

# A Border in the Sea? The Effect of Major Infrastructure Development on Bilateral Goods Trade

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## Abstract

A consistent finding in the literature is that national borders act as a barrier to the free flow of goods trade between nations. Recent evidence suggests that sea borders are subject to substantially greater friction than land borders for the transportation of goods (Groizard et al., 2014). In this paper, we use the quasi-natural experiment of the Øresund Bridge, which transformed the sea border between Denmark and Sweden into a land border, to estimate the effects on bilateral goods trade. We employ the Synthetic Control Method (SCM) to construct a synthetic counterfactual Danish-Swedish trading relationship to analyse how much trade the Øresund Bridge created. Our findings suggest that the value of bilateral goods trade between Denmark and Sweden is 19% higher than it would have been without the bridge. This result is robust to a number of sensitivity tests.

*Keywords:* Border effect, sea border v. land border, bridge, major infrastructure projects, synthetic control method

*JEL classification:* F14, F15

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# 1 Introduction

The gravity model, which dates back to Tinbergen (1962), has become a workhorse model of international trade. It has contributed significantly to our understanding of the nature of bilateral trade cost and to the pattern of trade across nations. In particular, it has taught economists the lesson that national borders represent substantial barriers to the free flow of trade (see for example Anderson and van Wincoop, 2003; Chen, 2004; Evans, 2003; Head and Mayer, 2000; McCallum, 1995). This finding is probably one of the most robust relationships in economics and may even be as certain as gravity itself.

The negative impact borders have on the bilateral trading relationships of nations is, however, not fixed over time. The last couple of decades have witnessed a substantial and ongoing process of globalisation in which countries have come together to break down the barriers that borders create. This is true at the global level through the auspices of the GATT/WTO but also regionally owing to the contemporary growth of preferential trade agreements.

There is nonetheless one type of border-barrier which, despite every effort and expense afforded by policy-makers, is difficult to mitigate. Many bilateral trading relationships do not involve direct land routes for the transportation of goods, but are separated by a sea border. Given the high incidence of such borders, it is surprising that the quantification of their potential adverse effects upon trade has received only marginal attention in the literature. One recent exception is found in Groizard et al. (2014). They find evidence from intra-national trade in Spain that sea borders represent significant barriers over land borders. Specifically, they find that a sea border, and the mode of transportation involved in crossing such border, is more important than distance in explaining the additional trade cost between two regions.

July 2000 saw the completion of a major infrastructure project, the rail and road bridge between Denmark and Sweden — two small to medium sized countries in Scandinavia -- which is called the Øresund Bridge. This bridge transformed the nature of the border between Denmark and Sweden from one of a sea border to a land border. In this paper, we seek to use this quasi-natural field experiment to estimate the impact of a sea border on bilateral goods trade. Our approach therefore exploits time variation rather than cross-sectional variation as in Groizard et al., 2014.

There are several reasons why we expect the bridge to have led to increased goods trade between Denmark and Sweden. First, a fixed-link route between the two countries has reduced capacity constraints for road and rail transport. Second, the competition between transport services (the bridge and the remaining ferry routes) has put downward pressure on cost.<sup>1</sup> Third, fixed links offer flexibility through continuous service and eliminate bottlenecks from queues and waiting times. There is evidence that delays significantly impede trade (see for example Hummels and Schaur, 2013). Finally, in the long run, and in the light of the fact that the bridge integrated two strategically important urban areas of Denmark and Sweden – Malmö and Copenhagen – the development of business and personal networks might have been conducive to the establishment of deeper trade links over time.

To estimate the trade creating effects of the Øresund Bridge we employ the Synthetic Control Method (SCM) which is becoming increasingly commonplace for comparative studies. We use this methodology to construct a counterfactual Danish-Swedish trading relationship — a synthetic model -- to analyse how much trade the Øresund Bridge has created. Our benchmark results indicate that the value of bilateral goods trade between Denmark and Sweden is 19% higher than it would have been if the Øresund Bridge had not been built. We run a series of robustness checks to analyse the sensitivity of our results to alternative specifications.

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<sup>1</sup>Competing ferry operators continue to hold on to a relatively large share of long-distance lorry traffic (Knowles, 2006). See Section 2 for further details.

In particular, we find that the synthetic model is robust to the choice of matching window, and in addition our results are supported by standard econometric techniques such as difference-in-differences and panel fixed effects.

In addition to contributing to our understanding of the cost of sea borders, the Øresund Bridge is a major infrastructure project. Governments spend a significant amount of resources on such projects with the aim of boosting economic integration and output. For example, the fixed-link Euro tunnel between the United Kingdom (UK) and France was intended to increase transportation capacity and reduce trade costs, thereby integrating the UK and the continental European economies. From a scholarly point of view it is important to quantify any such economic gains to be able to judge their merits relative to other forms of government expenditure.

Analyses of the bilateral trade effects of major infrastructure projects can also be found elsewhere, however. Studies indicate that transport infrastructure has a positive impact on bilateral trade. Bougheas et al. (1999) model the role of general transport infrastructure on bilateral trade and find a positive and significant relationship between the level of such infrastructure and trade volumes. Similarly, evidence found in Donaubauer et al. (2018) indicate that trade costs are significantly reduced by improved transport infrastructure.

Donaldson (2018) finds that railroads in colonial India increases interregional and international trade. Evidence by Bernard et al. (2016) suggests that high-speed train lines in Japan lower production costs by reducing commuting times. There is also evidence that large-scale road infrastructure developments have a positive impact on trade. For example, Durantón et al. (2014) investigate the effects on cities' exports of interstate highways in the US and find strong positive and significant effects. Volpe Martincus et al. (2014) find that road closures following an earthquake in Chile has negative effects on exports.

Nevertheless, relatively little is known about how major infrastructure development directly connecting two countries affect bilateral trade. Volpe Martincus and Blyde (2013) analyse a temporary closure of the San Martín International Bridge between Argentina and Uruguay and find negative effects on exports. Previous studies have analysed the trade-creating impact of the Øresund Bridge. Åkerman (2009) finds that exports from firms in Malmö to Denmark increase following the opening of the bridge and so does aggregate productivity. Similarly, Arnarson (2015) shows that aggregate exports, mainly driven by the manufacturing sector, in the Malmö region increases due to the bridge. Åkerman (2009) and Arnarson (2015), however, restrict attention to localised effects of the bridge in Sweden using similar Swedish regions as comparison units. Further, Achten et al. (2019) find positive regional economic effects in southern Sweden. Their paper focuses solely on regional economic outcomes and excludes Denmark from the analysis. To the authors' knowledge, no attempt has been made to estimate the macroeconomic (i.e. bilateral trade) impact of the Øresund Bridge or more broadly little evidence exists for the bilateral trade creation of major infrastructure projects. As such, we believe this paper will be contributing towards our understanding of major infrastructure development. This might be relevant for major infrastructure developments currently in their planning stage such as the bridge between Denmark and Germany.

## 2 Introducing the Øresund Bridge

Southern Sweden and eastern Denmark are separated by a narrow strait, commonly known in English as the *Sound* (Öresund in Swedish, and Øresund in Danish), which connects the Kattegat strait with the Baltic Sea. The region surrounding the Sound is economically important for both countries, containing for example

both the Danish capital Copenhagen – by far the largest city in the country – and Malmö, Sweden’s third largest city. Discussions about connecting the two countries with a fixed link, such as a bridge or a tunnel, go back many decades. However, the formal decision to build the Øresund Bridge as a land connection between Copenhagen and Malmö was not taken until 1991. Due to political opposition in Sweden, linked among other things to concerns about adverse environmental effects, it then took until 1995 for construction work to begin. On 1 July, 2000, the Øresund Bridge was officially opened.

While the land connection between Copenhagen and Malmö is typically referred to as the “Øresund Bridge”, strictly speaking it is a fixed link which consists of three parts: a road and railway *bridge*, a road and railway *tunnel*, and an artificial *island* that serves as the connecting point between the bridge and the tunnel. Please note that throughout the paper, we will, for convenience and in accordance with common usage, typically employ the term “Øresund Bridge”, even though what we actually mean is the entire fixed land link between Copenhagen and Malmö.

Before the Øresund Bridge was built, Denmark and Sweden were connected by ferry services. The most important ferry route for goods transportation was between Elsinore, 46 km north of Copenhagen, and Helsingborg, 65 km north of Malmö, but there was also a ferry service between Malmö and Dragør just outside of Copenhagen. While the latter closed already in October 1999, the Elsinore-Helsingborg ferries have stayed in business, even though they stopped carrying trains as soon as the bridge opened. Thus, in practical terms, before the bridge opened, goods could only be transported via the various ferries across the Sound. From the year 2000, firms still had the possibility to send their lorries across the Elsinore-Helsingborg ferries, but in addition, they could also choose the Copenhagen-Malmö route across the bridge.<sup>2</sup>

### 3 Data and methodology

In this section we describe how we estimate the value of bilateral trade flows between Denmark and Sweden in the event the Øresund Bridge had not been built. We employ the SCM, adapted from Abadie and Gardeazabal (2003), Abadie et al. (2010) and Abadie et al. (2015), which is becoming increasingly commonplace for comparative case studies. Our sample consists of Denmark and Sweden, the remaining countries in EU15<sup>3</sup> as well as three EFTA<sup>4</sup> countries (Norway, Switzerland and Iceland), which are observed over our sample period 1980-2015. Belgium-Luxembourg is treated as one unit and so this leaves us with 17 countries and a set  $X$  containing 136 bilateral country pairs (ignoring the direction of trade). Of these 136 pairs, the subset  $X^{NT}$  comprises 105 bilateral pairs that do not contain Denmark and/or Sweden and this set will therefore serve as our “donor pool”, that is, our stock of potential comparison units. The subset  $X^T$  comprises the 31 bilateral pairs involving Denmark and/or Sweden. It is assumed that our comparison units in  $X^{NT}$  are not affected by the treatment.

