Trade and Catching Up to the Industrial Leader

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JUAN CARLOS CONESA, MATTHEW J DELVENTHAL, PAU S PUJOLAS & GAJENDRAN RAVEENDRANATHAN

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Juan Carlos Conesa Ma

Matthew J. Delventhal

Stony Brook University

Claremont McKenna College

Pau S. Pujolas

Gajendran Raveendranathan

McMaster University

McMaster University

October 2019

Abstract

We study the impact of trade on a country catching up to the industrial leader. We calibrate our dynamic, two-country model to Spain and UK from 1850 to 2000, accounting for the inter-war trade collapse (IWTC) and the subsequent catch up by Spain. In our model, the effects of trade disruptions are stronger with more distance to the leader and more openness. A collapse today (less distance, more openness) similar to the IWTC (more distance, less openness) decreases the capital stock thrice as much (12% instead of 4%). Importantly, traded varieties would fall today but increased during the IWTC.

Keywords: Structural Transformation, International Trade. **JEL Codes**: F11, F12, N10, N60

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1 Introduction

In this paper we quantify the impact of trade disruptions at different stages of development. In order to do that, we build a quantitative theory of an economy (Spain) catching-up to and trading with the industrial leader (the United Kingdom). Our period of interest spans from 1850 until today. During this time period Spain converges to the U.K., experiences a process of structural transformation, and faces the three canonical trade regimes of the industrialized world: the First and Second Waves of Globalization, and in between the Inter-war Trade Collapse (1913-1946; henceforth IWTC). We calibrate our model to match the evolution of Spanish exports to GDP and of Spanish and U.K.'s GDP per capita. Our model accounts for the (non-targeted) evolution of Spanish investment, sectoral GDP, and the bilateral trade patterns between Spain and the U.K. over the period 1850 to 2000. Our main exercise is to compare the effects of the IWTC to a similar trade collapse today. We find that the capital stock falls three times more with a collapse today than it did during the IWTC (12% instead of 4%), mainly because the economies are substantially more open today. The pattern in consumption goods is similar. Interestingly, during the IWTC the increase in trade barriers contributed to Spanish industrialization, while today it would have the opposite effect.

Trade has always been a key ingredient of the debate about structural transformation, development, and convergence to the technological frontier. It suffices to look at the experience of European and East Asian countries in the post-war period, and continuing with the more recent experiences of China or India. In contrast, Latin America is an example of attempts of inward looking industrialization, with explicit import substitution policies between the fifties and the eighties. China or India had also followed such development strategies in the past, but progressively abandoned them. As such, the relationship between trade policy, industrialization and growth in a globalized world is currently a hotly debated issue. While the link between trade and structural transformation is well recognized in practice, the recent literature has not addressed it sufficiently. Most of the literature in structural transformation has focused on closed economies, or in the dynamics of a small economy opened to the rest of the world. We contribute to this literature by focusing on the evolution of the bilateral trade relationship between a developing country along the process of converging to and trading with a country at the technology frontier. To the best of our knowledge, we are the first to do so.

The first contribution of this paper is to provide a detailed series of bilateral trade flows between Spain and the U.K., starting in 1850. We do so by digitizing and categorizing the information obtained in historical customs data. We manually assign each of these trade flows to SITC Rev.1 categories, available in Spain since 1962. This allows us to observe the changes in trade patterns along with structural transformation during a period spanning one and a half centuries.

Next, we build a dynamic, two-country model of trade and structural transformation. Households accumulate capital and have Stone-Geary preferences over agriculture (modelled as a necessity), manufacturing, and services. Trade only occurs in intermediate goods, with agriculture and services trade happening à la Armington (1969; one domestic, one foreign varieties produced with constant returns to scale), and manufacturing trade happening à la Krugman (1980; many differentiated varieties produced with increasing returns to scale). Our model is simple, yet rich enough to generate predictions regarding the rise in production and trade of manufacturing varieties.

We calibrate the model targeting a number of moments of the Spanish economy in both years 1850 and 2000 and matching the entire paths of exports over GDP of Spain and of GDP per working age population in Spain and the U.K. We validate our calibrated model by looking at a number of non-targeted moments. On the macro side, the model correctly predicts a declining agricultural sector, a moderate increase in the manufacturing sector, and a secular increase in the services sector. It also captures the evolution of investment well: Spain went from investing a small fraction of GDP to investing a much larger fraction. On the trade side, the model correctly predicts the evolution of the number of varieties that Spain imports and exports, as well as the fraction of imports and exports that is accounted for by agriculture.

We then perform the two main exercises of our paper. In the first exercise we compare the benchmark economy with a counter-factual where the IWTC would have not occurred. In the second exercise we compare the benchmark economy (which assumes low trade costs after 2000 and into the future) with a counter-factual where a trade collapse similar to the IWTC would happen today. We find that the IWTC caused a decrease in Spanish capital stock of about 4% at its trough, whereas today it would fall by up to 12%. The pattern in consumption is similar, with consumption of agriculture falling the least, manufacturing the most, and services in between the two. As in the case of capital, the drops in consumption are much larger today than during the IWTC. Taken as a whole, these results imply that a trade collapse today would be significantly more costly than the IWTC.

