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Trade Effects of Monetary Non-Integration: Evidence from Denmark

By

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Abstract

This study examines the impact of monetary non-integration on trade flows, specifically focusing on Denmark and how Danish trade with the founding members of the Eurozone would have developed if Denmark would have adopted the Euro in 1999. We turn to the Synthetic Control Method (SCM) to create a synthetic Denmark that adopted the Euro in 1999 and find significant negative effects for Danish trade. While Danish exports are 3% lower, Danish imports are 18% lower than what they could have been had Denmark introduced the Euro in 1999, resulting in a treatment effect of -12% for bilateral trade with the Eurozone members. Lastly, our results are robust to various robustness checks, with the Difference-in-Differences estimates suggesting a higher treatment effect of monetary non-integration.

Keywords: *Denmark, Eurozone, Trade, Synthetic Control Method, Monetary Integration*

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1 Introduction

The path toward monetary integration in Europe has been a challenging and contentious process. Despite significant efforts, progress across the continent has been uneven, with countries adopting the unified monetary policy and common currency to differing extents. Denmark is one such country which has chosen to retain its own national currency, the Danish Krone, having negotiated an opt-out clause for eventually adopting the Euro as part of the Maastricht Treaty in 1992 (Delivorias, 2015).

The Krone is not operational in isolation, however, and has been operating under a fixed exchange rate regime since 1982; first to the Deutsche Mark (D-Mark), and then to the Euro upon its introduction in 1999 (Spange and Toftdahl, 2014). In this, the Krone is allowed to fluctuate against the Euro, but only within the boundaries of a strict band – in the instance that the Krone deviates from this narrow fixed exchange rate regime, both the Danish Central Bank (Danmarks Nationalbank) and the European Central Bank (ECB) are obliged to intervene (Danmarks Nationalbank, 2010; Czech National Bank, n.d). As the ECB maintains a balance sheet substantially larger than the total circulating supply of Danish Krone, should the Krone weaken to the bottom of its bilateral band, the ECB would simply sell Euro in exchange for Krone. Given the substantial resources at its disposal, there are effectively no constraints on the ECB's capacity to intervene (Eichengreen, 2023). Belief in this shared commitment by both the ECB and Danmarks Nationalbank to uphold the fixed exchange rate ultimately limits, not just the immediate risk of volatility, but also the overall expectation of it (Eichengreen, 2023; Spange and Toftdahl, 2014).

In effect, this has allowed Denmark to retain official monetary independence whilst also mitigating against exchange rate volatility and investment risk – two potentially significant impediments to trade[1], the prevention of which is often cited as the central advantage of currency unions in the first place (Mundell, 1961; Santos Silva and

[1]Price stability, and the effective management of inflation expectations is the explicitly stated and mandated purpose of Denmark's fixed exchange rate scheme. Any potential or existing trade effects seen as a result of its implementation are a consequence rather than intention (Denmarks Nationalbank, 2010).

Tenreyro, 2010)[2]. This fixed exchange rate regime, however, blurs the lines between sovereignty and independence; Denmark has still, in effect, surrendered its autonomous monetary policy – acquiescing in its responsibilities concerning price stability to the authority of the ECB. If Krone-to-Euro exchange is then, under this regime, not impacted by the same risk or potential inconveniences as between other, non-pegged currencies, what is the implication of this hybrid status on trade? This is the primary question which we aim to investigate as part of this thesis. Is a fixed exchange rate a substitute for actually joining a currency union in terms of trade integration? If this happens not to be the case, what can we say then as to the specific trade effects of Denmark's choice towards monetary non-integration?

To answer this question, we employ use of the Synthetic Control Method (SCM); studying the potential effect of Eurozone membership on Danish–EMU[3] trade had Denmark adopted the Euro in 1999. The SCM allows researcher to construct a counterfactual of the treated unit, therefore being able to quantify the effect of a treatment (Abadie, 2021). In our specific case, we construct a counterfactual Denmark which was not subject to the treatment of monetary non-integration. In this, we expand upon an existing body of literature examining the effects of currency unions and monetary non-integration. Similarly, Alessandro Saia (2017) looks at the effects of the United Kingdom's choice to retain the Pound Sterling, finding significant costs of approximately -16% to potential trade flows with the EMU in opting to do so. In contrast to the Danish Krone, the Pound Sterling is not pegged to the Euro and is allowed to fluctuate freely, leading to the existence of exchange rate risk for trade flows between the two currency areas.

Theoretically, we would expect our results to be contrary to Saia (2017), finding no significant trade effect for Denmark; as outlined, currency unions serve to harmonise

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[2] Mundell specifically points to the lowered transaction costs and greater predictability of relative prices due to the elimination of currency conversion costs and nominal exchange rate fluctuations as the central mechanism through which trade is encouraged. It is worth noting that in a fixed exchange rate scheme the latter is eliminated, however, the former is clearly not.

[3] EMU (European Monetary Union) refers in this case, and throughout our paper, to the original 11 founding states who initially adopted the Euro in 1999. That is Germany, Italy, Belgium, The Netherlands, Spain, Finland, Luxembourg, Austria, France, Portugal and Ireland.

member-economies, minimising barriers to trade and bolstering overall integration. Within a currency union, countries may eliminate the uncertainties of fluctuating exchange rates, fostering a stable and integrated economic environment, which is conducive to growth, trade, and overall collaboration (Spange and Toftdahl, 2014). In effect, Denmark has been able to do this without joining a currency union by keeping its currency successfully fixed against the Euro (Eichengreen, 2023). If exchange rate volatility is the primary impediment to inter-currency trade, and Denmark-to-EMU trade has eliminated this risk[4], would we then expect to see any difference had Denmark joined the Euro? We find a notable gap in the literature examining the long-term trade impacts of a country aligned with, but not fully integrated into, a currency union. Denmark is a compelling case, in this sense, due to the potential of non-integration costs incurred whilst also retaining a successful, stable peg. The costs to monetary non-integration in the case of Denmark, should we find them, are then not tied to exchange rate volatility but rather some other broader implication of remaining outside a union.

