In Figures 5a, 5b, and 5c, we plot the share of output accounted for by agriculture, manufacturing, and services both in the data (solid line, using the accounts from Prados de la Escosura, 2015) and the model (dashed line). The model does reasonably well in accounting for the composition of Spanish GDP over time given that these moments were not targeted in our calibration. In the case of agriculture, both the model and the data exhibit a remarkably similar pattern. In both data and model there is a fall, which is more pronounced since the beginning of the second globalization. For the manufacturing sector, again model and data exhibit similar patterns except in the last two decades of the 20th century. For the services sector, both in the model and data, we observe an increase over time. The series from the model grows consistently at a similar rate, but the series from the data exhibits a flatter behavior throughout the first century and rapidly grows during the second wave of globalization.

Non-homotheticity in the benchmark model stems from Stone-Geary preferences (subsistence consumption for agriculture) and the assumption about fixed costs of producing a manufacturing variety being in units of the final manufacturing good rather than in units of labor. Among these two features, when productivities change in a sector-neutral way like in our benchmark model, preferences generate the structural transformation in our calibration. Furthermore, the change in trade costs have almost no impact on the structural transformation. We illustrate these takeaways in Appendix K.

In Appendices L and M, we show that the model also qualitatively accounts for the structural transformation of the UK and the evolution of relative prices in Spain, respectively.

In Figure 6a, we plot the percentage of Spanish GDP that is used for investment in the data (solid line) and the model (dashed line). Although the model slightly over-predicts the level of investment in the first half of our period and under-predicts it in the second half, it is nonetheless able to reproduce the transition from a low-investment to a high-investment economy.[16] It is remarkable how well the model captures the fall and spike in investment that occurred in the second half of the inter-war period and the beginning of the second wave of globalization. In Figure 6b, we show that the model also accounts for the level of and changes in Spain's capital-to-GDP ratio.

Figure 6: Non-targeted moments: investment and capital in Spain



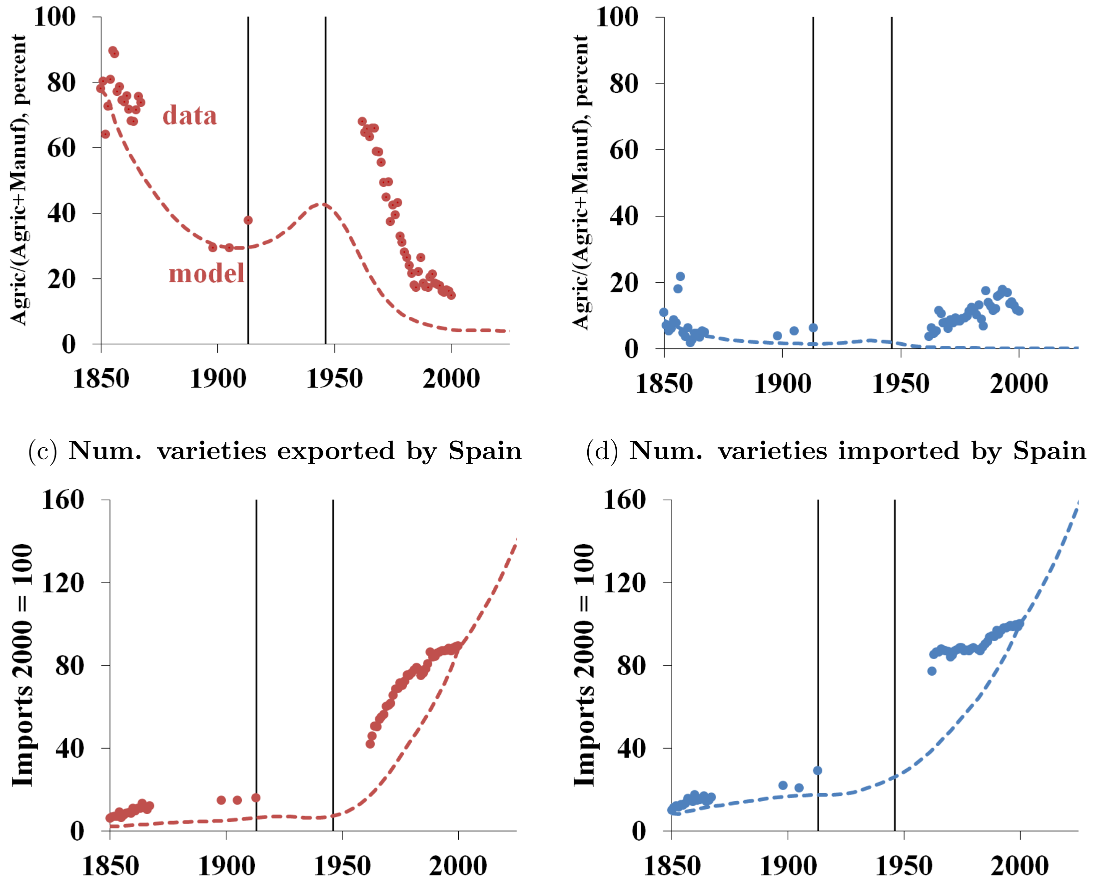
Notes: Figure 6a plots investment as a share of GDP in the model and data for Spain. Figure 6b plots capital as a ratio of GDP for Spain.

Having shown that our model rationalizes observed patterns related to the sectoral composition of GDP and total investment from 1850 to 2000 in Spain, we now validate the model against observed trade patterns in the same time period. In Figures 7a and 7b, we plot Spain's exports (imports) in agriculture normalized by the sum of exports (imports) in agriculture and manufacturing. The scattered dots are the data and the dashed lines are the model. Importantly, the only values that are targeted are those in 1850. For Spain's agricultural exports to the UK (Figure 7a), the model rationalizes the observed fall from 1850 to the early 1900s. Unfortunately, data are not available for the inter-war period, and they do not start again until the 1960s. In the 1960s, the share of agriculture is again very high in the data but it decreases sharply again. The model generates a similar pattern, with the hump peaking right before the 1950s and a pronounced decline afterward. While this result

[16] In the early 1850s, Spain's value-added share in manufacturing (Figure 5b) is roughly 15%, whereas both Spain's investment to GDP (Figure 6a) and manufacturing consumption to GDP (Figure 34b) are roughly 10% each. This implies that Spain must be running a trade deficit in manufacturing at that time period. We compare the manufacturing trade balance with data in Appendix N.

implies that the model generates the second fall in the share of agriculture a bit prematurely, the similarity between the data and model is remarkable, especially taking into consideration that we did not target these moments. Regarding Spain's imports of agriculture (Figure 7b), both the model and the data are consistent in that agricultural import shares are small over the whole time period. The main difference arises closer to the 2000s, when the share of agricultural imports converges to zero in the model because of Stone-Geary preferences.

Figure 7: Non-targeted moments: trade variables



(a) **Spain's trade in agriculture, exports** (b) **Spain's trade in agriculture, imports**

(c) **Num. varieties exported by Spain** (d) **Num. varieties imported by Spain**

Notes: Figures 7a and 7b plot Spain's exports (imports) in agriculture normalized by the sum of exports (imports) in agriculture and manufacturing in the model (dashed line) and data (scattered dots). Figures 7c and 7d plot Spain's number of traded varieties for both exports and imports in the model (dashed line) and data (scattered dots).

In Figures 7c and 7d, we show that the model does a good job at replicating the path of the number of traded varieties for both exports and imports. Recall that the only calibration target is the number of varieties in the year 2000. Despite having only calibrated that year, our model accounts for the fact that there are more varieties imported than exported, and that both series grow over time, especially during the second wave of globalization. Varieties grow over time with productivity growth because we assume that the fixed costs of producing a manufacturing variety are in units of the final good rather than in units of labor.

Given the model's success in accounting for the evolution of sectoral shares of output, total investment, and composition of trade between 1850 and 2000, we use it to study the impact of trade disruptions. In the following section, we compare the IWTC to a similar collapse today.

5 The cost of trade disruptions

In this section, we draw a comparison between the IWTC and a comparable trade collapse today. Given that our calibration reveals an abrupt surge in trade costs during the IWTC (as depicted in Figure 4a), we evaluate the impacts of that escalation against a relatively identical increase in trade costs today.

In our first experiment, we compare the benchmark economy to an alternative economy (counterfactual-1), where the abrupt rise in trade costs did not materialize. For counterfactual-1, we assume that trade costs for $t > 1913$ were the minimum of the calibrated trade costs at the commencement of the IWTC (τ_{1913}) and the calibrated trade costs in period t (τ_t). We denote the trade costs for counterfactual-1 as τ_t^{cf1}. For $t > 1913$, the trade costs are defined by

$$\tau_t^{\text{cf1}} = \min[\tau_{1913}, \tau_t].$$

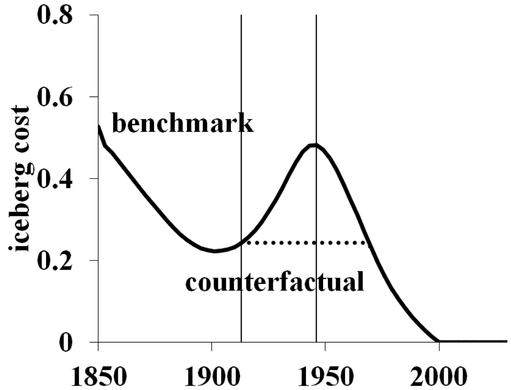
Figure 8a illustrates the trade costs in the benchmark model (solid line) and the hypothetical counterfactual-1 scenario (dashed line).

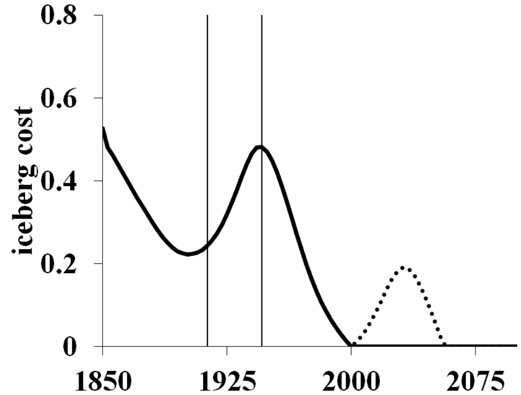
In our second experiment, we compare the benchmark model to a hypothetical economy (counterfactual-2) where a trade collapse occurs starting in the year 2000. To ensure comparability between the current trade collapse and the one during the IWTC, we set the relative increase in costs to be the same in both counterfactuals. Specifically, we ensure that the percentage increase in trade costs since 2000 is equivalent to the percentage increase in trade costs since 1913. Therefore, the trade costs for counterfactual-2, denoted as τ_t^{cf2}, satisfy the following equation:

$$\frac{1 + \tau_{2000+t}^{\text{cf2}}}{1 + \tau_{2000+t}} = \frac{1 + \tau_{1913+t}}{1 + \tau_{1913+t}^{\text{cf1}}}, \tag{9}$$

where τ_t^{cf1} are the iceberg trade costs in counterfactual-1 and $\tau_{2000+t} = 0$ are the iceberg trade costs in counterfactual-2. The trade costs for counterfactual-2 are represented by the dashed line in Figure 8b, with the solid line denoting the benchmark. Due to the lower level

Figure 8: Iceberg costs





Notes: Figure 8a plots the trade costs in counterfactual-1 (dashed line) along with the calibrated trade costs in our benchmark model (solid line). Figure 8b plots the trade costs in counterfactual-2 (dashed line) along with the calibrated trade costs in our benchmark model (solid line).

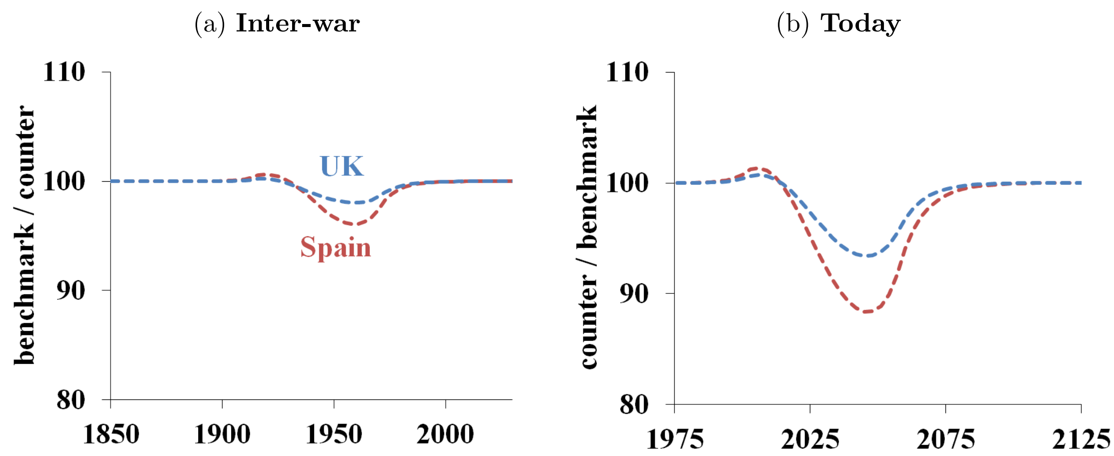
of openness in 1913 than in 2000, the increase in τ during the IWTC (from 1913 to the peak) is 23.8 percentage points, while the increase in τ today (from 2000 to the peak) is 19.2 percentage points. In Appendix O, we elaborate more on how spikes in trade costs affect imports-to-domestic expenditure in the model.

Figure 9a illustrates the evolution of capital $(a_{h,t}, a_{f,t})$ in the benchmark economy versus counterfactual-1. The red line represents Spain, and the blue line represents the UK. We observe a slight increase in the capital stock just before the increase in trade costs, enabling consumers to benefit from temporary lower input costs. Subsequently, the more expensive inputs cause a decline in the capital stock. The trough in Spain is around 4 percent, while the UK's fall in the capital stock is less severe.

In Figure 9b, we plot the evolution of capital in counterfactual-2 compared to the benchmark economy. The pattern is qualitatively similar to Figure 9a, but the magnitudes are vastly different. In fact, the trough in Spain is 12 percent, which is substantially larger than during the IWTC. The UK's fall is less severe than in Spain but larger than its fall during the IWTC.

In Figure 10a, we plot the change in consumption by sector during the IWTC. The trough depicts a fall of around 3 percent in manufacturing. By contrast, services fall less, and agriculture shows an increase throughout the disruption. In Figure 10b, we can see that the fall in consumption today in Spain is approximately 9 percent in manufacturing around the trough. This fall is almost three times larger than during the IWTC. Additionally, services

Figure 9: Capital



Notes: Figure 9a plots the evolution of capital in the benchmark (where there is an IWTC) as a percentage of counterfactual-1 (where there is no spike in trade costs; Figure 8a) for both Spain (red line) and the UK (blue line). Figure 9b plots the evolution of capital in counterfactual-2 (where there is a new trade collapse; Figure 8b) as a percentage of the benchmark (where there is no spike in trade costs in the 2000s) for both Spain (red line) and the UK (blue line).