Let  $BTF_{DNK-SWE,t}^N$  be the bilateral trade flow between Denmark and Sweden which would be observed at time  $t$  in the absence of the Øresund Bridge, and  $BTF_{DNK-SWE,t}^I$  the actual recorded bilateral trade flow at time  $t$  after the Øresund Bridge was built. Using this notation we can identify, from a theoretical perspective, the gain or loss (in percentage terms) to bilateral trade as a result of constructing the Øresund

<sup>2</sup>Note that the closing of the ferry between Dragør and Malmö in 1999 should be of little consequence in this context. According to Knowles (2006), less than 5 percent of all lorries crossing the Sound in 1999 chose the Dragør-Malmö ferry.

<sup>3</sup>The EU15 comprises the following countries: Austria, Belgium, Denmark, Finland, France, Germany, Greece, Ireland, Italy, Luxembourg, Netherlands, Portugal, Spain, Sweden, United Kingdom.

<sup>4</sup>EFTA is the European Free Trade Association between Norway, Switzerland, Iceland and Liechtenstein

Bridge between Denmark and Sweden as:

$$\alpha_{DNK-SWE,2001-2015} = \frac{\sum_{t=2001}^{2015} (BTF_{DNK-SWE,t}^I - BTF_{DNK-SWE,t}^N)}{\sum_{t=2001}^{2015} BTF_{DNK-SWE,t}^N}. \quad (1)$$

The Øresund Bridge was dedicated in July 2000 and we therefore set the treatment period as 2001-2015. Our placebo-in-time analysis below demonstrates that our results are robust to alternative treatment periods. It is assumed that the Øresund Bridge does not affect bilateral trade flows between Denmark and Sweden prior to its dedication in 2001 such that:

$$\alpha_{DNK-SWE,1980-2000} = \frac{\sum_{t=1980}^{2000} (BTF_{DNK-SWE,t}^I - BTF_{DNK-SWE,t}^N)}{\sum_{t=1980}^{2000} BTF_{DNK-SWE,t}^N} = 0.$$

In practice, however, it is possible that the treatment might have impacted bilateral trade flows prior to 2001 through various channels, such as the announcement of the construction of the bridge. We shall examine anticipation effects in more detail below. Since the Øresund Bridge was completed in 2001 we do not observe the bilateral trade flow which would have occurred in its absence. The challenge is therefore to construct a credible counterfactual. One possibility is to select a bilateral country pair from our donor pool  $X^{NT}$ , for example, the bilateral trade flow between Switzerland and Austria. This approach, however raises some concerns. First, how can we be certain that the bilateral trade flow between Switzerland and Austria is representative of the trade flow that would have occurred between Denmark and Sweden if the Øresund Bridge had not been built? Second, the selection of Austria and Switzerland is inevitably arbitrary since this bilateral pair is just one of 105 potential counterfactuals. The logic behind the SCM is to restrict the donor pool to comparison units which closely resemble the structural process driving the case of interest prior to the treatment. We index the counterfactual bilateral country pairs in our donor pool  $i = 1, \dots, n$  such that  $X_t^{NT} = \{BTF_{1,t}, \dots, BTF_{n,t}\}$ . An estimate of  $\alpha_{DNK-SWE,2001-2015}$  in (1) can now be constructed as:

$$\hat{\alpha}_{DNK-SWE,2001-2015} = \frac{\sum_{t=2001}^{2015} (BTF_{DNK-SWE,t}^I - \sum_{i=1}^n w_i BTF_{i,t})}{\sum_{t=2001}^{2015} \sum_{i=1}^n w_i BTF_{i,t}}. \quad (2)$$

where  $\sum_{i=1}^n w_i BTF_{i,t}$  is our post-treatment synthetic bilateral trade flow between Denmark Sweden, that is, a weighted combination of bilateral country pairs in our donor pool. The parameter  $w_i$  is the weight associated with the  $i$ th counterfactual unit in  $X^{NT}$  such that  $\sum_{i=1}^n w_i = 1$ . As is standard in literature on SCM we select the vector  $\mathbf{W}^*$  of weights which minimises,

$$\arg \min \sqrt{(\mathbf{Y}_{DNK-SWE} - \mathbf{Y}\mathbf{W})' \mathbf{V} (\mathbf{Y}_{DNK-SWE} - \mathbf{Y}\mathbf{W})}, \quad (3)$$

where  $\mathbf{Y}_{DNK-SWE}$  is a vector of pre-Øresund characteristics of our treated unit, and  $\mathbf{Y}$  is a matrix of pre-Øresund characteristics of our potential comparison units that are assumed not to be affected by the treatment. The SCM exercise is performed using five pre-Øresund characteristics that are motivated by the gravity model of trade (Tinbergen, 1962). In particular, we use the log of the product of each country's GDP in every bilateral pair at time  $t$ ; the weighted distance between each country; a dummy variable equal to unity for adjacency; a dummy variable equal to unity if 9% of their populations speak a common language; and a dummy equal to unity if both countries are members of the EU. We obtain these variables from Centre d'Études Prospectives et d'Informations Internationales (CEPII). The bilateral trade flows have been extracted from the International Monetary Fund's (IMF) Direction of Trade Statistics. The term  $\mathbf{V}$  is a

diagonal and positive definite matrix containing the non-negative weights measuring the importance of each pre-Øresund characteristic.  $\mathbf{V}$  is chosen such that the mean squared prediction error of the outcome variable is minimised for the pre-treatment periods. As argued in Abadie et al. (2010) and Abadie et al. (2015), if the pre-treatment matching window is large enough, matching on pre-intervention outcomes helps to control for unobserved factors and for the heterogeneity of observed and unobserved factors. This is because “only units that are alike in both observed and unobserved determinants of the outcome variable as well as in the effect of those determinants on the outcome variable should produce similar trajectories of the outcome variable over extended periods of time” (Abadie et al., 2015). As long as the treatment unit as well as the synthetic control can be established to display very similar trajectories prior to the intervention, any discrepancy which occurs after the treatment can be interpreted as the effect of the treatment upon the outcome variable.

Within the standard application of the SCM, the use of inferential techniques is limited since probabilistic sampling is not employed to select the comparison units. As such, we only obtain one estimate of  $\mathbf{W}^*$ . In this paper, therefore, we will use an alternative approach to assess the statistical significance based on the subsampling procedure in Politis and Romano (1994) – a technique which was first proposed as an application to the SCM in Saia (2017). We construct  $j = 1, \dots, m$  subsamples of  $X^{NT}$ , where for each subsample we randomly exclude a fraction  $z$  of the comparison units. For each subsample  $j$  we run a synthetic control as described above,

$$\alpha_{DNK-SWE,j,2001-2015} = \frac{\sum_{t=2001}^{2015} (BTF_{DNK-SWE,t}^I - \sum_{i=1}^n w_{i,j} BTF_{i,j,t})}{\sum_{t=2001}^{2015} \sum_{i=1}^n w_{i,j} BTF_{i,j,t}}. \quad (4)$$

Then we compute the average,

$$\bar{\alpha}_{DNK-SWE,2001-2015} = \frac{1}{m} \sum_{j=1}^m \left[ \frac{\sum_{t=2001}^{2015} (BTF_{DNK-SWE,t}^I - \sum_{i=1}^n w_{i,j} BTF_{i,j,t})}{\sum_{t=2001}^{2015} \sum_{i=1}^n w_{i,j} BTF_{i,j,t}} \right], \quad (5)$$

and standard deviation,

$$\sigma_{DNK-SWE,2001-2015} = \sqrt{\frac{1}{m-1} \sum_{j=1}^m (\alpha_{DNK-SWE,j,2001-2015} - \bar{\alpha}_{DNK-SWE,2001-2015})^2}. \quad (6)$$

