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# Spain, Split and Talk:

# Quantifying Regional Independence *

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**Abstract**

We quantify the economic impact of a potential secession of Catalonia from Spain. Using a novel dataset of trade flows between 17 Spanish sub-national regions and 142 countries, we estimate the effects of different levels of borders on trade flows and uncover heterogeneity in country-to-country, region-to-country, region-to-region, and EU border effects. We use a general equilibrium analysis to understand the consequences of a potential Catalan secession, considering the associated political uncertainty. In counterfactual experiments, we impose new borders on Catalan trade, potentially within or outside the EU, resulting in a welfare decline for Catalonia and the remaining Spanish regions.

***Keywords***— international trade; regional trade; border effects; regional independence

***JEL***— F10, F13, F14, H77, R12

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# 1 Introduction

In December 2019, during a heated rivalry football match between FC Barcelona and Real Madrid, Catalan pro-independence supporters unveiled banners with the rallying prompt "Spain, sit and talk". The slogan was intended to encourage the Spanish government in Madrid to sit around the negotiating table and talk about the potential secession of the region from Spain. The match ended in a 0–0 draw, symbolising the political impasse that has gripped Catalonia since the referendum in October 2017. After the referendum, the Spanish government stripped the Catalan government of power, leaving the region in political limbo until the regional elections in December 2017 elected another pro-independence leader. Catalan independence has remained on the political agenda in Catalonia, reinforcing it at the elections in 2021, where pro-independence parties gained a majority of the votes.

In this paper, we analyse the potential economic consequences of Catalan secession. We study the period from 2001 to 2017 with a detailed focus on two years: 2012, the year in which the process reignited with the massive independence demonstration in Barcelona; and 2017, the year of the referendum, we quantify the effects of Catalan independence, had it taken place. These insights shed light on the consequences one may expect if the independence process becomes successful one day. We place our analysis into an international trade setting and acknowledge that, in the present status quo, Catalonia's trade is subject to different levels of borders (regional, international, or EU borders), which would change if it became an independent state within or outside the EU. This border change is what we use in our analysis to model different independence scenarios.

Our contribution to the literature is twofold. First, we contribute to the literature on border effects in international trade. International border effects are widely observed and reduce international trade compared to trade among regions within a country. For a review of different studies on international border effects, see Havranek and Irsova (2017). In our context, borders refer to trade barriers that result in higher levels of domestic

than international or inter-regional trade. To estimate different levels of border effects, we construct a novel dataset that nests 17 Spanish regions' international, inter-regional, and domestic trade flows into the International Trade and Production Database for Estimation (ITPD-E Release 2) dataset with international and domestic trade flows from which we use 142 countries worldwide. Having data on domestic trade at the regional and country levels allows us to estimate different levels of border effects (region–region, region–country, country–country borders, as well as borders within the EU) and to uncover sizeable heterogeneity. Focusing on Catalonia's border over the period 2001–2017 reveals that its border with other Spanish regions became thicker, especially in the aftermath of Spain's economic collapse following the Great Recession. At the same time, Catalonia's international border became thinner, in line with recent evidence, such as Almunia et al. (2021). This suggests that Catalonia became more integrated internationally, decreasing the cost of independence from Spain, which implies thicker borders (i.e., more costly trade) with the remaining Spanish regions.

The second contribution is quantifying the potential economic consequences of a hypothetical secession of Catalonia from Spain using the theoretical properties of the structural gravity equation in a general equilibrium (GE) analysis. We expand the scant previous work in this area (e.g., Comerford and Rodríguez Mora, 2019) by accounting for the political uncertainty regarding the conditions under which Catalonia would become independent. Particularly regarding its EU membership, we consider different counterfactual scenarios, where Catalonia remains in the EU or where it is no longer part of the EU. We also consider a further scenario where Catalonia is outside the EU and not a member of the World Trade Organization (WTO). Our approach allows us to shed light on the potential economic consequences of regional independence and thereby add to the political discussion on regional, specifically Catalan, independence. The findings suggest increasingly high losses for the decreasingly integrated scenarios, for both consumers and producers in Catalonia, while the loss is lower and very similar across the different scenarios for the rest of Spain. This implies that the government in Madrid may have greater leverage than Catalonia in hypothetical political negotiations.

The rest of the paper is organised as follows. Section 2 offers some background on the Catalan independence process and the relevant literature; Section 3 outlines the theory and methods; Section 4 describes the data; Section 5 reports the regression results; Section 6 presents the GE counterfactual experiments; and Section 7 concludes.

# 2 Background

## 2.1 The Catalan Independence Process

Spain is a member state of the European Union and operates in a decentralized, de facto federal manner, consisting of 17 autonomous regions, two of which are groups of islands in the Atlantic and the Mediterranean. Each region has unique cultural traits, and some speak co-official indigenous languages.[1] These regions have a high degree of political autonomy, with the regional parliament electing the executive government that legislates over many areas, such as education and healthcare. However, regions have limited autonomy in other areas, especially personal income, capital, donations, and inheritance taxation. The degree of autonomy varies and is ruled by de-centralisation bills in the national parliament, subject to ad-hoc political bargaining within constitutional limits. The Basque Country on the northern Atlantic coast has the highest degree of autonomy, including fiscal autonomy, police corps, K-12 education, and their university system, including instruction in the Basque language. Catalonia, an autonomous region on the northeast Mediterranean coast of the Iberian Peninsula, has a similar degree of autonomy, except for a reduced fiscal space. The prevailing view among Catalan independence supporters is that the economically vibrant Catalonia contributes more to the Spanish state than it receives in return, for example, by needing to remit parts of its profits made from the Spanish domestic market to the Spanish state (see Alòs-Moner and Pastor, 2014). This economic argument is backed by institutional, cultural, and political arguments for Catalan independence.

[1] Catalonia, Valencia, and the Balearic Islands speak dialectal variations of the Catalan language, the Basque Country and Navarra speak Euskera, and Galicia speaks Galician.

In 2012, when the independence process reignited and there were massive demonstrations on Barcelona's streets, the highly developed and industrialized region of Catalonia represented 16% of the Spanish population with about 7.5 million people and 19% of the Spanish GDP with 206 billion euros. Catalonia's GDP per capita at the time was 25,804 euros, making it 17% higher than the Spanish average.[2] The Spanish Constitutional Court ruled unconstitutional an exclusively Catalan referendum, where only Catalan citizens voted on independence. The Court interpreted Article 1 of the Spanish Constitution, which states that national sovereignty is vested in the Spanish people, to mean that all Spanish citizens should be allowed to vote in a secession referendum. Nonetheless, in 2014, the ruling pro-independence coalition in Catalonia made two attempts to hold non-binding independence referenda. However, the Spanish judiciary ruled against them and imposed fines and political ineligibility for office on the organisers. The Spanish and Catalan police were authorised by the judiciary to use violent force to prevent the second referendum on October 1st, 2017, which triggered a series of events. These events culminated in the proclamation of independence on October 27th, while at the same time, the Spanish Senate triggered a constitutional article that revoked Catalan autonomy. This led to the dismissal of the Catalan government, and the dissolution of parliament, and called for new elections, which were held in December 2017. The deposed pro-independence coalition won again, leading to a 50-50 political divide in votes.

Given these developments, we investigate the consequences of a potential Catalan secession, following a hypothetically successful proclamation of independence. Catalan independence would come along with new national borders surrounding it, changing the borders crossed by Catalan exports and imports, and making trade with the remaining Spanish regions more costly. Although the Spanish market is an important destination for Catalan exports, there has been a recent shift towards international exports at the expense of the domestic market, as we document later with evidence for a growing regional and a decreasing international border for Catalonia from 2001 to 2017, in line with Castells (2014a). International trade is an essential part of the Catalan economy

[2]Source: ARDECO, available at https://urban.jrc.ec.europa.eu/ardeco.

and Catalonia exported more than 25% of Spanish total exports in the past years (see Alòs-Moner and Pastor, 2014, p. 20). Additionally, Catalonia is an important hub for Spanish road and maritime exports because of its strategic location in the northeast Iberian peninsula. Its road connection with northern Europe, which avoids the Pyrenees mountains that separate France from Spain, is the pathway of most of the exports by truck. The Port of Barcelona is the largest port in the region for accommodating cruise ship traffic and it ranks fifth in container traffic volume in the Mediterranean.

Hence, the welfare consequences of Catalan independence will depend on how Catalonia integrates into the international trade network. This will be influenced by the circumstances under which it secedes from Spain, and whether it will also need to leave the EU and the WTO. While there are arguments for an independent Catalonia to remain in the EU and the single market (see for example Castells, 2014b; Granell, 2014), it is unclear whether a fragmented state from an EU member would automatically be granted access to the EU.[3] The European Commission has suggested that a seceding Catalonia would be considered outside the European Union, as stated in the "Prodi-doctrine" of EC President Romano Prodi in 2004.[4] In case Catalonia leaves the EU, a possible scenario is a situation similar to Brexit. After leaving the EU, the UK had to renegotiate any existing trade agreement which it was automatically part of as a member of the EU. Until agreements are made, trade policy abides by WTO rules. However, it is uncertain whether Catalonia would be a member of the WTO after its secession, since EU member states are also members of the WTO in their own right, while Catalonia is not a listed member of the WTO. Hence, Catalonia would likely have to apply for WTO membership.[5] Given the uncertainties regarding EU and WTO membership, we simulate different scenarios in our counterfactual analysis in Section 6.

[3]Legal discussions on this possibility can be found in Gounin (2013), Tierney (2013), Kenealy (2014), Closa (2016), Guirao (2016), and Piris (2017), among others.

[4]Regarding the events in Catalonia in 2017, the European Commission stated: "If a referendum were to be organised in line with the Spanish Constitution it would mean that the territory leaving would find itself outside of the European Union."

[5]Nowrot (2019) provides legal aspects of WTO membership for non-recognised territorial entities.

## 2.2 Related Literature

The subject of regional independence has been extensively studied by researchers from different disciplines, such as legal scholars and political scientists. We focus our discussion here on our contribution to two strands of the economics literature. On the one hand, there are studies examining the partial effects of regional independence and state fragmentation on regional growth. For instance, Rodríguez-Pose and Stermšek (2015) quantify the impact of the fragmentation of the former Yugoslavia on regional growth in real GDP using data between 1956 and 2011. They conclude that the economic impact of independence depends not only on the mere occurrence of secession but also on how it takes place. For Catalonia, this means that the economic impact of its secession will depend on whether it maintains its economic ties to other countries, which we model in our counterfactual experiments. Using the synthetic control method, further studies demonstrate the effects of regional independence on GDP per capita. Monastiriotis and Zilic (2020), for instance, focus on Serbia and Montenegro and find positive short-run effects of state independence on GDP per capita, which level off in the long run. Reynaerts and Vanschoonbeek (2021) estimate the average effect of secession on GDP per capita for a panel of countries that became independent between 1940 and 2016. They find heterogeneous effects of secession, depending on the country.

The other strand of literature takes a perspective on international trade. Within the international trade literature, there have been extensive studies of international disintegration, particularly on the effects of the recent United Kingdom's exit from the EU. For example, Dhingra et al. (2017) examine the welfare implications of reduced trade after Brexit, while Breinlich et al. (2020) analyse the effects of Brexit on FDI, and McGrattan and Waddle (2020) quantify its effects on foreign investment, production, and welfare.

Using examples for individual countries, some studies focus on the trade effects of regional secession. Using trade flows for Canadian provinces and US states as well as estimates of border effects, Helliwell (1996) assesses the implications for Quebec separation. Fidrmuc and Fidrmuc (2003) analyse the trade impact of the disintegration of the Soviet Union, Yugoslavia, and Czechoslovakia. More recently, Huang et al. (2021) quantify the

economic consequences of Scottish independence from the United Kingdom (UK) using an increase in trade costs due to a change in the border between Scotland and the UK. The Catalan independence has been studied, for example, by Comerford et al. (2014), who use a three-country Melitz (2003) model with data on Catalonia, the rest of Spain, and the rest of the world and find a 3% decrease in income for an independent Catalonia in the EU, using Portugal as a benchmark. Comerford and Rodríguez Mora (2019) compute the border effect of the "Head–Ries Index" (Head and Ries, 2001) for subnational and international trade data. They find a 12.5% loss in welfare for an independent Catalonia that has the same trade frictions with Spain as Portugal.[6]

While our approach is similar to that of Comerford and Rodríguez Mora (2019), our analysis differs in several respects. First, we apply the latest developments in the estimation of structural gravity models to a multi-country, multi-region setting. Our novel dataset nesting all of the 17 individual Spanish regions' trade flows into trade flows of 142 countries during 2001-2017 allows us to differentiate between regional and international borders, as well as EU borders. We estimate the effects of these different border levels and use the estimates in our GE analysis, implementing different scenarios of Catalan independence, such as Catalonia remaining in or leaving the EU or the WTO. Second, we do not limit our study to the consequences for Catalonia and also quantify the effect on the remaining Spanish regions and on countries worldwide. This is relevant in light of policy uncertainty: by analysing the rest of Spain, we get insights into the political economy of regional independence (i.e., the leverage of Madrid in political negotiations). Third, our welfare analysis allows us to compute effects on consumer and producer prices along with overall real GDP per capita effects. Fourth, while Comerford and Rodríguez Mora (2019) use Catalan data from 2005 and Spanish data from 2006 for goods only, we expand the time period and the sectors, allowing us to gain insights into the economic rationale for regional secession. That is, we capitalise on more up-to-date data, as we use data for hte period 2001-2017 (with a detailed focus on 2012 and 2017). Furthermore, our data

[6]Castells (2014b) provides additional results and references on the effects of a potential Catalonian secession based on descriptive statistics or standard border effect estimates.

includes higher quality for the domestic trade flows based on raw data, which is crucial to identifying the border effects.

Our analysis is also related to the literature on border effects, spurred by McCallum (1995) and Anderson and van Wincoop (2003). The widely observed border puzzle uncovers much lower levels of international trade relative to trade among regions within a country. For example, McCallum (1995) and Anderson and van Wincoop (2003) use trade among Canadian provinces, among US states, as well as between Canadian provinces and US States to investigate the effect of borders for trade between Canada and the US. More recently, some studies highlight regional border effects, which reduce trade between regions relative to regional domestic sales. Estimating border effects for different samples including trade flows for US states, Coughlin and Novy (2021) demonstrate heterogeneous border effects depending on the size of the region. In their US-only sample, they combine domestic trade flows with inter-state flows, while in their multi-country sample, they combine inter-state flows with international trade flows from US states to the 50 largest US export destinations. Santamaría et al. (2023) explore regional borders in Europe using trade data between and within regions in Europe, while García-Santana and Santamaría (2023) document regional borders in public procurement using procurement contracts awarded in France and Spain. We contribute to this literature by combining worldwide international trade flows and Spanish regional trade data with domestic sales at both levels and employing the most recent developments in the trade gravity literature.

## 3 Theoretical Foundation and Empirical Strategy

Our empirical specification for quantifying border effects as well as our counterfactual analysis rely on the structural gravity model of trade. The seminal article by Anderson and van Wincoop (2003) assesses the effects of the US-Canada border solving McCallum's (1995) border puzzle by suggesting an estimating procedure that controls for omitted variable bias and by performing a theory-based comparative static analysis. Since Anderson and van Wincoop (2003), additional best practices in estimating gravity equa-

tions and performing counterfactual analyses have been developed: i) estimate the model in its multiplicative form using Poisson Pseudo-Maximum-Likelihood (PPML) (Santos Silva and Tenreyro, 2006), ii) include exporter and importer fixed effects (Baldwin and Taglioni, 2006; Feenstra, 2016; Hummels, 2001), and iii) include intra-national alongside international trade flows (Heid et al., 2021; Yotov, 2012). We follow these recommendations for our estimating equation and utilise the results from Fally (2015) with the procedure from Anderson et al. (2018) to perform our counterfactual analysis.

The underlying theoretical model consists of $N$ different trading partners, from which 142 are countries, and Spain is split into its 17 autonomous communities. Each trading partner is assumed to produce a variety of goods that are differentiated by place of origin (Armington, 1969). Consumer preferences are represented by a constant elasticity of substitution (CES) utility function with a common elasticity of substitution $\sigma$ and a CES preference parameter $\gamma_i > 0$. Utility maximisation, taking into account the budget constraint $\sum_i p_{ij} c_{ij} = E_j$ (where $p_{ij}$ denotes prices paid by consumers in $j$ for goods from $i$, $c_{ij}$ is the quantity consumed in $j$ from $i$, and $E_j$ are total expenditures in $j$) leads to the following demand equation for the value of goods from $i$ demanded in $j$:

$$X_{ij} = \left( \frac{\gamma_i p_{ij}}{P_j} \right)^{1-\sigma} E_j, \tag{1}$$

where $P_j$ is the CES consumer price index given by $P_j = \left[ \sum_i \left( \gamma_i p_{ij} \right)^{1-\sigma} \right]^{\frac{1}{1-\sigma}}$.