Next, we explore the causes behind the difference in effects across the two episodes we consider in our counterfactuals. In the first episode, Spanish productivity is far from the technological frontier and trade costs are large. In contrast, today, the distance in productivities and trade costs are small. We find that the larger the distance to the leader and the more open the economy, the larger the negative impact of trade disruptions. Therefore, the IWTC should generate a greater cost because the distance to the technological frontier was larger, and a collapse today should generate a greater cost because trade is more open. Our exercise shows that the latter effect is quantitatively more important.

Finally, our quantitative results imply that the number of Spanish manufacturing varieties would decrease today while they would have increased during the IWTC. To understand the mechanism, we again solve for the number of varieties in steady state for different productivity differences and trade costs. In general, increases in trade costs lower the number of varieties. The mechanism is simple: expensive foreign inputs lower the capital stock. With less capital, countries can afford to produce less varieties. When the technological leader is sufficiently more productive however, increases in trade costs generate an increase in the number of varieties in the poor country. This happens because the technological asymmetry makes the poor country have a comparative disadvantage at building varieties domestically. When trade costs are low enough, the poor country benefits from the varieties built by the technological leader. When there is a spike in trade costs, foreign varieties become too expensive, and the poor country industrializes. This mechanism is reminiscent of import substitution policies; however, despite the increase in industrialization, trade barriers are detrimental to welfare.

Our paper shares the methodological approach with Steinberg (2019a) and McGrattan and Waddle (2019), who build models to address the question of Brexit, while Steinberg (2019b) analyzes to potential termination of NAFTA. In a similar vein, our paper contributes to a growing literature which assesses the impact of trade policy changes in dynamic models with factor 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 focusing on the U.S. 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 generate structural transformation 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 Starting with Matsuyama (1992) and Echevarria (1995) the literature linking trade and structural transformation is usually confined to a single open economy. Stokey (2001), Desmet and Parente (2012) and Ferreira, Pessôa, and dos Santos (2016) focus on the role of trade in the Industrial Revolution. Uy, Yi, and Zhang (2013), Teignier (2018), Betts, Giri, and Verma (2017) and Święcki (2017) study the

¹Buera 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 confronting models to observed historical patterns in the data. Some examples of this include Boppart (2014), Comin, Mestieri, and Lashkari (2019), and García-Santana, Pijoan-Mas, and Villacorta (2018).

interaction between structural transformation and international trade in the South Korean context.

Our model differs from all that previous literature in that we propose a two-country, three-sector model with capital accumulation and bilateral trade. We contribute to this literature by linking structural transformation to changes in bilateral trade patterns between the industrial leader and countries going through different stages of the development process.

2 Data

We first look at GDP per working-age person for both the UK and Spain. We use the data provided in Maddison Project (2013), expressed in Geary-Khamis dollars. The World Bank's World Development Indicators provides data on working-age population starting in 1960. We make the assumption that working-age population is constant as a share of total population prior to 1960 and use total population as reported in the Maddison Project. The two solid lines in Figure 1a are GDP per working-age person: the blue line is for the U.K., and the red one for Spain. Notice that Spain starts in 1850 way below the U.K., but it catches up very rapidly during the Second Wave of Globalization. Since we are focusing on long-run trends in this paper, we smooth the GDP measures using the Hodrick-Prescott filter (after Hodrick and Prescott, 1997; the dashed lines in the Figure) to calibrate the model.

Figure 1: GDP and exports.



In Figure 1b we plot the evolution of Spanish exports to GDP (solid line, the dashed line is the HP-filtered data). The figure of imports to GDP is very similar. Notice how the importance of trade grows during the First and Second Waves of Globalization, and

experiences a major drop during the inter-war period. Again, we will use the Hodrick-Prescott filtered series to calibrate the model. This data comes from the Historical National Accounts dataset from Prados de la Escosura (2015), that is available only for Spain.

In Figure 2a we show that agriculture's share of value added decreased over time, while the opposite happened to services (together with construction). Importantly, manufacturing grew to one quarter of GDP and stayed there during the second globalization, with a slight fall after the mid-1970s. Another relevant data for the Spanish economy is the evolution of investment as a percentage of GDP, which we plot in Figure 2b. Starting from a low level, it has been constantly growing over time. The data for these figures is also data from Prados de la Escosura (2015).

Figure 2: Sectoral GDP and investment.