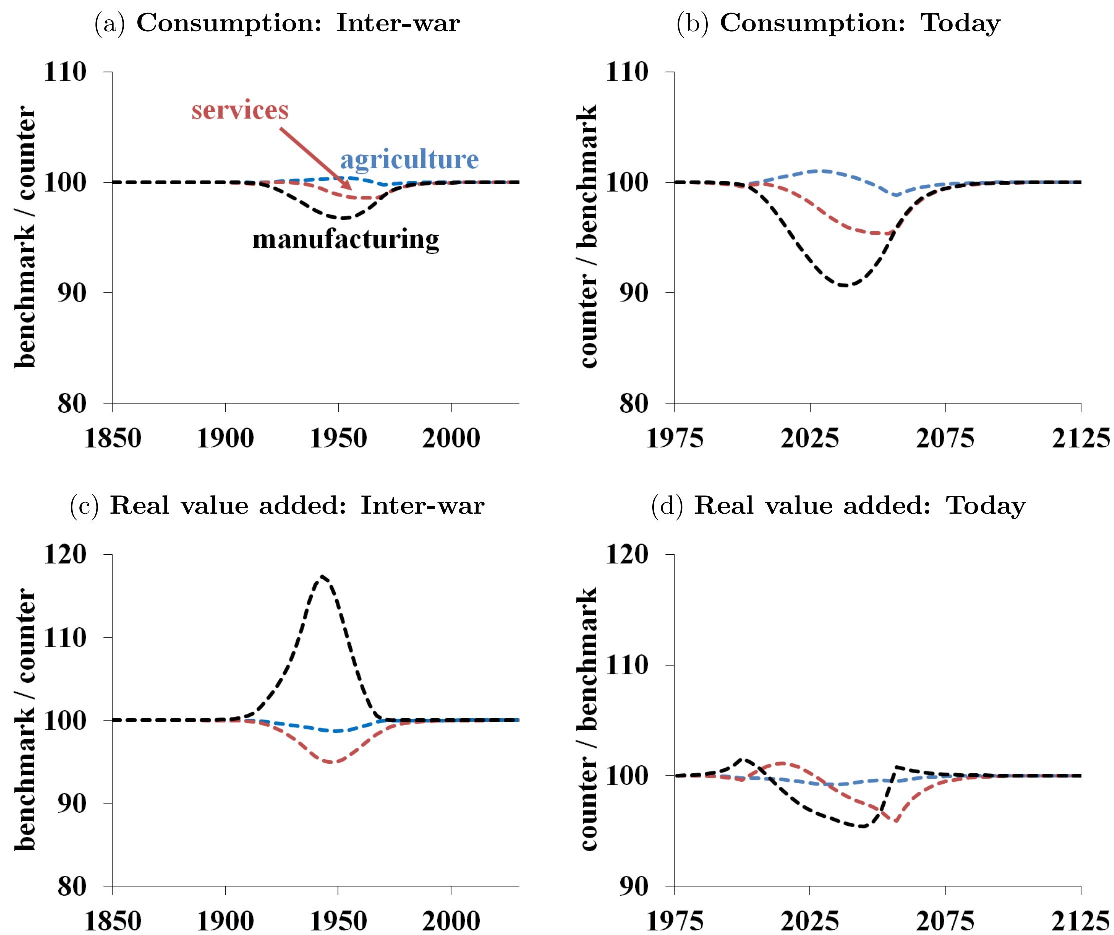
fall more, and agriculture increases slightly more than during the IWTC. The greater decline in the consumption of manufacturing and services highlights that the cost of a trade collapse today is higher than that during the inter-war period. Below, we expand on the implications that these changes in consumption have for welfare.

In Appendix P, we investigate further the rise in agricultural consumption, the moderate fall in services consumption, and the larger fall in manufacturing consumption observed during both trade collapses. We find that these results are mainly driven by differences in home bias parameters. Therefore, in what follows we discuss how results would change if these parameters were similar.

Recall that agriculture has the highest home bias, services has the second highest home bias, and manufacturing has the lowest home bias (Table 2). If we assume that the home bias for services is equal to that of manufacturing ($\nu_{h,m} = \nu_{f,m} = \nu_{h,s} = \nu_{f,s}$), recalibrate the model (after dropping the target moment related to home bias in services: Spain services exports/Total exports in 2000) and re-study the trade disruptions, we find that the drop in consumption in manufacturing and services becomes essentially the same in both trade disruptions (see Figures 36a and 36d in Appendix P for a depiction of these results).

If we go one step further and assume that the home bias in agriculture is also equal to that of manufacturing and services ($\nu_{h,m} = \nu_{f,m} = \nu_{h,s} = \nu_{f,s} = \nu_{h,a} = \nu_{f,a}$), recalibrate the model (after dropping the target moments related to home bias in services and agriculture: Spain services exports/Total exports in 2000 and Spain's share of agricultural exports and

Figure 10: Consumption and real value added by sector in Spain



Notes: Figure 10a plots the evolution of consumption by sector in the benchmark (where there is an IWTC) as a percentage of counterfactual-1 (where there is no spike in trade costs; Figure 8a) for Spain. Figure 10b plots the evolution of consumption by sector in counterfactual-2 (where there is a new trade collaps; Figure 8b) as a percentage of the benchmark (where there is no spike in trade costs in the 2000s) for Spain. Analogously, Figures 10c and 10d plots the real value added by sector.

imports in 1850) and re-study the trade disruptions, we find that consumption in agriculture no longer increases during the two trade disruptions (see Figures 36b and 36e in Appendix P for a depiction of these results).

Furthermore, we find that the rise in consumption of agricultural goods in Spain during the trade disruptions in the benchmark model is driven by Spain consuming a higher share of its own agriculture intermediate, as shown in Figure 15b, Section 6 (as opposed to, for instance, an increase in labor employed in agriculture; see Figure 15a). Furthermore, we note that subsistence consumption for agriculture amplifies the response because of the income effect. Without it ($\bar{c}_a = 0$; model recalibrated after dropping target moment: agriculture's share of GDP in 1850 for Spain), the rise in consumption in agriculture is mitigated for the IWTC and reversed for the collapse today (see Figures 36c and 36f in Appendix P for a depiction of these results).

In summary, our analysis finds that the home bias is a significant driver of changes in consumption across sectors during trade disruptions. We also show that the rise in consumption of agricultural goods in Spain is due to an increase in Spain's consumption of its own agricultural intermediate, and subsistence consumption plays a crucial role.

We investigate the impact of the trade collapse on the sectoral structure of the Spanish economy as well. To do so, we analyze the changes in value added across different sectors, which are illustrated in Figures 10c and 10d. We find that the IWTC resulted in a contraction of services and agriculture, but it increased output in manufacturing. By contrast, the shock today contracts manufacturing and services, but leaves agriculture roughly unchanged. In the next section, we provide economic intuition for why output in manufacturing increases.

Welfare. To measure welfare, we use consumption equivalence variation. That is, we ask by what percentage consumption in every sector and every period must change in the economy without the trade disruption for the household to be indifferent between the economy with the trade disruption and the economy without the trade disruption. In this measure, negative values indicate losses and positive values indicate gains. Formally, we compute consumption equivalence, g, for the IWTC as follows:

$$\sum_{t=1913}^{\infty} \beta^t U((1+g)c_{a,t}^{\mathrm{cf1}}, (1+g)c_{m,t}^{\mathrm{cf1}}, (1+g)c_{s,t}^{\mathrm{cf1}}) = \sum_{t=1913}^{\infty} \beta^t U(c_{a,t}, c_{m,t}, c_{s,t}) \tag{10}$$

where

$$U(c_a, c_m, c_s) = \frac{(\mu_a(c_a - \bar{c}_a)^\epsilon + \mu_m(c_m)^\epsilon + \mu_s(c_s)^\epsilon)^{\frac{1-\sigma}{\epsilon}}}{1-\sigma},$$

the LHS represents the present value of the flow utility of consumption in the counterfactual without the trade collapse scaled by $1+g$ and the RHS represents the present value of the flow utility of consumption in the benchmark with the IWTC.[17] As reported in Table 3, the welfare loss of a trade disruption now for Spain is equivalent to 1.58 percent of lifetime consumption while the welfare loss from the IWTC is equivalent to a lifetime consumption loss of 0.37 percent. The analogous numbers for the UK are 0.88 and 0.30 percent. Therefore,

[17]For the counterfactual trade collapse in 2000, we compute consumption equivalence as follows:

$$\sum_{t=2000}^{\infty} \beta^t U((1+g)c_{a,t}, (1+g)c_{m,t}, (1+g)c_{s,t}) = \sum_{t=2000}^{\infty} \beta^t U(c_{a,t}^{\mathrm{cf2}}, c_{m,t}^{\mathrm{cf2}}, c_{s,t}^{\mathrm{cf2}}).$$

a trade disruption today would be a lot more costly than the trade disruption during the inter-war period.

In the benchmark model, we assume perfect foresight starting in 1850 after the announcement for the sequences of productivities and iceberg costs. This assumption could, in principle, affect our welfare estimates because we compute lifetime utilities starting in 1913 for the IWTC and starting in 2000 for today's trade collapse. For robustness, we re-do counterfactual-1 as a sudden, unanticipated (until 1913) increase in trade costs, and re-do counterfactual-2 as a sudden, unanticipated (until 2000) increase in trade costs.[18] In this case, Table 3 shows that the welfare losses are somewhat larger. This quantifies the extent to which the assumption of perfect foresight does not allow the agent to mitigate the impact of the trade disruption.

Table 3: **Welfare (unit = percentage lifetime consumption)**

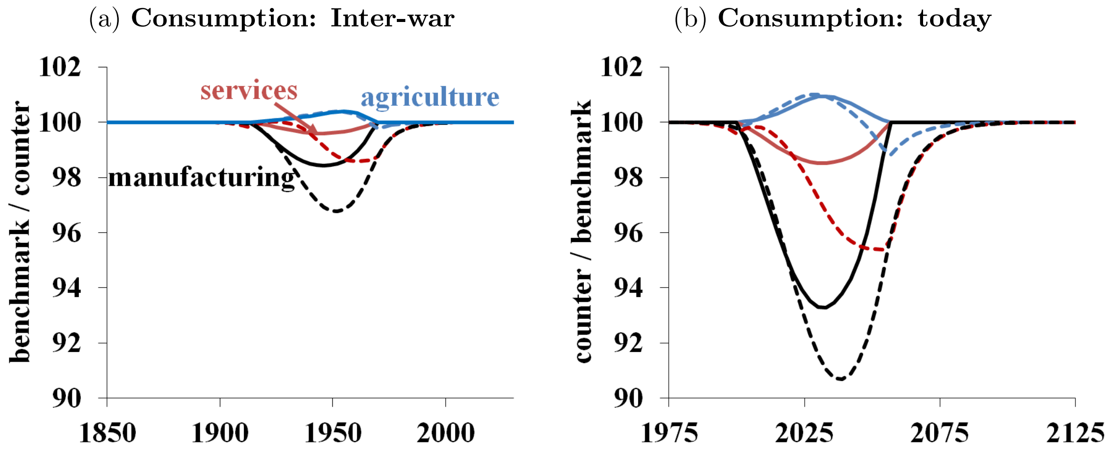
Model	**Spain**		**UK**	
	Inter-war	**Today**	**Inter-war**	**Today**
Benchmark	-0.37	-1.58	-0.30	-0.88
Benchmark: unanticipated disruption	-0.42	-1.68	-0.32	-0.94
No dynamics/Static	-0.20	-0.94	-0.22	-0.53

Role of dynamics. Capital accumulation plays a significant role in generating the costs of trade disruptions. To highlight the importance of capital accumulation, we consider a sensitivity analysis where we set the capital share parameters to zero ($\alpha_m = \alpha_s = 0$), eliminate the savings decision from the consumer's problem, and re-evaluate the costs of the two trade disruptions. Figures 11a and 11b compare the response in consumption by sector in the benchmark model against the static model. While the behavior of consumption in agriculture is quantitatively similar in the benchmark model and the static model, the drop in consumption in manufacturing and services is larger. This suggests that the cost of trade disruptions are larger when there is capital accumulation.

We also verify this implication in terms of welfare in Table 3. We compare the welfare losses during the trade disruptions for Spain and the UK, between the static model and the benchmark model. The results show that in the static model, the welfare losses in Spain are 0.20 percent of life-time consumption during the IWTC and 0.94 percent today, which is slightly more than half of the costs obtained using the benchmark model (0.37 percent and

[18]More specifically, for the IWTC, we take the capital stock of Spain and UK as given in 1913 from the counterfactual without the IWTC and simulate the economy starting in 1913. For the trade collapse today, we take the capital stock from the year 2000 in the benchmark model as given and simulate the trade collapse starting the model economy in the year 2000.

Figure 11: Spain's consumption by sector: Benchmark (dashed) vs. Static (solid)



Notes: Figures 11a and 11b compare the response in consumption by sector in the benchmark model (dashed) against the static model (solid). For the static case, we set the capital share parameters to zero ($\alpha_m = \alpha_s = 0$), eliminate the savings decision from the consumer's problem, use parameters from the benchmark calibration, and re-evaluate the costs of the two trade disruptions.

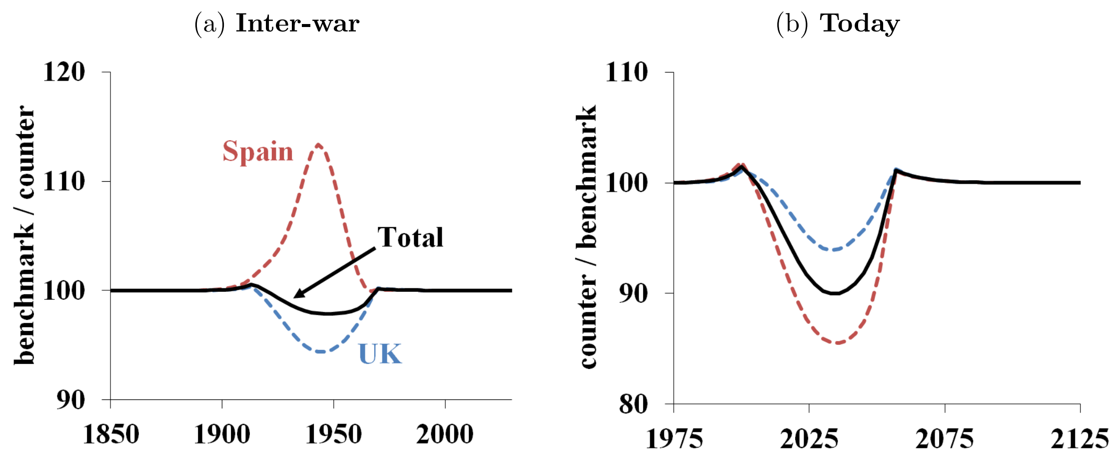
1.58 percent, respectively). Similarly, for the UK, the costs of the disruptions according to the static model are also smaller than in the benchmark model (0.22 percent and 0.53 percent compared to 0.30 percent and 0.88 percent). These numbers highlight the importance of dynamics and capital accumulation in the model.[19]

Number of varieties. Changes in trade costs play a major role in how many varieties are produced in each country. In Figure 12a, we plot the evolution of the number of varieties in Spain (red), in the UK (blue), and in total (black) during the IWTC. Likewise, in Figure 12b, we do the same for the collapse today. The most striking pattern is that, while a trade disruption always lowers the total number of varieties available for both countries, as well as the number of varieties produced in the UK, the number of varieties produced in Spain increases during the IWTC, but decreases today.

The number of varieties produced in Spain falls with a spike in trade costs today because the two countries are similar in productivity and very integrated (trade costs are already very low). Larger trade costs imply that the producers of varieties in each country cannot

[19] We have also analyzed the case where we re-calibrate the entire model without capital accumulation. In that case, the increase in GDP accounted for by capital in the benchmark model is loaded onto much larger increases in productivity. In other words, in the recalibrated model, the benchmark's endogenous dynamics stemming from capital accumulation are replaced by exogenous dynamics implied by larger changes in productivity. As such, the welfare numbers implied by trade disruptions are more similar to the benchmark, at 0.39 percent and 1.51 percent for Spain, and 0.26 percent and 0.76 percent for the UK.

