Autarky in Franco's Spain: the costs of a closed economy

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Online appendix

A Identification

The estimating equation can be written as

$$X_{ijt} = \exp(\Lambda_{ijt}) + \varepsilon_{ijt},$$

where

$$\Lambda_{ijt} = \gamma_t I(i \neq j) + \theta_t I(i \neq j)[I(i = \text{Spain}) + I(j = \text{Spain})] + \phi_{it} + \psi_{jt} + \boldsymbol{\beta}^T\mathbf{z}_{ij}$$

The parameter θ identifies the average of outward and inward border thickness. To show this, we focus on the case $\boldsymbol{\beta}^T\mathbf{z}_{ij} = 0$ and on a single date t, and remove the subscript t for simplicity.

The estimating equation then becomes

$$\begin{aligned}\Lambda_{ij} &= \gamma I(i \neq j) + \theta I(i \neq j)[I(i = \text{Spain}) + I(j = \text{Spain})] + \phi_i + \psi_j \\ &= \gamma I(i \neq j) + \theta[1 - I(i = j)][I(i = \text{Spain}) + I(j = \text{Spain})] + \phi_i + \psi_j \\ &= \gamma I(i \neq j) - 2\theta I(i = j = \text{Spain}) + [\phi_i + \theta I(i = \text{Spain})] + [\psi_j + \theta I(j = \text{Spain})] \qquad \text{(A1)}\end{aligned}$$

Suppose that we wanted to distinguish between inward and outward border thickness and wished to estimate a specification of the form

$$\Lambda'_{ij} = \gamma' I(i \neq j) + \theta^x I(i \neq j) I(i = \text{Spain}) + \theta^m I(i \neq j) I(j = \text{Spain}) + \phi'_i + \psi'_j.$$

We show that only the average $\theta = (\theta^x + \theta^m)/2$ is identified in this case.

$$\begin{aligned}\Lambda'_{ij} &= \gamma' I(i \neq j) + \theta^x I(i \neq j) I(i = \text{Spain}) + \theta^m I(i \neq j) I(j = \text{Spain}) + \phi'_i + \psi'_j \\ &= \gamma' I(i \neq j) + \theta^x [1 - I(i = j)] I(i = \text{Spain}) + \theta^m [1 - I(i = j)] I(j = \text{Spain}) + \phi'_i + \psi'_j \\ &= \gamma' I(i \neq j) - \theta^x I(i = j) I(i = \text{Spain}) - \theta^m I(i = j) I(j = \text{Spain}) + \phi''_i + \psi_j'' \\ &= \gamma' I(i \neq j) - (\theta^x + \theta^m) I(i = j = \text{Spain}) + \phi''_i + \psi_j'', \qquad \text{(A2)}\end{aligned}$$

where $\phi'' = \phi' + \theta^x$ if i is Spain, and $\phi'' = \phi'$ otherwise, and $\psi_j'' = \psi'_j + \theta^m$ if j is Spain, and $\psi_j'' = \psi'_j$ otherwise. The parameters, θ^x and θ^m cannot be identified separately because (A2) delivers only three estimates for four unknowns (the unknowns are the two parameters of interest and the two fixed effects for Spain). Moreover, the comparison of the expressions in (A1) and (A2) shows that $\theta = (\theta^x + \theta^m)/2$.

B Theoretical model

This section describes the methodology used in our general equilibrium computations. Neither the model nor the solution method are novel; they are part of the toolkit commonly used by trade economists. The model is a standard Armington model (Anderson and van Wincoop, 2003) with exogenous trade deficits (Dekle et al., 2007). The algorithm for comparative statics uses the methods of Dekle et al. (2007) and our description is based on the steps described by Head and Mayer (2014) and Baier et al. (2019).

B.1 Trade model

Preferences and demand

Consumers in country j consume $q_{ij} \geq 0$ units of the product produced in country i. Utility exhibits a constant elasticity of substitution (CES), $\sigma > 1$, over all the country-specific products:

$$U_j = \left(\sum_i \alpha_{ij}^{\frac{1}{\sigma}} q_{ij}^{\frac{\sigma-1}{\sigma}}\right)^{\frac{\sigma}{\sigma-1}} \qquad (B1)$$