Finally, we turn to the evolution of bilateral trade patterns between Spain and the U.K. over the period considered. In order to do so, we digitize historical trade data between Great Britain and Spain for years between 1849 and 1913. The historical data is taken from the yearly statistical publications of the Spanish Customs Agency, the "General Ledger of the Foreign Trade of Spain with its Overseas Possessions and Foreign Powers" for years 1849-1855,² and "General Statistical Report of the Foreign Trade of Spain with its Overseas Possessions and Foreign Powers" from 1856 onwards.³ The trade patterns after 1962 are directly reported in SITC Rev. 1 4-digit categories. In order to have a consistent measure of trade patterns for the entire period we assigned manually each ledger prior to 1962 to the

²Original, in Spanish: "Cuadro General del Comercio Exterior de España con sus Posesiones Ultramarinas y Potencias Estrangeras." Dirección General de Aduanas de España (1849–1855)

³Original, in Spanish: "Estadística General del Comercio Exterior de España con sus Posesiones Ultramarinas y Potencias Extranjeras." Dirección General de Aduanas de España (1856–1867,1898,1905,1913)

4-digit SITC Rev. 1 code that provides the best match.⁴

Based on the data we constructed, we report facts about the composition of trade between agriculture and manufacturing (note that neither the historical accounts nor the SITC Rev. 1 contain information in trade in services), and the count number of traded varieties. In Figure 3a we plot the fraction of exports (red dots) and imports (blue dots) accounted for by agricultural goods. The pattern that emerges is clear: Spain has not been importing many agricultural goods at all. However, Spain was exporting a lot of agricultural goods at the beginning of both globalizations (around 80% in 1850 and 70% in 1960) and very little by the end of these time periods (about 30% in 1900 and 20% in 2000).





Regarding the number of varieties traded, we use the count number of non-empty, nonagricultural SITC codes each year. We plot the series in Figure 3b. Over time, the number of varieties has been growing. More importantly however, the number of varieties imported (blue dots) is larger than the number of varieties exported (red dots).

The overall picture that emerges for Spain is that of a country catching-up country to a technologically more advanced trading partner. Over this very long period of time, Spain undergoes a standard structural transformation, accompanied with large changes in trade patterns. Our objective is to build a model about the interaction between the stages of development and trade patterns, and use such a model to quantify the impact of trade disruptions at different stages of the development process.

⁴In 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.

3 Model

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.

Each country's productivity changes over time, and it is the same in the three sectors. Ngai and Pissarides (2007) show that allowing for differential productivity per sector generates structural change in the model that is consistent with the data. Our model is simpler along this dimension, and still generates an evolution of sectoral GDP roughly consistent with the data. Finally, we assume that both countries' trade is subject to the same iceberg transportation cost, and trade balances every period.

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 of f and h). The Household maximizes the discounted flow of utilities choosing how much consumption of agriculture, $c_{a,h,t}$, manufacturing, $c_{m,h,t}$, and services, $c_{s,h,t}$, to purchase as well as next period assets, $a_{h,t+1}$. The problem is described by

$$\max \sum_{t=0}^{\infty} \beta^{t} \frac{\left(\mu_{a}(c_{a,h,t} - \bar{c}_{a})^{\epsilon} + \mu_{m}(c_{m,h,t})^{\epsilon} + \mu_{s}(c_{s,h,t})^{\epsilon}\right)^{\frac{\sigma-1}{\epsilon}}}{\sigma-1}$$

subject to:
$$p_{a,h,t}c_{a,h,t} + p_{m,h,t}(c_{m,h,t} + a_{h,t+1} - (1 - \delta)a_{h,t}) + p_{s,h,t}c_{s,h,t}$$
$$= r_{h,t}^{K}a_{h,t} + w_{h,t} + r_{h,t}^{L}L_{h,t} + \pi_{h,t}$$
(1)

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, $r_{h,t}^{K}$ is the return on investment, $w_{h,t}$ is the wage, $r_{h,t}^{L}$ 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 the amount of land. The parameters governing the model are the following: β is the discount factor, δ is the depreciation rate of capital, and σ is the inter-temporal elasticity of substitution, ϵ governs the elasticity of substitution across sectors, and μ_a , μ_m and μ_s govern 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.

Agriculture

The agricultural sector consists of final producers selling the final good (which is a CESaggregate of domestic and foreign intermediates) to households, and intermediate producers selling both domestically and abroad. As before, we now discuss the producers in country h, with country f producers facing an analogous problem.

The final agricultural producer builds (and sells) $y_{a,h,t}$ 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 $q_{a,h,f,t}$). Namely, the problem is

$$\max p_{a,h,t} y_{a,h,t} - q_{a,h,h,t} x_{a,h,h,t} - q_{a,h,f,t} x_{a,h,f,t}$$
s.t. $y_{a,h,t} = \left(\nu_a x_{a,h,h,t}^{\rho_a} + (1 - \nu_a) x_{a,h,f,t}^{\rho_a}\right)^{1/\rho_a}$. (2)

Parameter ν_a is a measure of the home-bias in agricultural consumption, and ρ_a governs the agricultural trade elasticity.