We arbitrarily set  $z = \frac{1}{6}$  and  $m = 500$ . We also construct synthetic counterfactuals for the remaining bilateral trading pairs involving Denmark and Sweden in the set  $X^T$ . We index the bilateral pairs in  $X^T$  as  $k = 1, \dots, l$  and construct a synthetic model for each  $k$ . Suppose the first 15 bilateral pairs in this index are country pairs involving Denmark, the 16th pair is the Danish-Swedish bilateral pair and the pairs  $k = 17, \dots, 31$  are pairs involving Sweden. We compute the effect (if any) on aggregate trade following the completion of the Øresund Bridge for Sweden,

$$\bar{A}_{SWE,2001-2015} = \frac{1}{m} \sum_{j=1}^m \left[ \frac{\sum_{t=2001}^{2015} \left( \sum_{k=16}^{31} BTF_{DNK-SWE,t}^I - \sum_{k=16}^{31} \sum_{i=1}^n w_{i,j} BTF_{i,j,t} \right)}{\sum_{t=2001}^{2015} \sum_{k=16}^{31} \sum_{i=1}^n w_{i,j} BTF_{i,j,t}} \right], \quad (7)$$

and for Denmark

$$\bar{A}_{DNK,2001-2015} = \frac{1}{m} \sum_{j=1}^m \left[ \frac{\sum_{t=2001}^{2015} \left( \sum_{k=1}^{16} BTF_{DNK-SWE,t}^I - \sum_{k=1}^{16} \sum_{i=1}^n w_{i,j} BTF_{i,j,t} \right)}{\sum_{t=2001}^{2015} \sum_{k=1}^{16} \sum_{i=1}^n w_{i,j} BTF_{i,j,t}} \right]. \quad (8)$$

## 4 Results

Figure 1 plots the evolution of the actual bilateral trade flow between Denmark and Sweden (solid line) and the synthetic counterfactual (dashed line) over the period 1980-2015. As explained in the previous section, the synthetic trade flow is obtained through an algorithm which computes the weighted combination of comparison units providing the best fit of the actual trade flow prior to the opening of the Øresund Bridge. We compute 500 synthetic trade flows, where for every model we randomly exclude  $\frac{1}{6}$ th of the 105 comparison units in the donor pool. The dashed line is the average of the 500 synthetic models, and the dark gray area is the 99% confidence interval. We indicate the post-Øresund period as the light gray area in the figure. Note that the pre-Øresund synthetic trade flow provides a good approximation of the actual flow. Actual trade between Denmark and Sweden was subject to a boost between 1993 and 1995, an observation which is likely explained by a combination of factors. First, most European nations were affected by the early 1990s recession which had led to trade falling between many bilateral country pairs in our sample. Sweden was particularly badly hit after a severe credit crunch and widespread bank insolvency in 1991-1992. As such, the boost to bilateral trade observed between 1993 and 1995 was partly a recovery in international trade. Second, the completion of the European Single Market in 1992, the agreement between the European Economic Area (EEA)<sup>5</sup> and the EU in 1994 effectively granting Sweden full access to the internal market and Sweden’s commitment to further European integration are likely to have contributed to increased trade.

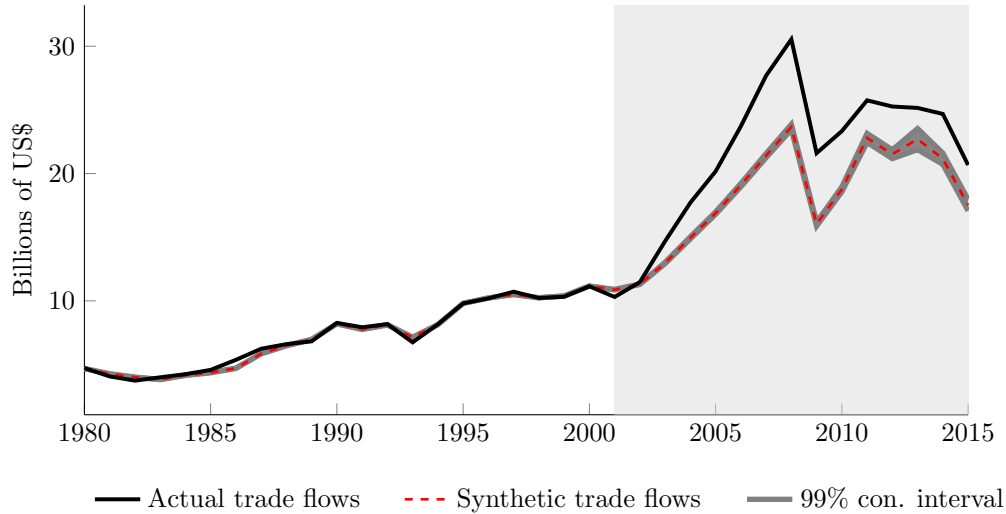


Figure 1: Bilateral trade flow between Denmark and Sweden vs the synthetic counterfactual.

The synthetic trade flow is the flow that would have occurred if the bridge between Denmark and Sweden had not been built. Actual Danish-Swedish bilateral trade diverges substantially from synthetic trade after

<sup>5</sup>The EEA comprises Iceland, Norway and Liechtenstein. In 1994, Sweden was part of this group before its formal entry into the EU in 1995.

2001, and this evolution of actual trade lies outside the 99% confidence interval of the synthetic trade indicated in Figure 1. While we observe a slight fall in Danish-Swedish bilateral trade from 2000 to 2001, the growth of actual trade picks up from 2001 onwards, substantially outstripping the growth of the synthetic counterfactual. In Table 1 we report the percentage difference between actual and synthetic bilateral trade over different periods. During the period before the opening of the Øresund Bridge – our matching window – Danish-Swedish trade performed slightly better than the synthetic trade by around 0.7%. The actual trade in the full post-Øresund period exceeds the synthetic counterfactual. In fact, our estimate of the benefit in terms of increased trade from the Øresund Bridge is 18.798% over the full post-treatment period – 2001-2015. Our estimates also suggest that the initial effect of the Øresund Bridge on bilateral trade was relatively smaller (10.936%) in the first five years after its dedication. Subsequently, in 2006-2010, the effect rises to roughly 28.226% and in our latest period, 2011-2015, the effect drops to just 14.957%. This latter drop appears to be explained by Danish-Swedish bilateral trade experiencing a comparatively larger reduction in trade than their comparison units in the aftermath of the financial crisis. These post-treatment effects are highly significant at the 1% level. In the last two columns of Table 1, we compute the Øresund effect for, respectively, the eight years leading up to the financial crisis and the seven years succeeding it. The motivation for splitting the sample into these two periods is because the period after the financial crisis was characterised by significant volatility in the trade flows of all bilateral country pairs in our sample. There is evidence that international trade is more volatile than domestic production during recessions (see for example Novy and Taylor, 2014). Our concern is that the weights chosen by our synthetic algorithm may not be able to simultaneously model the long-run exponential trade growth of bilateral trade and the large and potentially country-pair specific shocks produced by the financial crisis and its aftermath. Our results in the pre-financial crisis period indicate that actual Danish-Swedish bilateral trade exceeds the synthetic counterfactual by 19.146% whereas for the post-financial crisis period the equivalent figure is 18.473%.

	1980-2000	2001-2015					
		2001-2015	2001-2005	2006-2010	2011-2015	2001-2008	2009-2015
Diff. actual vs synth.	0.707 (0.021)	18.798 (0.436)	10.936 (0.147)	28.226 (0.372)	14.957 (0.814)	19.146 (0.248)	18.473 (0.725)

Table 1: Danish Swedish bilateral trade

In Figure 2 we sum up all 16 synthetic bilateral trade flows of, respectively, Sweden (left panel) and Denmark (right panel), according to (7) and (8). The aggregate synthetic trade flows follow the actual trade flows closely in both the pre- and post-Øresund periods for both Denmark and Sweden. Our synthetic models of, respectively, Denmark’s and Sweden’s aggregate trade are therefore good models of actual trade, indicating that the two countries’ bilateral trade series have not undergone significant structural change in the post-Øresund period. In tables 2 and 3 we have produced the percentage effects over different periods of time. Both countries’ aggregate trade slightly overperforms in the pre-treatment period, whereas Sweden slightly overperforms and Denmark slightly underperforms after the Øresund Bridge was built. Upon further inspection of Tables 2 and 3, respectively, we note that both Sweden’s and Denmark’s actual aggregate trade underperform in the initial years after the Øresund Bridge. While Sweden’s actual trade recovered in 2006-2010, Denmark’s actual trade fell short of its synthetic counterfactual until 2011-2015. In the last two columns of tables (7) and (8), respectively, we have decomposed the Øresund effect into a pre- and post-financial crisis effect. For aggregate Swedish trade, the Øresund effect after the financial crisis is slightly lower than it was in the pre-financial crisis period. Sweden underperformed relative to its synthetic counterfactual by -6.218%



before the financial crisis, and underperformed by slightly less after the financial crisis (by -4.202%). For Denmark, the underperformance of aggregate trade relative to its synthetic model was -4.617% before the financial crisis and -6.999% after.