For simplicity, we assume an endowment economy and each trading partner is endowed with a fixed amount of $Q_i$. Total nominal income in $i$ is then given by $Y_i = p_i Q_i$, where $p_i$ is the factory-gate producer price. Assuming iceberg transport costs (Samuelson, 1952), the producer price is related to the consumer price by $p_{ij} = p_i t_{ij}$, where $t_{ij} \geq 1$ is the total amount of goods that have to be sent for one unit to arrive.

In equilibrium, markets clear and the total amount of goods produced is equal to the total amount demanded: $Y_i = \sum_j X_{ij}$. Using the expression for $X_{ij}$ from (1), solving for $\gamma_i p_i$, and defining $\Pi_i^{1-\sigma} = \sum_j \left( \frac{t_{ij}}{P_j} \right)^{1-\sigma} E_j$, we end up with the following structural gravity system:

$$X_{ij} = \left(\frac{t_{ij}}{\Pi_i P_j}\right)^{1-\sigma} Y_i E_j, \tag{2}$$

$$P_j^{1-\sigma} = \sum_i \left(\frac{t_{ij}}{\Pi_i}\right)^{1-\sigma} Y_i, \tag{3}$$

$$\Pi_i^{1-\sigma} = \sum_j \left(\frac{t_{ij}}{P_j}\right)^{1-\sigma} E_j, \tag{4}$$

$$p_j = \frac{Y_j^{\frac{1}{1-\sigma}}}{\gamma_j \Pi_j}. \tag{5}$$

Taking the best practice recommendations for gravity equation estimation onboard, Equation 1 can be translated into the following estimating equation:

$$X_{ij} = \exp\left(\mathbf{T}_{ij}\boldsymbol{\beta} + \pi_i + \chi_j\right) \times \epsilon_{ij}. \tag{6}$$

$\mathbf{T}_{ij}$ is the vector collecting all bilateral explanatory variables approximating trade costs $t_{ij}$, $\boldsymbol{\beta}$ is the corresponding parameter vector, $\pi_i$ denotes the exporter fixed effects that control for the outward multilateral resistances $\Pi_i$ and for outputs $Y_i$, $\chi_j$ denotes the importer fixed effects that control for the inward multilateral resistances $P_j$ and for expenditures $E_j$, and $\epsilon_{ij}$ is a multiplicative remainder error term assumed to be independent of the explanatory variables and with conditional expectation equal to one.[7]

To quantify the border effects, which are part of the explanatory variables of the trade costs $\mathbf{T}_{ij}$, we construct several different variables which utilise the features of our data. First, a variable BRDR_ALL captures any border, i.e., it distinguishes between domestic sales and sales crossing any border, be it either trade between Spanish regions, between a Spanish region and another country, or between two countries. Our dataset allows us to split the general BRDR_ALL into three different border levels: i) international borders between countries (not including the border between countries and Spanish regions), INTL_BRDR, ii) international borders between a country and a Spanish re-

[7]Without any implications of what follows, we also could have introduced an additive error term. See for a discussion Santos Silva and Tenreyro (2006) and Anderson et al. (2018).

gion, INTL_SPAIN, and iii) borders between Spanish regions, INTER_REGION. The distinction of these three different border variables is possible because we split Spain into regions and we have domestic sales for countries as well as for Spanish regions. In some specifications, we split the INTL_BRDR and INTL_SPAIN dummies further into INTL_BRDR_EU, indicating an international border between EU member countries; INTL_BRDR_no_EU, indicating an international border between two non-EU member countries or an EU member country and a non-EU member country; and, similar, for INTL_SPAIN_EU and INTL_SPAIN_no_EU, indicating trade between a Spanish region and an EU member country and between a Spanish region and a non-EU member country, respectively. For further analysis, we even split the variables further to allow for country-specific and region-specific border effects.

Besides the border variables, we also control for the standard gravity variables used in cross-section gravity specifications, such as the natural logarithm of bilateral distance (LN_DIST), a dummy variable indicating whether two trading partners (countries or regions) share a common border (CONTIG), a dummy variable indicating whether two trading partners share a common language (COM_LANG), a dummy variable indicating whether two trading partners have a regional trade agreement in place (RTA), a dummy variable indicating whether both trading partners are a member of the European Union (EU, zero for domestic trade flows and for trade between Spanish regions), a religious proximity index (COM_REL), a dummy variable indicating whether two trading partners share a common legal system (COM_LEG), a dummy variable indicating whether at least one of the trading partners is an island (ISLAND), and a dummy variable indicating whether at least one of the trading partners is landlocked (LAND).

For our counterfactual analysis, we rely on the structure of the theoretical model described above and the property highlighted by Fally (2015) that the estimates of the fixed effects from gravity estimations are perfectly consistent with the structural gravity terms (assuming that the data generating process follows the assumed underlying model). Dropping one importer fixed effect, $\chi_0$, and the constant, and using as a normalisation for the system (3)-(4) the multilateral resistance that corresponds to the dropped importer

fixed effect, i.e., $\widetilde{P}_0 = 1$, the $\Pi_i^{1-\sigma}$ and $P_j^{1-\sigma}$ can be recovered from the fixed effects as follows:

$$\widetilde{\Pi_i^{1-\sigma}} = E_0 Y_i \exp\left(-\widetilde{\pi}_i\right), \tag{7}$$

and

$$\widetilde{P_j^{1-\sigma}} = \frac{E_j}{E_0} \exp\left(-\widetilde{\chi}_j\right), \tag{8}$$

where $\widetilde{\pi}_i$ and $\widetilde{\chi}_j$ are the estimated fixed effects from Equation (6), and $E_0$ denotes the expenditure of the country chosen as numéraire. Using the GEPPML procedure from Anderson et al. (2018), we can calculate counterfactual effects by changing the trade cost vectors to suit our counterfactual experiment, more precisely by imposing different levels of borders for Catalan trade. We then obtain counterfactual values for output, $Y_i^c = \left(p_i^c / p_i\right) Y_i$, expenditures, $E_i^c = \left(p_i^c / p_i\right) E_i$ (assuming that trade imbalance ratios $\phi_i = E_i / Y_i$ are constant in the counterfactual for each country $i$), trade flows, $\widetilde{X}_{ij}^c$ (using Equation (2), $\left(\widetilde{\Pi_i^{1-\sigma}}\right)^c$ and $\left(\widetilde{P_j^{1-\sigma}}\right)^c$ (using Equations (7) and (8)). The reported results are then the percentage changes between baseline and counterfactual values, i.e., for output Output% $= (Y_i^c - Y_i)/Y_i \times 100$.

# 4 Data

For constructing our novel dataset which nests Spanish regions into worldwide country-level trade data (i.e., we replace Spain's country trade flows with all regional trade flows), we use two main data sources. First, we use country-to-country international trade flows from the ITPD-E Release 2 dataset of the US International Trade Commission (USITC), described by Borchert et al. (2021, 2022a,b).

Second, we use trade flows for the 17 Spanish regions (NUTS2 level) within regions, between regions, as well as between regions and countries in the ITPD-E data from the C-Intereg project.[8] Previous waves of this dataset are thoroughly described by Llano et al. (2017, 2010). The C-Intereg dataset is unique, as its construction is not based on

[8] https://www.c-intereg.es/.

gravity and it is hence suitable for gravity estimation.[9] The C-Intereg merges freight datasets by transport mode (roads, railway, sea, and air) and type of products with product-specific price vectors and imposes output and trade constraints at the national and regional levels. The international trade flows of Spanish regions are based on the official files published yearly by the Spanish Tax Agency (AEAT), which we scaled to match the ITDP-E flows of the year 2001.

The international control variables come from the Dynamic Gravity Dataset of the USITC, which collects data from different sources (see Gurevich and Herman, 2018), as well as from the CEPII dataset (see Conte et al., 2022). Distance between regions is taken from Llano et al. (2010). Regional distance, averaged and weighted using the population of origin and destination provinces, corresponds to the most representative distance, being road deliveries (the largest share of deliveries observed in Spain). We have manually adjusted contiguity and common language dummies for the Spanish regions. We have merged the ITPD-E and the Spanish datasets at the four-digit industry level and aggregated them at the regional/country level. We used the C-Intereg broad R5 industry classification of Agriculture, Consumer goods, Equipment Goods, Intermediates, and Energy, which we matched with ITPD-E and aggregated at the region/country level.[10] We matched the HS6 product codes included in each broad sectors of C-Intereg with the equivalent HS4 codes available for ITPD-E and collapsed the trade flows at the country/region level.[11]

Our dataset covers the years between 2001 and 2017, with 2001 representing a period of Spanish economic growth, and 2017 marking the post-independence referendum era. We utilise cross-sectional estimates of trade costs, particularly the effects of borders, in

[9]There is neither an official source of administrative interregional trade data nor a consensus on constructing them. Some authors rely on data sources that use goods shipments to construct or complete regional trade flows (e.g., Potters et al., 2015; Santamaría et al., 2023).

[10]The subsectors for each broad industry classification are: 1) Agriculture: Livestock, Cereals, Unprocessed Food Products, and Wood; 2) Consumer goods: Processed Food Products, Oils, Tobacco, Beverages, Textile and Clothing, Leather and Footwear, Paper, Furniture; 3) Equipment Goods: Steel Products, Non-electric Machinery, Devices and Engines, Tractors, Agricultural Machinery and Equipment, Electric Machinery, Devices and Engines, Transportation Materials; 4) Intermediates: Cement and Limestone, Glass, Building Materials, Fertilisers, Chemical Products, Plastic and Rubber, Wood and Cork; 5) Energy: Carbons, Minerals, Liquid Fuels, Minerals, Stones and Earth, and Salt.

[11]Product code equivalence are available from the authors upon demand.

various scenarios of our general equilibrium analyses for these different years. By doing so, we can assess and compare the costs of independence for Catalonia and the remaining Spanish regions over the period 2001–2017. Given that the Catalan independence process reignited in 2011, culminating in the massive demonstration in September 2012, our main illustrations focus on 2012, when Spain was in a recession following the financial crisis of 2007–2008. We compare our results to results obtained for 2017 (the year of the referendum) as a robustness check.

# 5 Estimation Results

## 5.1 Estimating Different Trade Border Levels

Table 1 reports the results of estimating Equation (6) when splitting the borders into different levels.[12] Column (1) of Table 1 reports estimates of the international border effect obtained using a sample of 143 countries in 2012, where Spain is considered as a single entity instead of being split into its regions. In Column (2), Spain is split into its regions and the dataset comprises region-with-country trade flows instead of Spain-with-country trade and region-with-region or domestic regional trade flows instead of Spanish domestic trade. The overall border effect is slightly less negative than in Column (1). The observation that the average border becomes a little thinner can be explained by the fact that we are creating borders within Spain, counting region-with-region trade as trade across a border, whereas it counts as Spain's domestic trade in Column (1). While the border effects estimated in Columns (1) and (2) capture overall borders, in Column (3) we differentiate between country-to-country, region-to-country[13], and region-to-region borders. All border coefficients are negative and highly significant, while the border between Spanish regions and other countries is slightly thicker than the border among other countries, suggesting that Spanish regions are a little less integrated than

[12] Remember that border effects essentially estimate the difference between domestic and cross-border trade.

[13] When referring to region-to-country borders, we also mean country-to-region borders, i.e., we include all trade flows between Spanish regions and other countries, in both directions.

other countries. Accordingly, two countries trade about 97.96% less with each other than domestically $\big((\exp(-3.893) - 1) \times 100 \approx -97.96\big)$, while a Spanish region and a country trade about 98.16% less with each other than domestically. Although regional borders are thinner, they are still significant and substantial, suggesting that regions trade about 73.58% less with each other than domestically. This reveals that Spanish regions are not fully integrated, in line with previous findings in the literature on the border effect in Spain (Gil-Pareja et al., 2006, 2005; Requena and Llano, 2010). When using these estimates to answer our research question, a counterfactual scenario of Catalan independence could involve expanding the Spanish regional borders for Catalonia by about 25 percentage points from 73.58% to 98.16%. In Column (4), we split the country-to-country and region-to-country borders into EU and non-EU borders. The results confirm that EU borders are thinner than non-EU borders, but nonetheless significant and sizeable.[14] In all specifications, the coefficient estimates of the further gravity control variables are as expected.

Overall, Table 1 reveals highly significant and large negative border coefficients, which are in line with the "border puzzle" literature. Since border effects quantify the difference between domestic and cross-border trade, proper identification of borders requires the dataset to include sales in the home market. Our dataset allows us to identify border effects both at the country level and at the regional level since it includes domestic sales for both levels.[15] Similar to our large estimates in Table 1, Borchert et al. (2021) report sizeable effects.[16] Other papers, such as Bergstrand et al. (2015), use panel estimates with bilateral fixed effects. In this case, the level of the border is captured in the bilateral fixed effects. Only if interacted with a time dummy, the change in border effects over time (relative to the omitted base category) can be quantified. When estimating these interaction terms, the magnitudes of the coefficients are substantially smaller and capture the relative importance of borders over time, also associated in the literature

[14] It is worth noting that we did not include the EU variable in our gravity controls for this specification.

[15] For example, Yotov (2012) shows the importance of domestic sales for the distance elasticity estimates (but does not report border estimates).

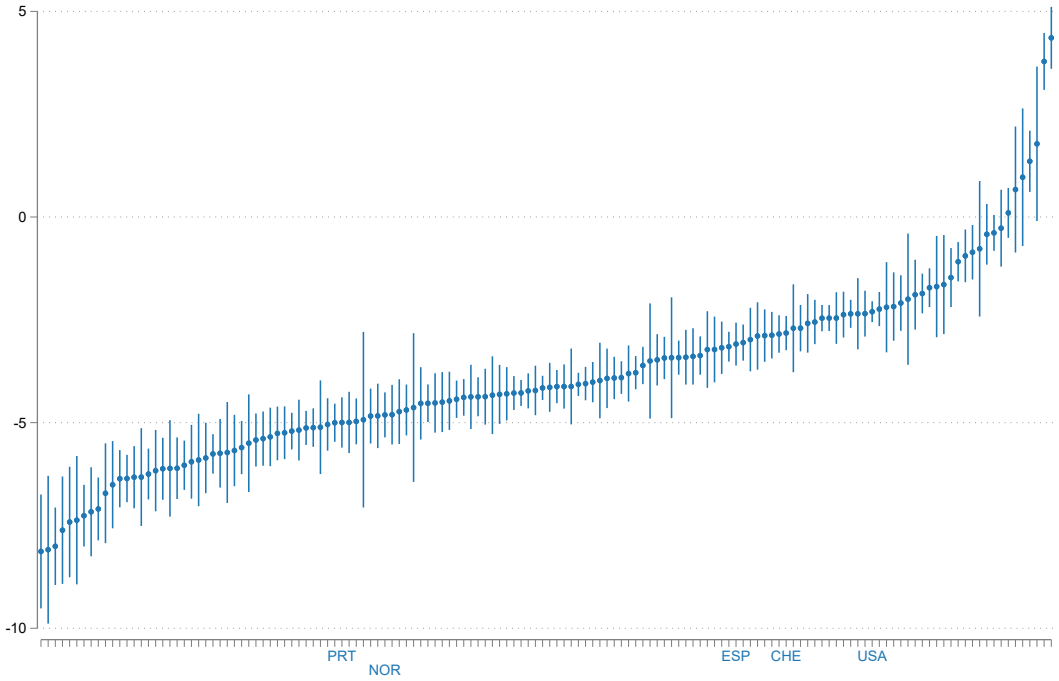
[16] They use a dummy variable for trade within the same country, which can be transformed into our international border dummy by subtracting the same-country dummy from a vector of ones.

with globalisation. As we are not concerned about globalisation, but rather interested in differences in the thickness of different types of borders, we stick to a cross-section analysis in our main specifications, where the estimated border effects are in levels. Since we focus on the difference between the various level effect estimates, general differences in domestic sales versus cross-border flows that are captured by our border dummies will be differenced out.