By using the SCM, also employed by Saia (2017), we can effectively compare Denmark's true trade flows against a counterfactual scenario in which Denmark is a full Eurozone member; although counterfactual trends can definitionally not be proven, this methodology quantitatively and robustly assesses the trade-offs involved in its non-integration strategy. Our findings aim to enrich the current body of research by examining the influence of monetary non-integration on trade, as well as the further trade implications of pegged currency schemes; overall, providing a comprehensive overview of the potential pathways and policies that countries like Denmark can adopt in navigating their relationships with larger monetary unions.

It is additionally worth noting that in terms of 2023 GDP, the 11 founding member states of the Eurozone account for 81% of total EU GDP and hence play an important role in European trade. The nine countries that have joined after 1999 account for just

[4] Naturally, a currency peg is only as good as the faith vested in its stability; volatility is ultimately non-escapable. In this case, however, the Krone's fixed exchange rate regime has been remarkably stable over the past 42 years. Though the potential for exchange rate volatility remains, as shown by Sweden's exit from its own pegged scheme in 1992, it is a reasonable assumption to state that this risk is, as of writing, more or less negligible.

4% of EU GDP on the other hand and are therefore unlikely to substantially impact Danish trade (Eurostat, 2024). This highlights the fact that by focusing on the 11 founding members we are able to capture most of intra currency union trade flows in terms of trade values. If trade flows between Denmark and these 11 founding members would have increased under the Euro, our research would show that exchange rate volatility is not a main impediment to trade and fixing the exchange rate is not a substitute to actually adopting the Euro. This would then contradict the existing theory about exchange rate volatility and trade flows.

Our findings do, in fact, show this contradiction. Our main analysis reveals that Danish trade with the initial Eurozone members is 12% smaller than what it could have been under full monetary integration between 1999 and 2015, effects seen most significantly in import flows from these countries. Additionally, our Difference-in-Differences (DiD) estimates support these findings, showing a more pronounced effect of approximately 14% on overall trade between Denmark and EMU countries. Additional robustness checks, including in-time and in-space placebo tests as well as synthetic difference-in-differences estimators, serve to further validate our SCM approach. Concerning the difference between imports and exports, it is worth noting that while imports flow in and exports flow out, this is not the sole distinction between the two. In the Danish case, there is considerable heterogeneity between bundles of goods which are imported, and which are exported (OEC World, 2022; Statistics Denmark, 2024). It is likely then that the differences we find here in respective synthetic trade flows is related, not to potential heterogenous directional effects of currency union membership on trade, but rather this inherent difference in goods. Overall, our results are clear and robust, and provide new insight into the associated impact of monetary non-integration on trade.

The paper is structured as follows. Chapter 2 provides relevant background to the history of monetary integration in Europe, as well as how Denmark fits into this broader picture. Chapter 3 frames the theoretical foundations of currency areas and trade, with Chapter 4 outlining previous findings on this topic. Chapter 5 provides a detailed overview of our empirical strategy. In turn, results are analysed in Chapter 6, along

with a description of the various checks for robustness provided in Chapter 7. Chapter 8 concludes our thesis.

2 Background

2.1 European (Monetary) Integration

Predicated on the principle that international economic activities should be facilitated through free trade and stable exchange rates, the signing of the Bretton Woods Agreement marked the first stage of modern monetary integration in Europe (Chang, 2010) as highlighted in Table 1. Under the Bretton Woods system, countries were required to guarantee the convertibility of their currencies to the U.S. dollar within 1% of fixed parity rates, whereby the dollar would be pegged to gold at a rate of $35 per ounce. The agreement, although signed in 1944, was not immediately operational; due to post-World War II economic conditions, many currencies remained non-convertible and trade was largely limited to non-transferable bilateral credit agreements between countries.

Table 1: Major Milestones of Monetary Integration

European Monetary Integration	
1944	Bretton-Woods Agreement
1948	Organisation for European Economic Cooperation (OEEC)
1950	European Payments Union (EPU)
1957	Treaty of Rome
1962	Marjolin Memorandum
1971	US stop gold convertibility of the US-Dollar
1972	Basel Agreement
1979	European Monetary System (EMS)
1992	Signing of Maastricht Treaty
1999	Euro introduction as digital currency in 11 member states
2002	Euro banknotes introduced

To oversee Marshall Plan aid distribution and to address these issues, the Organisation for European Economic Cooperation (OEEC) and the European Payments Union (EPU) were established in 1948 and 1950, respectively. In 1957, upon ratification of the Treaty of Rome, currency convertibility was fully reinstated, and the European Monetary Agreement was put into place. This agreement established a European Fund and a Multilateral System of Settlements to support member states with balance of payments challenges and to streamline transaction settlements amongst them (Delivorias, 2015). Moreover, the Treaty established the European Economic Community (EEC) and European Atomic Energy Community (Euratom), with aims of implementing a common market and customs union. Despite only modest initiatives for monetary integration at this point, the 1962 Marjolin Memorandum spurred initial discussions on a shared currency and further monetary cooperation, and, as the U.S. began to encounter balance of payment difficulties, doubts about the Dollar's stability and the overall integrity of the international monetary system, as defined by Bretton Woods, began to emerge (Delivorias, 2015).