The coefficient $\alpha_{ij} \geq 0$ is a utility shifter that can be thought of as an index of the quality of country i's product. The price paid for good q_{ij} is p_{ij}. Denote total expenditure by consumers in country j by E_j. Utility maximization subject to the budget constraint

$$\sum_i p_{ij} q_{ij} = E_j \qquad (B2)$$

leads to the well-known CES demand function:

$$q_{ij} = \alpha_{ij} p_{ij}^{-\sigma} E_j P_j^{\sigma-1}, \quad \forall(i,j) \qquad (B3)$$

where

$$P_j = \left(\sum_j \alpha_{ij} p_{ij}^{1-\sigma}\right)^{\frac{1}{1-\sigma}} \qquad (B4)$$

is the Dixit-Stiglitz price index. Using optimal demands (B3) in the utility function (B1), it can be shown that indirect utility depends only on expenditure E_j and the price index P_j:

$$V(E_j, P_j) = \frac{E_j}{P_j} \qquad (B5)$$

Technology and trade costs

Each country i produces a single differentiated good using only labor L_i. Labor is inelastically supplied, immobile across countries, and its factor price is the wage rate w_i. The production technology is $f(L_i) = A_i L_i$, where $A_i > 0$ is a productivity parameter specific to country i. We assume perfect competition, so that the factory price in the country were a good is produced is equal to the marginal cost:

$$p_i = \frac{w_i}{A_i}, \qquad \forall i \qquad (B6)$$

Shipping this good to another country incurs in so-called iceberg costs (the good melts while it is being transported). It is necessary to ship $\tau_{ij} q_{ij}$ in country i so that q_{ij} arrives at its destination in country j. Trade costs $\tau_{ij} \geq 1$ are specific to each country pair. Arbitrage in international markets then implies that the price paid for the good of country i country j is

$$p_{ij} = \tau_{ij} p_i = \tau_{ij} \frac{w_i}{A_i}, \quad \forall(i,j) \qquad (B7)$$

Because of zero profits, a country's total income equals the value of output and also the total wage bill:

$$Y_i = p_i A_i L_i = w_i L_i, \quad \forall i \qquad (B8)$$

Excess demands and market clearing

The trade deficit (or excess demand) of an arbitrary country ` equals the value of its imports minus the value of its exports, or the difference between its income and expenditure:

$$\begin{aligned} D_l &\equiv \sum_{i \neq l} p_{il} q_{il} - \sum_{i \neq l} p_{lj} q_{lj} = (E_l - p_{ll} q_{ll}) - (Y_l - p_{ll} q_{ll}) \\ &= E_l - Y_l \qquad (B9) \end{aligned}$$

Naturally, the sum of trade deficits over all countries must be zero in equilibrium:

$$\sum_i D_i = \sum_i (E_i - Y_i) = 0 \qquad (B10)$$

Market clearing in the goods market implies that the supply of a country's good is equal to total demand, including the resource cost of transporting goods to different destinations:

$$A_i L_i = \sum_j \tau_{ij} q_{ij}, \quad \forall i \qquad (B11)$$

Definition of an equilibrium

Given preference parameters $\{\alpha_{ij}\}$ and σ, productivities $\{A_i\}$, labor endowments $\{L_i\}$, and exogenous trade deficits $\{D_i\}$ that satisfy the restriction in (23), an equilibrium is defined as collection of allocations $\{q_{ij}\}$, goods prices in the destination country $\{p_{ij}\}$, and local wages $\{w_i\}$, such that

1. consumer demands are optimal given budget constraints (B2), as in (B3) with the definition in (B4),
2. local prices equal local marginal costs and simultaneously international prices satisfy a no-arbitrage condition, as in (B7),
3. and goods markets clear, as in (B11).

B.2 Comparative statics

For given exogenous variables, equilibrium allocations and prices solve a system of equations. In general, this system needs to be solved numerically after specifying all exogenous variables. The characterization of comparative statics removes the need to specify all exogenous variables. Using "hat algebra", comparative statics can be obtained numerically by solving a system of equations that depends only on the elasticity of substitution σ, the exogenous change assumed for trade deficits, and on observed trade flows. Variables with hats indicate the ratio of the value of a variable in a counterfactual equilibrium (denoted with primes) and an observed equilibrium (without primes): $\hat{x} = x'/x$ for any variable *x*.

Algorithm

The inputs for the comparative statics exercise are the full matrix of observed trade flows $\{X_{ij}\}$, a value for the parameter σ, and a matrix of exogenous changes in trade costs $\{\hat{\tau}_{ij}\}$. The steps for the comparative statics exercise are the following:

1. Calculate $Y_i = \sum_j X_{ij}$ for all *i* and $E_j = \sum_i X_{ij}$ for all *j*.
2. Calculate trade shares $\lambda_{ij} = \frac{X_{ij}}{E_j}$ for all combinations of *i* and *j*.
3. Solve for wage changes $\widehat{w}_i$ in the system of equations

$$\widehat{w}_i = \frac{1}{Y_i}\sum_j \frac{\lambda_{ij}(\widehat{w}_i\hat{\tau}_{ij})^{1-\sigma}}{\sum_k \lambda_{kj}\left(\widehat{w}_k\hat{\tau}_{kj}\right)^{1-\sigma}}\widehat{w}_j E_j, \quad \forall i$$

   with the normalization $\sum_i \widehat{w}_i = 0$.