The sizeable border effects invoke the question of whether the border between an independent Catalonia and the remaining Spanish regions would actually expand by the differences in the effects for the different border levels, as illustrated for the results in Column (3). In response, it is important to note that the estimates so far only capture partial effects and abstract from any general equilibrium adjustments (such as price and income effects, or trade diversion due to relative trade cost changes) that may occur after Catalan independence. This is a reason why we use a general equilibrium analysis to quantify the effects of Catalan independence. When modelling our counterfactual experiments, we want to change the Catalan regional border to a Catalan country border. We can do this by estimating Catalonia-specific borders (such as the Catalan region-to-region border or its region-to-country border) and then using these for our counterfactual experiments. Hence, we dissect all borders shown in the specifications of Table 1 into country- or region-specific borders and present coefficient estimates along with 95% confidence intervals in plots. Dissecting the overall border from Column (1) into country-specific borders, we obtain an individual border coefficient for each country, depicted in Figure 1, which highlights Portugal and Norway with relatively thick borders, followed by Spain, Switzerland, and the US with thinner borders.[17] Figure 2 depicts the estimates obtained when dissecting the overall border from Column (2) into country-specific and region-specific borders. It shows that Catalonia and Madrid have the thinnest borders among the Spanish regions, indicating their relatively strong international and interre-

[17]We calculate country-specific border effects by assigning the country-specific border variable the value 0.5 whenever the country is the exporter or importer, such that the sum of the country-specific border variables is the overall border variable BRDR_ALL. In the setting of overall borders, the same results are obtained when assigning the country-specific border variable a 1 whenever the respective country is the exporter or, equivalently, whenever the country is the importer.

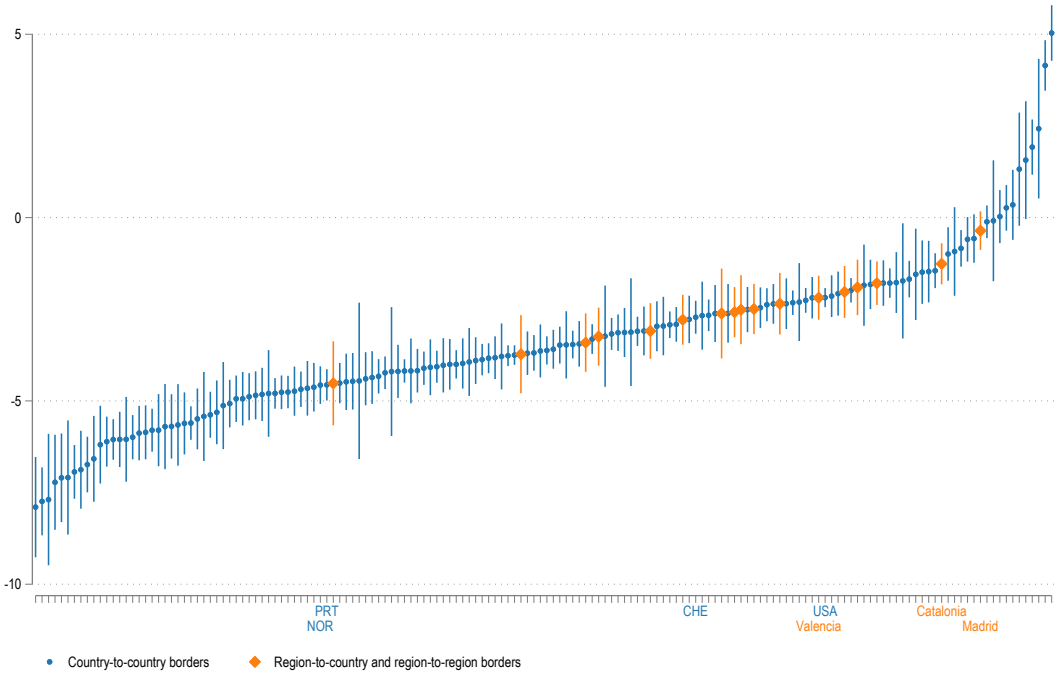
Figure 1: Country Borders (year 2012).




*Notes:* Coefficient estimates and 95% confidence intervals of country-specific borders, dissected from the specification shown in column (1) of Table 1. The labels highlight a selection of country borders (where PRT is Portugal, NOR is Norway, ESP is Spain, CHE is Switzerland, and USA is the United States).

gional trade links. This finding is consistent with other research highlighting Catalonia as a relatively strongly integrated region (e.g., Alòs-Moner and Pastor, 2014). In Figure

Figure 2: Country and Region Borders (year 2012).

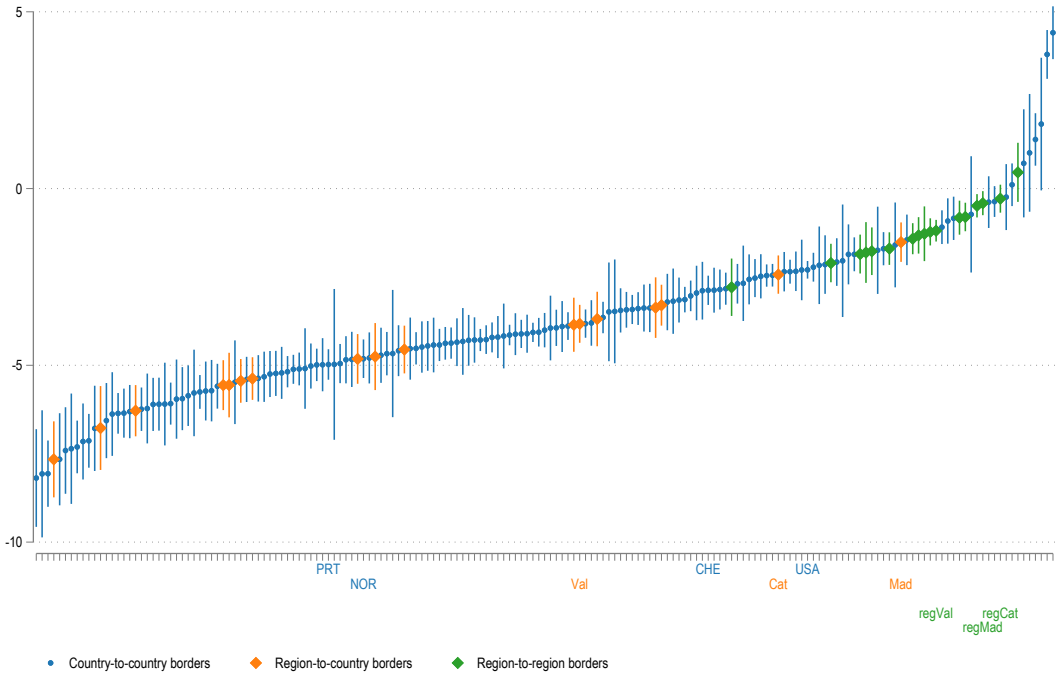



*Notes:* Coefficient estimates and 95% confidence intervals of country- and region-specific borders, dissected from the specification shown in column (2) of Table 1. The labels highlight a selection of country borders (where NOR is Norway, PRT is Portugal, CHE is Switzerland, and USA is the United States) and of Spanish regions' borders.

3 we present coefficient estimates of country-specific and region-specific borders obtained when dissecting the country borders, the region-to-country borders, and the regional borders from Column (3). It shows that Catalonia's region-to-region border is the thinnest among all region-to-region borders, followed by Madrid. This strongly suggests that other Spanish Autonomous regions are still the most important trading partners for Catalonia (which is reflected by the overall lower absolute level of border effects; see also Castells, 2014b). Hence, Catalonia would be strongly affected by higher trade costs when trading with other regions. Turning to the region-to-country borders, Catalonia's border

is the second thinnest among the Spanish regions, after Madrid which has the thinnest border among all regions. Figure 4 displays the country- and region-specific coefficients

Figure 3: Country, Region-to-Country, and Region-to-Region Borders (year 2012).

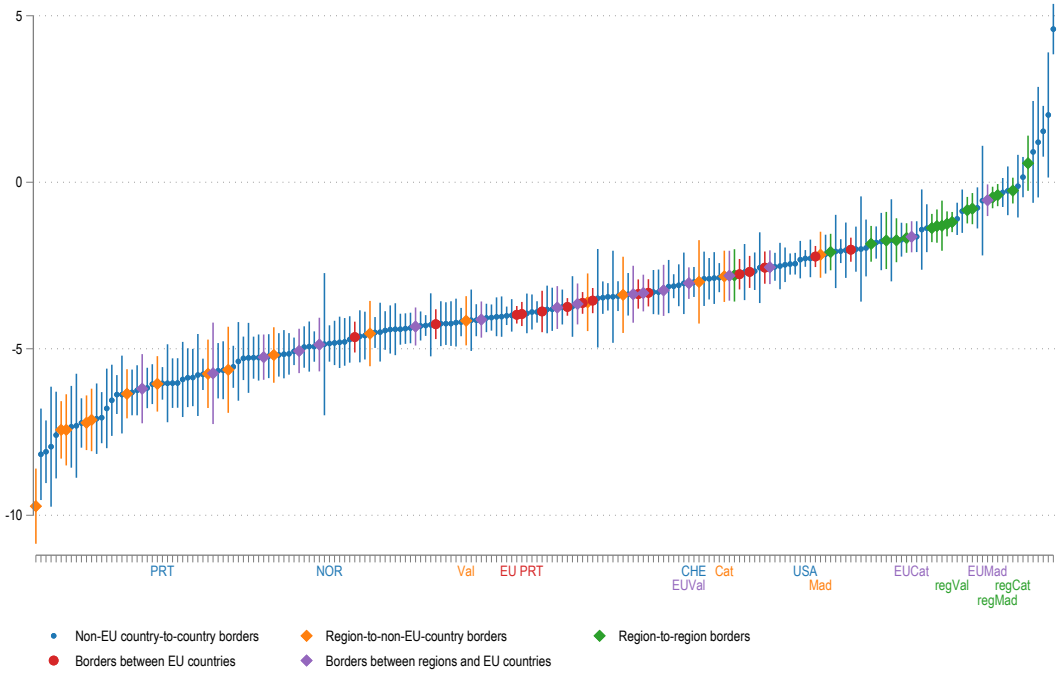



*Notes:* Coefficient estimates and 95% confidence intervals of country- and region-specific borders, dissected from the specification shown in column (3) of Table 1. The labels highlight a selection of country borders (where PRT is Portugal, NOR is Norway, ESP is Spain, CHE is Switzerland, and USA is the United States), of region-to-country borders (where Val is Valencia, Cat is Catalonia, and Mad is Madrid), and of region-to-region borders (where regVal is Valencia, regMad is Madrid, and regCat is Catalonia).

when dissecting the EU and non-EU borders from Column (4). The different levels of Catalonia's borders are of the expected order, where the regional border is the thinnest with an insignificant estimated coefficient, followed by the EU country border, and the non-EU country border is the thickest. We employ these Catalonia-specific estimates in our counterfactual experiments. In a scenario in which Catalonia stays in the EU, the Catalan regional border (i.e., the border between Catalonia and Madrid or between Catalonia and any other Spanish region) will be assigned the estimate we obtained for

the Catalan EU country border. In a scenario in which Catalonia leaves the EU, we accordingly use the estimate we obtained for the Catalan non-EU border. As Catalonia has a thinner EU border, which would become substantially thicker if it leaves the EU, independence may harm trade and welfare in Catalonia (see also Granell, 2014; Puig, 2014). The quantitative implications are explored in our following GE analysis.

Figure 4: EU vs. non-EU Country and Region Borders (year 2012).




*Notes:* Coefficient estimates and 95% confidence intervals of country- and region-specific borders, dissected from the specification shown in column (4) of Table 1. The labels highlight a selection of non-EU country borders (where PRT is Portugal, NOR is Norway, ESP is Spain, CHE is Switzerland, and USA is the United States), of EU country borders (where EU PRT is Portugal), of region-to-non-EU-country borders (where Val is Valencia, Cat is Catalonia, and Mad is Madrid), of region-to-EU-country borders (where EUVal is Valencia, EUCat is Catalonia, and EUMad is Madrid), and of region-to-region borders (where regVal is Valencia, regMad is Madrid, and regCat is Catalonia).

In Table A1 of the Appendix we show estimation results for 2017, the year in which the Catalan independence referendum took place. When comparing the border estimates

Table 1: Country Borders, Regional Borders, EU Borders (year 2012).

| | (1) | (2) | (3) | (4) |
|---|---|---|---|---|
| LN_DIST | -0.372*** | -0.386*** | -0.361*** | -0.361*** |
| | (0.049) | (0.048) | (0.049) | (0.049) |
| CONTIG | 0.590*** | 0.681*** | 0.672*** | 0.681*** |
| | (0.100) | (0.105) | (0.103) | (0.103) |
| COM_LANG | 0.333*** | 0.359*** | 0.329*** | 0.339*** |
| | (0.069) | (0.069) | (0.069) | (0.070) |
| RTA | 0.253*** | 0.189** | 0.241*** | 0.234*** |
| | (0.075) | (0.075) | (0.076) | (0.076) |
| EU | 0.218** | 0.158* | 0.195** | |
| | (0.093) | (0.090) | (0.092) | |
| COM_REL | 1.054*** | 1.124*** | 1.068*** | 1.051*** |
| | (0.140) | (0.138) | (0.139) | (0.139) |
| COM_LEG | -0.018 | -0.024 | -0.035 | -0.042 |
| | (0.065) | (0.062) | (0.064) | (0.064) |
| ISLAND | 0.414** | 0.452*** | 0.452*** | 0.454*** |
| | (0.163) | (0.162) | (0.164) | (0.164) |
| LAND | -0.830*** | -0.738*** | -0.762*** | -0.758*** |
| | (0.142) | (0.132) | (0.129) | (0.129) |
| BRDR_ALL | -3.830*** | -3.775*** | | |
| | (0.139) | (0.140) | | |
| INTL_BRDR | | | -3.893*** | |
| | | | (0.143) | |
| INTL_SPAIN | | | -3.996*** | |
| | | | (0.180) | |
| INTER_REGION | | | -1.331*** | -1.335*** |
| | | | (0.180) | (0.179) |
| INTL_BRDR_EU | | | | -3.715*** |
| | | | | (0.165) |
| INTL_BRDR_noEU | | | | -3.889*** |
| | | | | (0.143) |
| INTL_SPAIN_EU | | | | -3.574*** |
| | | | | (0.187) |
| INTL_SPAIN_noEU | | | | -4.250*** |
| | | | | (0.181) |
| Obs | 19807 | 24607 | 24607 | 24607 |
| $R^2$ | 0.983 | 0.983 | 0.983 | 0.983 |
| Imp, Exp FE | Yes | Yes | Yes | Yes |
| Spain Region | No | Yes | Yes | Yes |

*Notes:* Robust standard errors in parentheses. Column (1): Cross-country estimation with Spain included as a country (with Spanish domestic and international trade). Column (2): Estimation with Spain split up into regions (with regional domestic, region-to-region, and international trade). Column (3): Dissect the border: country-to-country (INTL_BRDR), region-to-country (INTL_SPAIN), region-to-region (INTER_REGION). Column (4): Dissect the border further: non-EU country-to-country (INTL_BRDR_noEU), non-EU region-to-country (INTL_SPAIN_noEU), EU country-to-country (INTL_BRDR_EU), EU region-to-country (INTL_SPAIN_EU), region-to-region (INTER_REGION). * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

with those in Table 1, all international borders are thinner in 2017 than in 2012, while the regional borders are thicker in 2017 than in 2012. The overall and relative magnitudes are similar in both years. Plots of the country- and region-specific borders for the year 2017 are also shown in the Appendix (Figures A1, A2, A3, A4), depicting very similar patterns for the country- and region-specific borders to the plots for 2012.