In 1968-69, this growing financial market volatility led ultimately to the revaluation of the D-Mark and the devaluation of the French franc, jeopardising the Common Agricultural Policy's (CAP) unified pricing system, and adversely affecting both intra-Community and global trade of the member states. In response, European leaders called on the Council to formulate a strategy for deeper monetary integration. The Werner Report, issued in 1970, proposed a three-stage process aimed at achieving economic and monetary union within the decade. This plan assumed stable exchange rates relative to the US dollar, a premise that was invalidated when the US suspended gold convertibility of the dollar in August 1971. Due to mounting pressure from the United States, the Werner plan was never fully realised, its principles however, laid the groundwork for subsequent monetary integration efforts (Delivorias, 2015).

Following the Smithsonian Agreement in 1971, the dollar underwent an 8.6% devaluation, resulting in the appreciation of major currencies such as the franc and D-Mark, and subsequently, the setting of exchange rate fluctuation margin against the dollar at +/− 2.25% (Humpage, 2013). The potential of a 4.5% spread among EEC

nations posed considerable risk to the stability of policies such as the CAP; to mitigate against these issues, EEC member states turned attention inwards, ultimately deciding to reduce reliance on the dollar and narrow the currency fluctuation margins within the Community itself.

In 1972, the EEC central-bank governors signed the Basel Agreement, initiating the 'snake in the tunnel' mechanism, which allowed Member States' currencies to fluctuate within narrow limits (bilateral margins between currencies were limited to 1.125%, implying a maximum spread of 2.5% across the Community). Initially, France, Germany, Italy, Luxembourg, and the Netherlands participated, followed soon by Denmark, Norway, and the United Kingdom. Short-lived, the snake lasted only a year – asymmetric effects of the 1973 oil crisis triggered asymmetric responses, and ultimately, total departure from the scheme – however, efforts for currency stability persisted. In 1977, Roy Jenkins, then President of the European Commission, proposed a new monetary union; initially met with scepticism, a more feasible vision soon developed, and, with the support of French President Valery Giscard d'Estaing and German Chancellor Helmut Schmidt, the European Monetary System (EMS) was launched in March 1979 (Delivorias, 2015). With eight original participating states – including Denmark – the EMS introduced the European Currency Unit (ECU), a basket of 12 national currencies, as well as established the Exchange Rate Mechanism (ERM), which set exchange rates towards the ECU for each currency, with additional mechanisms to prevent significant rate deviations.

The initial years of the EMS saw modest outcomes, however, a significant shift occurred in 1983 when the French government adopted a 'franc fort policy', aligning French monetary policy with that of Germany by using the currency exchange rate as an inflation anchor. This alignment under the EMS enabled France and other inflation-prone countries to significantly reduce inflation rates and converge their interest rates to lower levels. Signed in 1986, the Single European Act led to the completion of the single market, further underscoring the need for a unified currency due to the complexity and costs associated with multiple currencies and fluctuating exchange rates (Delivorias, 2015). In response, France and Italy championed stronger European

cooperation, prompting the European Council, in 1988, to establish a committee defining the three-stage process for achieving Economic and Monetary Union (EMU). The Madrid European Council in June 1989 agreed to initiate the first stage of EMU by July 1990, and by December 1991, the fall of the Berlin Wall had created a favourable political climate for the approval of the Maastricht Treaty, signed in 1992. By establishing the three-pillar structure comprising the European Communities, Common Foreign and Security Policy (CFSP) and Justice and Home Affairs (JHI), as well as introducing European Citizenship, the Maastricht treaty laid the way for the modern European Union (Delivorias, 2015). Importantly, Maastricht also introduced convergence criteria for countries wishing to adopt the Euro, including limits on inflation, government budget deficits, debt levels, exchange rate stability, and long-term interest rates. The setting of these criteria ensured that countries joining the monetary union would have stable economies and was a crucial step in the establishment of the single currency (Delivorias, 2015).

The early 1990's also saw a currency crisis, leading to a temporary expansion of the Exchange Rate Mechanism (ERM) margins in August 1993 to stabilise currencies. The Cannes European Council in June 1995 set 1999 as the start date for the EMU, and the new currency was named the 'Euro' by the Madrid European Council later that year. Amid growing scepticism, particularly in economically strong countries like Germany, the Stability and Growth Pact was introduced in December 1996 to balance fiscal discipline with economic growth, followed by a resolution in June 1997 to implement the ERM II by 1999. Countries participating in ERM II would be required to maintain their currencies within a narrow fluctuation margin of 15% around a central rate against the Euro without any major deviations. As part of this, participation in the ERM II ensured close coordination between national central banks and the ECB – necessarily aligning the distinct and varied monetary policies of Europe's central banks with the broader goals of the EU (Backé et al., 2004). By May 1998, 11 Member States met the euro convergence criteria, and by July 2000, Greece also qualified. The euro was introduced as a digital currency on January 1st, 1999, and became legal tender on

January 1st, 2002, with the eurozone expanding to include 20 countries by 2023 (Eurostat, 2024).

2.2 The Danish Case

In the 1970s and early 1980s Denmark faced serious economic challenges as inflation was rising, the government showed massive budget deficits and unemployment was at around 10 percent. Yields on log-term Danish government debt were hovering around 20 percent and real interest rate was in the double-digits. Even though Denmark was part of the European exchange rate mechanism (ERM) with partly fixed exchange rates from 1979 on, as shown in Table 2, it still devaluated its currency. Galvanised by soaring Danish current-account deficits, several policies were put forward to stabilise the Danish economy (Danmarks Nationalbank, 2010).