Figure 12: Number of varieties produced in Spain, in the UK, and in total



Notes: Figure 12a plots the evolution of the number of varieties in the benchmark (where there is an IWTC) as a percentage of counterfactual-1 (where there is no spike in trade costs; Figure 8a) for Spain (red line), in the UK (blue line), and in total (black line). Figure 12b plots the evolution of the number of varieties in counterfactual-2 (where there is a new trade collapse; Figure 8b) as a percentage of the benchmark (where there is no spike in trade costs in the 2000s) for Spain (red line), the UK (blue line), and in total (black line).

benefit as much from selling to the trading partner. Hence, the overall number of varieties declines, and the fall is split between the two countries.

The number of varieties produced in Spain increases with a spike in trade costs in the IWTC because Spain is much poorer than the UK. In this state, absent spikes in trade costs, Spain greatly benefits from cheaper varieties produced by the UK. Hence, Spain specializes in and exports agriculture, which it uses to import manufacturing goods. A spike in trade costs curtails Spain's ability to import cheap UK varieties. As a result, Spain increases its production of (costlier) varieties to compensate for the loss. Therefore, the industrialization generated in our model thanks to the increase in trade costs is quite costly. In Section 6, we elaborate more how distance in productivities between the two countries is what matters the most to explain the changes in varieties.

A crucial element of our model to generate changes in varieties consistent with the data, and hence generate the aforementioned industrialization of Spain during the IWTC, is the assumption that the fixed cost to produce a variety is paid in units of the final manufacturing good. If the cost was paid in units of labor, there would be little changes in the number of varieties throughout. In Appendix Q, Figure 37a plots the behavior of varieties in a re-calibrated model in which the fixed cost of producing a variety is in units of labor. In that case, we (almost) no longer observe the rise in varieties.

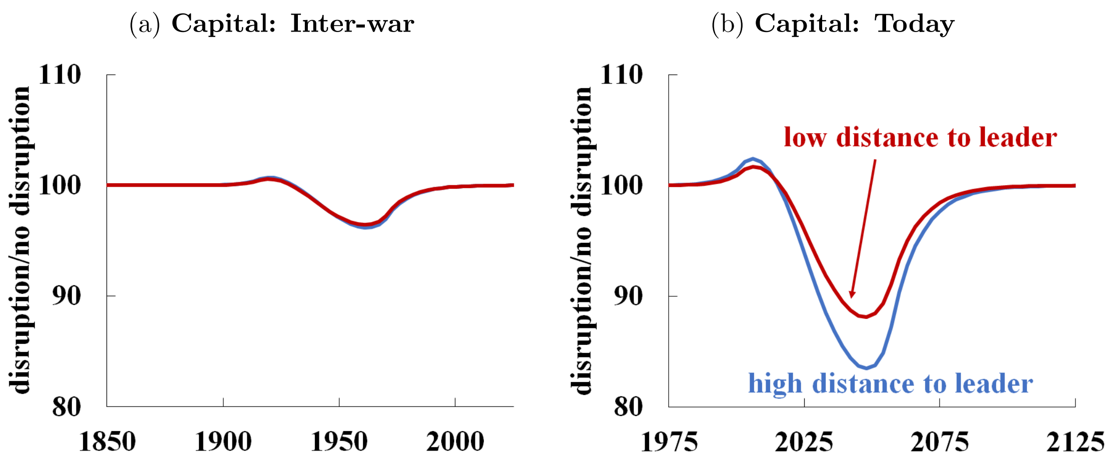
We also analyze how some of the other features in our benchmark model affect the increase in varieties in Appendix Q. Without subsistence consumption or when the home bias for manufacturing and services is the same (i.e., home bias for services decreases), Spain is able to divert more labor into manufacturing, which leads to a larger spike in varieties (Figures 37b and 37c). Features of the model such as capital accumulation and different fixed costs for each country do not play a significant role in affecting the number of varieties produced for the trade collapses we study (Figures 37d and 37e).

6 Technology, openness, and varieties

This section delves into the mechanisms underlying three major findings from the comparison between the IWTC and a comparable trade collapse today. Firstly, we examine why capital experiences a greater decline today than during the IWTC (as depicted in Figure 9). Secondly, we explore the drivers behind consumption patterns, particularly the rise in consumption of agriculture, during the two trade disruptions (illustrated in Figures 10a and 10b). Finally, we investigate why Spain's production of varieties experiences a sharp increase during the IWTC but not today (as shown in Figure 12).

Fall in Capital during IWTC vs today. One of our paper's findings indicates that capital falls three times more today than during the IWTC, despite both scenarios being subjected to the same relative trade shock. Our analyses involve two exogenous factors, namely, productivities and trade costs, that vary over time. In Figure 13a, we replicate the IWTC experiment, where trade costs are high, and compute the capital decline for different constant productivities in Spain and the UK. The blue line depicts the evolution of capital when productivities are set at the initial IWTC levels for all periods, resulting in a high distance to the leader. In contrast, the red line represents the same experiment but with both countries' productivities at today's levels, resulting in low distance to the leader.

Figure 13: The effects of trade costs and distance to the frontier for Spain



Notes: Figures 13a and 13b plot the evolution of Spain's capital stock in the economy with the trade disruption as a percentage of the capital stock in the economy without the trade disruption for the two trade disruptions (Figure 8a and 8b) under the following cases for constant productivities: (1) high distance to leader ($Z_{h,t} = Z_{h,1913}$ and $Z_{f,t} = Z_{f,1913}$, blue line) and (2) low distance to leader ($Z_{h,t} = Z_{h,2000}$ and $Z_{f,t} = Z_{f,2000}$, red line).

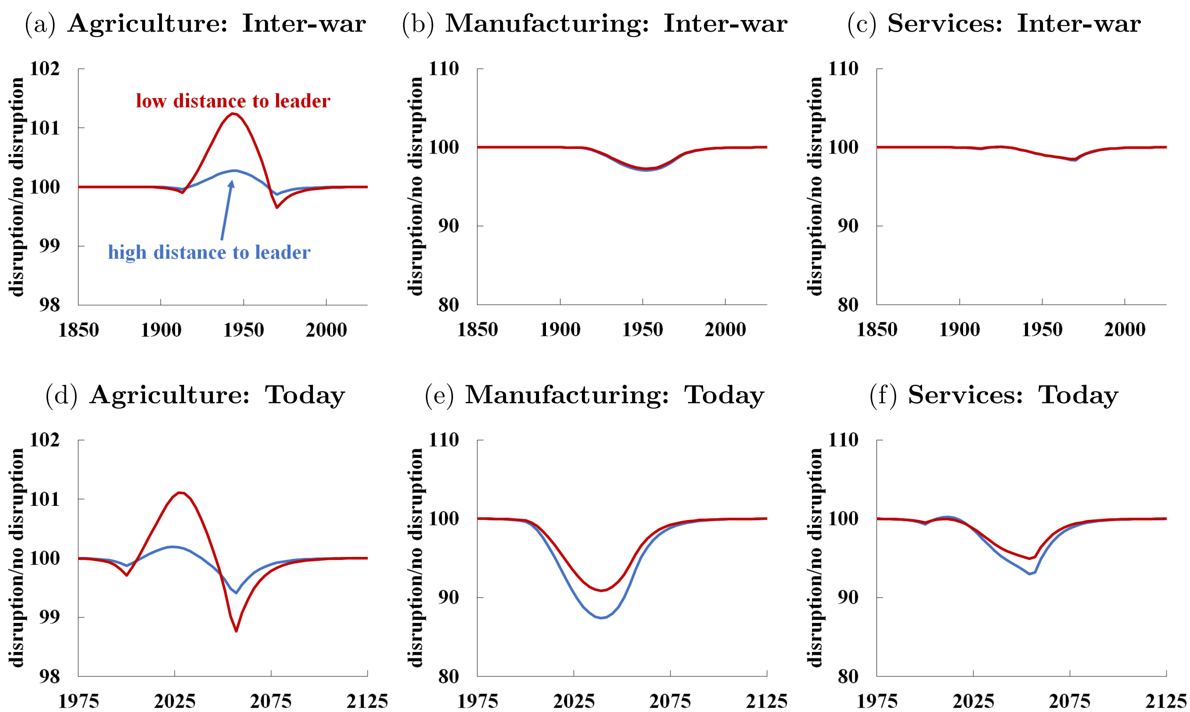
We observe that the decline in capital during the IWTC remains almost the same, irrespective of the productivity differences between Spain and the UK. Therefore, we conclude that the increase in trade costs is the main factor driving the capital decline for the IWTC.

In Figure 13b, we conduct a similar analysis for today's trade collapse. The red line replicates the counterfactual result with small differences in productivity, while the blue line repeats the same experiment with large productivity differences. Our findings suggest that if productivity convergence had not occurred, the fall in capital stock today would have been even more severe, at 17 percent instead of 12 percent. These results underscore the crucial role of trade costs in explaining the capital stock's decline (and welfare) illustrated in the previous section.

The impact of trade costs on capital varies depending on the degree of openness between countries and their productivity gap. In less open economies, a significant increase in trade costs causes a relatively small decline in capital, which is primarily due to the higher trade costs and not differences in productivity. On the other hand, in more open economies, a surge in trade costs results in a much larger reduction in capital, and this effect is magnified by greater gaps in productivity. This finding suggests that trade disruptions can be exceptionally costly for a country that is in the initial stages of development and has high levels of openness to trade with technologically advanced nations.

Consumption behavior during IWTC vs today. A second finding of our study concerns the evolution of consumption during the IWTC and today's trade collapse. While, as expected, we obtain that consumption declines more today than during the IWTC in manufacturing and services a striking pattern is that agriculture consumption increases during the trade collapses (see Figure 14). This result remains consistent regardless of the productivity distance between Spain and the UK.

Figure 14: Spanish consumption manufacturing and services

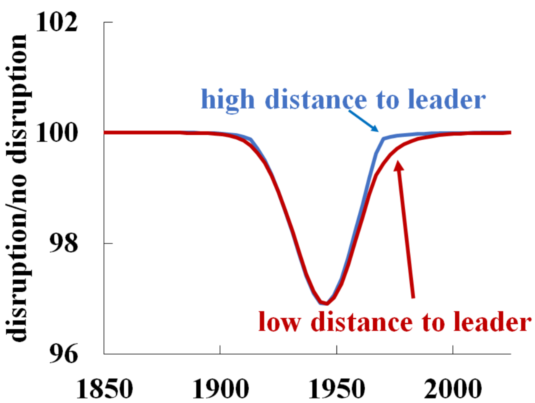


Notes: Figures 14a and 14d plot the evolution of Spain's consumption in agriculture in the economy with the trade disruption as a percentage of the consumption in the economy without the trade disruption for the two trade disruptions (Figure 8a and 8b) under the following cases for constant productivities: (1) high distance to leader ($Z_{h,t} = Z_{h,1913}$ and $Z_{f,t} = Z_{f,1913}$, blue line) and (2) low distance to leader ($Z_{h,t} = Z_{h,2000}$ and $Z_{f,t} = Z_{f,2000}$, red line). Analogously, Figures 14b and 14e plot the evolution of consumption in manufacturing, and Figures 14c and 14f plot the evolution of consumption in services.

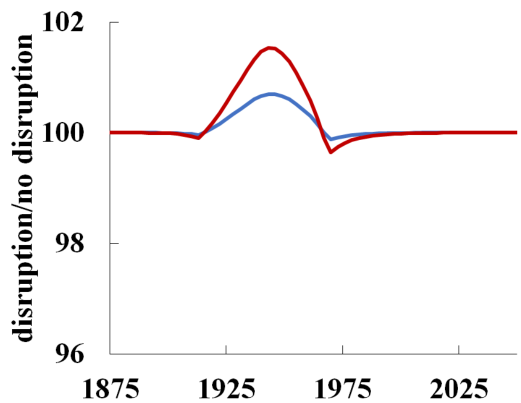
The increase in agricultural consumption in Spain during a trade collapse could be attributed to two effects. Firstly, it may be due to an increase in labor input in agriculture, as a fall in capital reduces the marginal product of a unit in manufacturing and services but not in agriculture. However, as shown in Figure 15a, this is not the case: labor in agriculture falls. In fact, labor increases in manufacturing, as more varieties need to be produced. This phenomenon will be discussed further in the subsequent subsection.

Figure 15: Labor in agriculture and consumption of domestic agriculture, IWTC, Spain

(a) **Labor in agriculture**



(b) **Consumption of domestic agric. good**

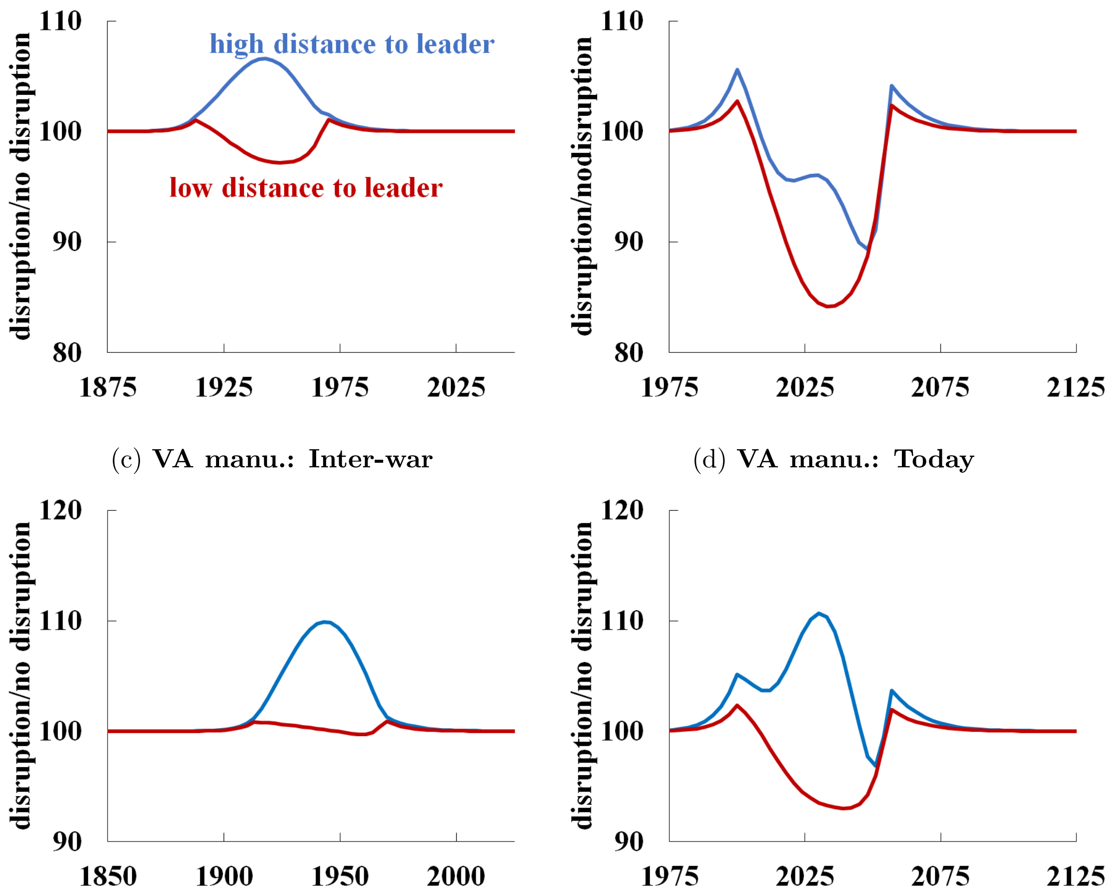


Notes: Figure 15a plots the evolution of Spain's labor in agriculture in the economy with the trade disruption as a percentage of the same variable in the economy without the trade disruption for the IWTC (Figure 8a) under the following cases for constant productivities: (1) high distance to leader ($Z_{h,t} = Z_{h,1913}$ and $Z_{f,t} = Z_{f,1913}$, blue line) and (2) low distance to leader ($Z_{h,t} = Z_{h,2000}$ and $Z_{f,t} = Z_{f,2000}$, red line). Likewise, Figure 15b plots evolution of Spain's consumption of its own intermediate in agriculture in the economy with the trade disruption as a percentage of the same variable in the economy without the trade disruption for the IWTC.