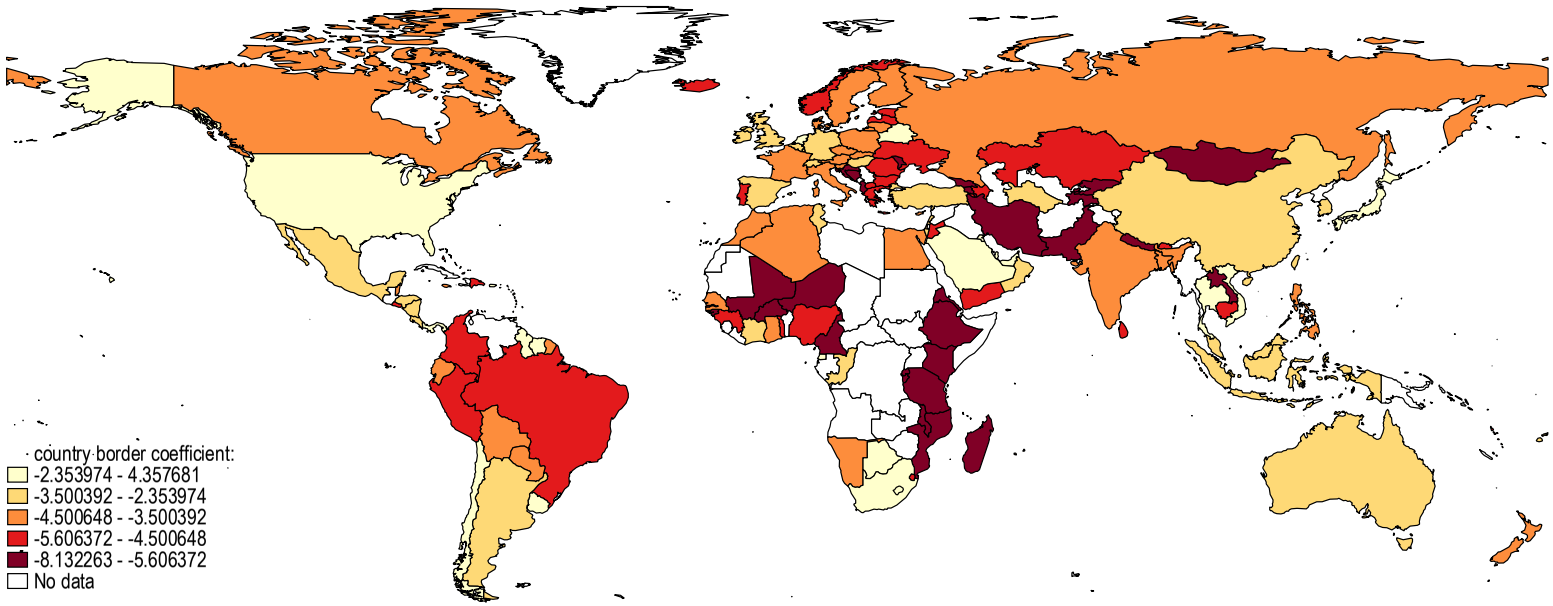
The heat map in Figure 5 displays the geographical distribution of the country-specific borders (whose coefficients are depicted in Figure 1). As may be anticipated, a positive association exists between GDP and border coefficients, resulting in sub-Saharan African countries having the thickest borders while Western countries and China have the thinnest.

Similarly, the heat map in Figure 6 shows the geographical distribution of the region-to-country borders of the Spanish regions (whose coefficients are depicted in Figure 3). It reveals that, among all Spanish regions, Catalonia has the thinnest border, together with the Basque Country and Madrid, while Extremadura and Castilla-La Mancha belong to the regions with the thickest borders. The latter regions are among the most rural and poorest in terms of GDP per capita. The regions with the thinnest borders are among the most developed regions in Spain. The observed pattern of thinner borders with increased development is in line with the pattern observed above for the country-to-country border effects, depicted in Figure 5.

### 5.2 Catalonia's Borders Over Time

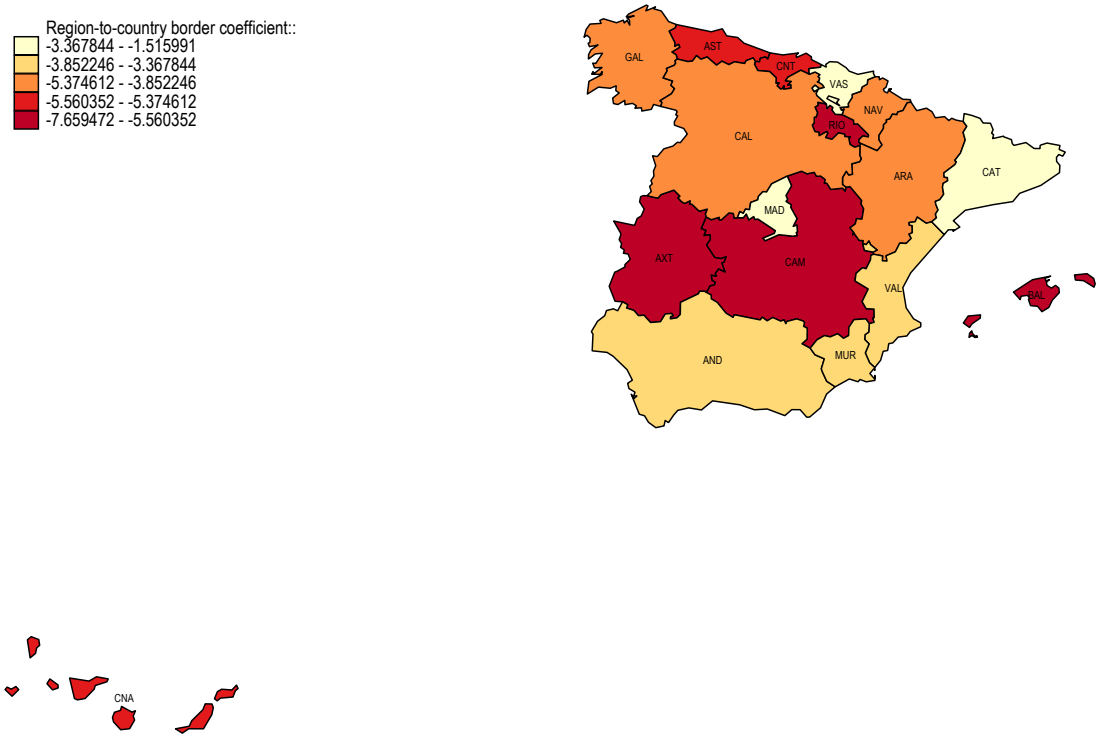
We estimate border effects for each cross-section from 2001 to 2017, allowing us to compare countries' and regions' levels of integration for different years. To this end, we estimate the same specifications as in Table 1 for all years between 2001 and 2017 individually and plot the respective coefficients, along with 95% confidence intervals. The coefficients corresponding to the specification shown in column (1) of Table 1 are shown in Figure 7, coefficients for column (2) are shown in Figure 8, those for column (3) are in Figure 9, and those for column (4) are in Figure 10. Within a type of border, we find no significant differences in the estimated coefficients over time. We see a significant

Figure 5: Border coefficients, heat map (year 2012).




*Notes:* Coefficient estimates of country-specific borders, dissected from the specification shown in column (1) of Table 1.

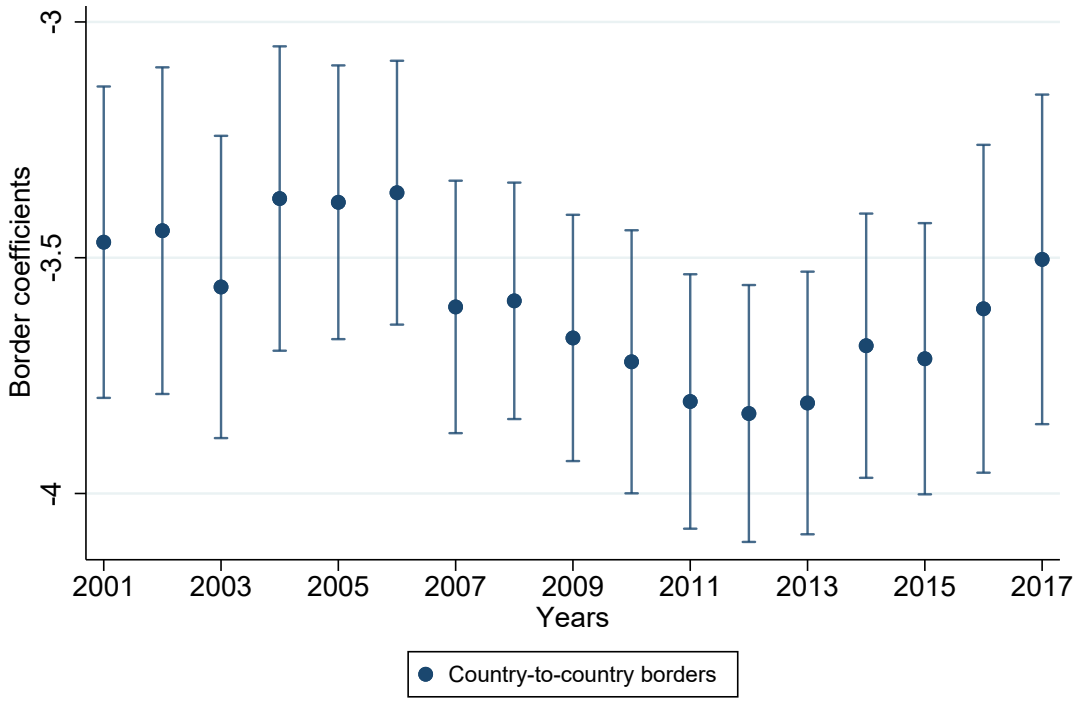
Figure 6: Region-to-country border coefficients, heat map (year 2012).




*Notes:* Coefficient estimates of region-specific borders, dissected from the specification shown in column (3) of Table 1.

difference between the regional and international borders in Figure 9, supporting our previous findings that regional borders are much thinner than international borders. In Figure 10, there seems to be a larger difference between the region-to-country EU borders and region-to-country non-EU borders than between the country-to-country EU borders and country-to-country non-EU borders. This suggests that being part of the EU market is rather important for Spanish regions and might have implications for Catalonia's independence, whose welfare implications could depend on whether it stays in the EU or not.

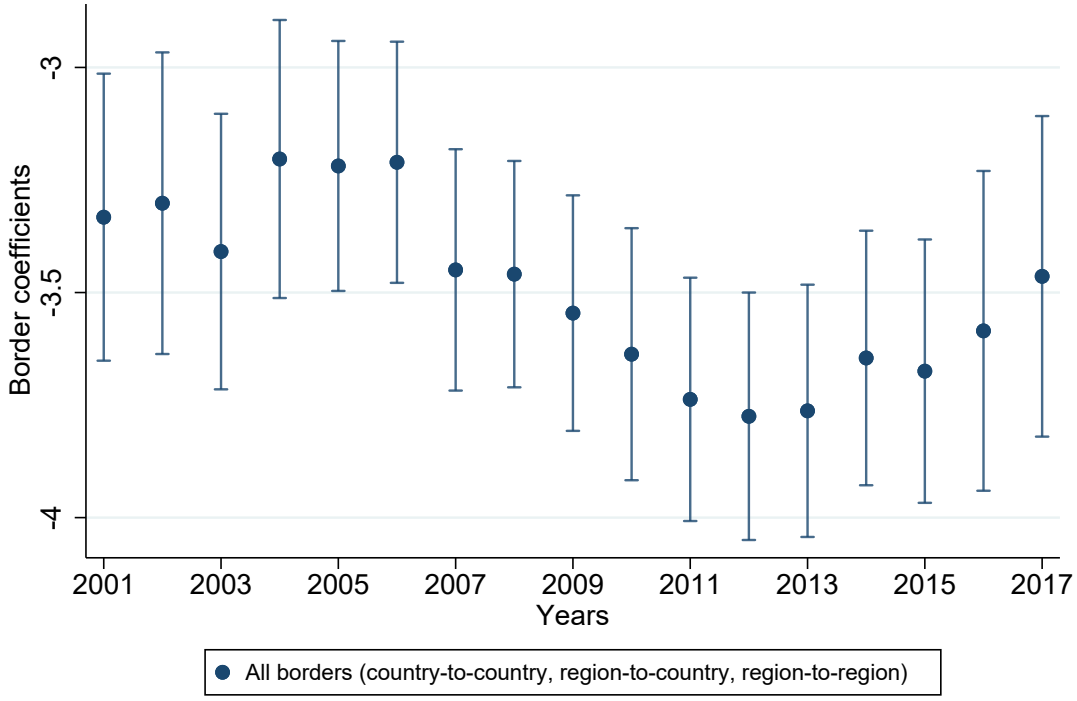
Figure 7: Country Borders (years 2001-2012).




*Notes:* Coefficient estimates and 95% confidence intervals from the specification shown in column (1) of Table 1 over time.

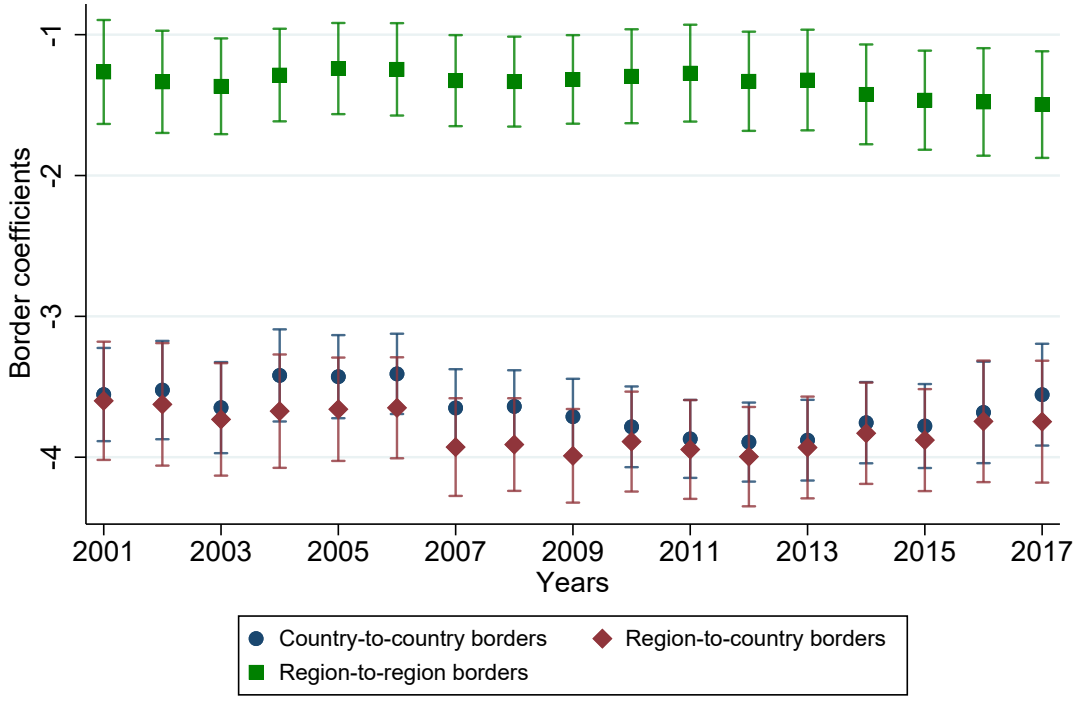
To assess how Catalonia's different borders evolved over time, we estimate Catalonia's regional border, its EU country border, and its non-EU country border for each cross-section from 2001 to 2017. We calculate the cumulative change over time in the absolute value of the respective type of border and plot the change in Figure 11. It shows that

Figure 8: Country and Region Borders (years 2001-2012).



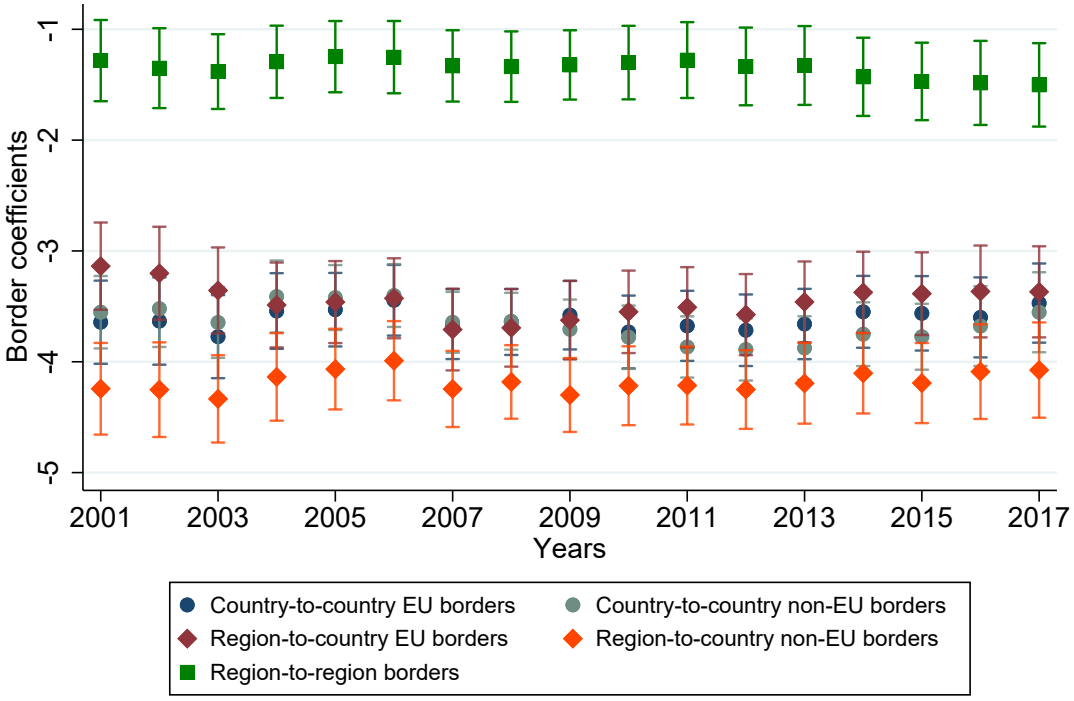

*Notes:* Coefficient estimates and 95% confidence intervals from the specification shown in column (2) of Table 1 over time.