In 1982 the Danish Central Bank (Danmarks Nationalbank) stopped the devaluation of the Krone and installed a fixed exchange rate policy. The policy entailed an exchange rate regime where the Danish Krone was kept stable vis-à-vis the D-Mark. In doing so, interest rates dropped sharply due to positive expectations what again led to increasing current account deficits. Subsequently, further fiscal policies were put in place enforcing austerity measures on the public budget. After years of economic turmoil, the Danish economy recovered and exhibited a current account surplus for the first time in over 25 years in 1990. The policies of the 1980s were seen as the cornerstone of economic recovery in Denmark. The following years were characterized by a sequence of currency crises in Europe caused by political events and speculators which put a heavy strain on the ERM (Danmarks Nationalbank, 2010).

As the original Maastricht Treaty was not ratified by the Danish electorate, the Edinburgh Agreement from 1992 granted Denmark four exceptions to the Maastricht Treaty so that it could be ratified by the Danish public. One of the key exceptions was that Denmark would not be obliged to adopt the Euro (EUR-Lex, 2006). With the start of the Euro in January 1999 the ERM II was launched as the successor of the original ERM. As Denmark did not plan to join the Eurozone from the beginning, it participated in the ERM II and started keeping its exchange rate against the Euro in

a 2.25 percent corridor around 7.46038 Krone to the Euro. In 2000, the Danish government called for a referendum to decide whether Denmark should join the Eurozone starting in 2002. Danmarks Nationalbank held the view that it would be beneficial for Denmark to join the Euro as a fixed exchange rate regime meant outsourcing monetary policy to the European Central Bank (ECB) while not being able to participate in the decision making (Danmarks Nationalbank, 2010).

However, in September 2000 the Danish electorate decided in favour of the Danish Krone and against the introduction of the Euro. While 53% of the voters voted against the Euro, 43% were in favour of the common European currency. The left map in figure A.1 in the appendix depicts the voting outcomes for the different regions in Denmark and shows only minor deviations in pro Euro voting behaviour (Cho and Wong, 2021). The figure on the right-hand side maps real GDP per capita measured in constant 2015 Euros. While the Capital Region including Copenhagen has by far the highest GDP per capita compared to Zealand and the western regions, the voting outcomes seem to not have been influenced by economic prosperity. Southern Denmark, which has close economic ties with Germany, one of the first countries to adopt the euro, did not vote in favour of introducing the Euro either (Cho and Wong, 2021). Jupille and Lanberg (2007) study the determinants of voting behaviour over the adoption of the Euro in Denmark and Sweden. Like Denmark, the Swedish electorate decided on a potential introduction of the Euro in a national referendum in 2003. The authors find that while in Denmark voters were mostly concerned about sovereignty and national identity issues such as giving up their own national currency and handing over power to a supranational organisation, Swedish voters were not only driven by political factors but also by economic ones such as giving up independent monetary policy and the floating exchange rate regime.

To this day Denmark is still part of the ERM II and has successfully kept its currency in the above-mentioned fluctuation band around the Euro with no further plans to introduce the Euro at any time soon. Alongside Denmark in the ERM II is Bulgaria which plans to adopt the Euro in the near future (ECB, 2020).

Table 2: Monetary History of Denmark

Danish Monetary History	
1979	Participation in European Exchange Rate Mechanism (ERM)
1982	Danish Krone pegged to the Deutsche Mark
1992	Approval of the Maastricht Treaty with exceptions
1999	Denmark part of the Exchange Rate Mechanism II (ERM II)
2000	National referendum rejects introduction of the Euro
1999–2024	Successful Danish Krone/Euro fixed exchange rate

2.3 The Eurozone Today

While the Eurozone initially started with eleven member states, it has significantly expanded since then as all members of the EU, except Denmark, are obliged to adopt the Euro once they meet the convergence criteria. As of 2024, 20 countries have adopted the Euro. Following the eleven founding states in 1999, Greece joined in 2001, Slovenia in 2007, Cyprus and Malta in 2008, Slovakia in 2009, Estonia in 2011, Latvia in 2014, Lithuania in 2015, and Croatia in 2023 (ECB, n.d.). Another six member states of the European Union are obliged to adopt the Euro once they meet the convergence criteria, namely Bulgaria, the Czech Republic, Hungary, Poland, Romania and Sweden[5]. As to date only Bulgaria is part of the ERM II beside Denmark and plans to introduce the Euro in the near future. Furthermore, with Andorra, Monaco, San Marino and Vatican City there are several countries that have adopted the Euro as their official currency while not being a member state of the European Union. Kosovo and Montenegro also use the Euro as their national currency, however, without any formal arrangement. In total more than 350 million people use the Euro as their legal tender today (ECB, n.d.).

[5] Sweden does currently meet four out of five convergence criteria, however, although not explicitly opting out like Denmark and the UK, in choosing not to join the ERM II (a further prerequisite for adopting the euro) Sweden has effectively been able to delay euro adoption. As of writing, there is no clear indication that Sweden will join the Eurozone anytime soon, with public and political sentiment playing a crucial role in this decision.

Furthermore, the Eurozone has been subject of intense political debates and discussions during the great financial crisis in 2008 and the following European sovereign debt crisis as the ECB had to resort to unconventional monetary policies in order to stabilise the Eurozone. This, however, is a separate topic and not subject of the present paper.