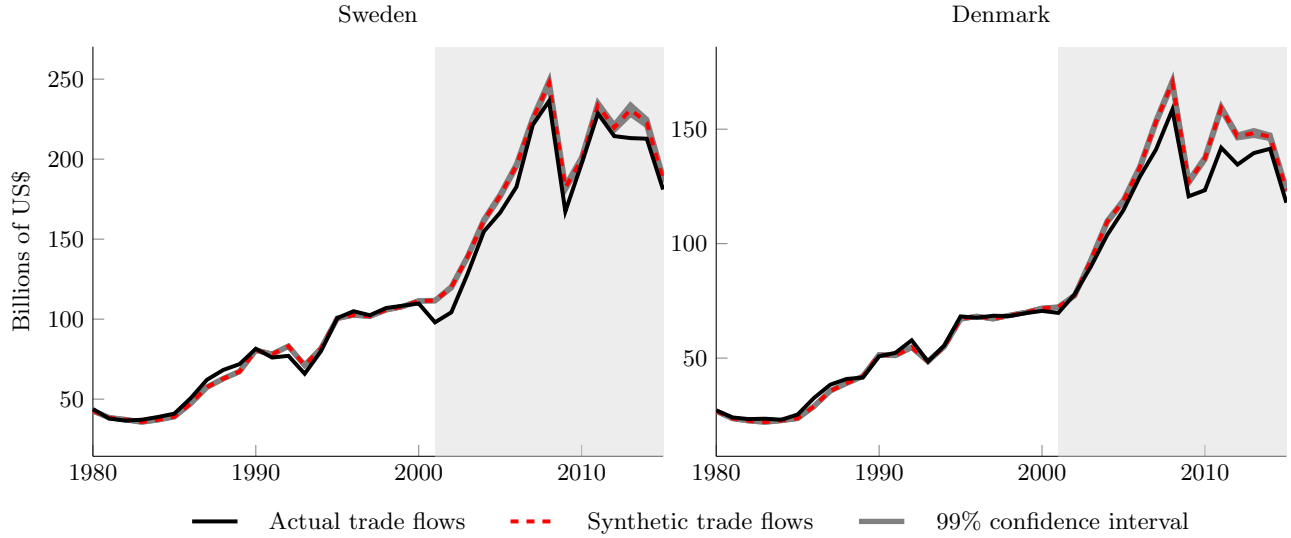


Figure 2: Aggregate Swedish (left-panel) and Danish (right-panel) trade.

	1980-2000	2001-2015					
		2001-2015	2001-2005	2006-2010	2011-2015	2001-2008	2009-2015
Diff. actual vs synth.	0.821 (0.020)	-5.175 (0.190)	-8.093 (0.102)	-4.364 (0.178)	-4.062 (0.293)	-6.218 (0.128)	-4.202 (0.265)

Table 2: Total Swedish trade

	1980-2000	2001-2015					
		2001-2015	2001-2005	2006-2010	2011-2015	2001-2008	2009-2015
Diff. actual vs synth.	1.744 (0.010)	-5.846 (0.110)	-3.108 (0.088)	-6.708 (0.131)	-6.767 (0.163)	-4.617 (0.110)	-6.999 (0.144)

Table 3: Total Danish trade

The underperformance of both Denmark and Sweden may be due to these countries' decision not to join the European Monetary Union in 1999. The poor aggregate trading performance of Denmark and Sweden is thus consistent with evidence in Saia (2017) who finds that Britain's (also a non-euro country) trade after the introduction of the Euro has performed similarly poorly (i.e. fallen short of the synthetic Britain which joined the eurozone).

In Tables 4 and 5, we produce Sweden's and Denmark's trade performance against individual country pairs in percentage terms. The corresponding evolution of the two countries actual and synthetic trade flows against all bilateral pairs are produced graphically for Sweden (Figure A1) and Denmark (Figure A2) in the Appendix. We note from Table 4 that for the post-Øresund period, Sweden's actual trade is below the synthetic trade against the majority of its bilateral trading relationships but there are important

exceptions. In fact, Sweden’s bilateral trade has overperformed against Germany and the Benelux (i.e. Belgium-Luxembourg and the Netherlands). This finding may be explained by the reduced road and rail transport costs facilitated by the Øresund Bridge especially for shorter distances. Put differently, this may represent evidence that the Øresund Bridge has facilitated easier access to geographically proximate European markets and supply chains. From Table 5 we observe a similar pattern for Sweden’s neighbour. Denmark has performed poorly against the majority of bilateral pairs yet its actual trade exceeds the synthetic counterpart for Norway. This may be due the land access the Øresund Bridge helped facilitate between the two countries. The Øresund effect seems to diminish with distance.

Diff actual vs synth.	AUT	BLX	CHE	DEU	ESP	FIN	FRA	GBR	GRC	IRL	ISL	ITA	NLD	NOR	PRT
1980-2000	-1.698 (0.052)	1.455 (0.032)	1.484 (0.061)	0.962 (0.011)	0.888 (0.031)	0.377 (0.034)	-0.162 (0.042)	1.080 (0.068)	-1.695 (0.036)	1.399 (0.042)	4.248 (0.098)	0.278 (0.028)	-0.851 (0.043)	2.556 (0.035)	3.213 (0.104)
2001-2015	-19.038 (0.173)	12.751 (0.831)	-48.268 (0.280)	9.730 (0.393)	-13.486 (0.382)	6.637 (0.450)	-19.253 (0.291)	-35.985 (0.156)	-33.446 (0.388)	-28.741 (0.418)	-39.723 (0.867)	2.787 (0.294)	0.652 (0.271)	0.745 (0.302)	-21.277 (0.307)

Table 4: Sweden against individual pairs

Diff actual vs synth.	AUT	BLX	CHE	DEU	ESP	FIN	FRA	GBR	GRC	IRL	ISL	ITA	NLD	NOR	PRT
1980-2000	-1.582 (0.040)	0.077 (0.038)	3.804 (0.057)	2.514 (0.015)	2.651 (0.018)	1.499 (0.041)	1.502 (0.022)	2.733 (0.040)	6.320 (0.046)	-0.132 (0.043)	5.559 (0.320)	2.551 (0.034)	-1.833 (0.029)	3.589 (0.025)	-2.893 (0.107)
2001-2015	-8.628 (0.243)	8.107 (0.435)	-35.028 (0.180)	-10.637 (0.124)	9.811 (0.153)	-13.313 (0.465)	-11.097 (0.286)	-31.815 (0.222)	-16.544 (0.236)	-20.358 (0.253)	-21.900 (0.267)	-6.549 (0.240)	17.014 (0.294)	5.400 (0.138)	-22.165 (0.182)

Table 5: Denmark against individual pairs

In tables A1 and A4 in the Appendix we report the average weights attached to the comparison units for, respectively, Denmark’s and Sweden’s synthetic models. For convenience, we reproduce the 28 weights used to construct the DNK-SWE synthetic model in Table 6, although we do not report units that received either zero or very small (or less than 0.001) average weight. In the last six columns of Table 6, we report specific characteristics of our counterfactual units. The third and fourth columns in the table are dummy variables indicating the type of border – land or maritime – within the bilateral country pair. After inspection of these columns it is clear that our synthetic algorithm has selected more bilateral pairs involving a maritime rather than a land border to produce the synthetic Danish-Swedish trading relationship. In fact, out of the seven bilateral pairs involving a maritime border in our sample, positive weights have been given to five. Out of the sixteen pairs identified as involving land borders, only two receive a positive weight and we also note that those weights are small (for example, the average weights given to BLX-DEU is 0.003 and for FRA-ITA it is 0.018). In the fifth column, labelled “maritime route only”, we report a dummy variable with a “Yes” value indicating that transportation of goods between the countries within the bilateral pair cannot be completed without crossing a maritime boundary for non-aviation freight.<sup>6</sup> Our synthetic algorithm systematically selects comparison units whose non-aviation freight involves a maritime crossing. Specifically, out of 57 maritime-route-only comparison units in our full sample, 22 are selected and therefore receive positive weight. Conversely, out of 48 bilateral pairs in which land routes are available in the full sample, only six receive positive weight. We also note from Table 6 that the four comparison units receiving the highest weights on average (FIN-GBR at 0.353, GBR-NOR at 0.191 and IRL-ISL at 0.150 and GBR-ITA at 0.119) either consist of countries sharing a maritime border (GBR-NOR) or have transportation routes

<sup>6</sup>We assume that a land route through the Baltic countries and Russia is not used for transportation of goods to and from, respectively, Sweden, Norway and Finland.

with maritime crossings (FIN-GBR, IRL-ISL, GBR-ITA). For a list of country-pairs that are non-adjacent or have a land or maritime border, the reader is referred to Table A3. We observe in the sixth column that there is no systematic relationship between the size of both countries in a bilateral country pair and whether or not the country pair, on average, receives positive weight in our synthetic algorithm. In fact, ten out of the 28 (35.7%) units selected involve country pairs where both countries are small (defined here as a country with a population less than 15m), whereas in our “donor pool” 44 out of 105 (41.9%) units involve two small countries. Moreover, the four comparison units which receive the largest average weights involve two bilateral pairs with one large country, one with two large countries and one with two small countries. The next column labelled “Non-EU before 1995” is a dummy variable indicating that at least one country in the country-pair was not a member of the European Union prior to 1995. In the full sample of comparison units, 57 of 105 (54.3%) bilateral pairs fulfill this criteria, yet out of the units receiving a positive weight in our synthetic algorithm, 18 of 28 (64.3%) involved one non-member. Apart from GBR-ITA, the comparison units receiving highest weight also involve at least one country which was not a member prior to 1995 (i.e. FIN-GBR, GBR-NOR and IRL-ISL). In the final column, we indicate country-pairs in which both countries adopted the euro currency in 1999 (or 2001 for Greece). While in the full sample of comparison units, 56 of 105 (53.3%) involve euro-pairs, only 10 of 28 (35.7%) of comparison units receiving a positive average weight involve bilateral pairs with two euro members. Moreover, none of the four country pairs with the largest weight involve two eurozone countries. Summarising our findings from Table 6, we find that our synthetic algorithm tends to select country-pairs either involving a maritime boundary or a maritime crossing; country-pairs with at least one country which was not a member of the EU prior to 1995; and non-eurozone pairs. The algorithm thus tends to select comparison units that possess characteristics that are similar to the DNK-SWE bilateral pair (i.e. Denmark and Sweden share a maritime border, Sweden joined the EU in 1995 and neither country are members of the eurozone).