   Calculate the change in trade shares as

$$\hat{\lambda}_{ij} = \frac{(\widehat{w}_i\hat{\tau}_{ij})^{1-\sigma}}{\sum_k \lambda_{kj}\left(\widehat{w}_k\hat{\tau}_{kj}\right)^{1-\sigma}}$$

   for all combinations of *i* and *j*.

4. For any particular country *j*, calculate the change in welfare using the formula

$$\widehat{V}_j = \hat{\lambda}_{jj}^{-\frac{1}{\sigma-1}}$$

Derivation of the steps in the comparative statics algorithm

Steps 1 and 2: nothing to show, these steps consist only of definitions.

Step 4: In equilibrium, the value of trade is flowing from country *i* to country *j* is

$$X_{ij} \equiv p_{ij} q_{ij} = \alpha_{ij} \frac{p_{ij}^{1-\sigma}}{P_j^{1-\sigma}} E_j = \alpha_{ij} \left(\frac{w_i}{A_i} \frac{\tau_{ij}}{P_j} \right)^{1-\sigma} E_j \qquad (B12)$$

where the second line uses the optimal demand for q_{ij} in (B3) and the third line uses (B7), which combines firm optimization with the no-arbitrage condition. From this equation, the trade elasticity is

$$\epsilon \equiv -\frac{\partial \ln X_{ij}}{\partial \ln \tau_{ij}} = \sigma - 1 > 0 \qquad (B13)$$

Another way of writing (B12) is dividing both sides by E_j and defining the share of trade out of expenditure:

$$\lambda_{ij} \equiv \frac{X_{ij}}{E_j} = \alpha_{ij} \left(\frac{w_i}{A_i} \frac{\tau_{ij}}{P_j} \right)^{1-\sigma} \qquad (B14)$$

Substituting the price index:

$$\lambda_{ij} = \frac{\alpha_{ij} \left(\frac{w_i \tau_{ij}}{A_i} \right)^{1-\sigma}}{\sum_k \alpha_{kj} \left(\frac{w_k \tau_{kj}}{A_k} \right)^{1-\sigma}} \qquad (B15)$$

In equilibrium, counterfactual trade shares are equal to

$$\lambda'_{ij} = \frac{\alpha_{ij} \left(\frac{w'_i \tau'_{ij}}{A_i} \right)^{1-\sigma}}{\sum_k \alpha_{kj} \left(\frac{w'_k \tau'_{kj}}{A_k} \right)^{1-\sigma}} = \frac{\alpha_{ij} \left(\frac{w_i \tau_{ij}}{A_i} \right)^{1-\sigma} \left(\widehat{w}_i \hat{\tau}_{ij} \right)^{1-\sigma}}{\sum_k \alpha_{kj} \left(\frac{w_k \tau_{kj}}{A_k} \right)^{1-\sigma} \left(\widehat{w}_k \hat{\tau}_{kj} \right)^{1-\sigma}}$$

$$= \frac{\lambda_{ij} \left(\widehat{w}_i \hat{\tau}_{ij} \right)^{1-\sigma}}{\sum_k \lambda_{kj} \left(\widehat{w}_k \hat{\tau}_{kj} \right)^{1-\sigma}} \qquad (B16)$$

The second equality uses $w_i' = \widehat{w}_i w_i$ and $w_k' = \widehat{w}_k w_k$, and the third equality divides numerator and denominator by $\sum_l \alpha_{lj} \left(\frac{w_l \tau_{lj}}{A_l}\right)^{1-\sigma}$ to reconstruct the trade shares. Dividing both sides by λ_{ij} leads to

$$\hat{\lambda}_{ij} \equiv \frac{\left(\widehat{w}_i \hat{\tau}_{ij}\right)^{1-\sigma}}{\sum_k \lambda_{kj} \left(\widehat{w}_k \hat{\tau}_{kj}\right)^{1-\sigma}} \qquad (B17)$$

Step 3: Notice that in equilibrium, the following relationships hold:

$$Y_i = p_i A_i L_i = p_i \sum_j \frac{1}{\tau_{ij}} q_{ij} \sum_j p_{ij} q_{ij} = \sum_j X_{ij} = \sum_j \lambda_{ij} E_j \qquad (B18)$$

The first equality is from the definition of a country's income in (B8), the second imposes the market clearing condition in (B11), the third uses the no-arbitrage condition in (B7). The last two equalities use the definition of trade flows and of trade shares, respectively. Because these relationships hold in any equilibrium, they also hold at the counterfactual equilibrium, and

$$Y_i' = \hat{Y}_i Y_i = \sum_j \lambda_{ij}' E_j' = \sum_j \hat{\lambda}_{ij} \lambda_{ij} E_j' \qquad (B19)$$