Just falling short to the US-Dollar, the Euro is the second most important currency in the international monetary system. In 2022, 20.5% of global official holdings of foreign exchange reserves were held in Euros and when measured at constant exchange rates, the Euro recorded a share of 38% in foreign exchange settlements (ECB 2023). Furthermore, the Euro is an important invoicing or settlement currency for Euro members when trading with countries outside the Eurozone. In 2022, 59% of exports leaving the Euro area where invoiced in Euro, and 52% of Euro area imports (ECB, 2023).

3 Theory of Currency Unions, Exchange Rate Volatility and Trade

Deliberations about the optimal number of currencies go back as far as the nineteenth century. Internationalist economists like John Stuart Mill were arguing for the abolition of national currencies and the instalment of one single world currency as they were concerned about the overall transaction costs associated with a variety of different currencies. Mill (1894) went as far as saying that

> "... so much of barbarism, however, still remains in the transactions of most civilised nations, that almost all independent countries choose to assert their nationality by having, to their own inconvenience and that of their neighbours, a peculiar currency of their own."

Over half a century later, the discussion was picked up by Robert Mundell who laid the theoretical foundation for the optimal currency area, rejecting the idea of a world currency however, as "the optimum currency area is not the world" (Mundell, 1961).

For Mundell (1961) there are two main benefits of joining a currency union. First, agreeing on a single currency eliminates transaction costs when exchanging different currencies and further the risks associated with exchange rate volatility. (Mundell, 1961; Ethier, 1973). This leads to reduced volatility in relative prices and enhanced economic integration. Furthermore, exchange rates for large currency unions are less likely to be affected by single speculators what reduces the risk of volatile exchange rates. This helps to build up trust in the currency and increases the use of the currency as a medium of exchange and trade overall. (Mundell, 1961; Santos Silva and Tenreyro, 2010).

Secondly, forming a currency union usually means transferring power from a national to a supranational organization which oversees the monetary policy of the currency area. Less political influence helps for a trustworthy commitment to monetary rules and the instalment of policies that are appropriate to combat inflation (Mundell, 1961; Santos Silva and Tenreyro, 2010). On the flipside, however, joining a currency union removes the opportunity for each member state to conduct monetary policy tailored to their specific needs and is often brought up as one of the main arguments against joining a currency union.

Exchange rate volatility is the main driver for exchange rate risk and does therefore impact international trade flows. The fundamental mechanism through which exchange rate volatility affects cross-border trade is invoicing and time-displaced contract closing and payment (Hooper and Kohlhagen, 1978; Ozturk, 2006). If a company agrees on a deal with a company in another country who uses a different currency an exchange rate is agreed on at the time of the contract closing. As shipment and delivery of the goods as well as the subsequent payment happen at a later stage, there is the risk that the exchange rate fluctuates, and future profits are not predictable. This reduces the benefit of international trade for companies and can therefore reduce overall cross-border trade between different currency areas. Financial markets offer the possibility to hedge against these future exchange rate fluctuations by securing a future exchange rate today what helps to increase the predictability of future profits. However, hedging comes with costs and limitations and is often not accessible for all companies. Limitations are

especially that "the size of the contracts is generally large, the maturity is relatively short, and it is difficult to plan the magnitude and timing of all international transactions to take advantage of the forward market" (Ozturk, 2006). Furthermore, Ozturk (2006) offers a comprehensive literature review of studies published since 1978 and concludes that most studies agree that exchange rate volatility negatively affects international trade. Klein and Shambaugh (2006) study the theoretical argument of trade promotion through fixed exchange rates and find empirical evidence that pegging a currency increases trade between the base country of the peg and the country that pegs its currency. They conclude that "countries hoping to expand trade may choose the less restrictive and permanent fixed rate as opposed to a currency union. In addition, countries already pegged may have already captured some of the gains of increased trade that appear available from creating a currency union" (Klein and Shambaugh, 2006). On the other hand, Bacchetta and van Wincoop (2002) use a general-equilibrium framework to study the effect of exchange rate stability on trade and welfare. Their analysis shows that there is no clear evidence for increased trade and welfare under a fixed exchange rate regime. While there is some heterogeneity in the literature regarding fixed exchange rates and its impact on trade, there are overall clear indications that fixing the exchange rate can have positive impacts on trade. As Denmark has successfully kept its exchange rate stable in the last decades, first against the D-Mark and then against the Euro, the theory and literature suggest that trade between Denmark and the EMU would not have increased substantially had Denmark joined the Euro in 1999.

Mundell (1961) further expands on his theory and specifies several optimum currency area (OCA) criteria which define a set of countries for which is it optimal to use one single common currency instead of individual national currencies. First, the reaction to shocks in different countries is crucial for the optimal size of the currency union. If the economy of a country moves in sync with that of the other members, common monetary policy is suitable to restore a state of equilibria in all participating countries (Mundell, 1961; Santos Silva and Tenreyro, 2010). Second, Mundell referred to factor mobility as a cornerstone for a successful currency union. If one country in

the union experiences a downturn while another a boom, unemployed workers can move from one region to another, restoring the equilibrium without the need of monetary policy interventions. Third, McKinnon (1963) builds upon Mundell (1961) and argues that the size as well as the openness of a country's economy decide whether a country should join the currency union or not. A small open economy is not able to effectively influence its real exchange rate by market interventions and therefore giving up the possibility of independent monetary policy is not a big loss (McKinnon, 1963; Santos Silva and Tenreyro, 2010). Fourth, Kenen (1969) extended the OCA criteria by introducing product diversification in domestic production and exports. A well-diversified export sector is less prone to transmit shocks into the economy, and further supports to stabilise investments. Fifth, Mundell (1961) points out the flexibility of wages and prices as an important OCA criterion. Last, Kenen (1969) shows that intra union fiscal transfers help to mitigate the impact of shocks for countries. Instead of using monetary policy to face economic disturbances, fiscal policy is used to counteract negative effects.