Comparison unit	Average weight	Land border	Maritime border	Maritime route only	Both small	Non-EU before 1995	Both in Euro
AUT-FRA	0.001 (0.000)	No	No	No	No	Yes	Yes
BLX-CHE	0.026 (0.003)	No	No	No	Yes	Yes	No
BLX-DEU	0.003 (0.000)	Yes	No	No	No	No	Yes
BLX-FIN	0.062 (0.006)	No	No	Yes	Yes	Yes	Yes
BLX-GBR	0.005 (0.001)	No	Yes	Yes	No	No	No
BLX-NOR	0.008 (0.002)	No	No	Yes	Yes	Yes	No
CHE-GBR	0.050 (0.005)	No	No	Yes	No	No	No
DEU-FIN	0.027 (0.002)	No	No	Yes	No	Yes	Yes
DEU-GBR	0.006 (0.001)	No	Yes	Yes	No	No	No
DEU-NOR	0.010 (0.002)	No	No	Yes	No	Yes	No
ESP-ITA	0.006 (0.001)	No	Yes	No	No	No	Yes
FIN-FRA	0.002 (0.001)	No	No	Yes	No	Yes	Yes
FIN-GBR	0.353 (0.002)	No	No	Yes	No	Yes	No
FIN-IRL	0.003 (0.001)	No	No	Yes	Yes	Yes	Yes
FIN-ISL	0.023 (0.003)	No	No	Yes	Yes	Yes	No
FIN-ITA	0.030 (0.002)	No	No	Yes	No	Yes	Yes
FRA-GRC	0.006 (0.001)	No	No	No	No	No	Yes
FRA-ITA	0.018 (0.001)	Yes	No	No	No	No	Yes
GBR-ITA	0.119 (0.002)	No	No	Yes	No	No	No
GBR-NLD	0.026 (0.001)	No	Yes	Yes	No	No	No
GBR-NOR	0.191 (0.001)	No	Yes	Yes	No	Yes	No
GBR-PRT	0.022 (0.003)	No	No	Yes	No	No	No
IRL-ISL	0.150 (0.003)	No	No	Yes	Yes	Yes	No
ISL-NLD	0.002 (0.001)	No	No	Yes	Yes	Yes	No
ISL-NOR	0.004 (0.001)	No	No	Yes	Yes	Yes	No
ISL-PRT	0.010 (0.001)	No	No	Yes	Yes	Yes	No
ITA-NOR	0.028 (0.003)	No	No	Yes	No	Yes	No
NLD-NOR	0.012 (0.002)	No	No	Yes	Yes	Yes	No

Table 6: Weights in the DNK-SWE synthetic model

## 5 Discussion and robustness

As we noted in the previous section, the use of inferential techniques is limited within the standard application of the SCM. We addressed this issue by using the subsampling procedure described in Politis and Romano (1994) to construct standard errors and confidence intervals. In this section, we will conduct further sensitivity tests that are common in literature on SCM. First, we will analyse the sensitivity of our results to the choice of matching window. Our concern is that if we obtain a large Øresund effect in a year in which the intervention did not occur, we could not be as confident as to the validity of our result. This is a standard falsification test which is usually referred to a “placebo-in-time” test. Second, we construct synthetic controls for all of our comparison units in the “donor pool”. The motivation behind running these models is to test whether our comparison units have been subject to treatments. If we observe a similar treatment effect for a large number of comparison units in our “donor pool”, then there may not be anything unusual about the Danish-Swedish trading relationship post Øresund. Such a test is usually referred to as a “placebo-in-space” test. Third, we

apply standard panel data techniques such as fixed effects as a further robustness check.

## 5.1 Placebo-in-time

We construct a SCM for Danish-Swedish trade as in the last section, but setting the matching window from 1980-1994 with the intervention year in 1995,

$$\bar{\alpha}_{DNK-SWE,1995-2015} = \frac{1}{m} \sum_{j=1}^m \left[ \frac{\sum_{t=1995}^{2015} (BTF_{DNK-SWE,t}^I - \sum_{i=1}^n w_{i,j} BTF_{i,j,t})}{\sum_{t=1995}^{2015} \sum_{i=1}^n w_{i,j} BTF_{i,j,t}} \right]. \quad (9)$$

Since the Øresund Bridge was not opened until July 2000, the year 1995 is essentially a “false” date in which the intervention did not occur. If we obtain a similar result when we set the intervention to the “false” year we cannot be as confident that the increase in Danish-Swedish trade relative to its synthetic counterfactual which occurred in 2001 can be attributed to the Øresund Bridge. However, 1995 was also the year in which the construction of the Øresund Bridge began. As such, any positive difference between the actual and synthetic trade may be attributed to an “anticipation” effect, i.e. the anticipation that the Øresund Bridge may facilitate more trade between Denmark and Sweden at some point in the future. In Figure 3 we plot the actual Danish-Swedish bilateral trade (solid) line and its synthetic counterfactual (dashed line) over the period 1980-2015 with the intervention year in 1995 (as opposed to 2001 in Figure 1). We observe that our synthetic counterfactual provides a good fit of actual trade throughout our matching window, 1980-1994. We also note that actual and synthetic trade is very similar between 1995 and 2001, implying that in that period Danish-Swedish trade can be modelled using a weighted average of comparison units. However, actual and synthetic Danish-Swedish trade clearly diverge around the time the Øresund Bridge was opened. We report

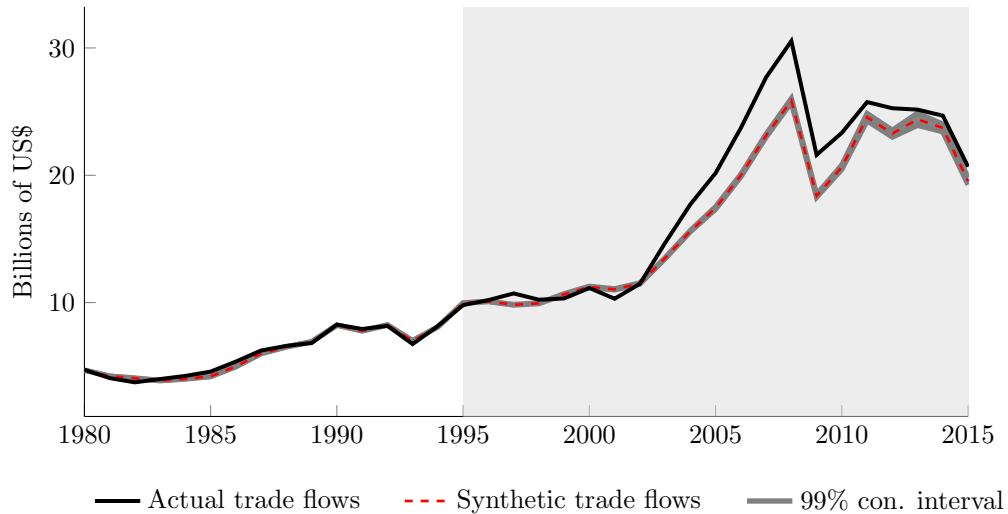


Figure 3: Bilateral trade flow between Denmark and Sweden vs the synthetic counterfactual with false treatment date 1995.

the results in percentages in Table 7. Using 1980-1994 as matching window, actual trade exceeds synthetic trade by 0.927% prior to the false intervention year. The aggregate effect in the entire ‘false’ post-Øresund period is 8.725%. However, we observe from the table that the percentage difference between actual and synthetic trade was 1.138% in 1995-2000, which may be indicative of a small pre-Øresund anticipation effect. The total Øresund effect from 2001-2015 using the shorter matching window is 10.326% which is smaller than

what we found when we used the entire pre-Øresund period as matching window. The results for 2001-2005, 2006-2010 and 2011-2015 are, respectively, 7.636%, 17.493% and 5.232%. Although these effects are smaller than when we used the full matching window, we find that the Øresund effect was largest in the period 2006-2010.

As such, although the matching window is set to the period 1980-1994, actual trade does not diverge from synthetic trade until around the time the Øresund Bridge opened. The fact that we cannot trace any noticeable departure of actual from synthetic trade between 1995 and 2001 is evidence against the notion that there were ‘anticipation’ effects of the bridge.