Secondly, the increase in agriculture consumption can be attributed to a decrease in Spanish exports to the UK. Since the UK decreases its imports of agricultural goods, Spain can increase its domestic agricultural consumption (see Figure 15b).

Number of varieties during IWTC vs today. One of the main findings of our paper is that, in our model, Spain produces more varieties despite the higher costs incurred during the IWTC. For the case of high distance to the leader, the blue line in Figure 16a illustrates the increase in the number of varieties in Spain due to the spike in trade costs during the IWTC. However, if the productivities of today were used instead of those of the IWTC, this increase would not have occurred, as shown by the red line. Similarly, Figure 16b demonstrates that the number of varieties would have decreased with a spike in trade costs today, regardless of whether the productivity levels were those of the IWTC (blue) or today (red).

Figure 16: Number of varieties and real value-added in manufacturing in Spain



(a) **Varieties: Inter-war**

(b) **Varieties: Today**

(c) **VA manu.: Inter-war**

(d) **VA manu.: Today**

Notes: Figures 16a and 16b plot the evolution of number of varieties for Spain in the economy with the trade disruption as a percentage of the varieties in the economy without the trade disruption for the two trade disruptions (Figure 8a and 8b) under the following cases for constant productivities: (1) high distance to leader ($Z_{h,t} = Z_{h,1913}$ and $Z_{f,t} = Z_{f,1913}$, blue line) and (2) low distance to leader ($Z_{h,t} = Z_{h,2000}$ and $Z_{f,t} = Z_{f,2000}$, red line). Analogously, Figures 16c and 16d plot the evolution of real value-added in manufacturing for Spain in the economy with the trade disruption as a percentage of the real value-added in manufacturing in the economy without the trade disruption for the two trade disruptions.

When Spain's productivity is similar to that of the UK, an increase in trade costs acts as a negative income shock. Spain is already industrialized, produces many varieties, and the spike in trade costs causes the number of varieties produced to decrease. On the other hand, if Spain is less productive than the UK, an increase in trade costs shifts resources from agriculture to manufacturing. This can be observed in the IWTC, where the trade collapse leads to an increase in the number of varieties produced in Spain (as shown in Figure 16a).

However, the scenario of low productivity and low trade costs (as depicted in Figure 16b) results in a decrease in the number of varieties in Spain if productivity differences are significant. The key to understanding this mechanism lies in Figures 16c and 16d, where we plot how the spike in trade costs affects the value added in manufacturing. In both cases, lower productivity increases the value added in manufacturing, while higher productivity decreases it in Spain. However, in the IWTC, the increase in value added is due to more varieties being produced, whereas in today's collapse, the increase is in the quantity per variety, not the total number of varieties produced. This is because in the IWTC, when trade costs are high, there are fewer varieties in total.[20] Therefore, a spike in trade costs makes the marginal value of an additional variety more significant. In contrast, in today's trade collapse, trade costs are already low, and there are many existing varieties. As a result, a spike in trade costs increases the marginal value of an extra unit of the good of an already existing variety.

7 Concluding remarks

We developed a model to evaluate the consequences of trade disruptions at different stages of the development process. Our analysis emphasizes two key factors: the productivity gap and the level of trade openness between countries. The economic impact of trade disruptions is greater when the productivity gap is wider and the trade openness is higher. Our quantitative results indicate that if a trade disruption were to occur between Spain and the UK today, it would lead to a significantly higher cost in terms of consumption and welfare compared to the Inter-War Trade Collapse of a century ago. The primary reason for the higher cost of the trade disruption is the greater extent of current trade openness. The smaller productivity gap between the two countries plays a less significant role in this scenario. Importantly, our paper also highlights the importance of capital accumulation to properly quantify the cost of a trade disruption.

Our analysis serves as a warning about the implications of trade in industrialization policies. In our model, trade disruptions can encourage the production of new manufacturing goods for countries that are not technologically advanced and are less integrated. However, this process has a significant impact on the welfare of the country. At the initial stage of development, it is more beneficial for countries to have access to a greater range of manufacturing goods. Therefore, a large trade disruption forces less-developed countries to manufacture goods that they could have imported from richer countries at a much lower cost.

Our primary focus is on Spain's attempts to catch up and trade with the UK, which was

[20] The total number of varieties is 10 percent lower in 1913 compared to 2000 for the case in which Spain's distance to the leader is high.

the industrial leader during the late 19th and early 20th centuries. However, our analysis has a broader scope in understanding the implications of trade disruptions for countries at various stages of development. This analysis can be used to study large trade disruptions between countries that are starting the catching-up process further away from the technological frontier, like India or China compared to the United States, or for highly integrated economies with similar development levels, such as the case of Brexit.

We incorporate trade à la Armington for agriculture and services, and à la Krugman for manufacturing into a standard model of structural transformation. Although our model's specification is simple, the resulting changes in trade patterns as countries progress and converge to the technology frontier are intricate and require additional investigation. Furthermore, our model abstracts from more sophisticated forms of value chains and integration of the production process. A promising avenue for future research is to integrate these elements into a trade model with capital accumulation.

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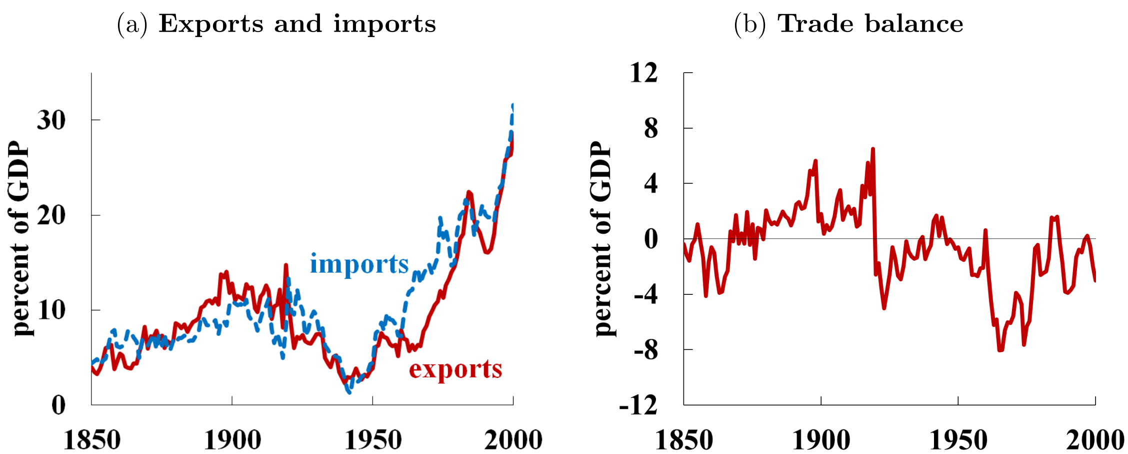
Appendices

A Spain's exports, imports, and trade balance

Figure 17a plots Spain's exports and imports as a percentage of GDP from 1850 to 2000. Figure 17b plots Spain's trade balance as a percentage of GDP from 1850 to 2000. Spain's trade is almost balanced in most periods. It ranges from -8.1 to 6.5% of GDP, and the average in this period is -0.8% of GDP. This empirical observation motivates our assumption of balanced trade in our model.

Figure 17: Spain's exports, imports, and trade balance (percentage of GDP)

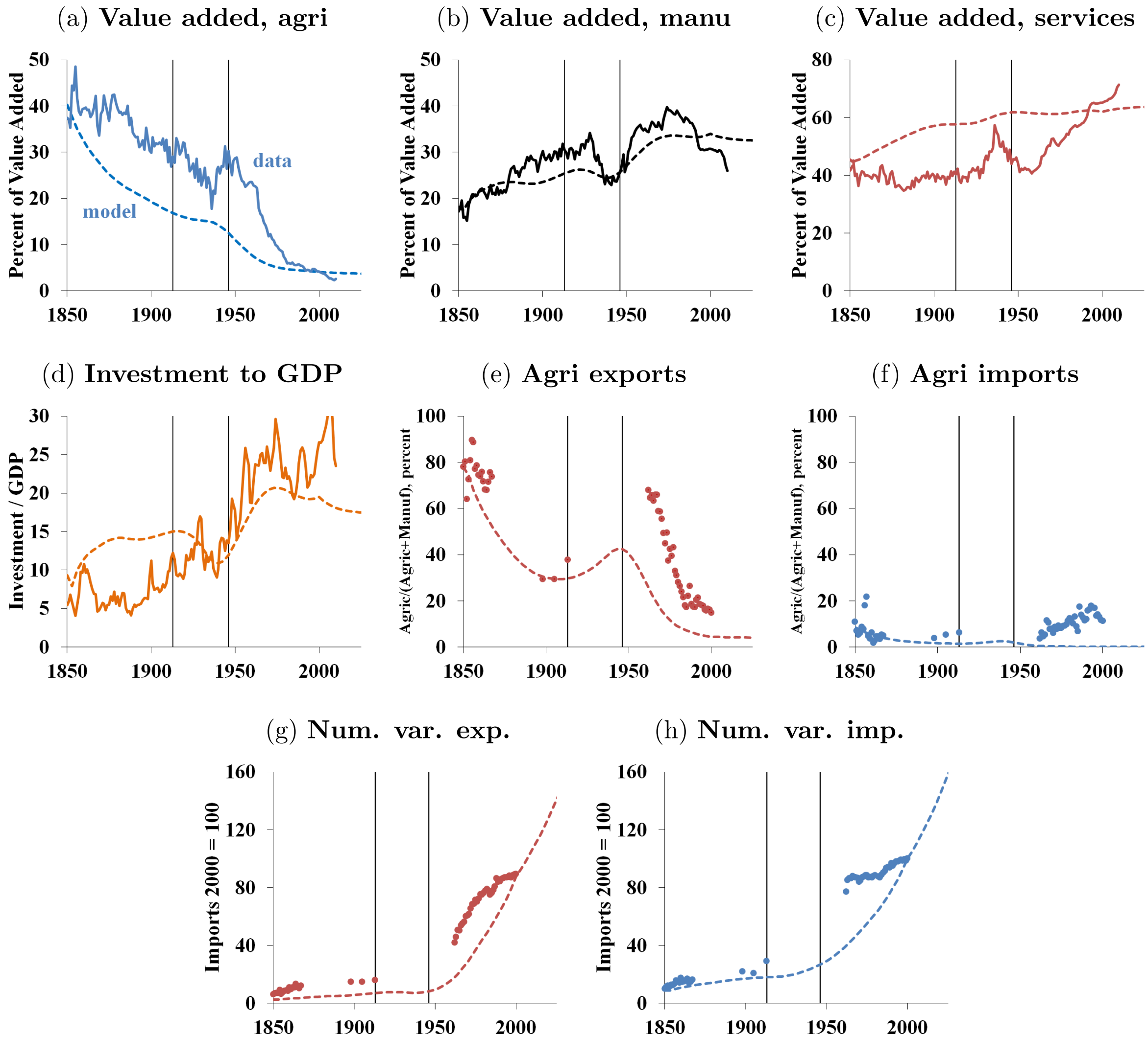


Notes: Figure 17a plots Spain's exports and imports as a percentage of GDP from 1850 to 2000. Figure 17b plots Spain's trade balance as a percentage of GDP from 1850 to 2000. Sources: Historical National Accounts dataset from Prados de la Escosura (2015).

B Construction in the data counted as manufacturing instead of services

In our benchmark calibration, we counted construction in services. In this section, we show that our main takeaways are not sensitive to this choice by considering an alternative where we count construction in manufacturing. With regard to the re-calibration, the target moment for the share of value added in manufacturing in 1850 for Spain increases from 15.0% to 18.3%. Figure 18 plots all the model validation figures. Figure 19 plots the behavior of Spain's consumption by sector and the behavior of both countries' production in varieties in both trade disruptions. Both figures show that the main takeaways barely change. Furthermore, Table 4 reports welfare implications that are almost the same in this variation and the benchmark.

Figure 18: Model validation (Spain)

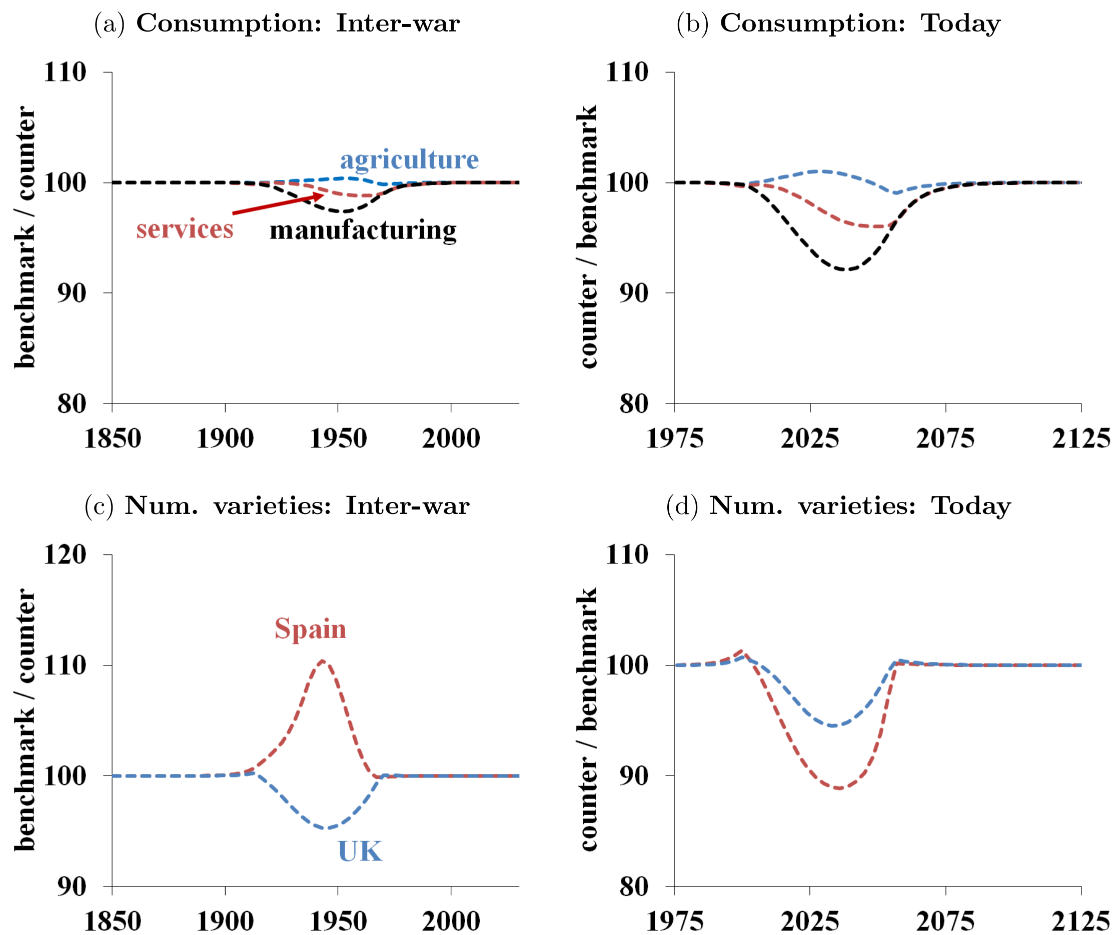


Notes: In Appendix B, we consider a calibration where we count construction in manufacturing instead of services, and re-calibrate the model to match exactly the same target moments as the benchmark calibration. Figure 18 plots the resulting model validation figures.