When the introduction of the EMU was looming in the early 1990s, economists started to assess to which extent the Eurozone would fulfill the OCA criteria. Several well-regarded economists argued that the Eurozone did indeed not meet the OCA criteria and would be prone to imbalances and crises (Aizenman, 2018).

4 Literature Review

A seminal paper examining the effect of currency unions on trade is 'One money, one market' (Rose et al., 2000). In this, the authors assess whether countries that share a common currency have larger trade engagement with one-another than with countries which they do not; the logic here being that presence of a common currency reduces transaction cost as well as exchange rate uncertainty, thus boosting trade. To do this, Rose expands the traditional gravity model to include a dummy variable indicating whether a pair of countries share a common currency, applying it to data covering over 200 countries from 1970 to 1990. His analysis reveals a substantial increase in trade among countries within the same currency union, estimating a trade boost of

approximately 200%, thereby supporting the hypothesis that currency unions significantly enhance trade flows among member countries.

Glick and Rose (2002) revisit these estimates; utilising an extended gravity model and dataset, they apply time-series analyses to examine how trade relationships evolve before and after the formation of a currency union. Their aim here, to determine whether the significant trade-enhancing effects observed in Rose's 2000 paper are consistent over time and across different currency unions. Glick and Rose (2002) confirm Rose's earlier findings, however, they note that the magnitude of the trade increase is generally smaller than initially estimated by Rose in 2000. Notably, the effects vary significantly across different currency unions, suggesting that economic context, size, and the economic heterogeneity of member countries plays a critical role in determining the impact of a common currency on trade. Additionally, their time-series approach also highlights that the trade-enhancing effects of currency unions are not only immediate but persist over time, confirming the robustness of the positive currency union effect on trade.

More pertinent to our own investigation, Micco, Stein and Ordoñez (2003) focus on the specific impact of the Eurozone on trade among its members shortly after its formation. Employing a Difference-in-Differences (DiD) approach alongside a gravity model set-up, they isolate the effect of the euro from other concurrent changes in the economic landscape by comparing changes in trade flows between EMU members before and after the euro's introduction with those between non-EMU members over the same period. Their findings suggest a positive, albeit modest, effect on trade among new members – statistically significant, however, less dramatic than had been indicated by earlier studies like Rose (2000). Notably, effects are also not uniform across members states, indicating that economic characteristics and pre-existing trade relationships also play a role in determining the extent of post-union trade effects. Capturing just the Euro's infancy, this study also naturally fails to offer insight into the long-term trade effects of the EMU – something which we aim to provide as part of our own investigation.

Unburdened by timeframe, however, and particularly relevant to our own paper is Saia (2017). Utilising the synthetic control method, the paper attempts to estimate the trade effects of the United Kingdom's decision not to adopt the euro. As for the predictor variables, Saia (2017) uses the pre-treatment outcomes for trade flows as well as four variables inspired by the gravity model; that is distance, GDP, adjacency, and common language. By constructing a synthetic UK from a group of countries which did, in fact, join the Eurozone, Saia concludes that the UK forwent significant increases in trade by opting out of the currency union. Trade flows between the UK and the Eurozone would have been 16% higher if the UK would have adopted the Euro in 1999. Large differences between actual and synthetic trade flows are especially observed for Finland (-58%), Italy (-41%), Portugal (-41%) and France (-20%). Trade between the UK and Germany would have been mostly unaffected with a difference of -2%. Furthermore, Saia (2017) shows that UK trade would have also increased by 15% with non-Euro members and that intra-European trade increased by 19% to 55% as a result of the common European currency. The synthetic control method is ideal for situations such as these, where comparative analysis involves a single unit treated with an intervention – in this case, the UK's decision not to adopt the euro. The UK's economic and political context is, of course, unique, and the specificity of its financial sector and evident scepticism-turned-disdain for European integration perhaps limits the generalisability of Saia's findings. This does provide us with an interesting opportunity, however, to examine the sole remaining ERM II participant exempt to joining the euro – Denmark.

Although the primary outcome of interest examined in these papers, and in ours, is common currencies' effect on trade, there are, too, broader implications associated with the expansion of currency unions. Gabriel and Pessoa (2020) evaluate the broader macroeconomic effects – such as GDP growth, unemployment, and inflation – of Euro adoption on member states. Counter to Saia, they construct synthetic non-Euro-adopting units to create a counterfactual scenario for how each country would have evolved without taking the Euro and abandoning their pre-Euro national currencies. Their findings here are mixed, with some clear winners and other 'mild losers'. Notably,

introduction of the euro also stimulated trade for most cases, but only Germany and Ireland bear positive net trade benefits overall.

Cho and Wong (2021) investigate how a potential adoption of the Euro would have affected regional income and disparity in the two Nordic countries Denmark and Sweden that have not introduce the Euro. Employing the SCM their results indicate that effects for Danish regions on GDP per capita are small and heterogeneous following a potential Euro accession. Furthermore, adopting the Euro would have decreased regional income disparity in Denmark, mainly driven by income losses in high-income regions. The authors conclude that their results highlight the costs associated with giving up independent monetary policy and a floating exchange rate regime.

Lin and Chen (2017) similarly explore the growth effects associated with adopting the Euro. Employing the synthetic control method, they find that adoption of the Euro had a varied impact on economic growth among member countries – with some benefitting from stability and increased trade facilitated by common currency, and others facing stifled growth due to loss of monetary flexibility. Akin to Gabriel and Pessoa (2020), the exact nature of macroeconomic effects due to adoption of the Euro are largely determined by heterogenous, pre-Euro characteristics.