Figure 9: Country and Region Borders (years 2001-2012).




*Notes:* Coefficient estimates and 95% confidence intervals from the specification shown in column (3) of Table 1 over time.

Figure 10: EU vs. non-EU Country and Region Borders (years 2001-2012).




*Notes:* Coefficient estimates and 95% confidence intervals from the specification shown in column (4) of Table 1 over time.

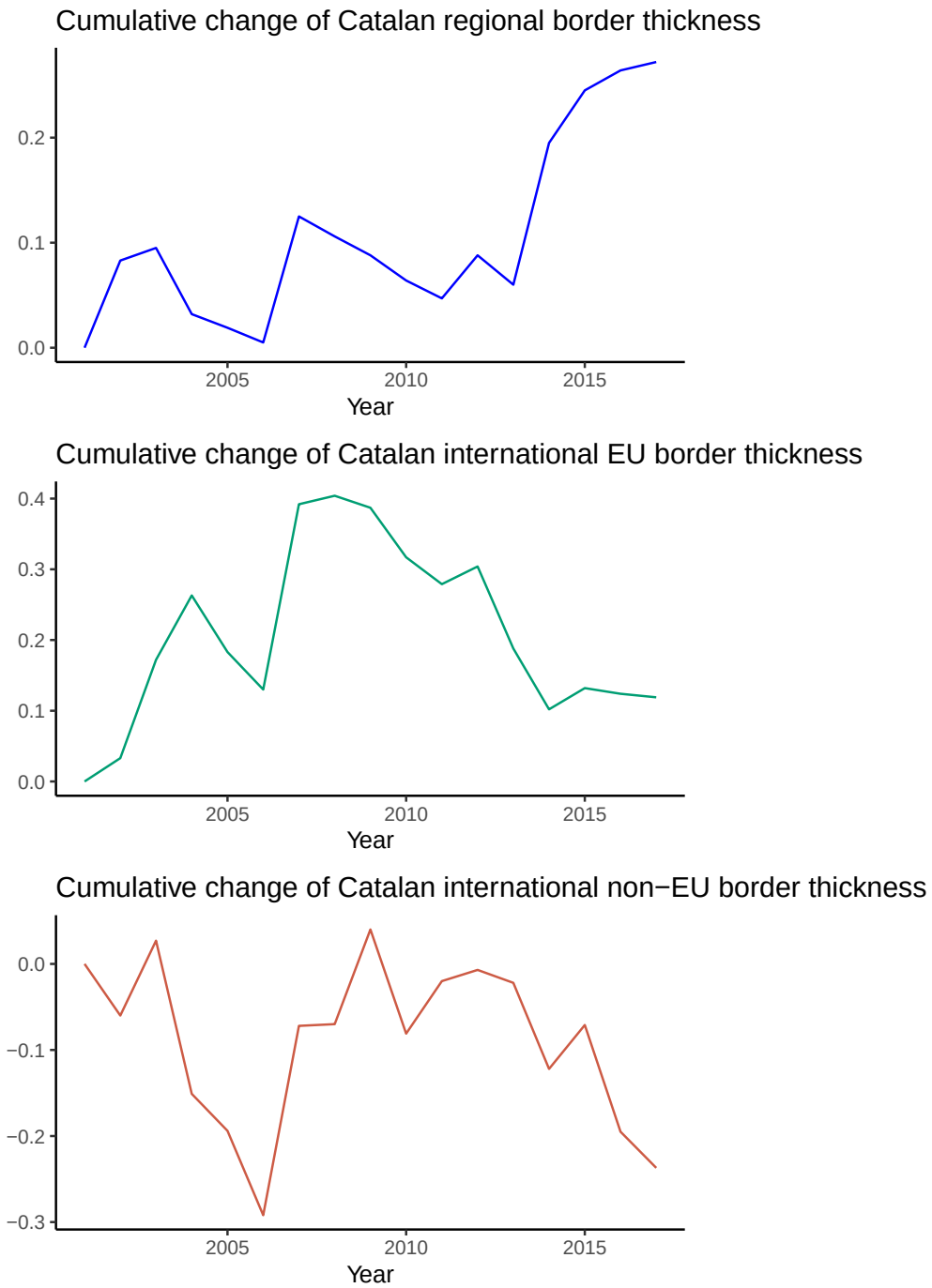
Catalonia's regional border became thicker while its international borders became thinner over time. The tendency shows that Catalonia became less integrated within Spain in later years, while it became better integrated internationally, both in the EU and globally. These findings align with recent results by Almunia et al. (2021), who show that Spanish firms increased their international exports in response to the recession in 2011-2012 during the aftermath of the financial crisis. The export increase was induced by an adjustment in unit labor costs, translating into lower wages for Spanish workers. The thinner international border and hence better international integration of Catalonia may imply that the costs of independence have decreased over time while also wages and welfare state benefits decreased. In 2001, independence and hence an increase in the relatively thin regional borders would have led to a more substantial rise in trade costs than in 2017.

# 6 General Equilibrium Analysis

In this section, we present and discuss the results of our various counterfactual experiments based on the structure of the theoretical model outlined in Section 3 and using data for the year 2012.

In a first counterfactual exercise, Catalonia secedes from Spain but stays in the EU. This would imply that the trade between an independent Catalonia and the remaining Spanish regions no longer crosses regional borders but instead crosses EU borders. We thus assign the same thickness to the counterfactual Catalan region-to-region borders as the Catalan region-to-EU-country border, depicted in Figure 4. Figure 12 and Table A2 in the Appendix report the effects on exports, consumer prices, and producer prices (relative to the United States, our numéraire), as well as on welfare, which, in our model, corresponds to real output, for Catalonia and the remaining Spanish regions. The trade-induced welfare loss is explained by a reduction in the consumer surplus due to higher domestic prices for consumers and lower income and a reduction in producer surplus due to lower domestic producer prices. So, both consumers and producers share the burden

Figure 11: Catalonia's Borders Over Time.



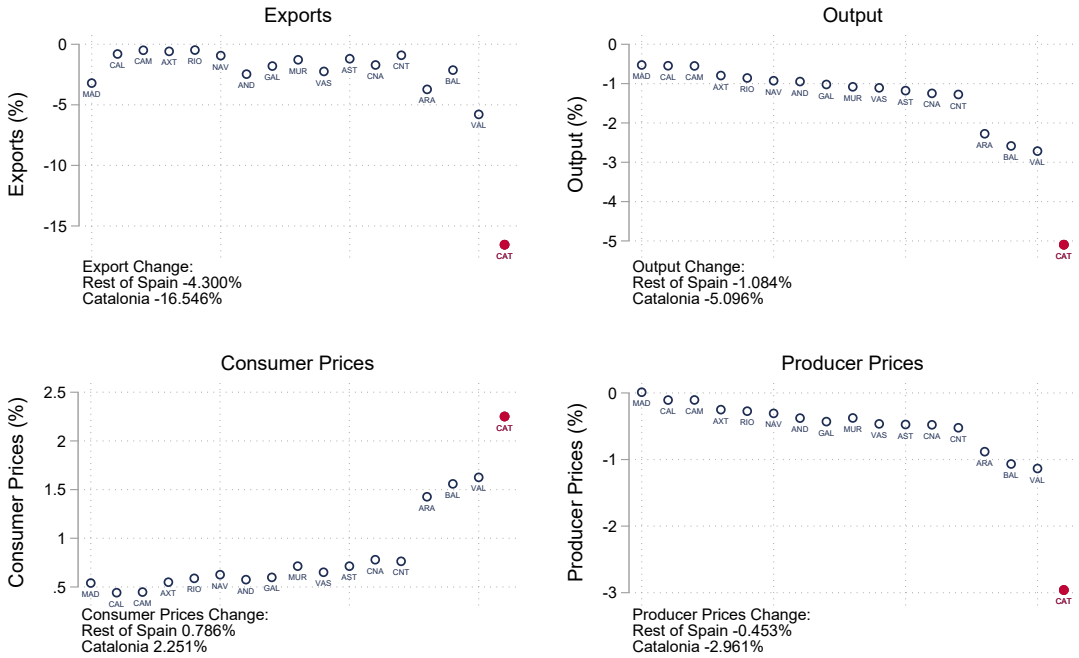

*Notes:* The graphs show the cumulative change in the absolute value of the respective type of border for Catalonia, i.e., an increase in the cumulative change implies that the border became thicker.

of increased trade costs, while producer prices tend to fall more than consumer prices rise. In this scenario, the loss in welfare is 5.1% for Catalonia, while it is between 0.5% and 2.7% for the remaining Spanish regions, resulting in an average loss of 1.1% for the rest of Spain. To assess the impact for all Spanish regions, Figure 13 shows the welfare change in a heat map. The regions that have a common border or close linguistic and cultural links with Catalonia (Aragón, Valencia, Balears) are the regions most impacted by Catalan independence. The landlocked regions of Madrid and both Castilles are the least impacted by Catalan independence. Most of the Atlantic coastal regions, including the Basque Country, lie in between.

Although we focus on the impact of Catalan independence on exports, output, consumer prices, and producer prices for Catalonia and the remaining Spanish regions, our analysis does not isolate the Spanish regions. Also, it obtains results for the other 142 countries in our worldwide dataset. The welfare changes for the countries are depicted in the heatmap in Figure 14. While most countries are only affected very moderately (welfare effects between -0.003 and 0.05), many countries in Europe and Latin America encounter small positive changes in real output, such as France with an increase of 0.01%, benefiting from a 6% increase in trade.

The first counterfactual may be overly optimistic since Catalonia's EU border may already include an orientation towards EU countries in anticipation of the possibility of independence. Hence, we consider another experiment to model the scenario in which Catalonia secedes from Spain but stays in the EU, by assigning it the same borders as Portugal's EU border. This implies a thicker Catalan border than in the previous counterfactual (see Figure 4) and may be a more "exogenous" change. This experiment is similar to the one conducted by Comerford et al. (2014) and Comerford and Rodríguez Mora (2019), while we can additionally show the impact on consumer and producer prices for Catalonia, the individual remaining Spanish regions, and even the impact for individual countries worldwide. The results are reported in Figure 15 and Table A3 for the Spanish regions, as well as in the heat map in Figure A5 in the Appendix for the other countries. As in the above scenario, the trade-induced welfare loss stems from even higher domestic

Figure 12: Counterfactual 1: Catalonia's Regional Border as EU Country Border.




*Notes:* The graphs report the effects on exports, consumer prices, and producer prices (relative to the United States), as well as on real output, for Catalonia and the remaining Spanish regions. The reported change for the rest of Spain is an average of the changes for the remaining Spanish regions. Real output is weighted by regional GDP, exports are weighted by regional trade, and prices are unweighted.

Figure 13: Counterfactual 1: Catalonia's Regional Border as EU Country Border. Change (in %) of Real Output for Spanish Regions.

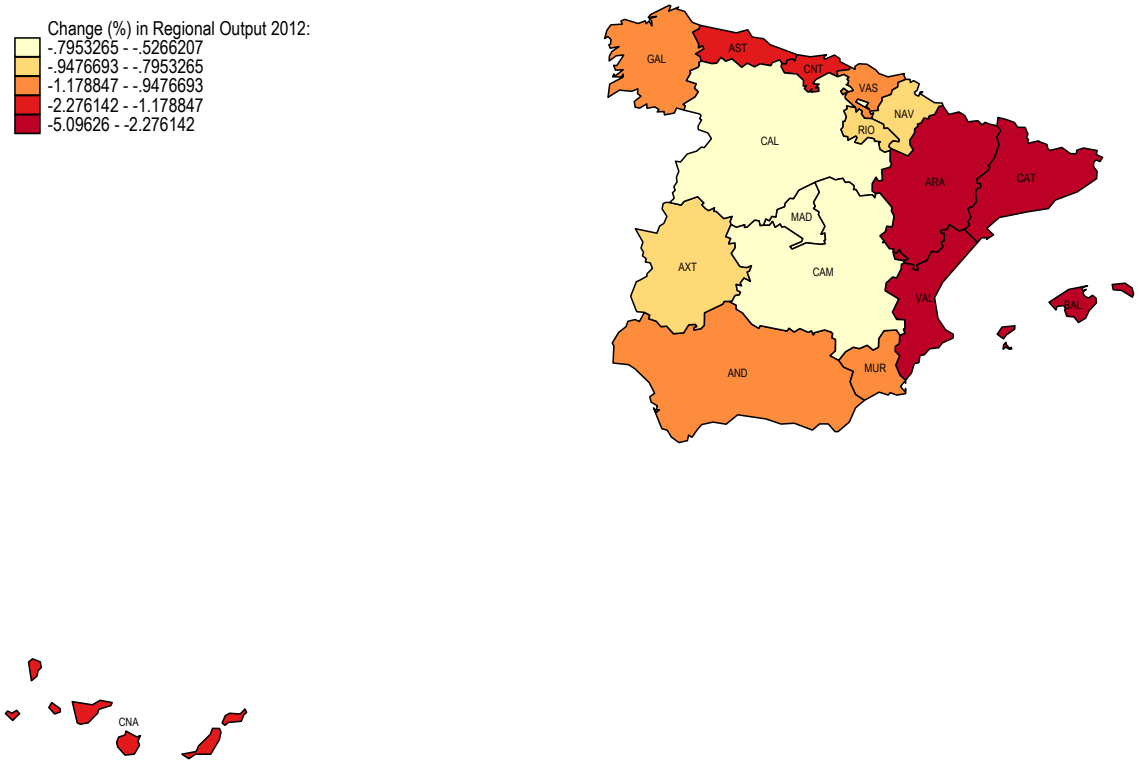
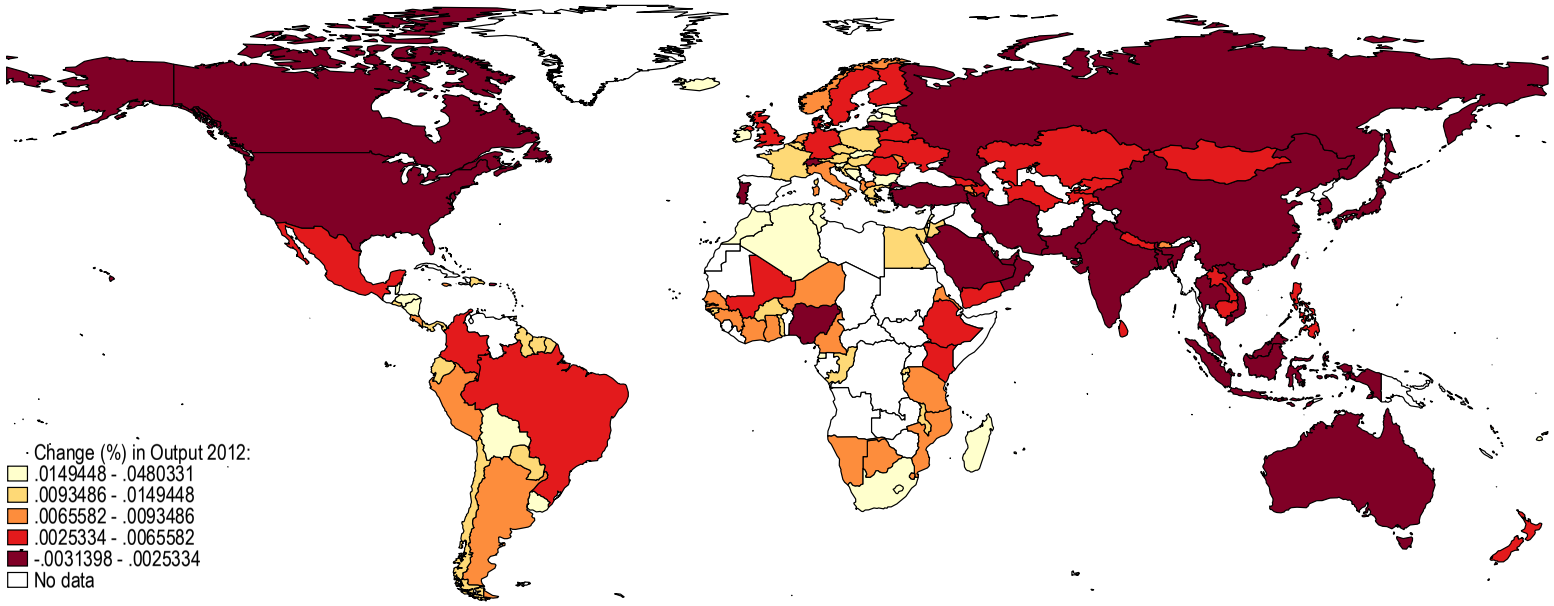
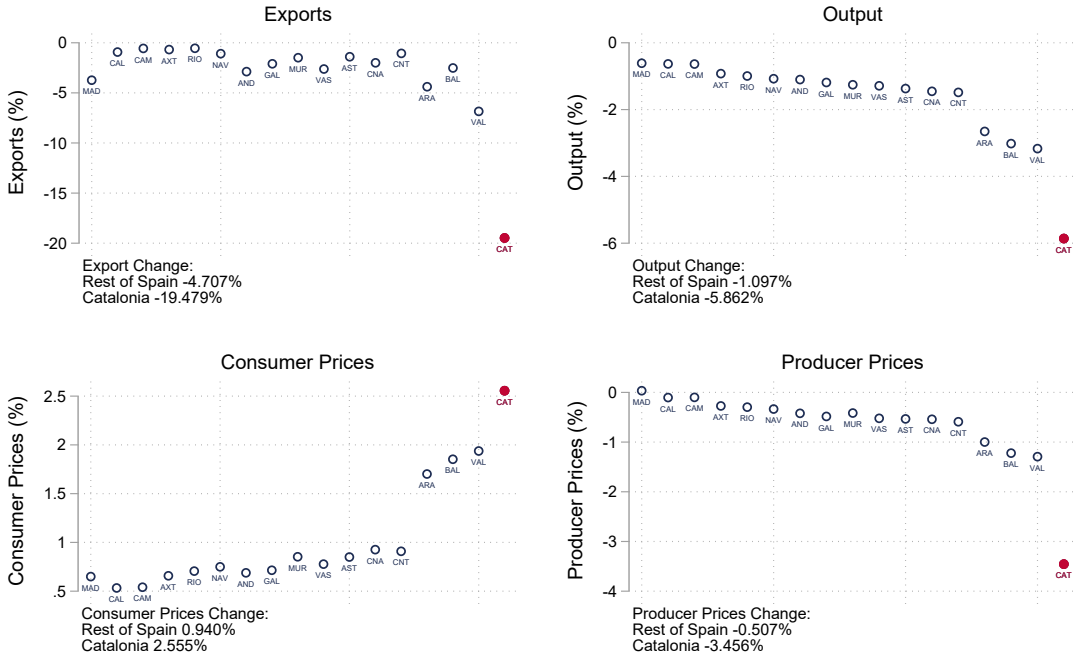