C Sector-specific productivities targeting value added shares

Our benchmark does not allow for sector-specific productivities. In this section, we recalibrate the model with sector-specific productivities to target the value added shares over time for Spain, the UK, and all other target moments used in the benchmark calibration. Figure 20a and 20c plot calibrated sector-specific productivities for Spain and the UK, respectively. Figures 20b and 20d plot value added shares by sector in Spain and the UK in data (filtered, solid lines) and model (dashed lines). Figure 21 shows that a trade disruption now leads to

Figure 19: Trade disruption results: Consumption (Spain) and varieties



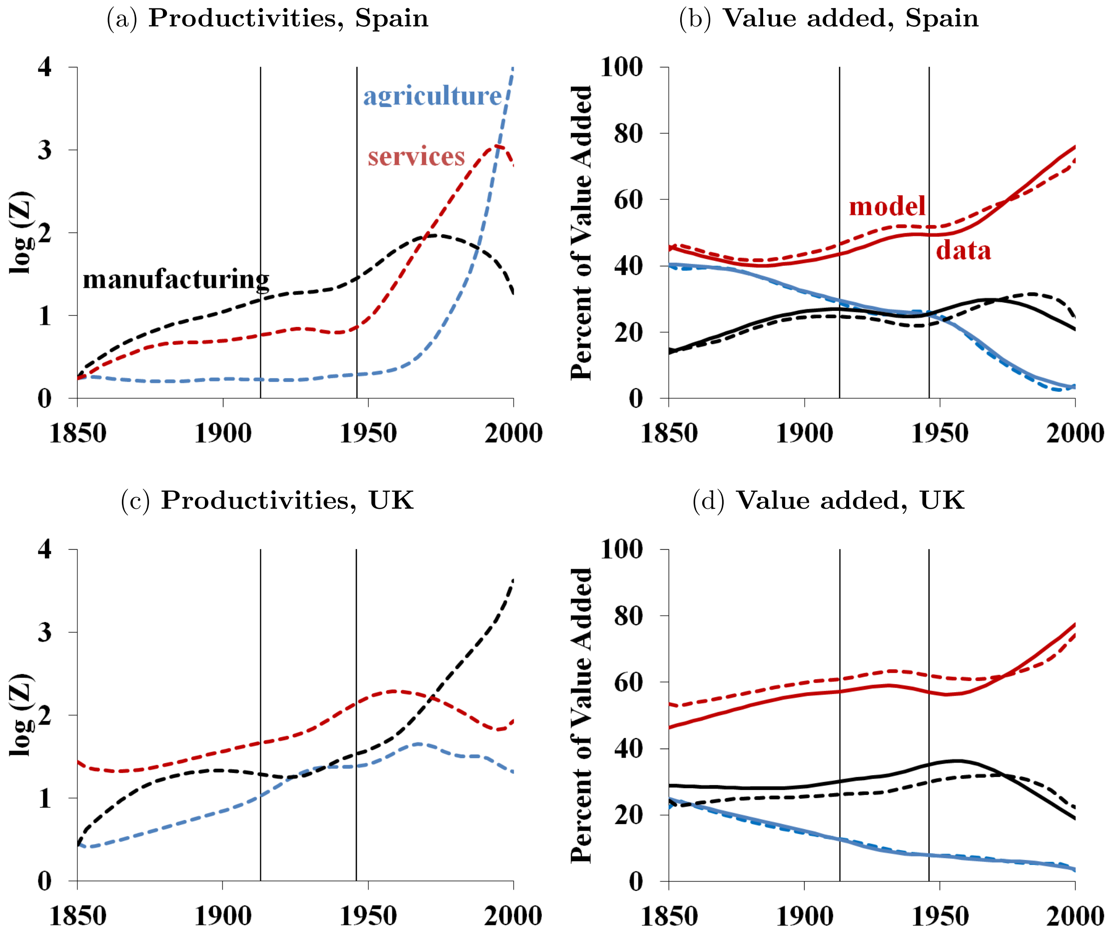
Notes: In Appendix B, we consider a calibration where we count construction in manufacturing instead of services, and re-calibrate the model to match exactly the same target moments as the benchmark calibration. Figure 19 plots the behavior of Spain's consumption by sector and varieties for both countries in both trade disruptions.

a significantly larger drop in the capital stock today compared to the inter-war period. Figure 22 shows similar implications for consumption by sector. Furthermore, Table 4 reports welfare implications that are qualitatively the same in this variation as in the benchmark: a disruption now is more costly. Furthermore, in this variation, the magnitudes are larger.

D Trade flows Spain-UK and Spain-rest of the world

Figure 23a, which plots Spain's agricultural exports as a share of its total exports in agriculture and manufacturing by trading partner, shows that the trend of agricultural exports from Spain to the UK is similar to that of Spain's with other trading partners. A similar takeaway emerges for imports, which we plot in Figure 23b. Therefore, trade flows between

Figure 20: Sector-specific productivities and new calibration targets for Spain and UK



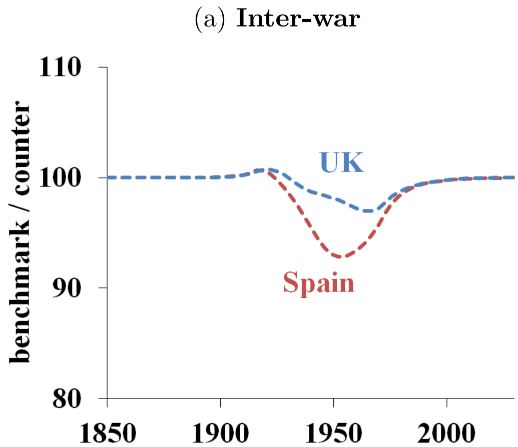
Notes: In Appendix C, we consider a calibration where we target value added shares by sector. Figure 20a and 20c plot calibrated sector-specific productivities for Spain and the UK, respectively. Figures 20b and 20d plot value added shares by sector in Spain and the UK in data (filtered, solid lines) and model (dashed lines).

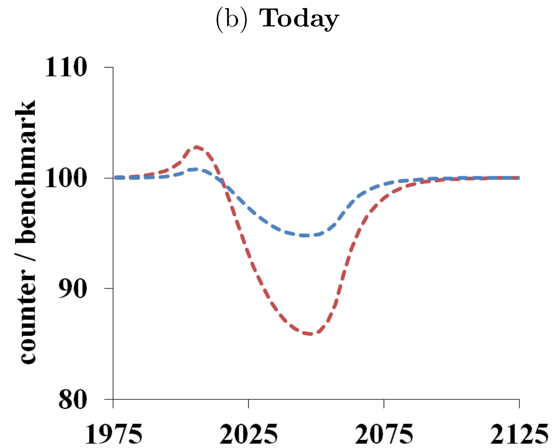
Spain and the UK are representative of the overall trade flows for Spain.

E Sensitivity of 1850 moments to initial steady state year

In our analysis, we assume that the economy is in its initial steady state in 1850. Note that even if the economy is already in transition in 1850, the allocations around the periods of the trade disruptions, which are our primary focus, will barely be affected because the trade disruptions happen after 1910 (i.e., at least 60 years from the initial steady state). Another way in which this assumption might matter is for our calibration. That is, in our calibration, we target some moments in 1850 (see Table 2). If the agents were aware of trajectories

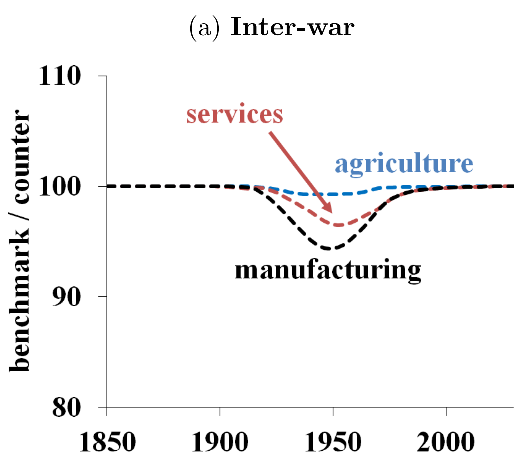
Figure 21: Capital

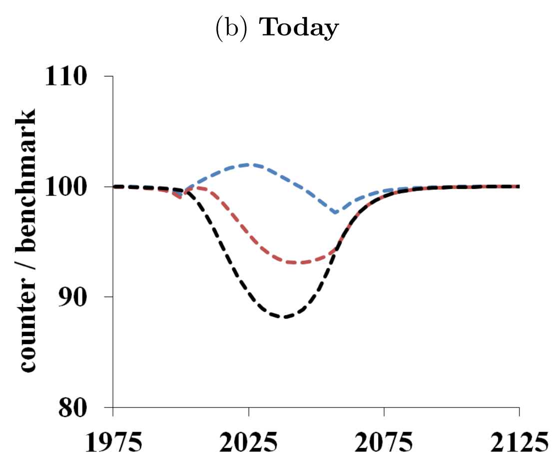




Notes: In Appendix C, we consider a calibration where we target value added shares by sector. Figure 21a plots the evolution of capital in the benchmark model, with sector-specific productivities calibrated to match value added shares by sector, (where there is an IWTC) as a percentage of counterfactual-1 (where there is no spike in trade costs) for both Spain (red line) and the UK (blue line). Figure 21b plots the evolution of capital in counterfactual-2 (where there is a new trade collapse), as a percentage of the benchmark model, with sector-specific productivities calibrated to match value added shares by sector, (where there is no spike in trade costs in the 2000s) for both Spain (red line) and the UK (blue line).

Figure 22: Consumption by sector in Spain





Notes: In Appendix C, we consider a calibration where we target value added shares by sector. Figure 22a plots the evolution of consumption by sector in the benchmark model, with sector-specific productivities calibrated to match value added shares by sector, (where there is an IWTC) as a percentage of counterfactual-1 (where there is no spike in trade costs) for Spain. Figure 22b plots the evolution of consumption by sector in counterfactual-2 (where there is a new trade collapse), as a percentage of the benchmark, with sector-specific productivities calibrated to match value added shares by sector, (where there is no spike in trade costs in the 2000s) for Spain.

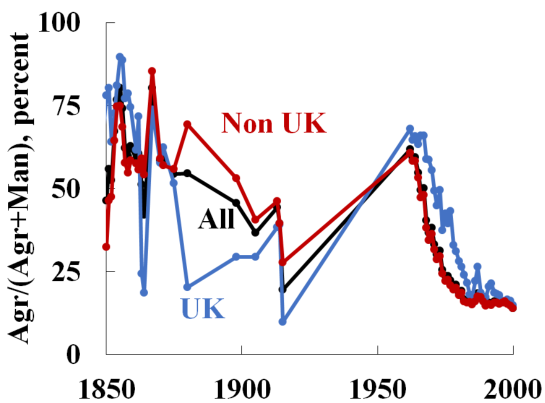
starting before 1850, those moments will likely be different. For robustness, we take the

Table 4: **Welfare (unit = percentage lifetime consumption)**

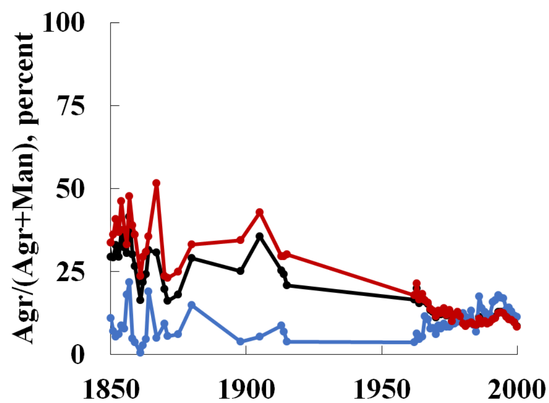
Model	Spain Inter-war	Spain Today	UK Inter-war	UK Today
Benchmark	-0.37	-1.58	-0.30	-0.88
Benchmark: unanticipated disruption	-0.42	-1.68	-0.32	-0.94
No dynamics/Static	-0.20	-0.94	-0.22	-0.53
Construction counted as manufacturing (Appendix B)	-0.37	-1.54	-0.30	-0.89
Sector-specific productivities: target value added (Appendix C)	-1.00	-2.86	-0.56	-0.92
Preferences: stronger complementarity (Appendix G)	-0.39	-1.44	-0.30	-0.86
No varieties (Appendix H)	-0.53	-1.41	-0.20	-0.76
Sector-specific iceberg cost and no home bias (Appendix I)	-0.36	-1.68	-0.31	-0.90

Figure 23: Spain's exports, imports by partner

(a) **Exports by partner**



(b) **Imports by partner**



Notes: Figure 23a plots Spain's agricultural exports as a share of its total exports in agriculture and manufacturing by trading partner. Similarly, Figure 23b plots Spain's agricultural imports as a share of its total imports in agriculture and manufacturing by trading partner. Sources: "General Ledger of the Foreign Trade of Spain with its Overseas Possessions and Foreign Powers,' 'and "General Statistical Report of the Foreign Trade of Spain with its Overseas Possessions and Foreign Powers."

parameters from our benchmark calibration, start the economy in 1835, assume that the evolution of productivities and iceberg costs are constant at their 1850 values from 1835-1850, and recompute the equilibrium. Table 5 reports the 1850 moments in the benchmark, data, and the case where we start the economy in 1835. The target moments for 1850 change only slightly. The reason is that the difference can only come as a result of differences in Spain's capital stock and the UK's capital stock in 1850. In the benchmark and in the case where we start the economy in 1835, the capital stock in 1850 is not that different. Spain's capital stock in 1850 in the benchmark and in the 1835-start are 0.098839671 and 0.093740909, respectively. The analogous numbers for the UK are 0.39243937 and 0.411299115.