	1980-1994	1995-2015					
		1995-2015	2001-2015	1995-2000	2001-2005	2006-2010	2011-2015
Diff. actual vs synth.	0.927 (0.053)	8.725 (0.274)	10.326 (0.323)	1.138 (0.080)	7.636 (0.148)	17.493 (0.263)	5.232 (0.495)

Table 7: Danish Swedish bilateral trade with ‘false’ 1995 intervention year

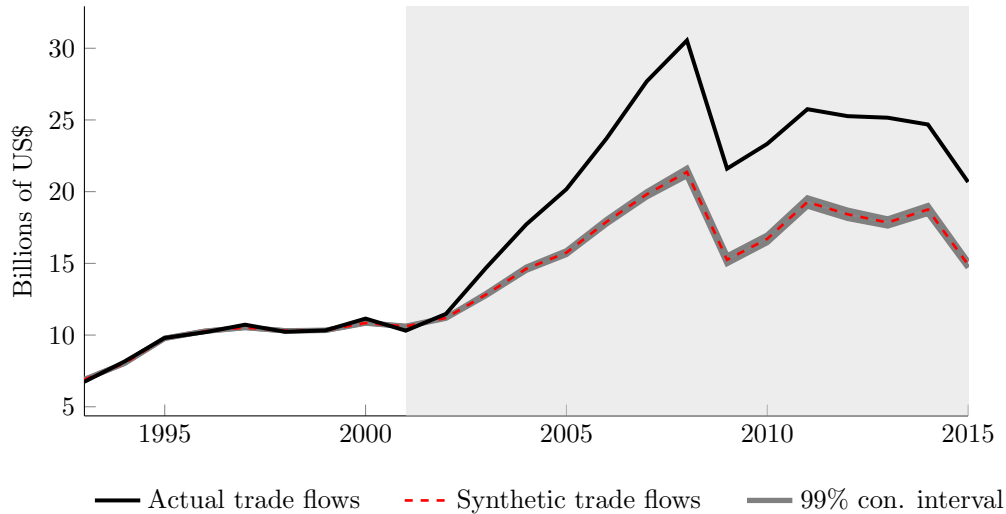


Figure 4: Bilateral trade flow between Denmark and Sweden vs the synthetic counterfactual over the period 1994-2008.

## 5.2 Placebo-in-space

The average weights applied to our comparison units in constructing our synthetic Danish-Swedish bilateral trade are reported in the last column in A1 and reproduced in the last column of A4 for exposition. Inspection of this column reveals that comparison units that receive positive average weights are mainly bilateral trading relationships relying on sea crossings for non-aviation freight. Indeed, 13 of 18 comparison units that receive positive average weight have no direct bilateral land-links, and 7 of 18 comparison units are bilateral trading pairs containing Ireland. We therefore conduct the following falsification test. We select the bilateral pair containing Ireland and the Netherlands and construct the corresponding synthetic counterfactual. There are similarities between this bilateral pair and that of Denmark and Sweden. Ireland and the Netherlands are small countries and their bilateral goods trade is inhibited by a sea border. We report our findings in Figure 5. Our synthetic model provides a good approximation of actual bilateral trade between the two countries

in the pre-treatment period as can be seen in the right panel of the figure. However, in the post-treatment period, actual bilateral trade performs poorly relative to synthetic trade from 2004 onwards. In the right panel we report aggregate Irish trade and its synthetic counterfactual. Our synthetic model provides a good approximation of Irish aggregate trade until 2006 onwards. Irish trade is particularly adverse impacted by the financial crisis erupting in 2007-2008 and the subsequent sovereign debt crisis.

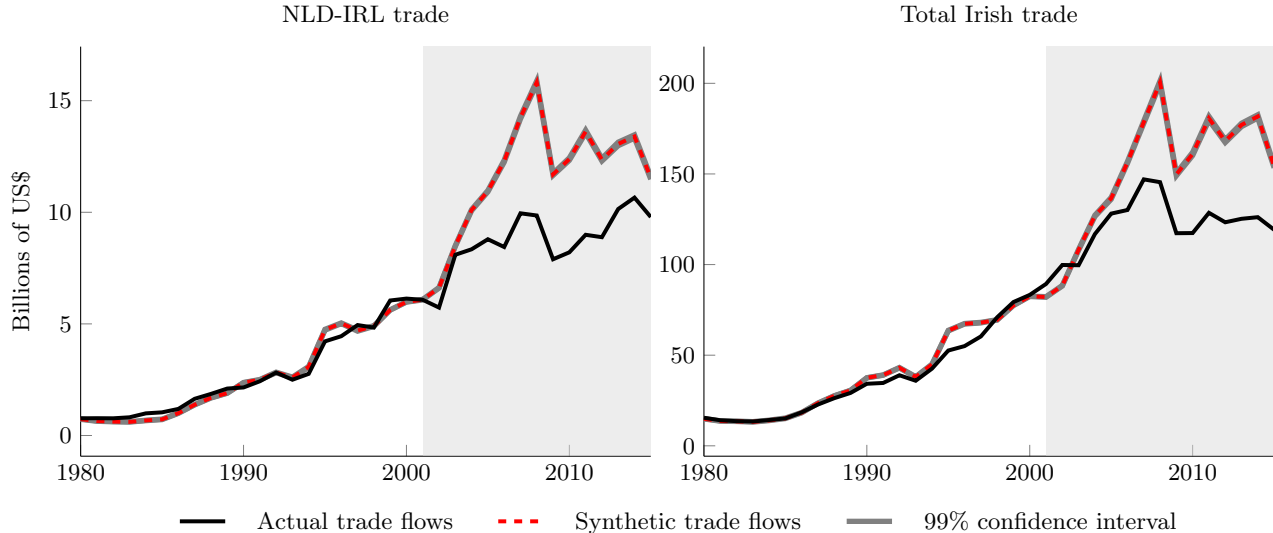


Figure 5: Dutch-Irish bilateral trade (left-panel) and total Irish trade (right-panel).

### 5.3 Standard econometric methodology

We supplement our SCM using a standard difference-in-differences estimator and a panel fixed effects estimator. Our difference-in-differences estimator regresses the log of exports on the following regressors:

$$\ln Exports_{ijt} = \beta_0 + \beta_1 \ln(GDP_{ijt} \times GDP_{ijt}) + \beta_2 Comcur_{ijt} + \beta_3 Contig_{ij} + \beta_4 Comlang_{ethno} + \beta_5 Distw_{ij} + \beta_6 Post_{oresund}_{ijt} + \beta_7 DNK_SWE + \beta_8 DNK_SWE_{post_{oresund}_{ijt}} + \epsilon_{ijt}. \quad (10)$$

$Comcur_{ijt}$  is a dummy variable equals one if the bilateral pair  $ij$  use a common currency;  $Contig_{ij}$  takes the value 1 if the pair shares a land border;  $Comlang_{ij}$  equals 1 if the pair share a common language spoken by 16% of their respective populations;  $Distw_{ij}$  is the distance in kilometres between the countries in the bilateral pair;  $Post_{oresund}_{ijt}$  takes the value 1 for the post-treatment period 2001-2015;  $DNK_SWE$  takes the value 1 for trade between Denmark and Sweden; and the interaction term  $DNK_SWE_{post_{oresund}}$  is 1 for Danish-Swedish trade post Øresund. We run this regression by OLS and report the results in Table 8 column (1). The coefficients on the product of the bilateral trading pairs' GDPs has the correct sign which is true of the remaining gravity variables. We are particularly interested in the coefficient on  $DNK_SWE_{post_{oresund}}$ . We note that this coefficient takes the value 0.8 and is significant at the 1% level. This coefficient estimate implies that Danish-Swedish Bilateral trade post Øresund rose by 122%. In column (2) we interact the Danish-Swedish dummy variable with 6 appropriate years chosen before the completion of the Øresund Bridge (1998, 1999, 2000) and after its completion (2001,2002, 2003). Inspection of column (2) shows that while all these interaction terms are positive, only post-Øresund coefficients are significant albeit at the 10%

level. We run the same regression by panel fixed effects in column (3) excluding time-invariant variables and find a positive and significant post-Øresund coefficient of 0.7 implying the Øresund Bridge resulted in a increase of trade of about 101%.

Table 8: Regression table

	(1)	(2)	(3)
$\ln GDP_i \times GDP_j$	0.779*** (0.090)	0.779*** (0.090)	0.778*** (0.090)
EU	0.134** (0.063)	0.134** (0.063)	0.137** (0.064)
Euro	0.153** (0.061)	0.153** (0.061)	0.152** (0.062)
DNK-SWE $\times$ post-Øresund 2001-2015	0.172** (0.066)		
DNK-SWE $\times$ post-Øresund 2001-2005		0.0884 (0.062)	0.0504 (0.075)
DNK-SWE $\times$ post-Øresund 2006-2010		0.277*** (0.069)	0.239*** (0.081)
DNK-SWE $\times$ post-Øresund 2011-2015		0.150** (0.070)	0.112 (0.082)
DNK-SWE $\times$ pre-Øresund 1996-2000			-0.151*** (0.057)
Observations	3816	3816	3816
$R^2$	0.887	0.887	0.888

Robust standard errors in parentheses

Year dummies not reported

\*  $p < 0.10$ , \*\*  $p < 0.05$ , \*\*\*  $p < 0.01$

## 6 Concluding remarks

In this paper we have examined the effect of the Øresund Bridge on bilateral goods trade between Denmark and Sweden. According to our benchmark model bilateral trade between the two countries is 44% higher than it would have been if the bridge had not been built. This finding is robust to a number of sensitivity checks.

The finding contributes to the literature on the effects on national borders on trade. The Øresund Bridge is a quasi-natural experiment involving a sea border which was effectively transformed into a land border. Our result can therefore guide researchers and policy-makers alike to the trade costs associated with sea crossings. In addition, given that the bridge is an example of a major infrastructure project it contributes to a growing literature which assesses their impact upon a range of economic variables. Our results are therefore likely to be relevant to other major infrastructure projects such as the planned bridge between Denmark and Germany and to any additional infrastructure linking the UK to continental Europe or the island of Ireland.