Figure 14: Counterfactual 1: Catalonia's Regional Border as EU Country Border. Change (in %) of Real Output for Countries in the Dataset.



prices for consumers and even lower domestic producer prices. We estimate that Catalonia would encounter a welfare decline of 5.9%, while the rest of Spain would lose 1.1% on average. Previous studies using Portugal as a benchmark found an average welfare loss for Catalonia between 10.5% and 12.8% (Comerford et al., 2014) and between 12.5% and 13.7% (Comerford and Rodríguez Mora, 2019). Compared to our results, the previous findings might be at the upper bound.

Figure 15: Counterfactual 2: Catalonia's Regional Border as Portugal's EU Border.




*Notes:* The graphs report the effects on exports, consumer prices, and producer prices (relative to the United States), as well as on real output, for Catalonia and the remaining Spanish regions. The reported change for the rest of Spain is an average of the changes for the remaining Spanish regions. Real output is weighted by regional GDP, exports are weighted by regional trade, and prices are unweighted.

The flexibility of our method surfaces in the wide variety of counterfactual experiments that we can design in light of the political uncertainty regarding the circumstances of a potential Catalan secession. The first two counterfactuals may underestimate the effects of Catalan independence, considering that Catalonia may not be granted EU mem-

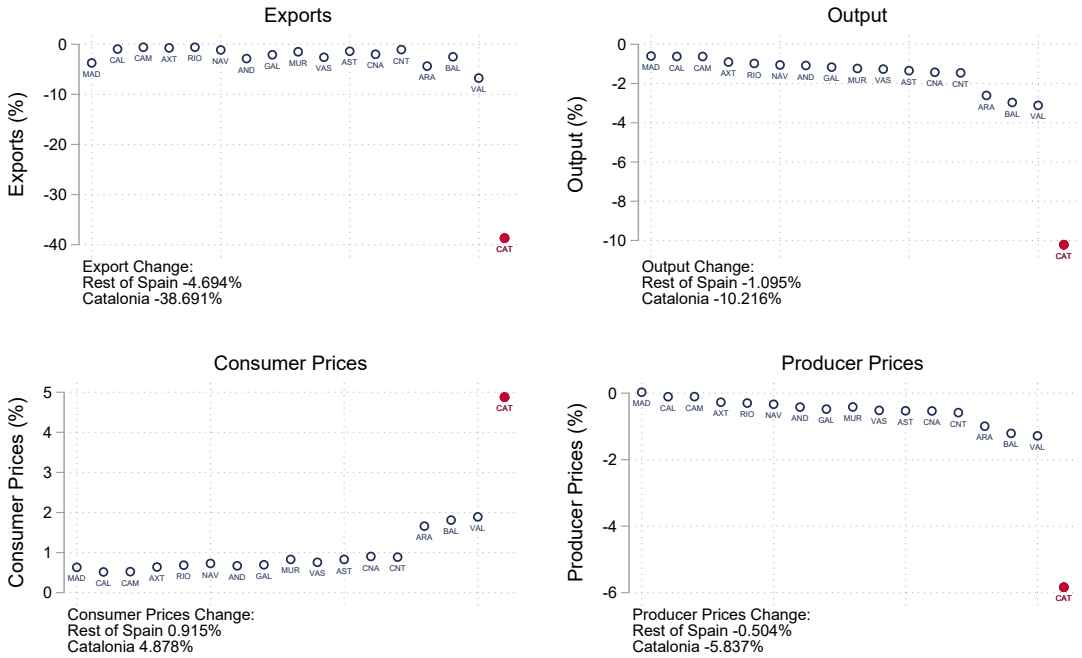
bership, as discussed in Section 2. Our third counterfactual thus considers a scenario in which Catalonia is no longer a member of the EU. Given Catalonia's relatively high level of integration, it is possible that it would become an independent state outside the EU, similar to Switzerland (see Figure 4 for a comparison between the Swiss and Catalan non-EU country borders). To model this scenario, we, therefore, assign the Swiss border to Catalonia's regional and EU country borders. Note that this does not imply that Catalonia has the same treaties or institutions as Switzerland. It merely assumes the same thickness of borders, which could be achieved by various policy changes and different from the way Switzerland established its borders. The results, reported in Figure 16 and Table A4 show this is the worst scenario so far, with a loss of 10.2% of Catalan welfare. In contrast, the average loss for the remaining regions is similar to the previous scenarios, at 1.1%. The heat map in Figure A6 shows that EU countries no longer slightly benefit from Catalan independence, as was the case in the previous scenarios where Catalonia stayed in the EU. For instance, France faces a welfare loss of 0.01%.

The fourth counterfactual is a worst-case scenario where Catalonia is not an EU member and not in the WTO, which may not be utterly implausible, at least for a transition period, considering the above discussion. To model this scenario, we impose the Swiss border on Catalonia's regional and EU borders and discontinue all of Spain's Regional Trade Agreements for Catalonia.[18] As highlighted by the results reported in Figure 17 and Table A5, this counterfactual is the worst for Catalonia with a loss of 11.2%. Still, the impact on the remaining Spanish regions is very similar to the previous scenarios.

The political economy consequences behind our last two counterfactuals are interesting. While EU and WTO membership is crucial to Catalan welfare after independence, Spain would face a similar loss whether or not Catalonia joins the EU or the WTO.

[18]Not being part of the WTO could also be modelled by switching a WTO dummy to zero. However, we model the worst-case scenario differently for three reasons: i) We want to capture a very severe cut in preferable relationships and therefore discontinue all regional trade agreements. ii) As we focus on borders, we take a non-EU country border to capture a discontinuity of being an EU member. iii) Many countries were already WTO members in 2012 and 2017, the years of our cross-sectional regressions. Hence, the trade cost change implied by not being a WTO member anymore would be driven by the non-member countries that are presumably not the main trading partners of Catalonia.

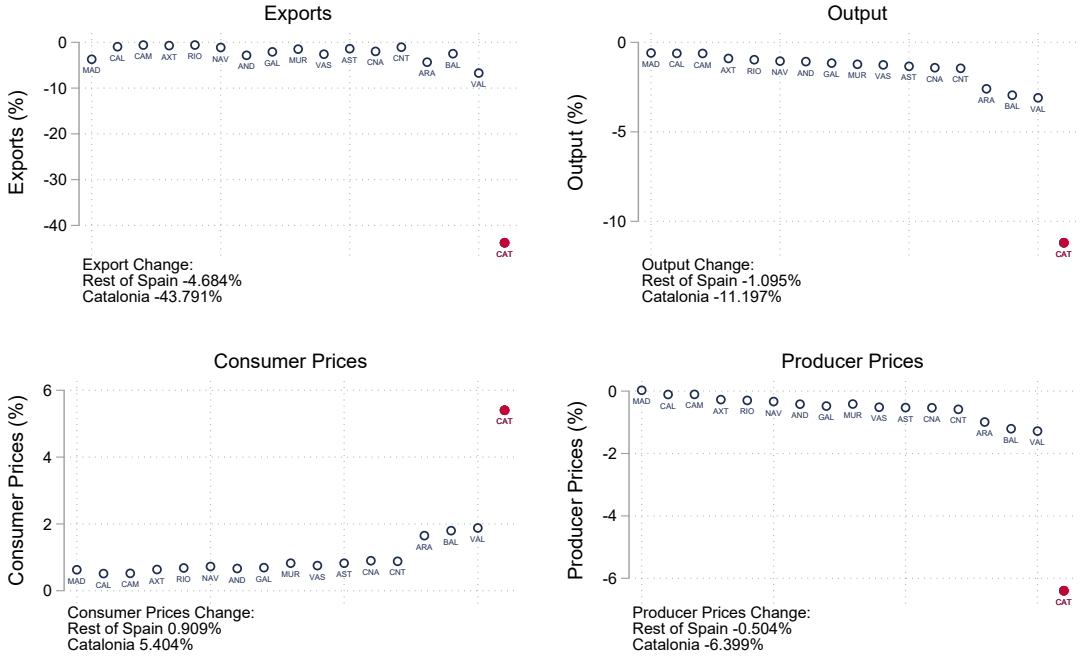
Figure 16: Counterfactual 3: Catalonia Outside the EU, Same Border as Switzerland.




*Notes:* The graphs report the effects on exports, consumer prices, and producer prices (relative to the United States), as well as on real output, for Catalonia and the remaining Spanish regions. The reported change for the rest of Spain is an average of the changes for the remaining Spanish regions. Real output is weighted by regional GDP, exports are weighted by regional trade, and prices are unweighted.

Therefore, the Spanish central government has little incentive to negotiate or vouch for a fast-track accession of Catalonia to the WTO or not to veto its entry into the EU. Therefore, Madrid's authorities can leverage EU and WTO membership in political negotiations.

Figure 17: Counterfactual 4: Catalonia Outside the EU and the WTO.




*Notes:* The graphs report the effects on exports, consumer prices, and producer prices (relative to the United States), as well as on real output, for Catalonia and the remaining Spanish regions. The reported change for the rest of Spain is an average of the changes for the remaining Spanish regions. Real output is weighted by regional GDP, exports are weighted by regional trade, and prices are unweighted.

To assess whether the economic costs of independence have changed over time for Catalonia and the remaining Spanish regions, we conduct our four GE analyses individually for the years 2001–2017. We plot the welfare change for Catalonia and the average of the remaining Spanish regions over time in Figure 18 and observe that Catalonia's cost of independence has decreased in recent years for all scenarios. The lightest blue line represents the welfare change for Catalonia in the scenario where it remains in the EU

and shares its EU border with the remaining Spanish regions. The costs of independence were highest for the years before 2012 and decreased after 2013. A similar pattern is observed for the blue line below, representing our second scenario, in which Catalonia remains in the EU and has the same border as Portugal. However, as in the results for 2012, the welfare loss is more pronounced than in the first scenario. The development of Catalonia's welfare when it is outside the EU (second blue line from the bottom) and outside both the EU and the WTO (darkest bottom line) are similar. At the same time, the levels for the more pessimistic scenario are stronger, as expected. For these scenarios, we also observe that the cost of independence decreased after 2011. These findings are consistent with the finding that Catalonia became more integrated internationally, such that the change from a regional border to an international border leads to a weaker increase in trade costs over time.

For the remaining Spanish regions, the average welfare changes are lower than those for Catalonia and very similar for all four scenarios. All four red lines lie very close to each other, while the scenario for Catalonia in the EU has a slightly smaller welfare loss, shown in Figure 19 with a more detailed scale. This implies that Madrid has significant bargaining power in possible negotiations. For example, Madrid's government veto on Catalonia's accession to the EU has essentially the same economic consequences for the rest of the Spanish regions as an amicable EU membership. We do not observe a strong change in the costs of independence for the regions, as the welfare loss only decreased by 0.17 percentage points between 2003 and 2017.

Figure 18: Change (in %) of Real Output after Independence for Catalonia and the Remaining Spanish Regions Over Time for Different Scenarios.

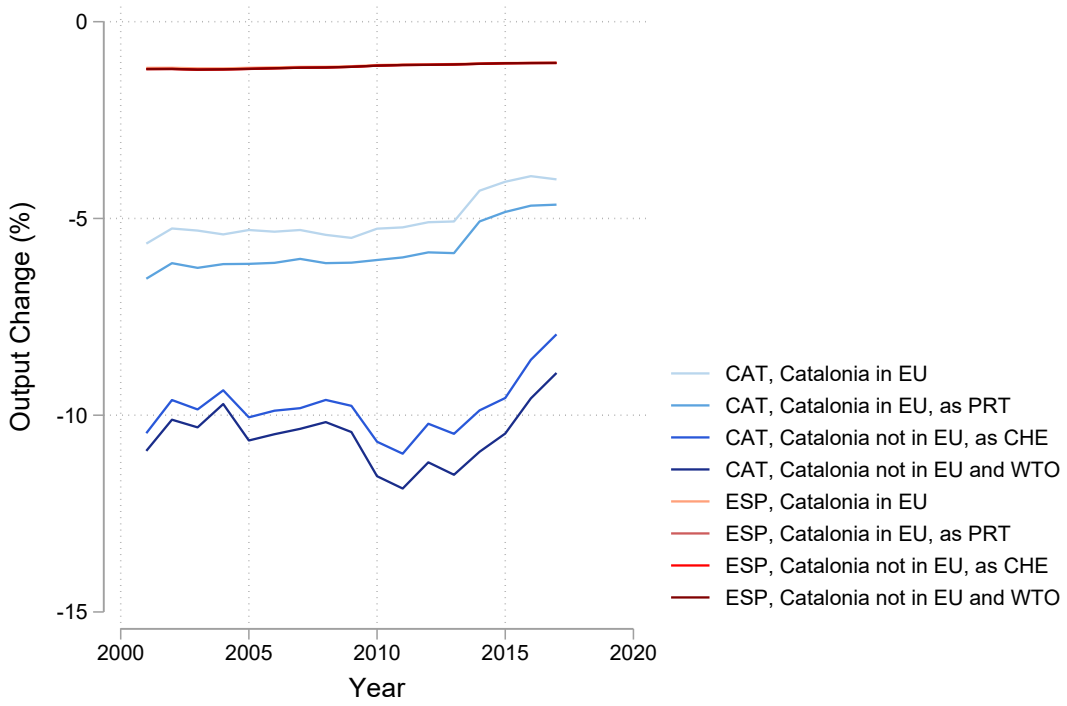
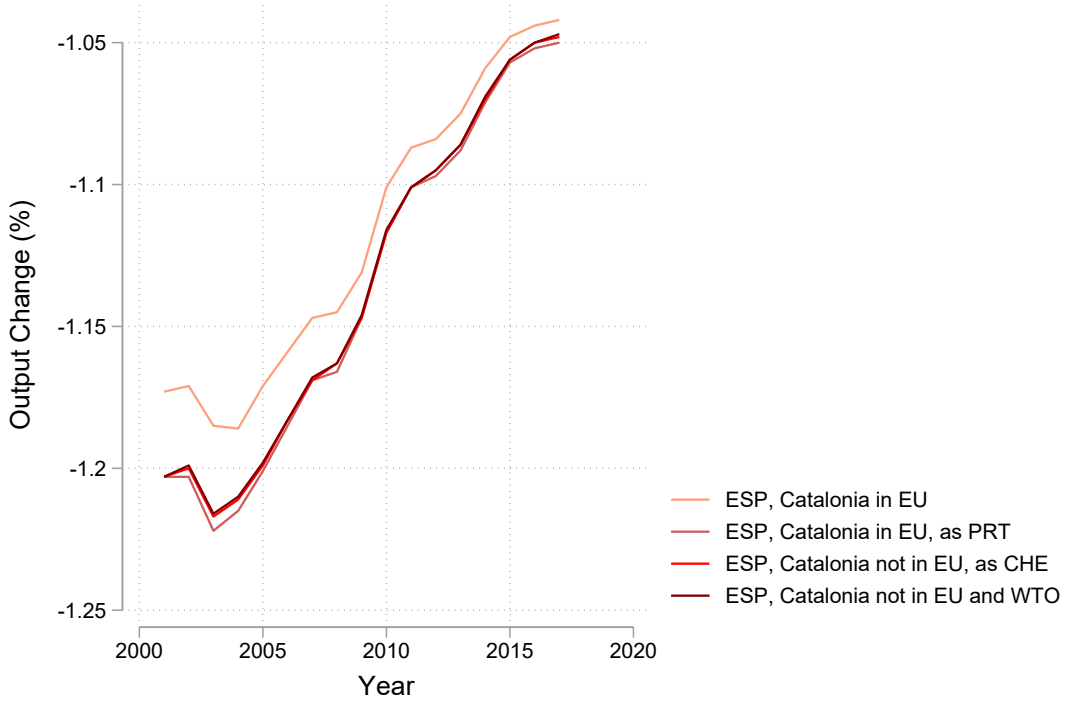


Figure 19: Change (in %) of Real Output after Independence for the Remaining Spanish Regions Over Time for Different Scenarios.