Table 5: **Sensitivity of 1850 moments to initial steady state year**

Parameter		**Value**	**Target**	**Benchmark**	**Data**	**1835-start**
$\bar{c}_a$	Agri cons floor	0.682	% Agri in GDP	*0.402*	*0.402*	*0.404*
μ_m	Manu utility share	0.097	% Manu in GDP	*0.149*	*0.150*	*0.125*
$\nu_{h,a}$	Spain Agri home bias	0.845	Spain Agri Imp/(Imp: Agri+Manu)	*0.085*	*0.085*	*0.091*
$\nu_{f,a}$	UK Agri home bias	0.662	Spain Agri Exp/(Exp: Agri+Manu)	*0.778*	*0.778*	*0.819*
$Z_{h,1850}$	Spain productivity	1.276	Spain GDP per WAP 1850	*0.403*	*0.403*	*0.397*
$Z_{f,1850}$	UK productivity	3.356	UK GDP per WAP 1850	*1.000*	*1.000*	*0.983*
τ_{1850}	Iceberg cost	0.526	Spain Exp/GDP 1850	*0.037*	*0.037*	*0.036*

F GDP computation

Under the expenditure approach, GDP (in current prices) for the home country is computed as

$$p_{a,h,t}c_{a,h,t} + p_{m,h,t}(c_{m,h,t} + a_{h,t+1} - (1-\delta)a_{h,t}) + p_{s,h,t}c_{s,h,t} + nex_{h,t} - nim_{h,t},$$

where $nex_{h,t}$ is the net exports of intermediaries and $nim_{h,t}$ is the net imports of intermediaries. Note that imported intermediaries are not included in GDP. Under the income approach, GDP is computed as

$$r^K_{h,t}a_{h,t} + w_{h,t} + r^L_{h,t}L_{h,t} + \pi_{h,t}.$$

Under the value added approach, GDP is computed as

$$q_{a,h,h,t}x_{a,h,h,t}+q_{a,f,h,t}x_{a,f,h,t}+[q_{m,h,h,t}x_{m,h,h,t}+q_{m,f,h,t}x_{m,f,h,t}-p_{m,h}F_h]N_h+q_{s,h,h,t}x_{s,h,h,t}+q_{s,f,h,t}x_{s,f,h,t}.$$

G Preferences with stronger complementarity

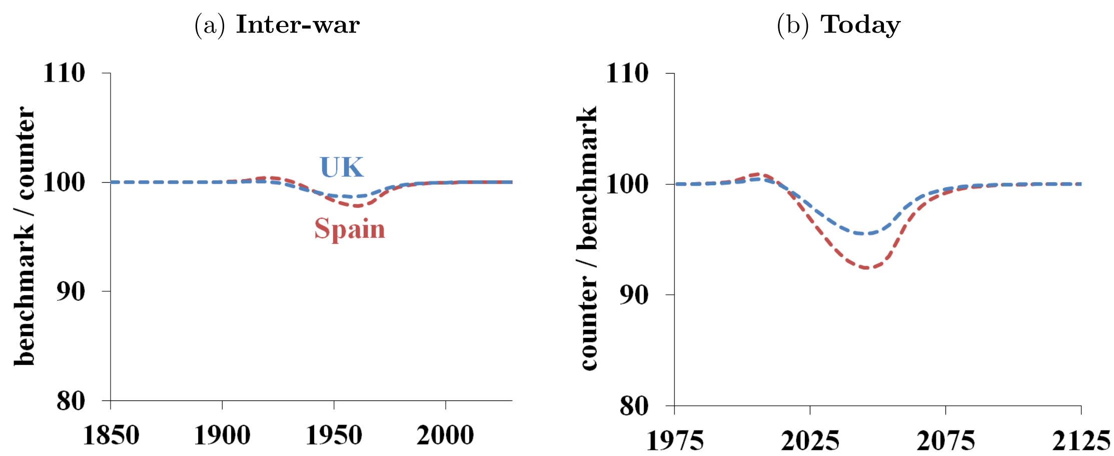
Our benchmark calibration relies on an elasticity of substitution across consumption goods of 0.85, which implies parameter $\epsilon = -0.176$. This parameter is taken from Herrendorf, Rogerson, and Valentinyi (2013). They show that in a model of structural transformation, this value broadly generates the observed structural transformation in the US economy when looking at final expenditure per sector. On the other hand, they also find that more complementarity is needed to account for patterns observed in value added per sector.

While we show that our calibrated model is validated using the sectoral composition of the Spanish economy, it is nonetheless important to perform a robustness check regarding the parameter ϵ. In this section, we recalibrate the model using $\epsilon = -10$, which implies an elasticity of substitution of 0.09.

Besides the important change in ϵ, our calibration is exactly the same as the one in the benchmark calibration (Section 4), and we are able to match the moments and validate the model again. In what follows, we show the similarities and differences between this calibration and the benchmark calibration with regard to the trade disruption results.

We start with the experiments regarding the fall in the capital stock in the two counterfactual scenarios. In Figures 24a and 24b, we plot the capital stock counterparts to Figures 9a and 9b.

Figure 24: Capital



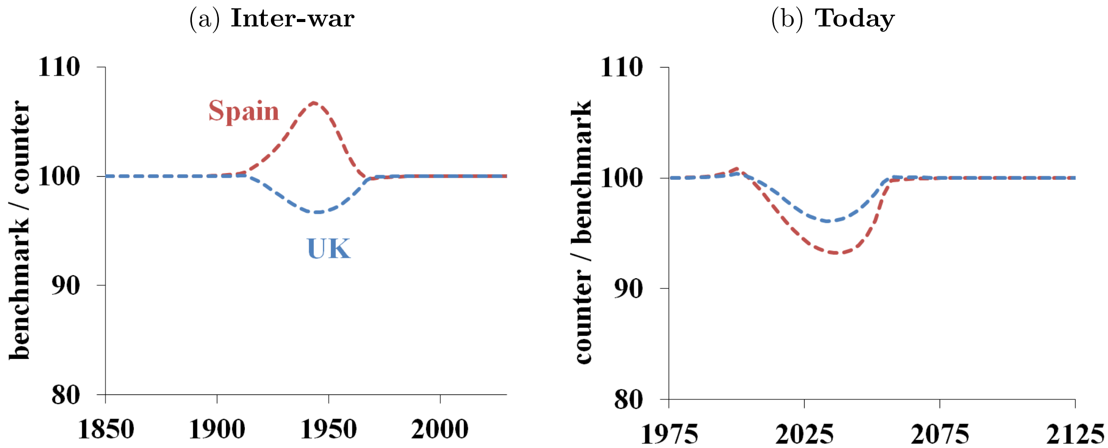
Notes: In Appendix G, we consider a calibration with stronger complementarity in preferences. Figure 24a plots the evolution of capital in the model with stronger complementarity in preferences (where there is an IWTC) as a percentage of counterfactual-1 (where there is no spike in trade costs) for both Spain (red line) and the UK (blue line). Figure 24b plots the evolution of capital in counterfactual-2 (where there is a new trade collapse), as a percentage of the model with stronger complementarity in preferences (where there is no spike in trade costs in the 2000s) for both Spain (red line) and the UK (blue line).

Our main result regarding the trade shock today being more costly in terms of capital than it was during the IWTC remains the same. However, the magnitude of the fall is larger in the benchmark (Figure 9).

The above result is similar to the one we obtain when we look at the change in varieties. In Figures 25a and 25b, we plot the counterparts to Figures 12a and 12b. Again, we find the same qualitative result under this calibration as we did in the benchmark: the number of varieties increased during the IWTC in Spain; at the same time, that number would decrease if there were a similar trade disruption today. As in the case of capital, the magnitudes of the increase in the IWTC and the fall today are smaller than in the benchmark.

The main difference between the benchmark and this sensitivity check has to do with consumption by sector. In Figures 26a and 26b, we plot the counterparts to Figures 10a and 10b. In the benchmark exercise, we found that each sector exhibited a different behavior in the presence of trade disruptions. We found that manufacturing decreased the most, followed

Figure 25: Number of varieties



Notes: In Appendix G, we consider a calibration with stronger complementarity in preferences. Figure 25a plots the evolution of the number of varieties in the model with stronger complementarity in preferences (where there is an IWTC) as a percentage of counterfactual-1 (where there is no spike in trade costs) for both Spain (red line) and the UK (blue line). Figure 25b plots the evolution of the number of varieties in counterfactual-2 (where there is a new trade collapse), as a percentage of the model with stronger complementarity in preferences (where there is no spike in trade costs in the 2000s) for both Spain (red line) and the UK (blue line).

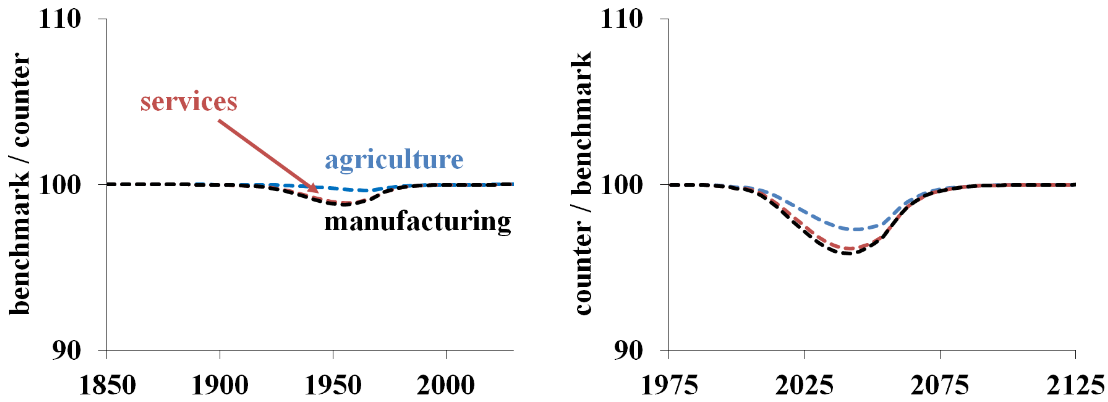
by services, and agriculture increases for some period of the trade disruption. This result is different in this sensitivity exercise: the three sectors fall, and their behavior is much more similar. This result is not surprising. The three sectors are now more complementary, and hence, if consumption in one sector falls, then consumption in the other sectors must fall too. Finally, while the behavior consumption across sectors is different, the welfare estimates are essentially the same as the benchmark (Table 4).

H Trade disruptions without varieties

Figure 27a plots the evolution of real value added by sector for Spain in the benchmark relative to the counterfactual without the IWTC. Similarly, Figure 27b plots the evolution of real value added in a framework that was re-calibrated without varieties (i.e., like the other sectors, manufacturing is also Armington with perfect competition) after dropping the target moment related to varieties (Spain/UK varieties in 2000). In the benchmark, industrialization increases during a trade disruption, whereas industrialization decreases in the alternative without varieties. This highlights the importance of incorporating varieties (with fixed costs in units of the final good) for our second main result.

Figure 26: Consumption by sector in Spain

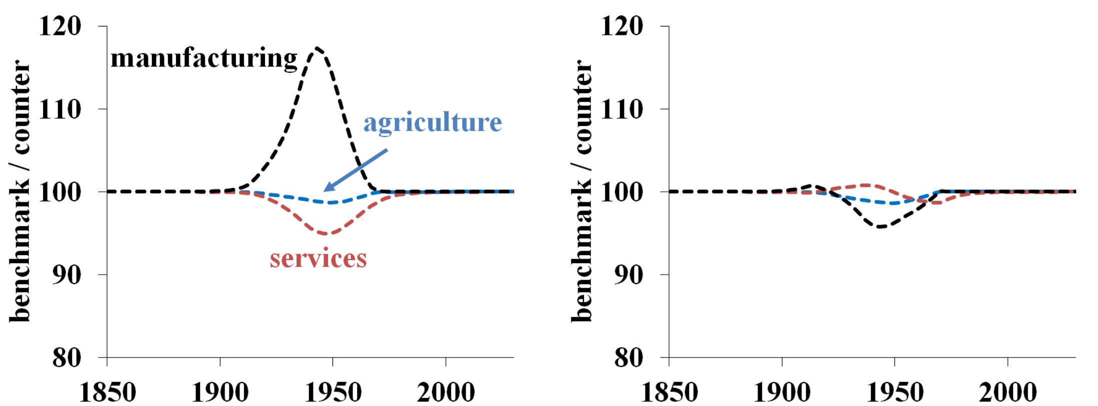
(a) **Inter-war** (b) **Today**



Notes: In Appendix G, we consider a calibration with stronger complementarity in preferences. Figure 26a plots the evolution of consumption by sector in the model with stronger complementarity in preferences (where there is an IWTC) as a percentage of counterfactual-1 (where there is no spike in trade costs) for Spain. Figure 26b plots the evolution of consumption by sector in counterfactual-2 (where there is a new trade collapse), as a percentage of the model with stronger complementarity in preferences (where there is no spike in trade costs in the 2000s) for Spain.

Figure 27: Spain's real value added by sector: IWTC

(a) **Benchmark** (b) **No varieties**



Notes: In Appendix H, we consider a trade disruption without varieties. Figures 27a plots the evolution of real value added by sector for Spain in the benchmark relative to the counterfactual without the IWTC. Similarly, Figure 27b plots the evolution of real value added in a framework that was re-calibrated without varieties after dropping the target moment related to varieties (Spain/UK varieties in 2000).

I Trade disruptions without home bias

In our benchmark model, we allowed for sector-specific home bias (country-specific as well for agriculture) and trade costs that are the same across sectors for both countries. In this section, we consider an alternative calibration where there is no home bias (i.e., all home bias parameters are set to 0.5). Instead, trade costs are sector-country specific for agriculture and only sector-specific for manufacturing and services. This allows the model to match exactly the same set of target moments as in the benchmark calibration.[21] Figure 28 plots the resulting iceberg costs along with all the model validation figures. Figure 29 plots the behavior of Spain's consumption by sector and varieties for both countries in both trade disruptions. Both figures show that the results barely change. Furthermore, Table 4 reports welfare implications that are almost the same in this version of the model and in the benchmark.

J Impact of iceberg costs and productivity on exports/GDP and GDP in benchmark calibration

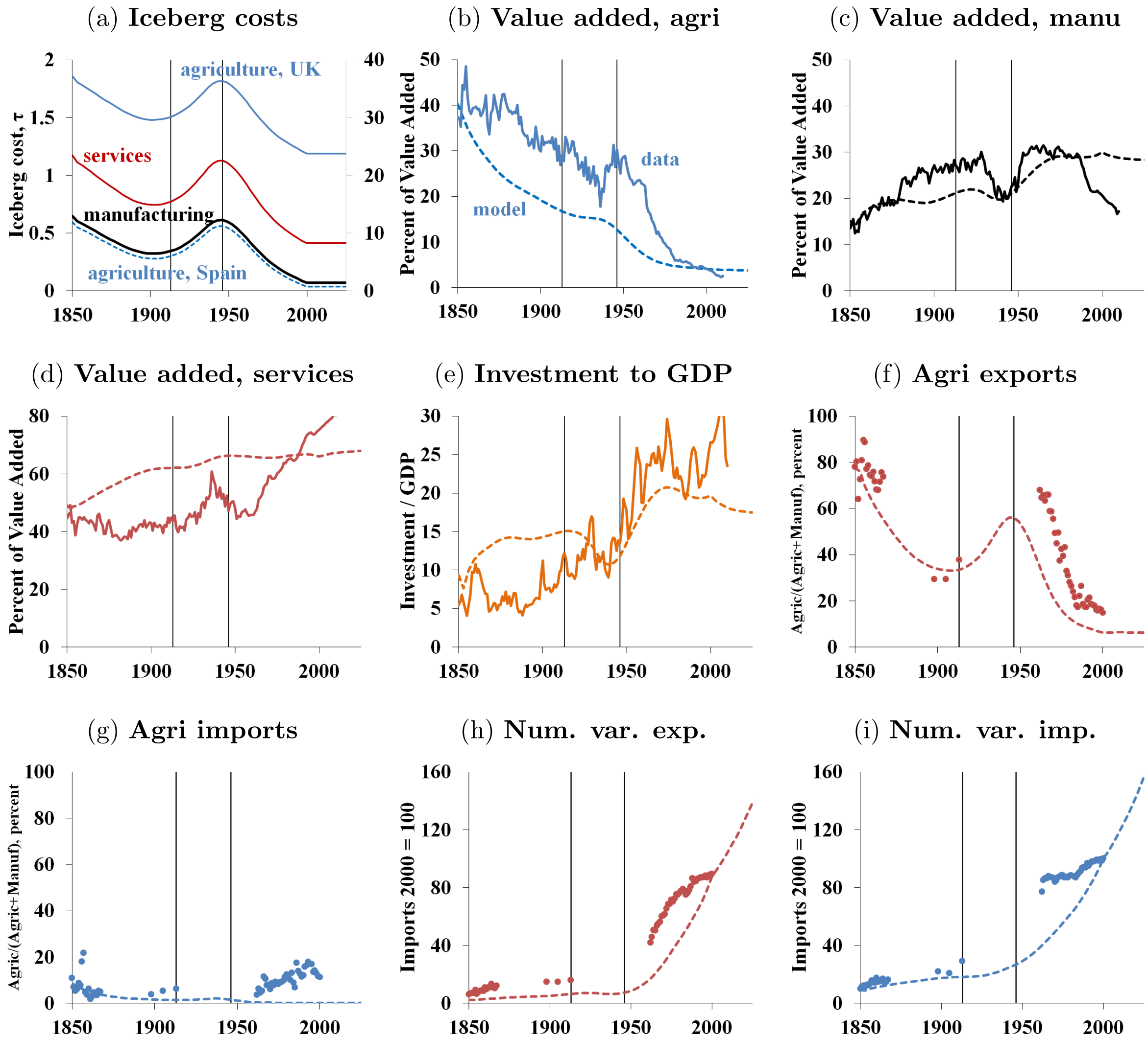
Figure 30 plots the evolution of Spain's export/GDP and GDP per working-age person under the following two cases for the benchmark calibration: (1) constant iceberg costs (at their 1850 levels) while productivities evolve as depicted in Figure 4c and (2) constant productivities (at their 1850 levels) while iceberg costs evolve as depicted in Figure 4a. Quantitatively, the impact of trade costs on GDP is small (Figures 30a and 30c) and the impact of productivity on exports/GDP is small (Figures 30b and 30d). This suggests that in our model, the main driver of a large fall in exports/GDP are iceberg costs, which is what we vary when analyzing a trade disruption.