Given productivity, $Z_{h,t}$, the intermediate agricultural producer, chooses how much labor, $\ell_{a,h,t}$, and land, $L_{h,t}$, to rent. The good is sold both to h, $x_{a,h,h,t}$, and to f, $x_{a,f,h,t}$, is produced using a Cobb-Douglas technology with land share parameter α_a . As a result, intermediate agricultural producers make zero profits. The problem of the intermediate agricultural producer is

$$\max q_{a,h,h,t} x_{a,h,h,t} + q_{a,f,h,t} x_{a,f,h,t} - w_{h,t} \ell_{a,h,t} - r_{h,t}^M L_{h,t}$$
s.t. $x_{a,h,h,t} + (1+\tau_t) x_{a,f,h,t} = Z_{h,t} L_{h,t}^{\alpha_a} \ell_{a,h,t}^{1-\alpha_a}$.
(3)

Note that for one unit of the good to arrive to f, the producer needs to ship $1 + \tau_t$ units of the good.

Manufacturing

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

The final manufacturing producer builds (and sells) $y_{m,h,t}$ units of the good for price $p_{m,h,t}$ buying intermediate goods from the $i \in N_h$ domestic producers (she purchases $x_{m,h,h,t}(i)$ units to 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 to producer j for price price $q_{m,h,f,t}(j)$). The problem is

$$\max \ p_{m,h,t} y_{m,h,t} - \int_{i \in N_h} q_{m,h,h,t}(i) x_{m,h,h,t}(i) di - \int_{j \in N_f} q_{m,h,f,t}(j) x_{m,h,f,t}(j) dj$$

s.t.
$$y_{m,h,t} = \left(\nu_m \int_{i \in N_h} x_{m,h,h,t}(i)^{\rho_m} di + (1 - \nu_m) \int_{j \in N_f} x_{m,h,f,t}(j)^{\rho_m} dj \right)^{1/\rho_m} .$$
 (4)

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 how much capital to rent, $k_{m,h,t}(i)$, and how much labor to hire, $\ell_{m,h,t}(i)$. The good produced is sold both to *h*, $x_{m,h,h,t}(i)$, and to *f*, $x_{m,f,h,t}(i)$, and is produced using a Cobb-Douglas technology with capital share parameter α_m . 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

$$\pi_{m,h,h,t}(i) = \max\left(0, \max\left(\begin{array}{c}q_{m,h,h,t}(i)x_{m,h,h,t}(i) + q_{m,f,h,t}(i)x_{m,f,h,t}(i)\\ -w_{h,t}\ell_{m,h,t}(i) - r_{h,t}k_{m,h,t}(i) - p_{m,h,t}F_{h}\end{array}\right)\right)$$
s.t. $x_{m,h,h,t}(i) + (1 + \tau_{t})x_{m,f,h,t}(i) = k_{m,h,t}(i)^{\alpha_{m}} \left(Z_{h,t}\ell_{m,h,t}(i)\right)^{1-\alpha_{m}}$
Given demand functions for $x_{m,h,h,t}(i)$ and $x_{m,h,f,t}(i)$.
(5)

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 producer produces (and sells) $y_{s,h,t}$ 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 from intermediate producer in f (with price $q_{s,f,h,t}$). Namely, they solve

$$\max p_{s,h,t} y_{s,h,t} - q_{s,h,h,t} x_{s,h,h,t} - q_{s,h,f,t} x_{s,h,f,t}$$

s.t. $y_{s,h,t} = \left(\nu_s x_{s,h,h,t}^{\rho_s} + (1 - \nu_s) x_{s,h,f,t}^{\rho_s}\right)^{1/\rho_s}$. (6)

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

$$\max q_{s,h,h,t} x_{s,h,h,t} + q_{s,f,h,t} x_{s,f,h,t} - w_{h,t} \ell_{s,h,t} - r_{h,t}^{K} k_{s,h,t}$$

s.t. $x_{s,h,h,t} + (1 + \tau_t) x_{s,f,h,t} = k_{s,h,t}^{\alpha_s} (Z_{h,t} \ell_{s,h,t})^{1-\alpha_s}$. (7)

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 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 either be consumed, or used to pay the fixed cost to operate intermediate manufacturing varieties, or saved by the household. Hence, $c_{m,h,t} + F_h \times N_h + a_{h,t+1} - (1 - \delta)a_{h,t} = y_{m,h,t}$.

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 solve for the equilibrium number of varieties producing, N_h . The total amount of labor in the country is used in either of the 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:

$$q_{a,f,h,t}x_{a,f,h,t} + \int_{i \in N_h} q_{m,f,h,t}(i)x_{m,f,h,t}(i)di + q_{s,f,h,t}x_{s,f,h,t}$$

$$= q_{a,h,f,t}x_{a,h,f,t} + \int_{i \in N_f} q_{m,h,f,t}(i)x_{m,h,f,t}(i)di + q_{s,h,f,t}x_{s,h,f,t}.$$
(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 chose 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 chose the foreign country to also look like the U.K. 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 the U.K. As a result, f is a scaled up version of the U.K. that accounts for the overall Spanish foreign sector. Importantly, throughout the years of our exercise, the U.K. is not only one of Spain's main trading partners,⁵ but also its trade composition is similar to that of Spanish trade with other major trading partners (at least in the last part of our sample period).