Rearranging, using the definition of trade deficits, and substituting from (B17),

$$\hat{Y}_i = \frac{1}{Y_i} \sum_j \frac{\lambda_{ij} \left(\widehat{w}_i \hat{\tau}_{ij}\right)^{1-\sigma}}{\sum_k \lambda_{kj} \left(\widehat{w}_k \hat{\tau}_{kj}\right)^{1-\sigma}} \left(\hat{Y}_j Y_j + \widehat{D}_j D_j\right) \qquad (B20)$$

Notice that from $Y_i = w_i L_i$, it follows that $\hat{Y}_i = \widehat{w}_i$. Using this result and the definition of trade deficits in the previous equation,

$$\widehat{w}_i = \frac{1}{Y_i} \sum_j \frac{\lambda_{ij} \left(\widehat{w}_i \hat{\tau}_{ij}\right)^{1-\sigma}}{\sum_k \lambda_{kj} \left(\widehat{w}_k \hat{\tau}_{kj}\right)^{1-\sigma}} \left[\widehat{w}_j Y_j + \widehat{D}_j (E_j - Y_j)\right], \quad \forall i \qquad (B21)$$

Assumption 1 *Trade deficits are a constant fraction of output:* $\widehat{D}_i = \hat{Y}_i$.

With this assumption,

$$\widehat{w}_i = \frac{1}{Y_i}\sum_j \frac{\lambda_{ij}\left(\widehat{w}_i\hat{\tau}_{ij}\right)^{1-\sigma}}{\sum_k \lambda_{kj}\left(\widehat{w}_k\hat{\tau}_{kj}\right)^{1-\sigma}}\widehat{w}_j E_j, \quad \forall i \qquad (B22)$$

This equation if homogeneous of degree zero (only changes in relative prices are determined). Therefore, a normalization is required for the numerical solution. As is usual in the recent literature, we normalize wages to maintain world income constant across scenarios:

$$\sum_i \hat{Y}_i = \sum_i \widehat{w}_i = 0. \qquad (B23)$$

Step 5: The formula in this last step does not follow directly from the results by Arkolakis et al. (2012), because one of their assumption (balanced trade) is not satisfied in this model. However, the usual ACR formula also holds in this version of the model. Welfare is obtained from the indirect utility function

$$\hat{V}_j = \frac{\hat{E}_j}{\hat{P}_j} = \frac{\widehat{w}_j}{\hat{P}_j} \qquad (B24)$$

To obtain $\hat{P}_j$, notice that

$$(P'_j)^{1-\sigma} = \sum_i \alpha_{ij}\left(\frac{w'_i}{A_i}\tau'_{ij}\right)^{1-\sigma} = \sum_i \alpha_{ij}\left(\frac{w_i}{A_i}\tau_{ij}\right)^{1-\sigma}(\widehat{w}_i\hat{\tau}_{ij})^{1-\sigma}$$

$$= P_j^{1-\sigma}\sum_i \lambda_{ij}(\widehat{w}_i\hat{\tau}_{ij})^{1-\sigma} \quad (B25)$$

Therefore,

$$\hat{P}_j^{1-\sigma} = \sum_i \lambda_{ij}\left(\widehat{w}_i\hat{\tau}_{ij}\right)^{1-\sigma} \qquad (B26)$$

From (B17), the change in the domestic trade share is

$$\hat{\lambda}_{jj} = \frac{\left(\hat{w}_j \hat{\tau}_{jj}\right)^{1-\sigma}}{\sum_k \lambda_{kj} \left(\hat{w}_k \hat{\tau}_{kj}\right)^{1-\sigma}} = \frac{\hat{w}_j^{\,1-\sigma}}{\hat{P}_j^{1-\sigma}} \qquad (B27)$$