The result that integration between two countries was substantially deepened by linking them through



major infrastructure may lead researchers to analyse other economic outcomes that may have been affected. First, a consistent finding in the literature is that trade integration leads to higher business cycle synchronisation between nations. The sudden increase in trade we have documented in this paper might serve as a quasi-natural experiment for testing whether business cycles have become more synchronised between Denmark and Sweden. Second, It is likely that Foreign Direct Investment has been boosted or that the bridge has affected migration patterns beyond Malmö and Copenhagen. Finally, since this paper has restricted attention to aggregate bilateral trade, we have not been able to pick up the heterogeneity across products which is likely to exist. Further research may address some of these issues.

## References

- Abadie, A., Diamond, A., and Hainmueller, J. (2010). Synthetic Control Methods for Comparative Case Studies: Estimating the Effect of California’s Tobacco Control Program. *Journal of the American Statistical Association*, 105(490):493–505.
- Abadie, A., Diamond, A., and Hainmueller, J. (2015). Comparative Politics and the Synthetic Control Method. *American Journal of Political Science*, 59(2):495–510.
- Abadie, A. and Gardeazabal, J. (2003). The Economic Costs of Conflict: A Case Study of the Basque Country. *American Economic Review*, 93(1):113–132.
- Achten, S., Beyer, L., Dietrich, A.-M., Ebeling, D., Lessmann, C., and Steinkraus, A. (2019). Large scale infrastructure investment and economic performance – a case study of oresund. *Applied Economics Letters*, 26(1):21–26.
- Anderson, J. E. and van Wincoop, E. (2003). Gravity with Gravitas: A Solution to the Border Puzzle. *American Economic Review*, 93(1):170–192.
- Arnarson, B. T. (2015). Bridging Trade Barriers: Evaluating Models of Multi-Product Exporters. Working Papers 2015:6, Lund University, Department of Economics.
- Bernard, A. B., Moxnes, A., and Saito, Y. U. (2016). Production Networks, Geography and Firm Performance. CEP Discussion Papers dp1435, Centre for Economic Performance, LSE.
- Bougheas, S., Demetriades, P. O., and Morgenroth, E. L. (1999). Infrastructure, transport costs and trade. *Journal of International Economics*, 47(1):169 – 189.
- Chen, N. (2004). Intra-national versus international trade in the european union: why do national borders matter? *Journal of International Economics*, 63(1):93–118.
- Donaldson, D. (2018). Railroads of the raj: Estimating the impact of transportation infrastructure. *American Economic Review*, 108(4-5):899–934.
- Donaubauer, J., Glas, A., Meyer, B., and Nunnenkamp, P. (2018). Disentangling the impact of infrastructure on trade using a new index of infrastructure. *Review of World Economics (Weltwirtschaftliches Archiv)*, 154(4):745–784.
- Durantón, G., Morrow, P. M., and Turner, M. A. (2014). Roads and Trade: Evidence from the US. *The Review of Economic Studies*, 81(2):681–724.
- Evans, C. L. (2003). The Economic Significance of National Border Effects. *American Economic Review*, 93(4):1291–1312.
- Groizard, J., Marques, H., and Gallego Santana, M. (2014). Islands in trade: Disentangling distance from border effects. Economics Discussion Papers 2014-27, Kiel Institute for the World Economy (IfW).
- Head, K. and Mayer, T. (2000). Non-europe: The magnitude and causes of market fragmentation in the eu. *Review of World Economics (Weltwirtschaftliches Archiv)*, 136(2):284–314.
- Hummels, D. L. and Schaur, G. (2013). Time as a trade barrier. *American Economic Review*, 103(7):2935–2959.

- Knowles, R. D. (2006). Transport impacts of the Öresund (Copenhagen to Malmö) fixed link. *Geography*, 91(3):227–240.
- McCallum, J. (1995). National Borders Matter: Canada-U.S. Regional Trade Patterns. *American Economic Review*, 85(3):615–623.
- Novy, D. and Taylor, A. M. (2014). Trade and Uncertainty. NBER Working Papers 19941, National Bureau of Economic Research, Inc.
- Politis, D. N. and Romano, J. P. (1994). Large sample confidence regions based on subsamples under minimal assumptions. *The Annals of Statistics*, 22(4):2031–2050.
- Saia, A. (2017). Choosing the open sea: The cost to the UK of staying out of the euro. *Journal of International Economics*, 108:82–98.
- Tinbergen, J. (1962). *Shaping the World Economy*. New York: Twentieth Century Fund.
- Volpe Martincus, C. and Blyde, J. (2013). Shaky roads and trembling exports: Assessing the trade effects of domestic infrastructure using a natural experiment. *Journal of International Economics*, 90(1):148 – 161.
- Volpe Martincus, C., Carballo, J., Garcia, P., and Graziano, A. (2014). How do transport costs affect firms’ exports? evidence from a vanishing bridge. *Economics Letters*, 123(2):149–153.
- Åkerman, A. (2009). Trade, Reallocations and Productivity: A Bridge between Theory and Data in Öresund. Working Paper Series 795, Research Institute of Industrial Economics.

# Appendix

Figure A1: The evolution of Swedish actual and synthetic trade against individual bilateral pairs

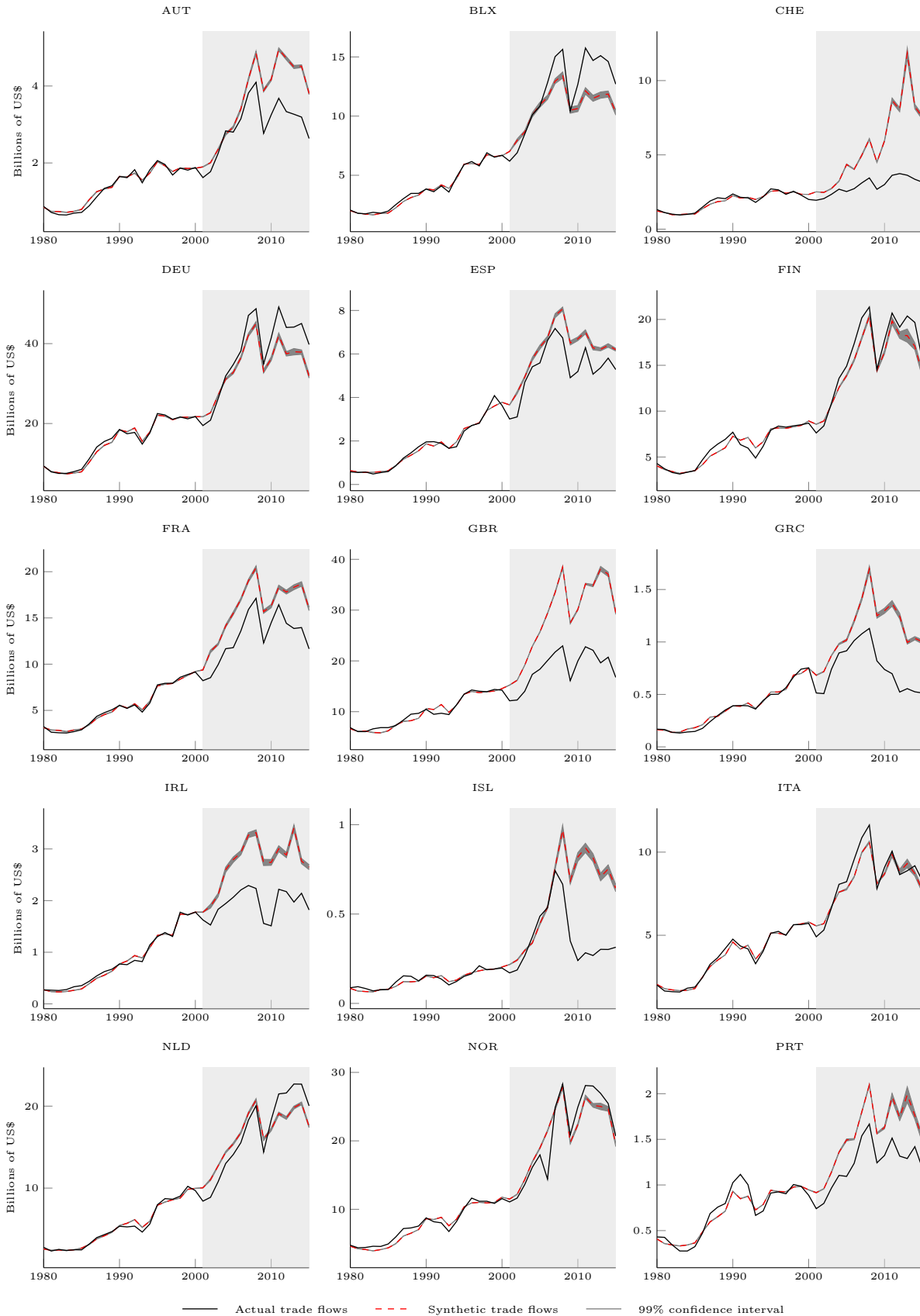
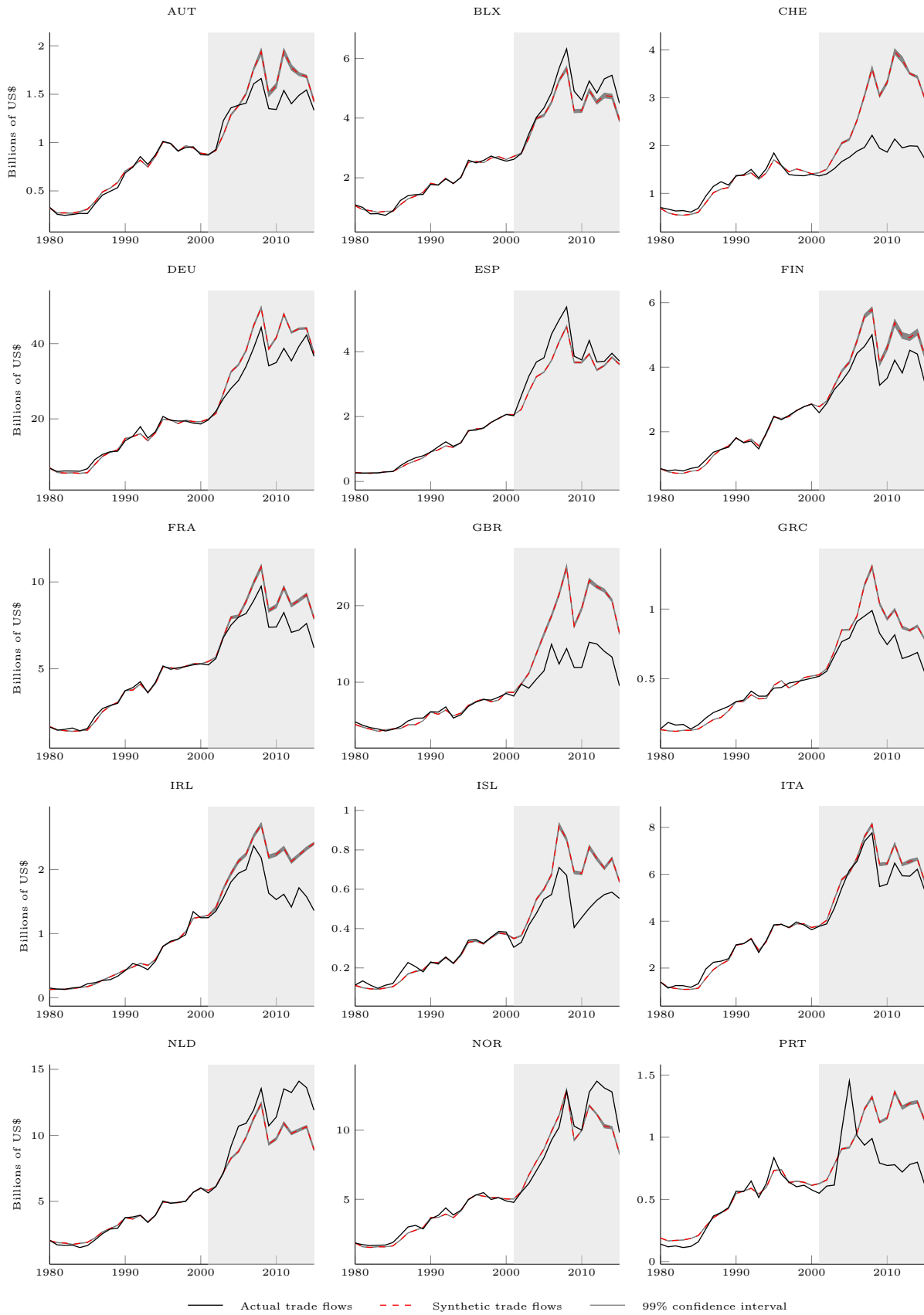