*Notes:* The results shown in this figure correspond with the results for the remaining Spanish regions in Figure 18, with a more detailed scale.

# 7 Conclusion

Employing the empirical methods of the structural gravity model to a novel dataset that combines Spanish sub-national and international trade data, we quantify the costs of Catalan regional independence using different levels of borders. This paper contributes to the literature on international economics and border effects. Specifically, we divide the international border dummy in the trade cost vector into more granular international, regional, and EU borders. We also emphasise the importance of using domestic country and regional sales to identify border effects accurately. Our analysis reveals substantial heterogeneity between country, regional, and EU border effects. Although regional borders within Spain and borders within the EU are thinner than international non-EU borders, they are negative and highly significant. When we split the borders into individual region- and country-specific borders, heterogeneity among countries and Spanish regions becomes apparent. Our findings highlight the substantial heterogeneity of regional border effects within Spain, which would not be evident if only country-level data were used to identify the Spanish border.

We apply our methods to study the economic consequences of the independence process of Catalonia from Spain. The estimates of the border effect show that Catalonia has a high degree of commercial integration with the rest of the Spanish regions, but also internationally. In various counterfactual experiments, we assess the economic impact of a potential Catalan secession by changing Catalonia's borders in different scenarios. These scenarios address the political uncertainties of whether and under which conditions an independent Catalonia would be a member of the EU or the WTO. Our findings reveal adverse effects for Catalonia and the remaining Spanish regions, with an expected welfare loss of between 5% and 11% for Catalonia and an average loss of 1% for the rest of Spain. These results shed light on the political economy involved in secession, with the Spanish government in Madrid holding higher bargaining power since the welfare impact on the remaining Spanish regions is largely insensitive to the conditions of Catalan independence. Countries worldwide are affected only moderately, while there

are differences in the welfare effects, especially regarding Catalonia's EU membership. Importantly, our analysis shows that some countries would benefit from Catalan secession, implying potentially diverse political interests when discussing a Catalan secession. Our method could be applied to different counterfactual experiments, such as the independence of other regions from other countries, provided the availability of regional trade flows (international, within-country, and domestic).

Our findings can inform evidence-based policies and provide citizens a better understanding of the economic consequences of trade border changes. Policymakers therefore should take into account that trade policies could have some influence on the independence process.

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# A Further Tables and Figures

Table A1: Country Borders, Regional Borders, EU Borders (year 2017).

| | (1) | (2) | (3) | (4) |
|---|---|---|---|---|
| LN_DIST | -0.417*** | -0.427*** | -0.407*** | -0.407*** |
| | (0.060) | (0.060) | (0.061) | (0.061) |
| CONTIG | 0.649*** | 0.733*** | 0.719*** | 0.729*** |
| | (0.107) | (0.114) | (0.113) | (0.113) |
| COM_LANG | 0.195** | 0.207** | 0.190** | 0.201** |
| | (0.082) | (0.082) | (0.082) | (0.083) |
| RTA | 0.075 | 0.019 | 0.063 | 0.057 |
| | (0.091) | (0.090) | (0.090) | (0.091) |
| EU | 0.127 | 0.074 | 0.108 | |
| | (0.103) | (0.101) | (0.102) | |
| COM_REL | 1.287*** | 1.358*** | 1.302*** | 1.284*** |
| | (0.155) | (0.151) | (0.152) | (0.152) |
| COM_LEG | -0.102 | -0.109 | -0.115 | -0.124* |
| | (0.072) | (0.069) | (0.071) | (0.071) |
| ISLAND | 0.219 | 0.257 | 0.251 | 0.254 |
| | (0.168) | (0.168) | (0.170) | (0.170) |
| LAND | -0.935*** | -0.860*** | -0.868*** | -0.864*** |
| | (0.154) | (0.144) | (0.142) | (0.143) |
| BRDR_ALL | -3.503*** | -3.464*** | | |
| | (0.178) | (0.182) | | |
| INTL_BRDR | | | -3.556*** | |
| | | | (0.184) | |
| INTL_SPAIN | | | -3.748*** | |
| | | | (0.221) | |
| INTER_REGION | | | -1.496*** | -1.502*** |
| | | | (0.193) | (0.192) |
| INTL_BRDR_EU | | | | -3.470*** |
| | | | | (0.182) |
| INTL_BRDR_noEU | | | | -3.553*** |
| | | | | (0.184) |
| INTL_SPAIN_EU | | | | -3.369*** |
| | | | | (0.210) |
| INTL_SPAIN_noEU | | | | -4.075*** |
| | | | | (0.219) |
| Obs | 19805 | 24605 | 24605 | 24605 |
| $R^2$ | 0.977 | 0.977 | 0.978 | 0.978 |
| Imp, Exp FE | Yes | Yes | Yes | Yes |
| Spain Region | No | Yes | Yes | Yes |

*Notes:* Robust standard errors in parentheses. Column (1): Cross-country estimation with Spain included as a country (with Spanish domestic and international trade). Column (2): Estimation with Spain split up into regions (with regional domestic, region-to-region, and international trade). Column (3): Dissect the border: country-to-country (INTL_BRDR), region-to-country (INTL_SPAIN), region-to-region (INTER_REGION). Column (4): Dissect the border further: non-EU country-to-country (INTL_BRDR_noEU), non-EU region-to-country (INTL_SPAIN_noEU), EU country-to-country (INTL_BRDR_EU), EU region-to-country (INTL_SPAIN_EU), region-to-region (INTER_REGION). * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

Table A2: General Equilibrium Results for Spanish Regions, Counterfactual Scenario 1 of an Independent Catalonia in the EU, year 2012

| Region | Exports Change (%) | Real Output Change (%) | Consumer Prices Change (%) | Producer Prices Change (%) |
|---|---|---|---|---|
| CAT (Catalonia) | -16.55 | -5.10 | 2.25 | -2.96 |
| VAL (Comunidad Valenciana) | -5.79 | -2.72 | 1.63 | -1.13 |
| BAL (Illes Balears) | -2.13 | -2.59 | 1.56 | -1.07 |
| ARA (Aragón) | -3.72 | -2.28 | 1.43 | -0.88 |
| CNT (Cantabria) | -0.91 | -1.28 | 0.76 | -0.52 |
| CNA (Canarias) | -1.71 | -1.25 | 0.78 | -0.48 |
| AST (Principado de Asturias) | -1.19 | -1.18 | 0.71 | -0.47 |
| VAS (País Vasco) | -2.24 | -1.11 | 0.65 | -0.46 |
| MUR (Región de Murcia) | -1.28 | -1.08 | 0.71 | -0.38 |
| GAL(Galicia) | -1.80 | -1.02 | 0.60 | -0.43 |
| AND (Andalucía) | -2.47 | -0.95 | 0.58 | -0.38 |
| NAV (Comunidad Foral de Navarra) | -0.94 | -0.93 | 0.63 | -0.31 |
| RIO (La Rioja) | -0.48 | -0.86 | 0.59 | -0.27 |
| AXT (Extremadura) | -0.59 | -0.80 | 0.55 | -0.25 |
| CAM (Castilla-La Mancha) | -0.49 | -0.55 | 0.45 | -0.11 |
| CAL (Castilla y León) | -0.80 | -0.55 | 0.44 | -0.11 |
| MAD (Communidad de Madrid) | -3.21 | -0.53 | 0.54 | 0.01 |

*Notes:* Changes in exports, real output, consumer prices, and producer prices are obtained using the GEPPML procedure.

Table A3: General Equilibrium Results for Spanish Regions, Counterfactual Scenario 2 of an Independent Catalonia in the EU as Portugal, year 2012

| Region | Exports Change (%) | Real Output Change (%) | Consumer Prices Change (%) | Producer Prices Change (%) |
|---|---|---|---|---|
| CAT (Catalonia) | -19.48 | -5.86 | 2.56 | -3.46 |
| VAL (Comunidad Valenciana) | -6.85 | -3.17 | 1.94 | -1.29 |
| BAL (Illes Balears) | -2.52 | -3.02 | 1.85 | -1.22 |
| ARA (Aragón) | -4.39 | -2.65 | 1.70 | -1.00 |
| CNT (Cantabria) | -1.06 | -1.49 | 0.91 | -0.59 |
| CNA (Canarias) | -2.00 | -1.45 | 0.93 | -0.54 |
| AST (Principado de Asturias) | -1.39 | -1.37 | 0.85 | -0.53 |
| VAS (País Vasco) | -2.62 | -1.29 | 0.78 | -0.52 |
| MUR (Región de Murcia) | -1.49 | -1.26 | 0.85 | -0.42 |
| GAL(Galicia) | -2.10 | -1.19 | 0.71 | -0.48 |
| AND (Andalucía) | -2.88 | -1.10 | 0.69 | -0.42 |
| NAV (Comunidad Foral de Navarra) | -1.09 | -1.08 | 0.75 | -0.34 |
| RIO (La Rioja) | -0.55 | -1.00 | 0.71 | -0.30 |
| AXT (Extremadura) | -0.68 | -0.92 | 0.66 | -0.27 |
| CAM (Castilla-La Mancha) | -0.56 | -0.64 | 0.54 | -0.10 |
| CAL (Castilla y León) | -0.93 | -0.63 | 0.53 | -0.10 |
| MAD (Communidad de Madrid) | -3.73 | -0.61 | 0.65 | 0.03 |

*Notes:* Changes in exports, real output, consumer prices, and producer prices are obtained using the GEPPML procedure.

Table A4: General Equilibrium Results for Spanish Regions, Counterfactual Scenario 3 of an Independent Catalonia Outside the EU as Switzerland, year 2012

| Region | Exports Change (%) | Real Output Change (%) | Consumer Prices Change (%) | Producer Prices Change (%) |
|---|---|---|---|---|
| CAT (Catalonia) | -38.69 | -10.22 | 4.88 | -5.84 |
| VAL (Comunidad Valenciana) | -6.75 | -3.11 | 1.89 | -1.28 |
| BAL (Illes Balears) | -2.50 | -2.97 | 1.81 | -1.21 |
| ARA (Aragón) | -4.36 | -2.61 | 1.66 | -0.99 |
| CNT (Cantabria) | -1.07 | -1.46 | 0.89 | -0.59 |
| CNA (Canarias) | -2.00 | -1.43 | 0.90 | -0.54 |
| AST (Principado de Asturias) | -1.40 | -1.35 | 0.83 | -0.53 |
| VAS (País Vasco) | -2.60 | -1.27 | 0.76 | -0.52 |
| MUR (Región de Murcia) | -1.49 | -1.23 | 0.83 | -0.41 |
| GAL(Galicia) | -2.09 | -1.17 | 0.70 | -0.48 |
| AND (Andalucía) | -2.86 | -1.08 | 0.67 | -0.42 |
| NAV (Comunidad Foral de Navarra) | -1.13 | -1.06 | 0.73 | -0.33 |
| RIO (La Rioja) | -0.59 | -0.98 | 0.69 | -0.30 |
| AXT (Extremadura) | -0.72 | -0.91 | 0.64 | -0.27 |
| CAM (Castilla-La Mancha) | -0.60 | -0.63 | 0.52 | -0.10 |
| CAL (Castilla y León) | -0.96 | -0.62 | 0.52 | -0.11 |
| MAD (Communidad de Madrid) | -3.72 | -0.60 | 0.63 | 0.03 |

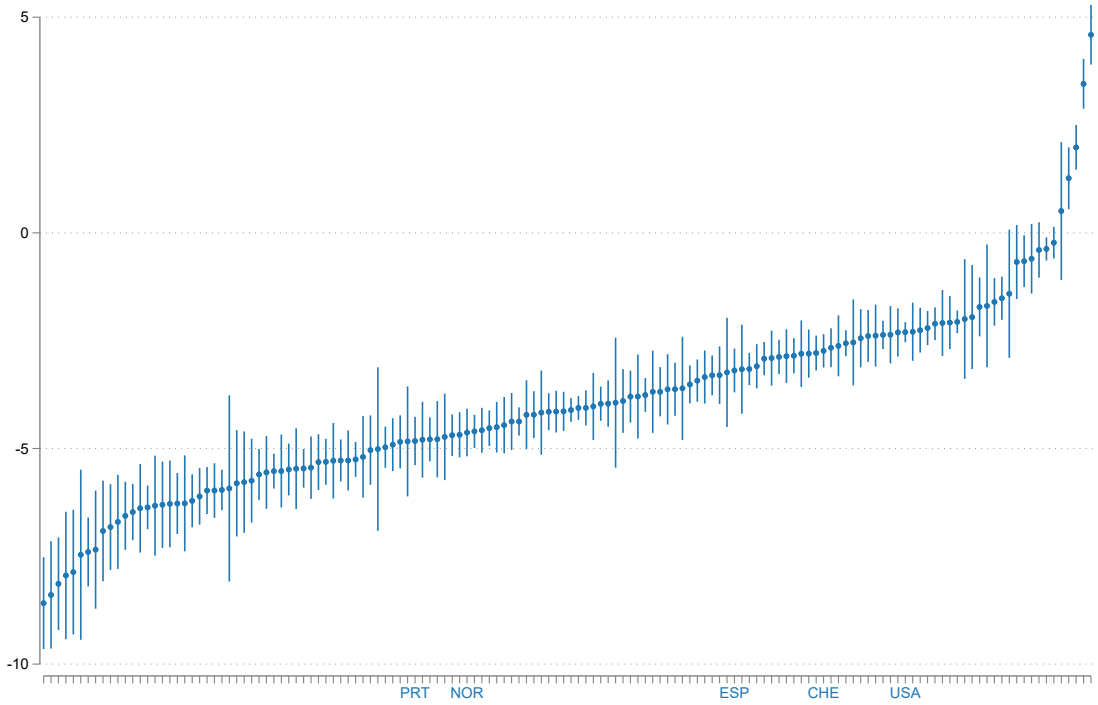
*Notes:* Changes in exports, real output, consumer prices, and producer prices are obtained using the GEPPML procedure.