where the second equality follows from $\hat{\tau}_{jj} = 1$. Rearranging,

$$\hat{P}_j = \hat{w}_j \hat{\lambda}_{jj}^{\frac{1}{\sigma-1}} \qquad (B28)$$

Therefore, the change in welfare is

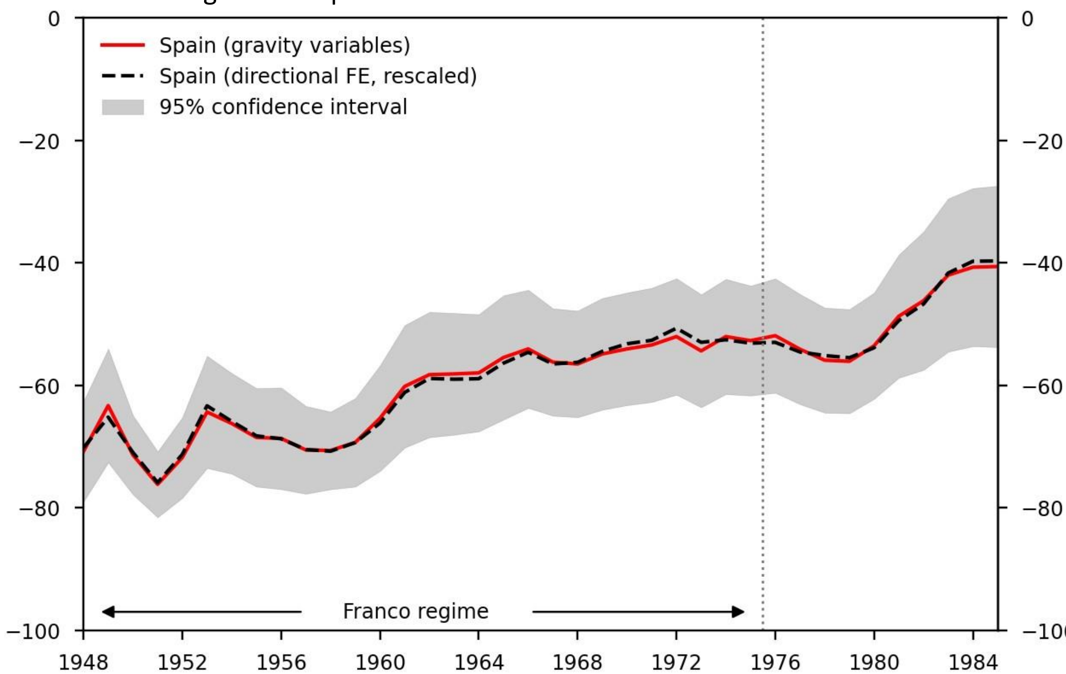
$$\hat{V}_j = \frac{\hat{E}_j}{\hat{P}_j} = \frac{\hat{w}_j}{\hat{P}_j} = \hat{\lambda}_{jj}^{-\frac{1}{\sigma-1}} = \hat{\lambda}_{jj}^{-\frac{1}{\epsilon}} \qquad (B29)$$

as in the ACR formula.

C Empirical appendix

C.1 Robustness: directional pair fixed effects

Figure C.1: Spain's relative border thickness: robustness



Notes: The figure plots the estimated relative thickness of Spain's borders measured as the percent deviation of Spain's border effect from the border effect of a typical country. The estimation with gravity variables (solid line) uses the specification in (1). The dashed line is an estimation in which gravity variables have been replaced with directional pair fixed effects and coefficients have been rescaled so that their average coincides with the average of the baseline specification. Marginal effects are constructed from estimates $\hat{\theta}_t$ using the transformation $100 \times [\exp(\hat{\theta}_t) - 1]$. The 95% confidence interval shown for the marginal effects of the specification with gravity variables is calculated using the delta method.