Figure A2: The evolution of Danish actual and synthetic trade against individual bilateral pairs







NLD-NOR	0.000 (0.000)	0.008 (0.001)	0.000 (0.000)	0.002 (0.000)	0.000 (0.000)	0.000 (0.000)	0.000 (0.000)	0.000 (0.000)	0.000 (0.000)	0.001 (0.000)	0.000 (0.000)	0.000 (0.000)	0.000 (0.000)	0.160 (0.004)	0.000 (0.000)	0.012 (0.002)
NLD-PRT	0.000 (0.000)	0.000 (0.000)	0.000 (0.000)	0.000 (0.000)	0.000 (0.000)	0.000 (0.000)	0.000 (0.000)	0.000 (0.000)	0.000 (0.000)	0.000 (0.000)	0.000 (0.000)	0.000 (0.000)	0.000 (0.000)	0.000 (0.000)	0.000 (0.000)	0.000 (0.000)
NOR-PRT	0.000 (0.000)	0.000 (0.000)	0.000 (0.000)	0.000 (0.000)	0.000 (0.000)	0.000 (0.000)	0.000 (0.000)	0.000 (0.000)	0.000 (0.000)	0.000 (0.000)	0.000 (0.000)	0.000 (0.000)	0.000 (0.000)	0.000 (0.000)	0.000 (0.000)	0.000 (0.000)



Table A2: Countries used in our dataset and their International Organization for Standardization (ISO) codes

Country	ISO code
Austria	AUT
Belgium-Luxembourg	BLX
Switzerland	CHE
Germany	DEU
Denmark	DNK
Spain	ESP
Finland	FIN
France	FRA
United Kingdom	GBR
Greece	GRC
Iceland	ISL
Ireland	IRL
Italy	ITA
Netherlands	NLD
Norway	NOR
Portugal	PRT
Sweden	SWE

Table A3: Bilateral boundary relationship

Non-adjacent	Land border	Maritime boundary
AUT-BLX	AUT-CHE	BLX-GBR
AUT-ESP	AUT-DEU	DEU-GBR
AUT-FIN	AUT-ITA	ESP-ITA
AUT-FRA	BLX-DEU	FRA-GBR
AUT-GBR	BLX-FRA	GBR-NLD
AUT-GRC	BLX-NLD	GBR-NOR
AUT-IRL	CHE-DEU	GRC-ITA
AUT-ISL	CHE-FRA	
AUT-NLD	CHE-ITA	
AUT-NOR	DEU-FRA	
AUT-PRT	DEU-NLD	
BLX-CHE	ESP-FRA	
BLX-ESP	ESP-PRT	
BLX-FIN	FIN-NOR	
BLX-GRC	FRA-ITA	
BLX-IRL	GBR-IRL	
BLX-ISL		
BLX-ITA		
BLX-NOR		
BLX-PRT		
CHE-ESP		
CHE-FIN		
CHE-GBR		
CHE-GRC		
CHE-IRL		
CHE-ISL		
CHE-NLD		
CHE-NOR		
CHE-PRT		
DEU-ESP		
DEU-FIN		
DEU-GRC		
DEU-IRL		
DEU-ISL		
DEU-ITA		
DEU-NOR		
DEU-PRT		
ESP-FIN		
ESP-GBR		
ESP-GRC		
ESP-IRL		
ESP-ISL		
ESP-NLD		
ESP-NOR		
FIN-FRA		
FIN-GBR		
FIN-GRC		
FIN-IRL		
FIN-ISL		
FIN-ITA		
FIN-NLD		
FIN-PRT		
FRA-GRC		
FRA-IRL		
FRA-ISL		
FRA-NLD		
FRA-NOR		
FRA-PRT		
GBR-GRC		
GBR-ISL		
GBR-ITA		
GBR-PRT		
GRC-IRL		
GRC-ISL		
GRC-NLD		
GRC-NOR		
GRC-PRT		
IRL-ISL		
IRL-ITA		
IRL-NLD		
IRL-NOR		
IRL-PRT		
ISL-ITA		
ISL-NLD		
ISL-NOR		
ISL-PRT		
ITA-NLD		
ITA-NOR		
ITA-PRT		
NLD-NOR		
NLD-PRT		
NOR-PRT		





NLD-NOR	0.000 (0.000)	0.000 (0.000)	0.000 (0.000)	0.000 (0.000)	0.000 (0.000)	0.000 (0.000)	0.001 (0.000)	0.000 (0.000)	0.000 (0.000)	0.000 (0.000)	0.003 (0.000)	0.000 (0.000)	0.000 (0.000)	0.029 (0.001)	0.000 (0.000)	0.012 (0.002)
NLD-PRT	0.000 (0.000)	0.000 (0.000)	0.000 (0.000)	0.000 (0.000)	0.013 (0.001)	0.000 (0.000)	0.004 (0.001)	0.000 (0.000)	0.000 (0.000)	0.000 (0.000)	0.000 (0.000)	0.000 (0.000)	0.001 (0.000)	0.000 (0.000)	0.000 (0.000)	0.000 (0.000)
NOR-PRT	0.000 (0.000)	0.000 (0.000)	0.000 (0.000)	0.000 (0.000)	0.000 (0.000)	0.000 (0.000)	0.000 (0.000)	0.000 (0.000)	0.000 (0.000)	0.000 (0.000)	0.000 (0.000)	0.000 (0.000)	0.000 (0.000)	0.000 (0.000)	0.000 (0.000)	0.000 (0.000)