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

The calibration exercise consists of two parts. First, we calibrate a number of parameters outside equilibrium. Then, we jointly calibrate a number of parameters so that the model matches both aggregate moments in 1850 and in 2000, and also the entire evolution of GDP in Spain and U.K. and of Spanish exports over GDP between 1850 and 2000.

We start by describing the parameters that are determined outside the model. We set $\beta = 0.885$ which implies an annual interest rate of 4 percent. Following Herrendorf, Rogerson, and Valentinyi (2013) we take the approach of focusing on final consumption expenditure and set $\epsilon = -0.176$, which implies an elasticity of substitution across goods of 0.85.⁶ We set $\sigma = 1$ and $\delta = 0.129$ which implies an inter-temporal elasticity of substitution of 1 and an annual depreciation rate of 4.5 percent.

Using the input-output tables from Spain in 2000 to compute the different sectoral labor shares, we find that $\alpha_a = 0.602$, $\alpha_m = 0.309$, and $\alpha_s = 0.315$. We set $\rho_a = 0.5$ and $\rho_m = \rho_s = 0.85$, which imply an agricultural trade elasticity of 2 and a manufacturing and services trade elasticity of 6.67. Bas et al. (2017) provide estimates on trade elasticities for agriculture to be between 1.08 and 2.71; our choice of an agricultural elasticity of 2

 $^{^{5}}$ The U.K. is either Spain's first or second trading partner during the XIXth century, with the other one being France.

⁶In our model final expenditure per sector and value added per sector are very similar. Herrendorf et al. (2013) point out that the parameter we use is appropriate to match U.S. 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 percentage of value added. In the Appendix, we re-do the exercise with Leontief preferences and find that our results are robust to the choice of parameter values.

is because it is a round number in between these two values. Similarly, their estimate of average elasticity (including agriculture) is between 4.74 and 5.71. These numbers 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 6.67 for the manufacturing elasticity because it is within the ranges considered. We are not aware of good estimates of services trade. We choose to set it equal to 6.67 because the aggregate trade elasticity of modern, rich economies is more similar to the manufacturing elasticity than to the agricultural elasticity.

Then, we do two normalizations. First, we set the fixed cost of producing a variety in the U.K. to $F_f = 1$. 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. Similarly, we set the final iceberg cost, τ_T , to zero, which assumes that trade by 2000 is totally free. Given $\tau_T = 0$, we calibrate the home bias parameters to target the right volume of trade in year 2000, and the evolution of τ_t to target the right volume of total trade over time. Table 1 summarizes this part of the calibration.

	Parameter	Description	Value
β	Discount rate	Annual interest rate 4%	0.885
ϵ	Final goods elasticity	= 0.85	-0.176
σ	Intertemporal elasticity	= 1	1.000
δ	Depreciation rate	Annual depreciation 4.5%	0.129
α_a	Land share Ag	Agriculture labor share	0.602
α_m	Capital share Man	Manufacturing labor share	0.309
α_s	Capital share Serv	Services labor share	0.315
$ ho_a$	Agriculture production elasticity	=2	0.631
$ ho_m$	Manu production elasticity	= 6.67	0.866
$ ho_s$	Services production elasticity	= 6.67	0.866
F_f	U.K. fixed cost	Normalization	1.000
$ au_T$	final iceberg	Normalization	0.000

 Table 1: Parameters determined outside of the model

The second set of parameters is jointly determined in equilibrium. We calibrate the following parameters to target moments in 1850. We set $\bar{c}_a = 0.607$ and $\mu_m = 0.098$ to match the sectoral composition of Spanish GDP. Similarly, we set $\nu_{h,a} = 0.866$ to match agricultural imports as a fraction of output and $\nu_{f,a} = 0.611$ for its exports counterpart. Subsequently, we calibrate the remaining parameters to target moments in 2000. We set $\mu_a = 0.027$ to match the percentage of agriculture in GDP. Given that μ_m had already been calibrated, μ_s is left as a residual to ensure that the sum of the three parameters is 1. We set $\nu_{h,m} = 0.513$ to match Spanish exports over GDP in 2000 (we set its U.K. counterpart, $\nu_{f,m}$,

to be the same value) and $\nu_{f,s} = 0.575$ to target the fraction of Spanish exports in services right (again setting its U.K. counterpart, $\nu_{f,s}$, to be the same value). Lastly, we calibrate the cost of operating a manufacturing variety in Spain, $F_h = 0.739$, to match the observed ratio of Spanish varieties over U.K. varieties in 2000. All these parameters are reported in Table 2.