C.2 Synthetic benchmarks

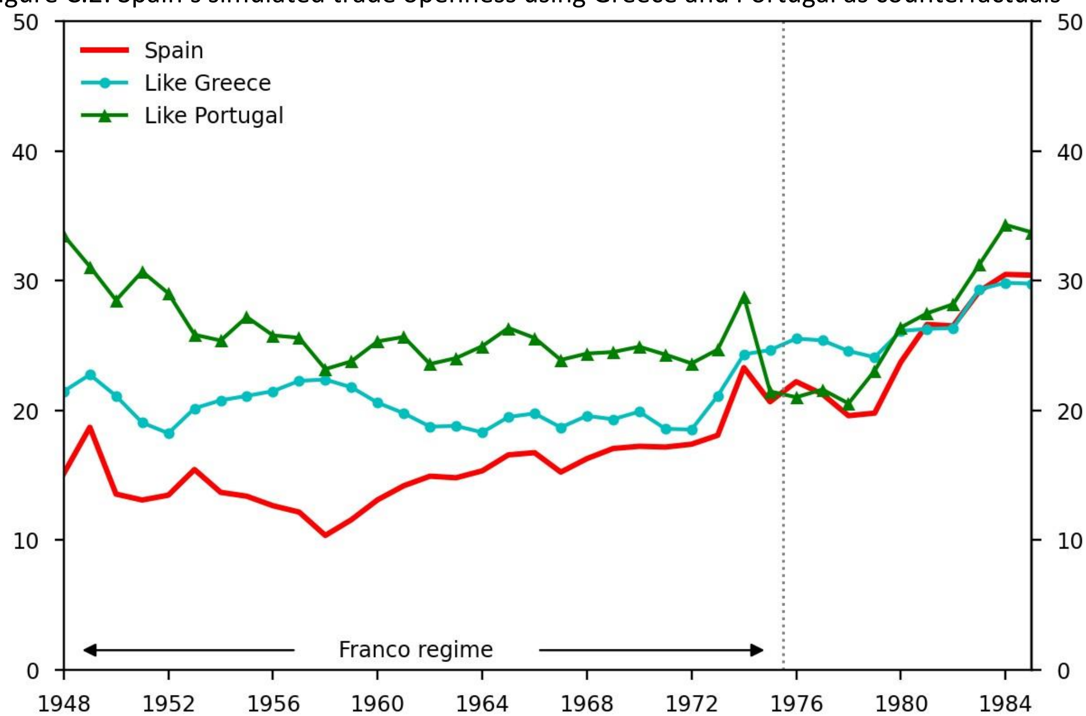
Table 2: Synthetic benchmark weights

	Synthetic Spain [1]	Synthetic Spain [2]
Argentina		
Austria		
Belgium		7.2%
Bulgaria	11.8%	
Bolivia		
Brazil		1.0%
Canada		
Switzerland		
Chile		
Colombia		
Denmark	1.5%	
Dominican Republic		
Ecuador		
Finland		
France		
United Kingdom		
Greece	23.3%	7.2%
Honduras		
Haiti		
Hungary		
Ireland		
Italy		
Mexico	27.2%	36.9%
Nicaragua		
Netherlands	1.4%	
Norway		
Panama		
Peru		
Poland		
Portugal	34.8%	12.2%
Paraguay		
Romania		
Sweden		
Uruguay		
United States		35.4%

Notes: optimal weights derived for each synthetic benchmark using the methodology described in the main text.

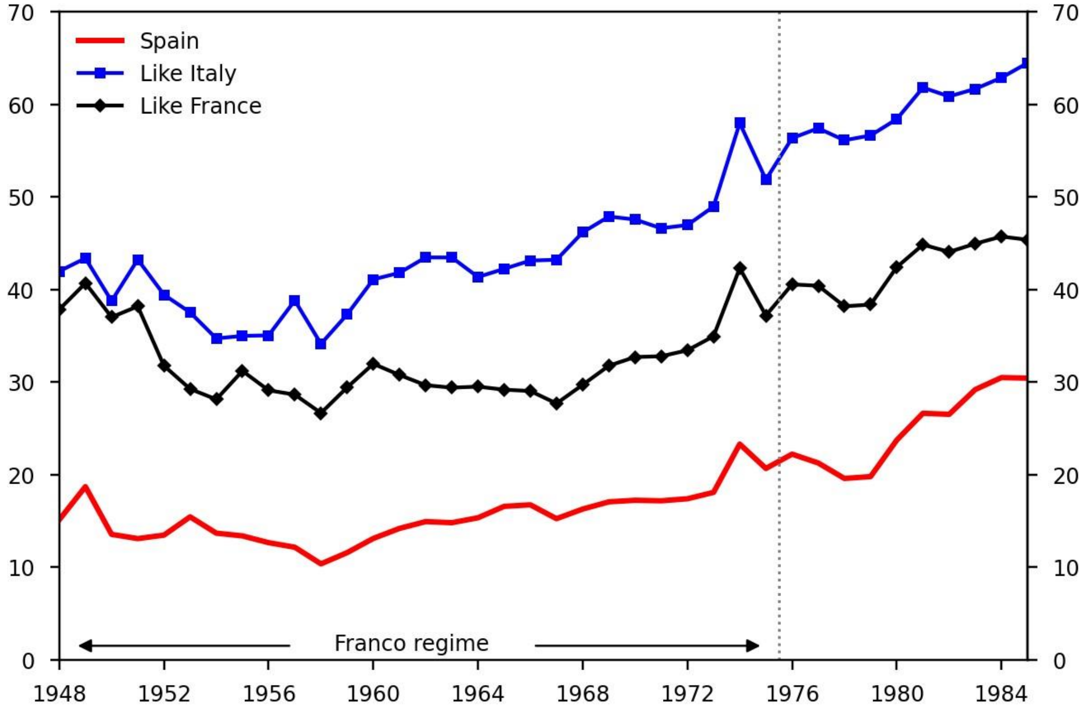
C.3 Simulation results

Figure C.2: Spain's simulated trade openness using Greece and Portugal as counterfactuals