5 Empirical Strategy & Data

5.1 The Synthetic Control Method

To estimate the effect on Danish trade of not joining the Euro area in 1999 we propose to use the Synthetic Control Method (SCM). The SCM allows us to create a synthetic Denmark that joined the common European currency and compare synthetic with actual trade flows to assess the effect of not joining the Euro. The SCM has drastically gained in popularity over the last decade and has been described as "arguably the most important innovation in the policy evaluation literature in the last 15 years" by Athey and Imbens (2017). Abadie and Gardeazabal (2003) introduced the SCM and have since then further expanded on the mechanics of the SCM (Abadie, Diamond and Hainmueller, 2010, 2015). At its core the SCM combines both techniques

used in difference-in-differences (DiD) approaches and in matching. It compares treated and untreated units before and after the treatment to estimate the effect of an intervention. Contrary to the DiD approach, the SCM does not rely on a single comparison unit but rather on a weighted combination of several untreated comparison units from the donor pool. Weights for each of the untreated units are picked to minimise the difference between actual and synthetic trend in the pre-treatment period so that the common trends assumption holds. This can be seen as one of the big advantages of the SCM as the counterfactual unit is not subject to arbitrary selection by the researcher but is rather derived by a data driven process. The process is very transparent about which units from the donor pool make up the counterfactual as weights for each unit are reported (Abadie, 2021).

More formally the SCM can be expressed using the following mathematical notation following Abadie (2021). Suppose we have $J+1$ units $(j = 1, 2, \ldots, J+1)$ where the first unit $(j = 1)$ is treated and is therefore affected by the intervention under consideration. In our specific case this is Denmark being affected by the policy of non-integration (not introducing the Euro in 1999). The set of unaffected units by the policy intervention, the donor pool, is $j = 2, \ldots, J+1$. These units are used to construct the synthetic counterfactual. Further, we assume that our data set spans T periods with T_0 periods before the intervention took place. Y_{it} defines the outcome of interest (trade) for unit i in period t. $X_{1j}, \ldots, X_{kj}$ is a set of k predictor variables for each unit j under consideration. The predictor variables are not affected by the treatment and can also contain values of the outcome of interest (Y_{it}) for the pre-treatment periods. Additionally, we define Y_{jt}^N as the outcome of each unit j in period t if no intervention has taken place, and Y_{jt}^I as the outcome if the intervention has taken place for $j = 1$ and $t > T_0$. The effect of treatment for the affected unit in the period $t > T_0$ can be written as:

$$\tau_{1t} = Y_{jt}^I - Y_{jt}^N$$

While we can observe Y_{jt}^I, the counterfactual outcome Y_{jt}^N cannot be observed. In DiD settings this problem is tackled by choosing an unaffected unit with similar

characteristics. The SCM on the other hand approaches this problem by selecting a combination of different units from the donor pool. Formally, assuming a *Jx1* vector of weights $W = (w_2, \ldots, w_{J+1})'$ the synthetic control estimator for Y_{jt}^N and τ_{1t} can be written as

$$\hat{Y}_{1t}^N = \sum_{j=2}^{J+1} w_j Y_{jt}$$

$$\hat{\tau}_{1t} = Y_{jt}^I - \hat{Y}_{jt}^N$$

The weights are restricted to sum to one and be non-negative. Furthermore, the weights are chosen so that the synthetic counterfactual resembles the actual values for the treated unit as closely as possible in the pre-treatment period. The optimal weights minimise...

$$\left(\sum_{h=1}^{k} v_h \left(X_{h1} - w_2 X_{h2} - \cdots - w_{J+1} X_{hJ+1} \right)^2 \right)^{1/2}$$

...where the positive constants $v_1, \ldots, v_K$ "reflect the relative importance of the synthetic control reproducing the values of each of the k predictors for the treated unit" (Abadie, 2021). Each $V = (v_1, \ldots, v_K)$ produces a synthetic control which can be obtained by minimizing the equation subject to the weights being greater than zero and sum of one.

V on the other hand is chosen to minimize the mean squared prediction error of the synthetic control.

5.2 Application of the Synthetic Control Method

Our research is focused on Denmark and its trade with the eleven founding members of the Eurozone that introduced the Euro in 1999. Eleven countries including Germany, Finland, Austria, Italy, Spain, France, the Netherlands, Greece, Belgium, Ireland and Luxembourg joined the Euro area in 1999 and have been using the Euro since then. As Belgium and Luxembourg only start reporting individual trade flows from 1996, we consider Belgium-Luxembourg as one country in our analysis. Including our country of interest, Denmark, our final data set spans across 11 countries leaving

us with 55 different country pairs. Of these 55 country pairs, 10 are Denmark–Euro country pairs. This leaves us with 45 potential Euro–Euro country pairs the algorithm assigns weights to in order to construct the synthetic counterfactual. For each of the 55 country pairs our data set contains two observations to account for differences in imports and exports which leaves us with 110 observations for every year.

Although Denmark joined the EU in 1973, economic integration does not simply occur overnight; to account for the non-immediacy of this process, we begin our pre-treatment period in 1977. At the other end of our timeline, we have chosen to limit our investigation to 2015; the reason for excluding data post-2015 is to avoid potential distortions due to changes in firm behavior as a result of the Brexit Referendum in 2016. This period, 1977–2015, with 1999 marking our treatment with the introduction of the Euro, provides both a substantial pre-treatment timeline for the algorithm to determine appropriate weights, as well as enough time post-1999 to draw clear inferences as to the effect of treatment.