K Drivers of structural transformation in benchmark exercise

In this Appendix, we show that the main feature that generates structural transformation in our benchmark calibration is Stone-Geary preferences. This can be see in Figure 31, which plots the evolution of value added shares by sector under the following cases: no Stone-Geary preferences ($\bar{c}_a = 0$), static/no dynamics ($\alpha_m = \alpha_s = 0$ and no savings decision for the consumer), fixed trade cost ($\tau_t = \tau_{1850}$), fixed cost in units of labor, and the benchmark calibration. The cases with no Stone-Geary preferences, static/no dynamics, and fixed costs in units of labor were re-calibrated after dropping the relevant target moments. Changes in trade frictions have no quantitatively significant impact on the structural transformation because the benchmark and the case with fixed trade costs have essentially the same pattern. The takeaway for the case with fixed costs in units of labor is similar. The key model ingredient to generate structural transformation is preferences. Without Stone-Geary

[21] For the periods between 1850 and 2000, we assume that the change in trade costs in relative terms (i.e., in $1+\tau$) is the same across sectors.

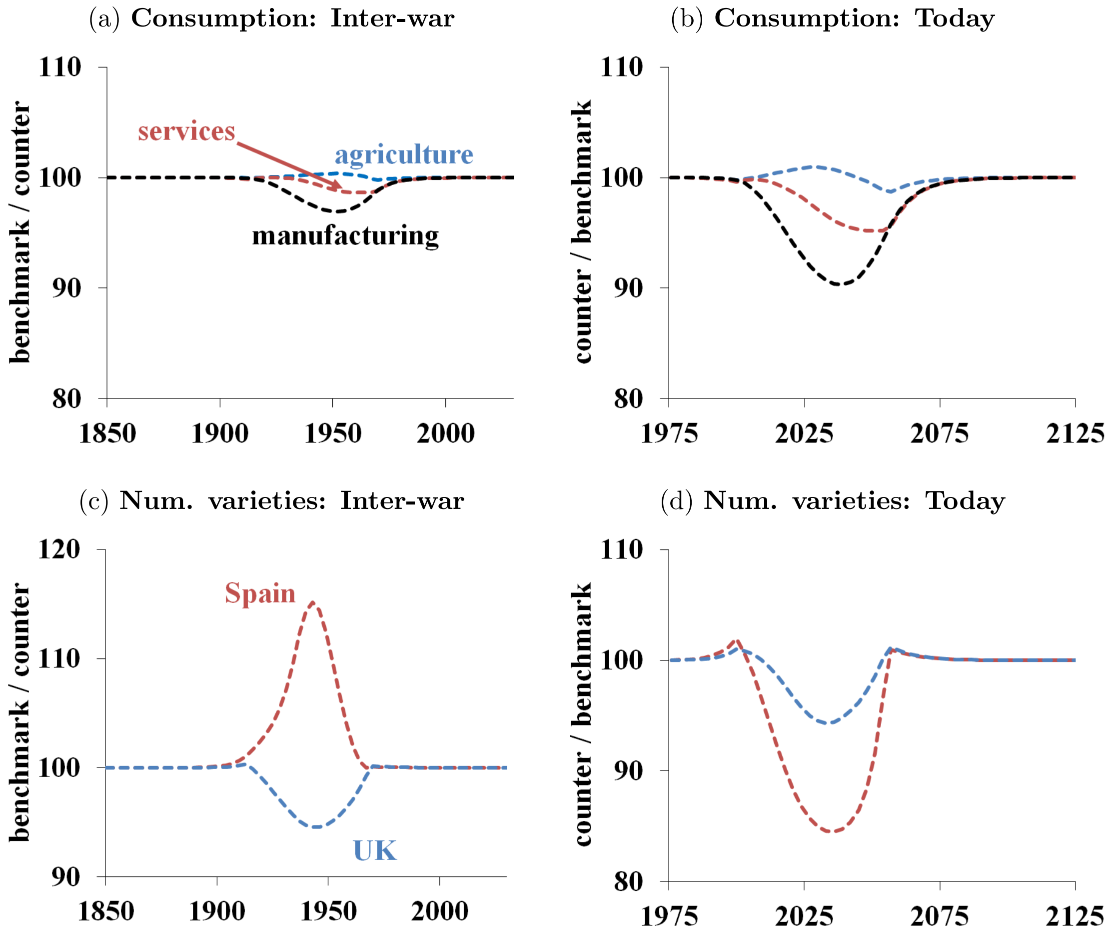
Figure 28: Iceberg costs and model validation (Spain)



Notes: In Appendix I, we assume no home bias (i.e., home bias is 0.5 in all sectors), allow for sector-specific iceberg costs, and re-calibrate the model to match exactly the same target moments as the benchmark calibration. Figure 28 plots the resulting iceberg costs along with all the model validation figures.

preferences, we almost no longer observe the structural transformation. A less important ingredient with regard to the structural transformation is dynamics: it leads to a higher level of value added in manufacturing and a lower level of value added in services towards the end of the twentieth century.

Figure 29: Trade disruption results: Consumption (Spain) and varieties



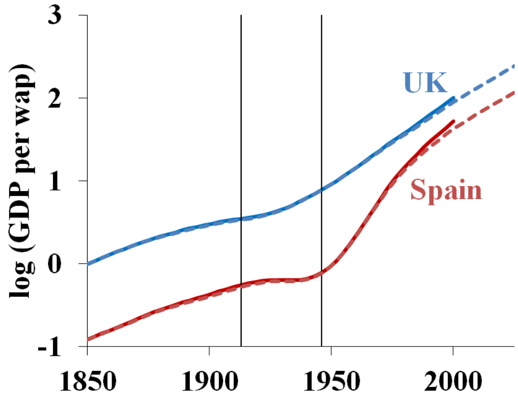
Notes: In Appendix I, we assume no home bias (i.e., home bias is 0.5 in all sectors), allow for sector-specific iceberg costs, and re-calibrate the model to match exactly the same target moments as the benchmark calibration. Figure 29 plots the behavior of Spain's consumption by sector and varieties for both countries in both trade disruptions.

L Structural transformation for the UK in benchmark exercise

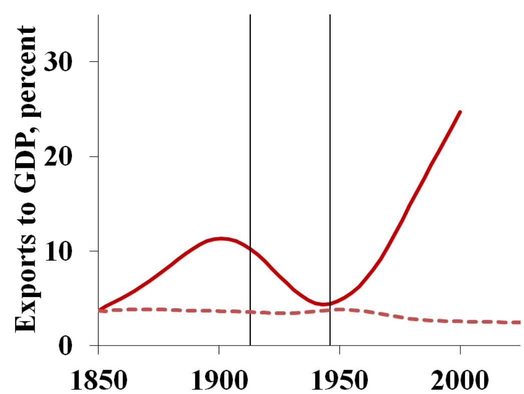
Figure 32 compares the evolution of value added shares by sector in the benchmark model (dashed lines) with data (solid lines) for the UK from 1850 to 2000 (relevant exogenous changes are presented in Figures 4a and 4c). The model does reasonably well in rationalizing the data except for the recent decline in the share of manufacturing. In Appendix C, we consider a sensitivity analysis in which we target value added shares by sector in both Spain and the UK. The main takeaways do not change.

Figure 30: GDP and Exports/GDP with fixed τ_t and fixed productivity $Z_{i,t}$

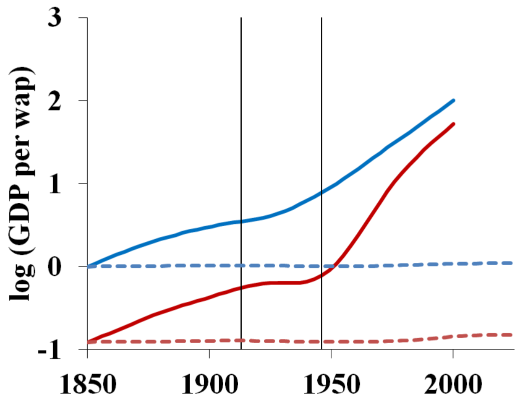
(a) **GDP per wap:** $\tau_t = \tau_{1850}$



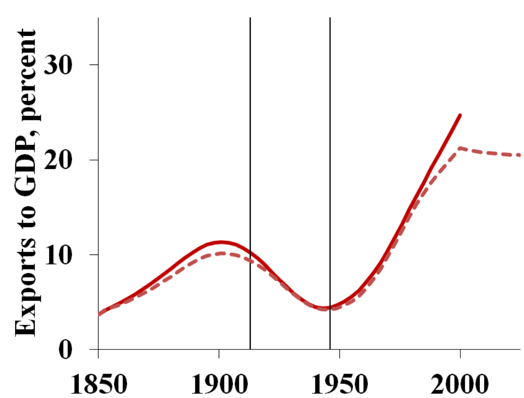
(b) **Exports/GDP:** $\tau_t = \tau_{1850}$



(c) **GDP per wap:** $Z_{i,t} = Z_{i,1850}$



(d) **Exports/GDP:** $Z_{i,t} = Z_{i,1850}$



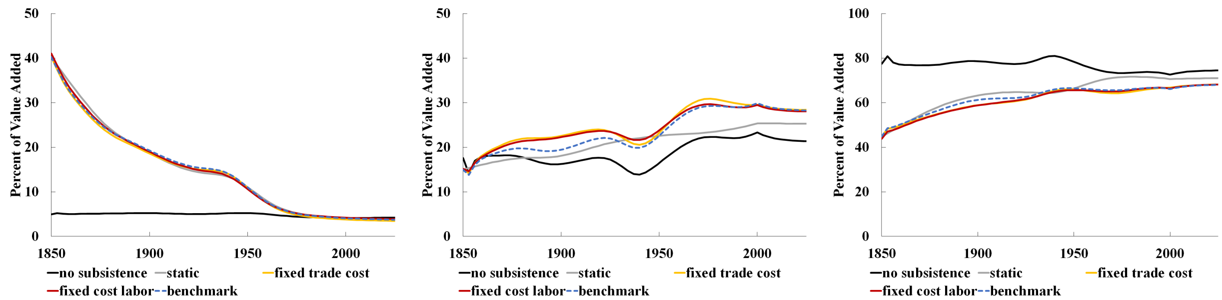
Notes: Figures 30a plots the evolution of GDP per working-age person for Spain, in red, and for the UK, in blue, in the benchmark calibration when $\tau_t = \tau_{1850}$ while productivities evolve as depicted in Figure 4c. Similarly, Figure 30b plots the evolution of exports over GDP for Spain. Analogously, Figures 30c and 30d consider the case when when $Z_{i,t} = Z_{i,1850}$ while iceberg costs evolve as depicted in Figure 4a.

M Spain's relative prices

Figure 33 compares the evolution of the relative price of agriculture to services and the relative price of manufacturing to services in the main exercises with data for Spain from 1850 to 2000. The benchmark model does remarkably well in accounting for the evolution of the relative price of manufacturing (Figure 33b). For the relative price of agriculture, the benchmark model accounts for the long-run decline but falls short in accounting for the evolution over time (Figure 33a). In contrast, the model in which we targeted value added shares in each sector for both Spain and the UK does remarkably well in accounting for the evolution of relative price of agriculture (Figure 33a), but does poorly in regard to

Figure 31: Value added shares in Spain under various specifications

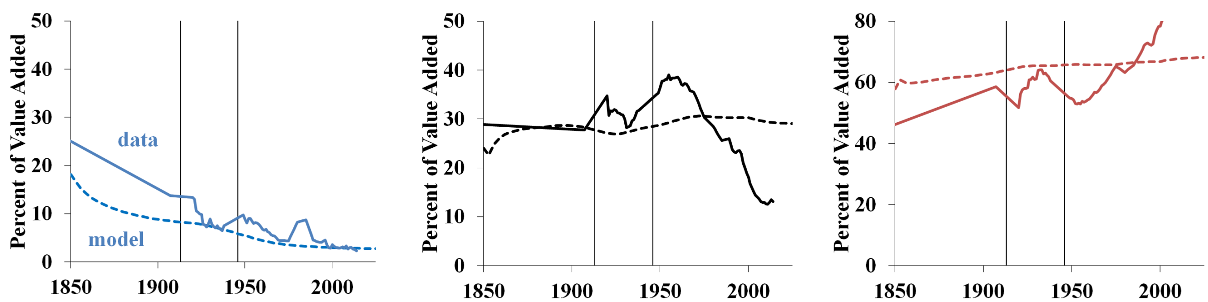
(a) **Value added, agr.** (b) **Value added, man.** (c) **Value added, ser.**



Notes: Figure 31 plots the evolution of value added shares by sector under the following cases: no Stone-Geary preferences ($\bar{c}_a = 0$), static/no dynamics ($\alpha_m = \alpha_s = 0$ and no savings decision for the consumer), fixed trade cost ($\tau_t = \tau_{1850}$), fixed cost in units of labor, and the benchmark calibration. The cases with no Stone-Geary preferences, static/no dynamics, and fixed costs in units of labor were re-calibrated after dropping the relevant target moments.