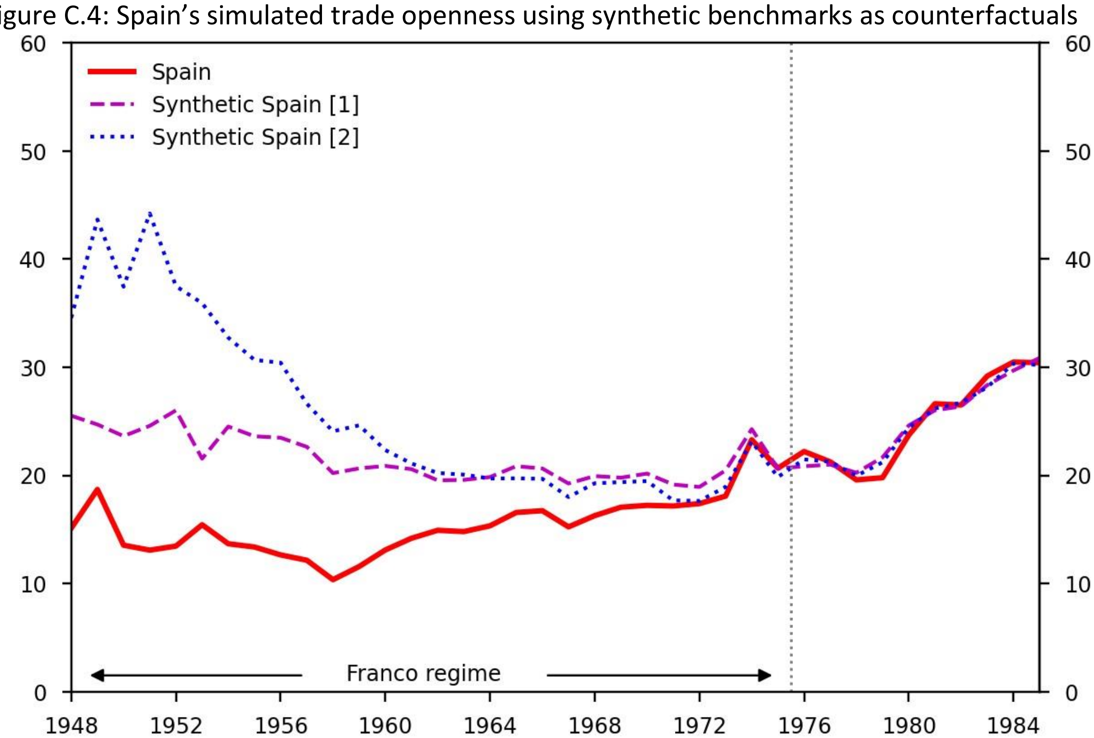
Notes: The figure plots Spain's trade openness (export plus imports as percent of GDP) compared to counterfactual exercises in which its border thickness has been set to that of Greece or Portugal.

Figure C.3: Spain's simulated trade openness using France and Italy as counterfactuals



Notes: The figure plots Spain's trade openness (export plus imports as percent of GDP) compared to counterfactual exercises in which its border thickness has been set to that of France or Italy.

Figure C.4: Spain's simulated trade openness using synthetic benchmarks as counterfactuals



Notes: The figure plots Spain's trade openness (export plus imports as percent of GDP) compared to counterfactual exercises in which its border thickness has been set to that of the synthetic benchmarks.

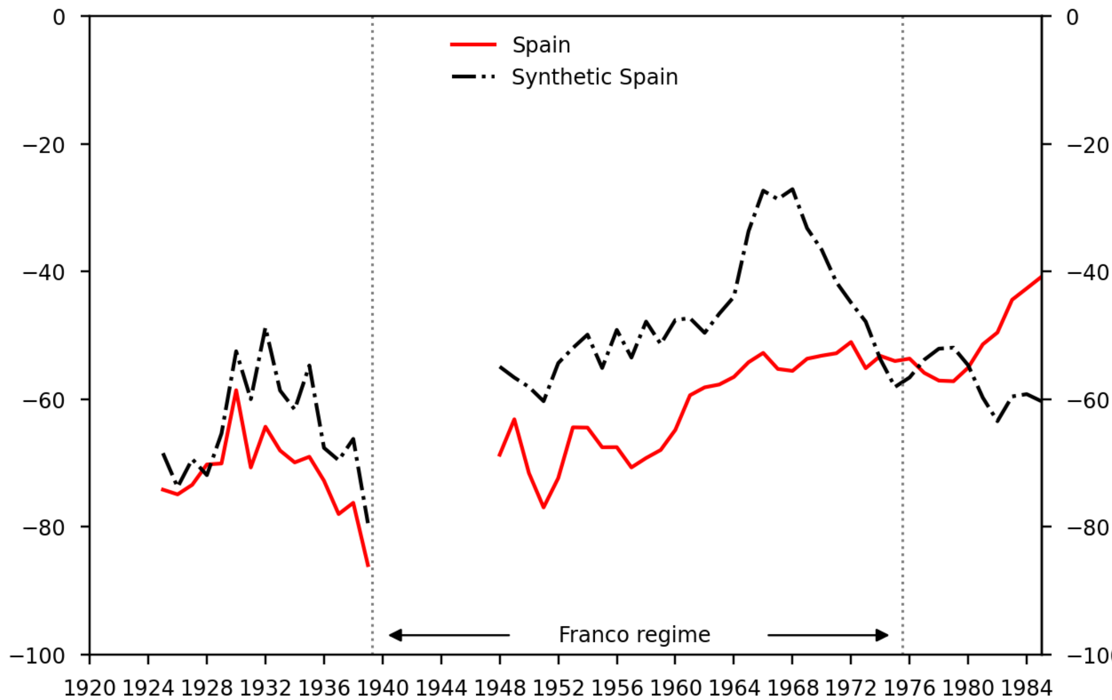
C.4 Synthetic benchmark using the pre-Franco period