Parameter		Value	Target	Year	Model	Data
\bar{c}_a	Ag cons floor	0.607	% Ag in GDP	1850	0.402	0.402
μ_m	Manu utility share	0.098	% Manu in GDP	1850	0.150	0.150
$ u_{h,a}$	Spain Ag home bias	0.866	Spain Ag Imp/GDP	1850	0.085	0.085
$\nu_{f,a}$	U.K. Ag home bias	0.611	Spain Ag Exp/GDP	1850	0.085	0.085
μ_a	Ag utility share	0.027	% Ag in GDP	2000	0.040	0.040
μ_s	Serv utility share	0.875	$1 - \mu_a - \mu_m$			
$ u_{h,m}$	Spain manu home bias	0.513	Spain Exp/GDP	2000	0.247	0.247
$ u_{f,m}$	U.K. manu home bias	0.513	$ u_{f,m} = u_{h,m} $			
$ u_{f,s}$	U.K. serv home bias	0.575	Spain Serv Exp/GDP	2000	0.310	0.310
$ u_{h,s}$	Spain serv home bias	0.575	$\nu_{h,s} = \nu_{f,s}$			
F_h	Spain fixed cost	0.739	Spain/U.K. varieties	2000	0.878	0.879

Table 2: Parameters determined jointly in equilibrium

The last two columns of Table 2 show the values for the targeted moment both in the data and in the model. In short, the calibration we do matches all the moments.

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 U.K. GDP per working age population) using three series of parameters: iceberg costs, $\{\tau_t\}_{t=1850}^{2000}$; Spanish productivities $\{Z_{h,t}\}_{t=1850}^{2000}$; and U.K. productivities $\{Z_{f,t}\}_{t=1850}^{2000}$.

In Figure 4a we plot the calibrated series for the iceberg cost, τ_t , since 1850. This series makes the model deliver the exact evolution of exports over GDP in Spain, which is what we plot in Figure 4b. The lower panel has two series: a solid line, the filtered data (as discussed in Section 2) and a dotted line, the predicted series by the model. Notice that the match between model and data is exact.

In Figure 4c we plot, in red, the calibrated series for the productivity series for Spain, $Z_{h,t}$, and, in blue, for the U.K., $Z_{f,t}$. Again, these series make the model deliver the exact evolution of GDP per working age population in Spain and in the U.K. This can be seen in Figure 4d. It has four series, two in red for Spain, and two in blue for the U.K. In both cases the solid line is the filtered data and the dotted line is the predicted series by the model. As it was the case in Figure 4b, the dotted lines lie on top of each other because the match



between model and data is exact.

Model validation

We have calibrated the model to reproduce the composition of trade and output at the beginning of the period, and to match the evolution of both GDP per capita in the two countries and the aggregate volume of trade. However, we do not target the time series for the composition of output, investment and trade patterns between 1850 and 2000. That is exactly the data of interest for us and is the data we use to validate the model.

The model does a good job accounting for the composition of Spanish GDP over time. 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 in the model (dashed line). In the case of agriculture both the model and the data

exhibit a remarkably similar pattern. In both cases there is a fall, which is more pronounced at the beginning of the second globalization. For the manufacturing sector, again model and data exhibit similar patterns. For the services sector, both model and data series grow. In this case the series from the model constantly grows 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.





In Figure 5d we plot the fraction of GDP that is used for investment in the data (solid line) and implied by the model (dashed line). Even though 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. 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 beginning of the second globalization.

In Figures 6a and 6b we plot the fraction of trade accounted for by agriculture over

manufacturing for both exports and imports. 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 Spanish exports to the U.K., the model implies a fall in the share of agriculture until the early 1900s. After that, the data does not start over again until we can use the SITC in the 1960s. At that time, the share of agriculture is again very high but it decreases sharply again. The model generates a similar pattern, with the hump peaking right before the 1950s, and having a pronounced decline afterwards. While this result implies that the model generates the second fall in the share of agriculture a bit prematurely, the similarity between data and model is remarkable, especially taking into consideration that we did not target any moment there. Regarding imports, both the model and the data are consistent in that agricultural imports are always small. The main difference arises at the end of the period, when agriculture almost vanishes in the model. This is an implication of Stone Geary preferences.

Figure 6: Non-targeted moments: trade variables.



In Figures 6c and 6d 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 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 2nd wave of globalization.

Given the model's success in accounting for these non-targeted series between 1850 and 2000, we use the model to study the impact of trade disruptions. In the following section we compare the IWTC to a similar collapse happening today.

5 Cost of trade disruptions

In this section we compare the Inter-war Trade Collapse (IWTC) to a similar collapse happening today. Our calibration implies a spike in trade costs during the IWTC. Hence, our first experiment is to compare the benchmark economy to an economy where that spike did not happen. Namely, the counter-factual trade costs are the dotted line in Figure 7a (and the solid line is the benchmark, which we plot for comparison purposes). Our second exercise is to compare the benchmark to an economy that faces a trade collapse today (starting in year 2000). To keep the exercises as close as possible, we make the relative increase in the cost be the same in the inter-war period and here. Namely, trade costs now, τ_t^{cf2} , satisfy

$$1 + \tau_{2000+t}^{cf2} = (1 + \tau_{1913+t})/(1 + \tau_{1913+t}^{cf1}),$$

where τ_t^{cf1} are the iceberg trade costs in the previous counter-factual. We plot the counter-factual trade costs as the dotted line in Figure 7b (again, the solid line is the benchmark).