Figure 32: Non-targeted moments: UK's value added shares by sector in benchmark model

(a) **Value added, agr.** (b) **Value added, man.** (c) **Value added, ser.**



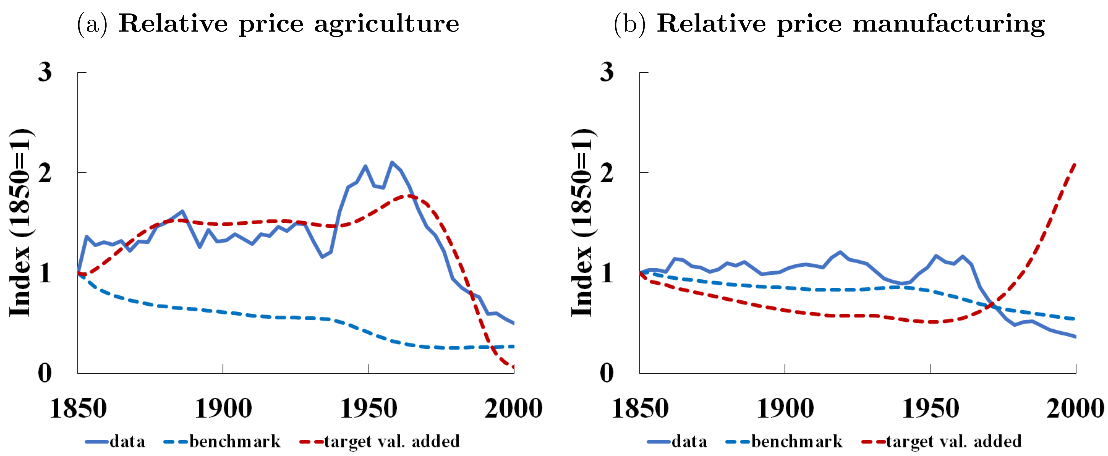
Notes: Figure 32 plots the evolution of value added shares by sector in the benchmark model (dashed lines) and data (solid lines) for the UK from 1850 to 2000. The exogenous changes that lead to this transition are presented in Figures 4a and 4c.

the relative price of manufacturing in the latter part of the twentieth century (Figure 33b). While each variation of the model fares better in each of the prices, the main takeaways of our study do not change.

N Spain's trade balance and consumption in manufacturing in benchmark exercise

In the early 1850s, Spain's value added share in manufacturing (Figure 5b) is roughly 15%, whereas both Spain's investment to GDP (Figure 6a) and manufacturing consumption to GDP (Figure 34b) are roughly 10% each. This implies that Spain must be running a trade

Figure 33: Non-targeted moments: Spain's relative prices



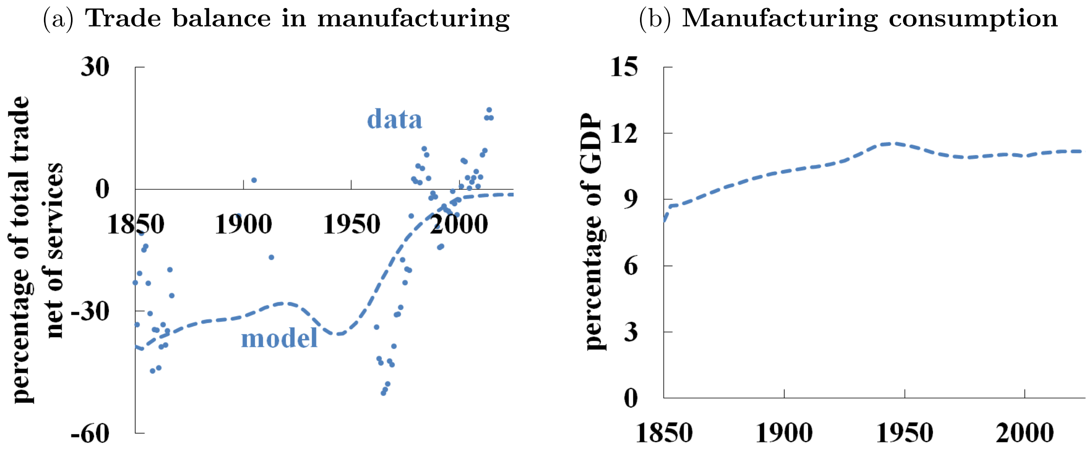
Notes: Figure 33 plots the evolution of Spain's relative price of agriculture to services and relative price of manufacturing to services in the following experiments from 1850 to 2000: data, benchmark (benchmark calibration), and target value added (target value added by sector for both countries with country-sector-specific productivities). Data source: Historical National Accounts dataset from Prados de la Escosura (2015).

deficit in manufacturing at that time period. While we do not have data on Spain's manufacturing consumption, we can compare the model with data for Spain's trade balance in manufacturing (using the digitized data with the UK; Figure 34a). Over the time period from 1850 to the 2000s, the model does reasonably well in accounting for the trade deficit from the 1850s until the 1950s, and the subsequent decline in the deficit.

O Relative change in import-to-domestic expenditure during trade disruptions in benchmark exercise

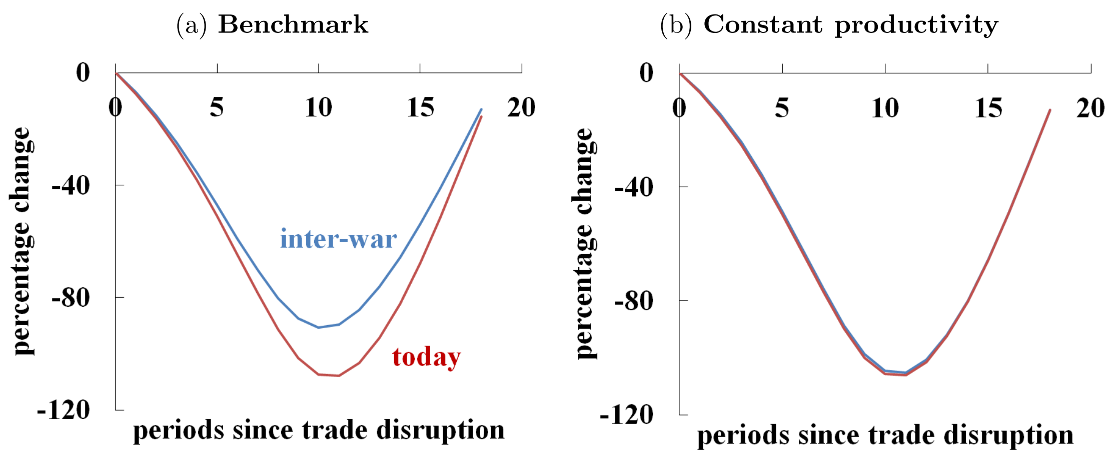
An implication of a standard, static model of trade is that for trade disruptions where the relative change in $1+\tau$ is the same, the relative change in import-to-domestic expenditure is the same — a result stemming from the model being consistent with the gravity equation. Despite our model being richer than this standard, static model, we show numerically that the relative change is almost the same in both trade disruptions. Figure 35 plots the relative change in import-to-domestic expenditure under the two trade disruptions (IWTC and today) in (a) the benchmark model and (b) with constant productivities ($Z_{h,t} = Z_{h,2000}$ and $Z_{f,t} = Z_{f,2000}$). When we control for the change in productivities in Figure 35b (constant productivity, i.e., only τ changes), the relative changes in import-to-domestic expenditure in both trade disruptions are almost the same.

Figure 34: Spain's trade balance in manufacturing



Notes: Figure 34a plots the evolution of Spain's trade balance in manufacturing as a percentage of its total trade net of services in the benchmark model and from the digitized data. Figure 34b plots the evolution of Spain's manufacturing consumption as a percentage of GDP in the benchmark exercise. The exogenous changes that lead to this transition are presented in Figures 4a and 4c.

Figure 35: Relative change in import-to-domestic expenditure during trade disruptions

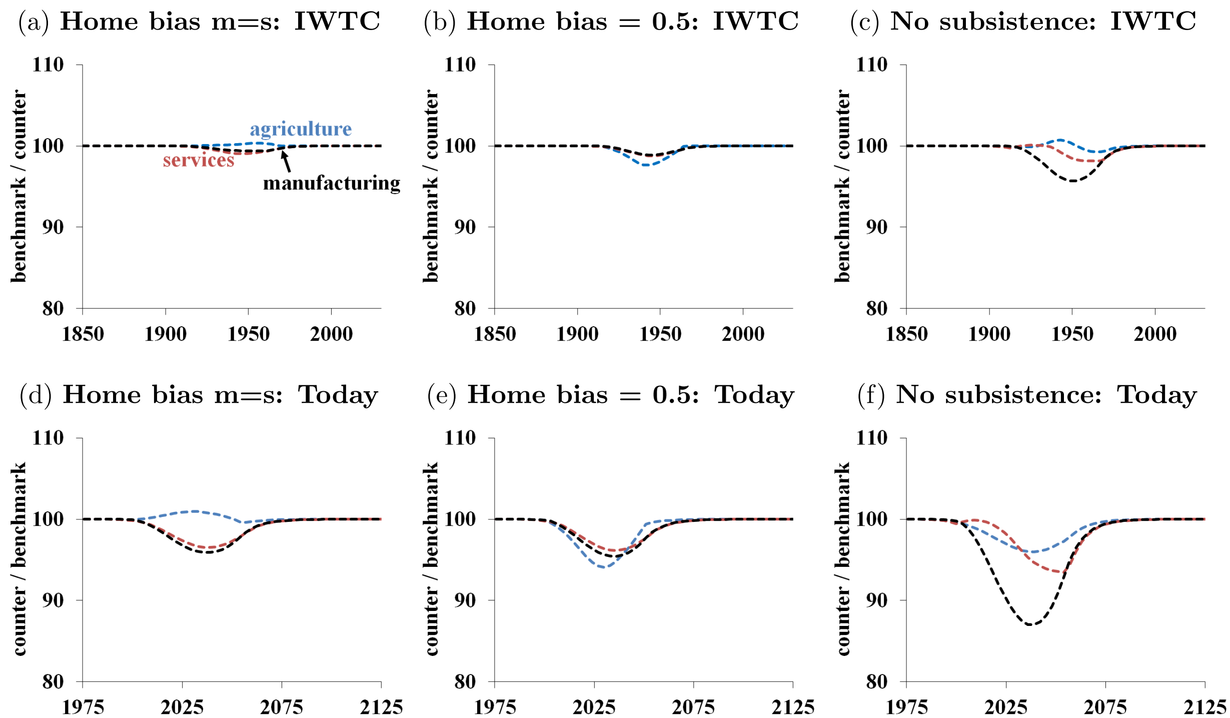


Notes: Figure 35 plots the relative change in import-to-domestic expenditure under the two trade disruptions (IWTC and today) in (a) the benchmark model and (b) constant productivities ($Z_{h,t} = Z_{h,2000}$ and $Z_{f,t} = Z_{f,2000}$).

P Consumption by sector for Spain under various specifications

Figure 36 serves to substantiate the discussion surrounding Figures 10a and 10b in the main text, which show that during both trade disruptions (IWTC and today), Spain's consumption in agriculture rises, consumption in services falls moderately, and consumption in manufacturing falls the most.

Figure 36: Spain's consumption under various specifications

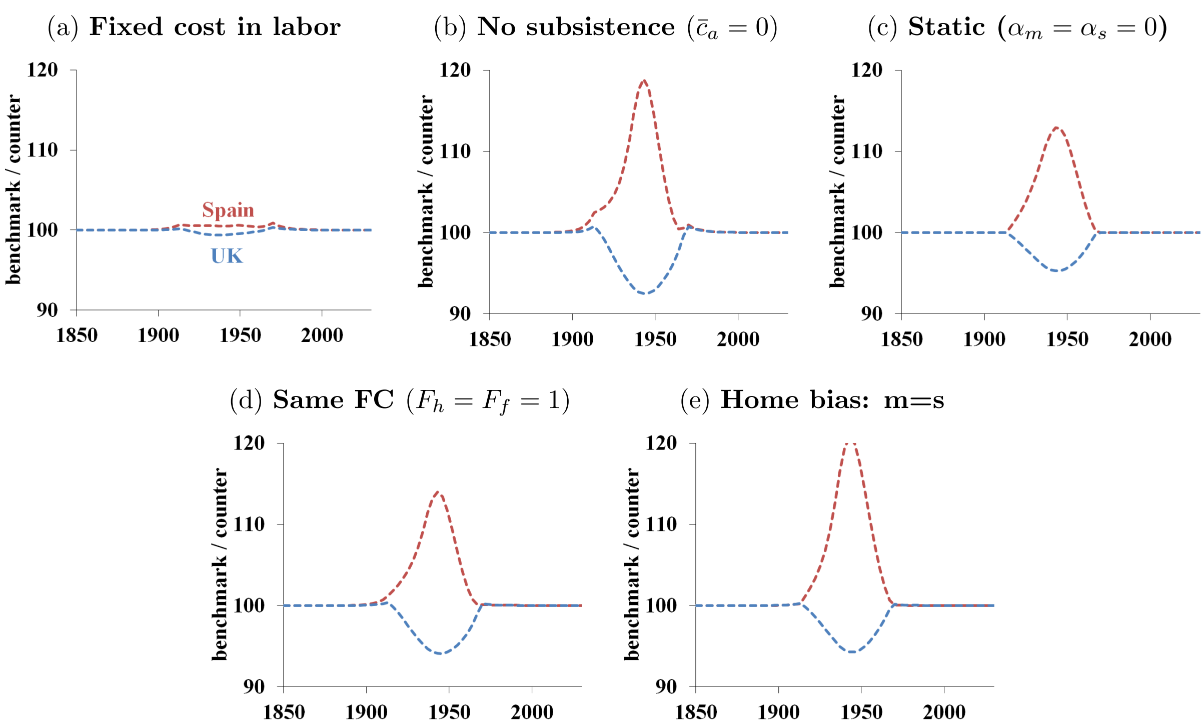


Notes: Figure 36 plots Spain's consumption by sector during the two trade disruptions under the following cases: home bias for services is equal to that of manufacturing ($\nu_{h,m} = \nu_{f,m} = \nu_{h,s} = \nu_{f,s}$), home bias is the same for all sectors ($\nu_{h,m} = \nu_{f,m} = \nu_{h,s} = \nu_{f,s} = \nu_{h,a} = \nu_{f,a}$), and the case without subsistence consumption for agriculture ($\bar{c}_a = 0$). Each variation was re-calibrated after dropping relevant target moments. See text surrounding Figures 10a and 10b in the main text for more details.

Q Varieties produced by Spain during IWTC under various specifications

One of the striking patterns observed in our benchmark analysis is the rise in the production of varieties in Spain during the IWTC (Figure 12a). In this section, we consider various re-calibrated specifications of our model to isolate essential features of the model for the rise in varieties. Figure 37 plots the behavior of varieties in Spain and the UK during the IWTC under the following cases: fixed costs in units of labor instead of the final manufacturing good, no subsistence consumption ($\bar{c}_a = 0$), no capital (static version of our model with $\alpha_m = \alpha_s = 0$ and no savings decision for the consumer), the fixed cost of producing a variety is the same in Spain and the UK ($F_h = F_f = 1$), and same level of home bias for manufacturing and services ($\nu_{h,m} = \nu_{f,m} = \nu_{h,s} = \nu_{f,s}$). The fixed costs assumed to be in units of the final good rather than in units of labor is an important feature (Figure 37a). Without it, we (almost) no longer see a rise in varieties. In Section 6, we show that the distance to the UK matters as well, where with higher distance, a trade disruption is more likely to lead to a spike in varieties for Spain. Furthermore, without subsistence consumption in agriculture and same home bias parameters for manufacturing and services (i.e., lower home bias for services relative to benchmark), the spike in varieties is higher (Figures 37b and 37c). This is because in these variations, it is less costly for Spain to divert resources from other sectors to produce more varieties. Features of the model such as capital accumulation and different fixed costs for each country do not play a significant role in affecting the number of varieties produced for the trade collapses we study (Figures 37d and 37e).

Figure 37: Spain's varieties under various specifications: IWTC



Notes: Figure 37 plots the behavior of varieties in Spain and the UK during the IWTC under the following cases: fixed costs in units of labor instead of the final manufacturing good, no subsistence consumption ($\bar{c}_a = 0$), no capital (static version of our model with $\alpha_m = \alpha_s = 0$ and no savings decision for the consumer), the fixed cost of producing a variety is the same in Spain and the UK ($F_h = F_f = 1$), and same level of home bias for manufacturing and services ($\nu_{h,m} = \nu_{f,m} = \nu_{h,s} = \nu_{f,s}$). Each model variation was re-calibrated.