Table A5: General Equilibrium Results for Spanish Regions, Counterfactual Scenario 4 of an Independent Catalonia Outside the EU as Switzerland and Outside the WTO, year 2012

| Region | Exports Change (%) | Real Output Change (%) | Consumer Prices Change (%) | Producer Prices Change (%) |
|---|---|---|---|---|
| CAT (Catalonia) | -43.79 | -11.20 | 5.40 | -6.40 |
| VAL (Comunidad Valenciana) | -6.72 | -3.10 | 1.88 | -1.28 |
| BAL (Illes Balears) | -2.49 | -2.95 | 1.80 | -1.21 |
| ARA (Aragón) | -4.34 | -2.60 | 1.65 | -0.99 |
| CNT (Cantabria) | -1.07 | -1.45 | 0.88 | -0.58 |
| CNA (Canarias) | -1.99 | -1.42 | 0.90 | -0.53 |
| AST (Principado de Asturias) | -1.39 | -1.34 | 0.82 | -0.53 |
| VAS (País Vasco) | -2.59 | -1.26 | 0.75 | -0.52 |
| MUR (Región de Murcia) | -1.49 | -1.23 | 0.82 | -0.41 |
| GAL(Galicia) | -2.08 | -1.16 | 0.69 | -0.48 |
| AND (Andalucía) | -2.85 | -1.08 | 0.66 | -0.42 |
| NAV (Comunidad Foral de Navarra) | -1.13 | -1.05 | 0.72 | -0.34 |
| RIO (La Rioja) | -0.60 | -0.97 | 0.68 | -0.30 |
| AXT (Extremadura) | -0.72 | -0.90 | 0.64 | -0.27 |
| CAM (Castilla-La Mancha) | -0.60 | -0.62 | 0.52 | -0.11 |
| CAL (Castilla y León) | -0.96 | -0.62 | 0.51 | -0.11 |
| MAD (Communidad de Madrid) | -3.71 | -0.60 | 0.63 | 0.03 |

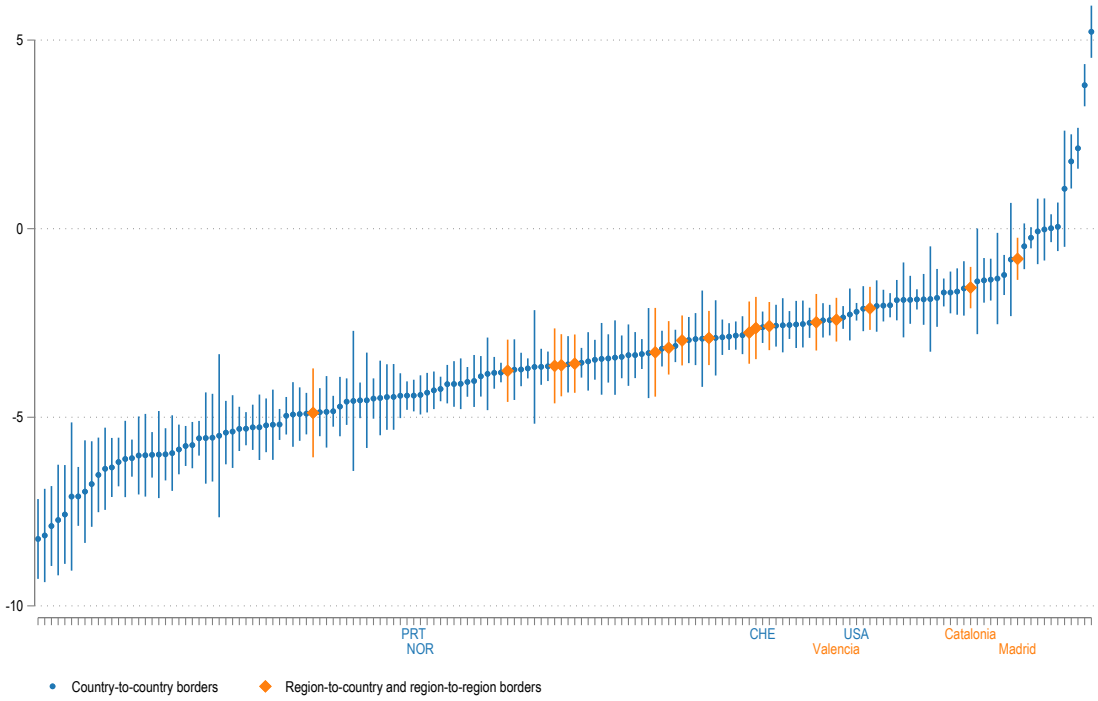
*Notes:* Changes in exports, real output, consumer prices, and producer prices are obtained using the GEPPML procedure.

Figure A1: Country Borders (year 2017).



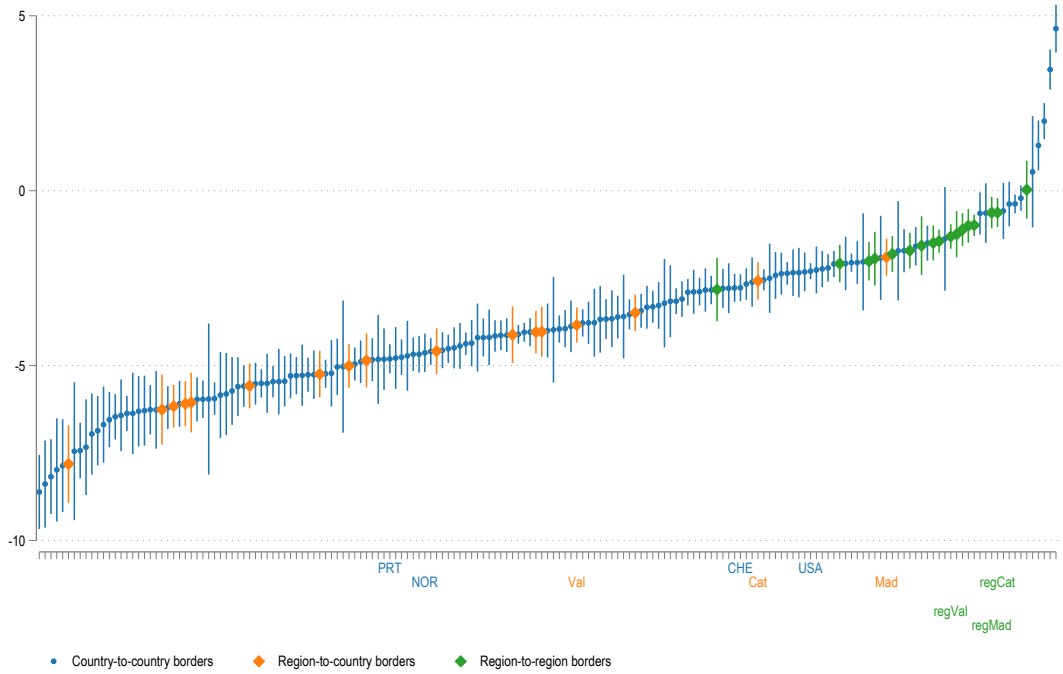

*Notes:* Coefficient estimates and 95% confidence intervals of country-specific borders, dissected from the specification shown in column (1) of Table A1. The labels highlight a selection of country borders (where PRT is Portugal, NOR is Norway, ESP is Spain, CHE is Switzerland, and USA is the United States).

Figure A2: Country and Region Borders (year 2017).



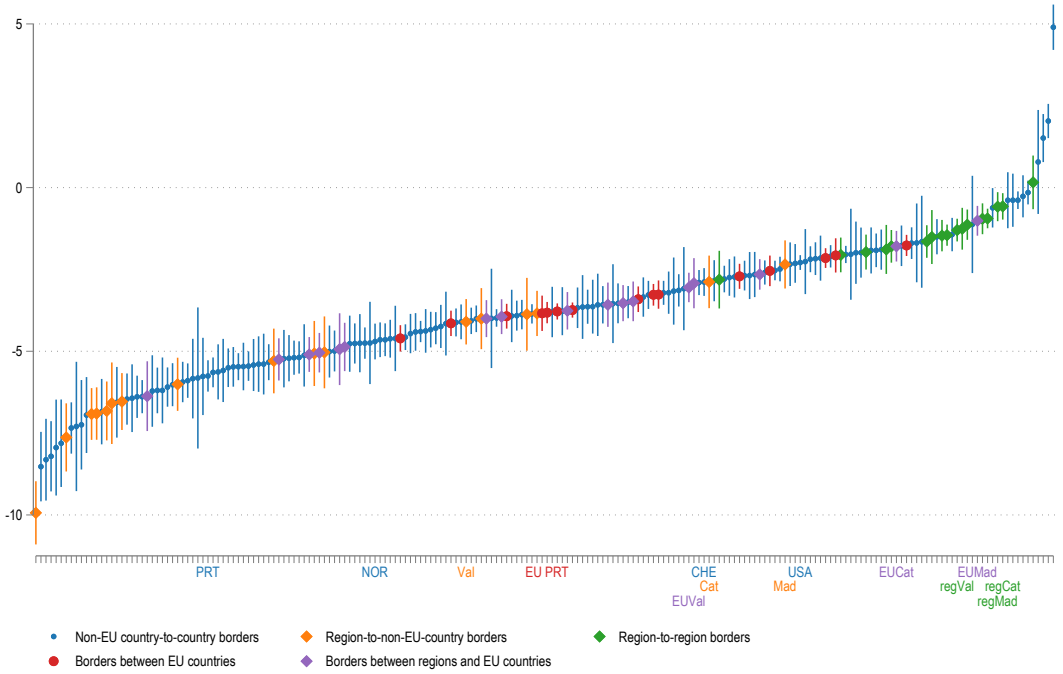

*Notes:* Coefficient estimates and 95% confidence intervals of country- and region-specific borders, dissected from the specification shown in column (2) of Table A1. The labels highlight a selection of country borders (where PRT is Portugal, NOR is Norway, CHE is Switzerland, and USA is the United States) and of Spanish regions' borders.

Figure A3: Country, Region-to-Country, and Region-to-Region Borders (year 2017).




*Notes:* Coefficient estimates and 95% confidence intervals of country- and region-specific borders, dissected from the specification shown in column (3) of Table A1. The labels highlight a selection of country borders (where PRT is Portugal, NOR is Norway, ESP is Spain, CHE is Switzerland, and USA is the United States), of region-to-country borders (where Val is Valencia, Cat is Catalonia, and Mad is Madrid), and of region-to-region borders (where regVal is Valencia, regMad is Madrid, and regCat is Catalonia).

Figure A4: EU vs. Non-EU Country and Region Borders (year 2017).




*Notes:* Coefficient estimates and 95% confidence intervals of country- and region-specific borders, dissected from the specification shown in column (4) of Table A1. The labels highlight a selection of non-EU country borders (where PRT is Portugal, NOR is Norway, ESP is Spain, CHE is Switzerland, and USA is the United States), of EU country borders (where EU PRT is Portugal), of region-to-non-EU-country borders (where Val is Valencia, Cat is Catalonia, and Mad is Madrid), of region-to-EU-country borders (where EUVal is Valencia, EUCat is Catalonia, and EUMad is Madrid), and of region-to-region borders (where regVal is Valencia, regMad is Madrid, and regCat is Catalonia).

Figure A5: Counterfactual 2: Catalonia's Regional Border as Portugal's EU border. Change (in %) of Real Output for Countries in the Dataset.

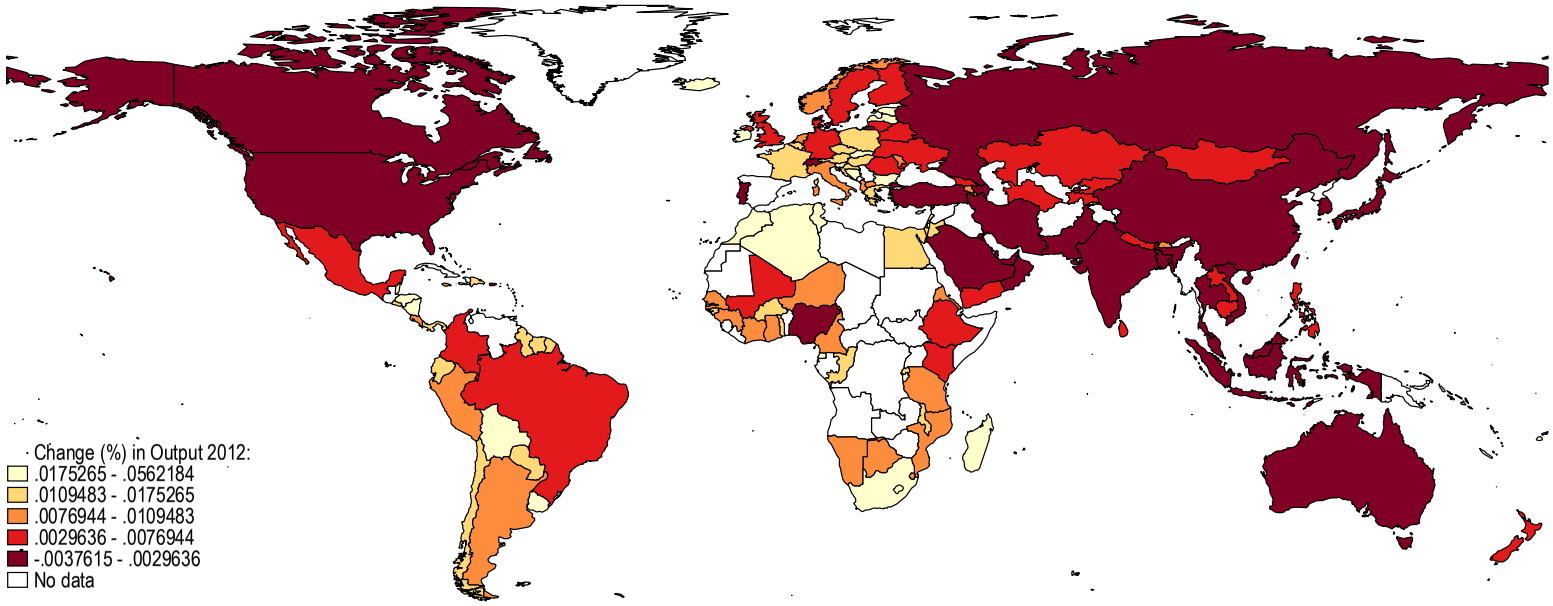


Figure A6: Counterfactual 3: Catalonia Outside the EU, Same Border as Switzerland. Change (in %) of Real Output for Countries in the Dataset.

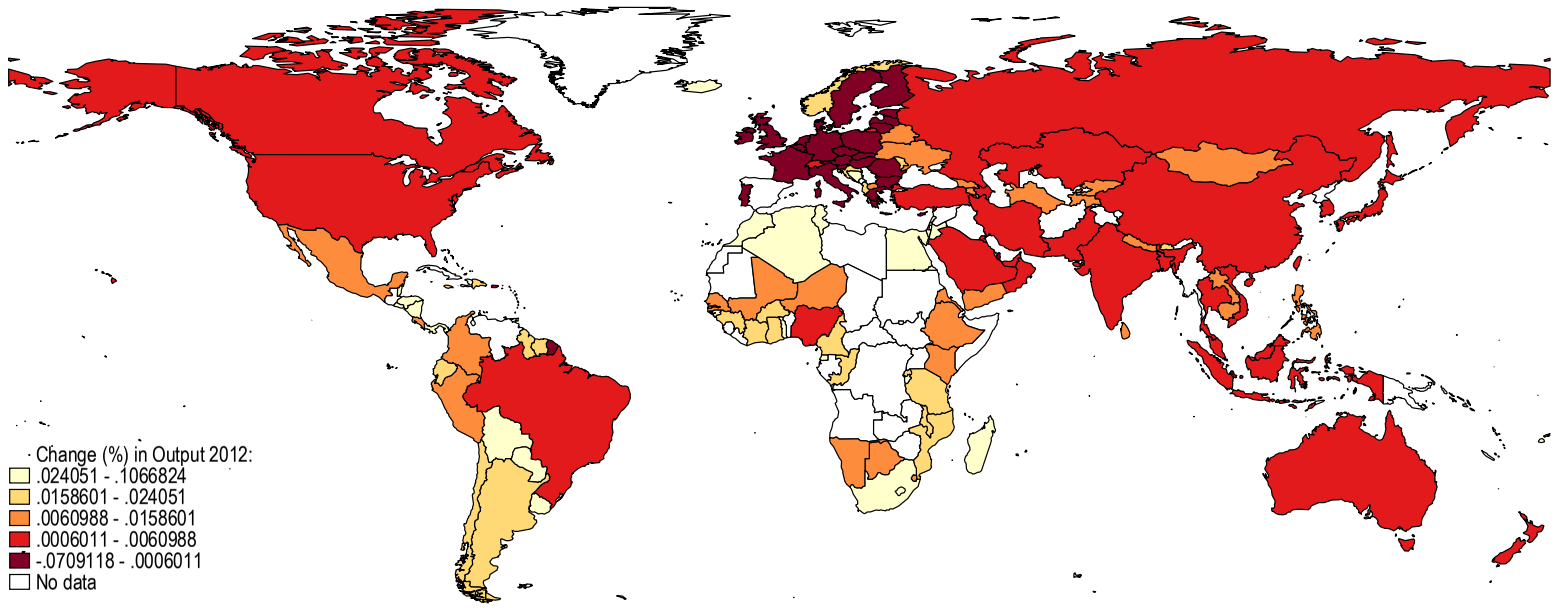


Figure A7: Counterfactual 4: Catalonia Outside the EU and the WTO. Change (in %) of Real Output for Countries in the Dataset.