In Figure 8a we plot the evolution of capital in the benchmark (when there is an IWTC) as a fraction of the counter-factual (when there is none). The red line plots the ratio for Spain, and the blue line plots the ratio for the U.K. We obtain that, right before trade costs increase, the capital stock grows to benefit from temporarily cheaper inputs. After that, more expensive inputs yield a lower capital stock. The capital stock in Spain falls by around 4% at the trough. In the U.K. the magnitude of the fall is smaller. In Figure 8b we plot the evolution of capital in the second counter-factual, when there is a new trade collapse, as a fraction of the benchmark (when there is none). Again, the red line plots the ratio for Spain and the blue line for the the U.K. Qualitatively, the picture is the same. However, the magnitudes differ substantially. In fact, the trough of the fall is at 12% in Spain. The fall in the U.K. is smaller than in Spain, but much larger than it was during the IWTC.

Figure 9a shows the fall in consumption during the IWTC. The fall is roughly 4% in

Figure 7: Iceberg costs.



Figure 8: Capital.



manufacturing around the trough. Services fall less, and the fall in agriculture is smallest, and for most of the period it actually increases. Figure 9b on the other hand, shows the fall in consumption today in Spain is roughly 12% in manufacturing around the trough. As with the case of the fall in the capital stock, this figure is about three times larger than during the IWTC. These results showcase that the cost of a trade collapse today is larger than during the inter-war period. The increase in agricultural consumption is driven by lower capital stock: less capital implies that the marginal product of labor is largest in agriculture (which only uses land) and hence output and consumption in that sector grows (although not very much). The results for the U.K. are similar, but of smaller magnitudes.

The inter-war trade collapse generated a drop in capital and consumption smaller than

Figure 9: Consumption in Spain.



what could happen in a similar collapse today. This result is driven, in part, by how the number of varieties was affected in both scenarios. In Figure 10a we plot the evolution of the number of varieties in Spain and the U.K. during the IWTC. Likewise, in Figure 10b we do so for the collapse today.

Figure 10: Number of varieties.



The most striking pattern is that the number of varieties falls for the U.K. in both scenarios and it also falls in Spain during the collapse today. In both cases the U.K. is the richer economy. When hit by a spike in trade costs, it loses access to the Spanish market and hence building varieties turns out more expensive. The fall of varieties in Spain in today's collapse happens because of a very similar reason — after all, Spain is technologically very close to the U.K. today. On the other hand, Spain increases the number of varieties

during the IWTC. This result is caused by the dire need of accumulating capital in Spain when it is very poor. While trade costs are low, capital is accumulated using cheap U.K. varieties. With a trade cost increase however, the country spends resources building their own varieties to increase the capital stock. The logic behind this is very similar to that of import substitution.

6 Technology, openness, and varieties

The counter-factual exercises that we discussed in the previous section yield two main results. First, an increase in trade frictions today of the same magnitude as the IWTC, would have a larger effect on the capital stock. Second, the IWTC led to an increase in the number of varieties consumed in Spain, but a similar collapse today would decrease them. In this section, we use steady-state analysis to highlight the key model mechanisms responsible for each of these two results.

From the perspective of Spain, the two trade collapses differ in two respects: distance to the technological frontier and the overall level of trade frictions. Spain is both closer to the frontier and enjoys lower overall trade costs today than just prior to the IWTC. In what follows, we show that distance to the frontier increases the impact of a trade collapse but a higher overall level of trade frictions decreases it. As a result, when comparing the IWTC to a trade collapse today, the second effect quantitatively dominates the first. We also find that if the distance to the frontier is sufficiently large, an increase in trade frictions leads to an increase in the number of manufacturing varieties produced in the catching-up country, i.e. trade barriers promote industrialization.

We solve the model at multiple steady states with different levels of iceberg costs and relative productivities, and perform comparative statics on the steady state level of capital, consumption, and the number of varieties. In Figure 11a we plot the level of Spain's capital stock when the productivity is the same as the U.K. (black line), when it is at 75% (red line), and when it is at 50% (blue line). Each line consists of all the steady states associated to different levels of iceberg costs, which range from 0 (when trade costs are at their level in year 2000) to 0.6 (the peak of calibrated trade costs). For comparability, the three lines are normalized to 1 when trade is costless. We find that increases in trade costs make the capital stock fall the most when Spain is at a greater distance from the U.K. (the black line is above the red, which is above the blue). At the same time, the fall is more pronounced when the economy is more open, that is, when the iceberg costs are lower (the three lines are concave).