Our synthetic benchmarks are constructed by matching country characteristics in the post-Franco period. As explained in the main text, there are a number of reasons why it is unwise to use the period before the start of Franco regime. There is the practical issue that trade data lack for many countries in the years corresponding to the Second World War and that data are in general relatively sparse in earlier years. More importantly, the extensive destruction of industries and infrastructure in European countries during the Second World War and in Spain during the Spanish Civil War is likely to have led to abrupt changes in economic structure, trade relations, and trade openness. This, together with shifts of country borders and the emergence of a Communist bloc in Europe in the post-war period, makes the assumption that time-invariant country weights calculated using pre-war data are informative for the post-war period untenable.

In this section we show the results from using the pre-Franco period to calibrate the weights. To do so, we extend the estimation of border thickness for the sample of European and Latin American countries used in the main analysis to start in 1925 and use the period 1925-1935 to match the characteristics of Spain and countries in the donor pool. We match the average border thickness and as additional criteria we employ the degree of trade openness (the sum of exports and imports over GDP) in all years (1925-1935), following the same strategy as in the first synthetic benchmark in the main text. The resulting benchmark places positive weight on only two countries: Honduras (75.3%) and Portugal (24.7%). The evolution of the synthetic benchmark for Spain using these weights is shown in Figure C.5.

The high weight placed on a single country, in this case Honduras, a country with an economic structure that was very different from Spain in the period of interest, casts doubt on this particular synthetic construct as an appropriate benchmark for Spain. Moreover, the synthetic benchmark using prior data does not align tightly with Spain's border thickness in the latter part of the period used for matching, which is an additional unattractive feature. This discrepancy is probably caused by a thin donor pool and the divergence between the openness indicator and border thickness, whose estimation is hampered by the scarcity of data (in contrast to the abundance of trade data for the post-war period).

Figure C.5: Synthetic Spain using the pre-Franco period



Notes: The figure plots the estimated relative thickness of the borders of Spain and a synthetic benchmark for Spain. Relative thickness is measured as the percent deviation from the border effect of the world excluding Europe and the Americas. The estimation uses the longer time period 1925-1985. The synthetic benchmark is constructed from individual country data using the weights described in this section.

D Data appendix

D.1 Variable definitions

Used for gravity regressions and construction of domestic trade flows:

Variable	Name in data source and transformation	Data source
Bilateral trade flows	FLOW	TRADHIST v.4
Gross domestic product	GDP_o, GDP_d	TRADHIST v.4
Bilateral distance	ln(Dist_coord)	TRADHIST v.4
Colonial relationship	Evercol	TRADHIST v.4
Contiguity	Contig	TRADHIST v.4
Common language	Comlang	TRADHIST v.4

Used for synthetic benchmarks:

Variable	Name in data source and transformation	Data source
Overall trade openness	(csh_x + csh_m)/2	PWT v.10.0
Labor productivity	rgdp_o/emp	PWT v.10.0
Rural population share	SP.RUR.TOTL.ZS	WDI
Cereal crop yield	AG.YLD.CREL.KG	WDI
Tractors per arable land	AG.LND.TRAC.ZS	WDI

D.2 Country group definitions

All country codes are defined as in the TRADHIST database.

Spain: ESP.

North-Western Europe: AUT, BEL, CHE, DEU, DNK, FIN, FRA, FRO, GBR, GRL, IRL, ISL, LUX, NLD, NOR, SWE, WDEU.

Southern Europe: AND, CYP, GIB, GRC, ITA, MLT, PRT, TRIEST.

Eastern Europe: ALB, BGR, CZSK, EDEU, HUN, LVA, POL, ROM, USSR, YUG.

Americas: ARG, BOL, BRA, CHL, COL, CRI, CUB, DOM, ECU, GTM, HND, HTI, JAM, MEX, NIC, PAN, PER, PRY, URY, USA, VEN.

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