In our model, the catching-up country benefits from openness to the industrial leader

Figure 11: The effects of trade costs and distance to the frontier



because trade provides access to differentiated, cheaper goods. The catching-up country both consumes these goods and uses them to build up its capital stock. The catching-up country benefits relatively more from foreign goods if the country is more open because these goods are cheaper. That is, a smaller τ boosts development. Similarly, the benefits are also larger if the industrial leader is relatively more developed because foreign goods become cheaper. Hence, a larger distance between Z_h and Z_f also boosts development in the catching-up country. In Figure 11b we plot the amount of foreign manufacturing intermediates as a percentage of total manufacturing. We find that foreign intermediates are more prominent when trade is cheaper. Hence, we find that the more open and the larger the distance, the larger the (negative) effect of a (negative) trade shock on the capital stock.

Next we look at the effect on consumption. In Figure 12a we plot manufacturing consumption and in Figure 12b we plot services consumption. The picture that emerges is qualitatively similar to that of capital: higher trade costs and higher distance to the leader lower consumption. The key difference is in the magnitudes, where the fall in services is less pronounced. This happens because manufacturing is used for both consumption and investment, while services are not.

We find an interesting feature with agricultural consumption, which we plot in Figure 13a. Spanish consumption of agriculture goes up with increases in trade costs. As trade costs increase and the U.K.'s demand for Spanish goods decreases, the three intermediate sectors in Spain need to produce less output. Manufacturing and services can adjust using less capital; the adjustment in agriculture can only come from using less labor because land is fixed. This, in turn, disproportionately reduces the price of intermediate agriculture in Spain,

Figure 12: Spanish consumption.



and Spanish consumers can expand their agricultural consumption. While this mechanism partially offsets the cost of higher trade costs, its effect is less strong when Spain is at a greater distance from the U.K.





Our results in this section indicate that trade costs are particularly costly when the economy is more open and at a greater distance from the industrial leader. Since the fall associated to the trade cost spike is larger today (more open, less distance) than during the IWTC (less open, more distance), we conclude that openness is quantitatively more important than distance for the comparison exercise we did in the previous section.

Last we analyze the role that varieties play in our model. As we showed in the previous section, the number of varieties in the U.K. falls in both exercises. This also happens in Spain with a trade cost occurring today. During the IWTC however, Spanish varieties grew. In Figure 13b we plot the number of varieties at the steady state under different iceberg cost and productivity differences. The number of varieties monotonically falls with increased trade costs when the distance in technologies is small (black and red lines). This happens because larger costs make both countries able to sell less to the foreign market, thereby reducing how many varieties can be produced. When the distance is large (blue line) and trade costs are large enough, the number of varieties grows with increased trade costs. The reason is that the less productive country wants to accumulate capital, and relies on cheaper inputs from the more productive trading partner. A spike in trade costs in that case forces the poorer country to start producing those (imperfectly substitutable, expensive) varieties domestically. The result looks like import substitution policies where the poor country loses access to trade and as a result has a spike in its industrialization.

7 Concluding remarks

In this paper we have constructed a model in order to understand the implications of trade disruptions at different stages of the development process, from the perspective of the catching up country. The key element highlighted in our analysis is the interaction between technological development and trade. While we focus on Spain catching up to and trading with the U.K., we believe our analysis is a first step towards understanding the same phenomenon for different countries at different points in time. This type of analysis could be used in the case of countries that start the catching-up process further away from the frontier and whose catching-up process is still ongoing (India or China with respect to the United States).

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Appendix

Our 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 U.S. economy when looking at final expenditure per sector. On the other hand, they also find that more complementarity is needed when looking at 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 parameter ϵ . In this Appendix we re-calibrate the model using $\epsilon = -10$, which implies an elasticity of substitution of 0.09.

Besides the important change in ϵ , our calibration is very similar to the one in the benchmark, 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 with regard to the results.

We start with the experiments regarding the fall in the capital stock in the two counterfactual scenarions. In Figures 14a and 14b we plot the counter-parts to Figures 8a and 8b.





Our main result regarding the trade shock today being twice as costly in terms of capital than it was during the IWTC remains the same. However, the magnitude of the falls are larger in the benchmark.

This finding is similar to the one we obtain when we look at the change in varieties. In

Figures 15a and 15b we plot the counter-parts to Figures 10a and 10b.

Figure 15: Robustness: Number of varieties.



Again we find the same qualitative result under this calibration as we did in the benchmark: the number of varieties increased during the IWTC; 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.

Last, the main difference between the benchmark and this robustness check has to do with consumption. In Figures 16a and 16b we plot the counter-parts to Figures 9a and 9b.

Figure 16: Robustness: Consumption in Spain.



In the benchmark we obtained that each sector experienced a different behavior in the presence of trade disruptions. We found that manufacturing decreased the most, followed by services, and agriculture barely falls, and it even increases for some period of the trade disruption. This result is different in this robustness exercise: the three sectors fall, and they have a much more similar behavior. This is not a surprising result however. The three sectors are now more complementary, and hence if consumption of one sector falls, then consumption in the other sectors has to fall too.