As for our variable of interest, Danish trade, we focus on both exports and imports separately. Specifically, we investigate Danish exports to the EMU countries, and Danish imports from the EMU countries. Potential differences could give interesting insights about the effect of joining a currency union on foreign trade and are highly relevant for policy makers. As the sum of exports and imports describe bilateral trade flows, this setup allows us to further draw conclusions about how Danish trade with the EMU would have developed overall. For each of the 55 country pairs we observe two trade flows where we use the trade reported by the importer. Using the country-pair Denmark – Italy as an example, DNK–ITA refers to Danish imports from Italy reported by Denmark, and ITA–DNK refers to Italian imports from Denmark reported by Italy (which is Danish exports to Italy).

In order to effectively generate our synthetic Denmark, we must first carefully select our predictor variables; these variables, which can include both pre-treatment values of the outcome variable as well as other influencing factors, serve to construct the synthetic counterfactual, that is, a Denmark that adopted the Euro in 1999 along the other member countries. By including both predictor variables and pre-treatment

periods we acknowledge the significance of including predictors beyond pre-treatment outcomes to avoid bias in estimating the treatment effect (Abadie, 2021; Botosaru and Ferman, 2019; Kaul et al., 2015). This approach follows from Saia (2017), including both pre-treatment outcome values from 1977 – 1998, as well as covariates like GDP, geographical distance, common language use, and border adjacency and is motivated by the workhorse model in international economics – the gravity model of trade.

Following Saia (2017) and choosing the country pair Denmark-Italy (DNK–ITA) for illustrative purpose here, we are interested in the percentage loss or gain in trade between Denmark and Italy after the Euro introduction given by the following formula.

$$\eta_{1999-2015,DNK-ITA} = \frac{\sum_{t=1999}^{2015}\left(Y_{t,DNK-ITA}(DKK€) - Y_{t,DNK-ITA}(€€)\right)}{\sum_{t=1999}^{2015}\left(Y_{t,DNK-ITA}(€€)\right)}$$

$Y_{t,DNK-ITA}(DKK€)$ indicates trade flows when Denmark uses the Danish Krone while $Y_{t,DNK-ITA}(€€)$ are bilateral trade flows when both countries use the Euro as legal tender. As $Y_{t,DNK-ITA}(€€)$ cannot be observed as Denmark never introduced the Euro, this term is therefore obtained using the SCM as described in the previous section. Hence, we estimate the following equation (Saia, 2017):

$$\hat{\eta}_{1999-2015,DNK-ITA} = \frac{\sum_{t=1999}^{2015}\left(Y_{t,DNK-ITA}(DKK€) - \sum_{j=2}^{J+1} w_j\, Y_{t,j}(€€)\right)}{\sum_{t=1999}^{2015}\sum_{j=2}^{J+1} w_j Y_{t,j}\,(€€)}$$

$\sum_{j=2}^{J+1} w_j Y_{t,j}\,(€€)$ represents the counterfactual Denmark-Italy country pair in this case where both countries share the Euro as their common currency.

Furthermore, there are three major key assumptions we need to make in our analysis (Cho and Wong, 2021). First, the treatment needs to be exogenous, and we do not have reverse causality as well as selection bias issues. In this case, the decision of Denmark not joining the Euro does not need to be based on economic but rather political or ideological considerations. As discussed previously, the decision of the

Danish electorate can be seen as mainly a political one and was not based on potential economic outcomes.

Secondly, the control group (donor pool) needs to be unaffected by the treatment. This means that the countries that joined the Euro in 1999 are unaffected by Denmark's decision to not join the common European currency (treatment to non-integration). Since Denmark is a relatively small country in economic terms compared to countries like Germany, France or Italy that joined the Euro area in 1999, spillover effects can be expected to be relatively small as well.

Lastly, we need to assume that our predictor variables, the pre-euro economic indicators, were unaffected by the currency's forthcoming adoption, thereby disregarding any anticipatory influences. In terms of predictor variables in our analysis adjacency, language and distance are static and are not impacted by a potential Euro accession. GDP and trade flows before the introduction of the Euro could potentially be influenced by anticipatory effects, as Denmark was not expected to join the Euro in 1999. Saia (2017) shows that for the UK negative trade effects can be observed starting in 2002 when the Euro was introduced as a physical currency, indicating the absence of anticipatory effects in the run-up to the Euro introduction.

5.3 Data

For our data we refer to the Gravity data set provided by CEPII which encompasses both bilateral trade flows and country-specific variables for country pairs between 1948 and 2020 (Conte, Cotterlaz and Meyer, 2022). Trade values are reported in current thousand US Dollars following an origin and destination framework and are sourced from the UNCTAD Comtrade database. As we compare actual and synthetic trade values within each year and not over time, we do not deflate trade values. As we aim to investigate Denmark's bilateral trade flows with the original members of the Eurozone, we restrict our sample to include only these eleven countries (Germany, Finland, Austria, Italy, Spain, France, the Netherlands, Greece, Belgium, Ireland, and Luxembourg). Additionally, as Belgium and Luxembourg recorded trade as a single reporting zone until 1996, we treat Belgium-Luxembourg as one country. As the

German reunification in 1990 also falls within our investigated time period, we use trade for western Germany before the reunification and trade values for the unified Germany from 1990 on.[6] Table 3 contains summary statistics for the variables of interest.

Table 3: Descriptive Statistics

Variable	**Mean**	**Std. Dev**	**Min**	**Max**
Trade	8004332	1.48e+07	4554.643	1.21e+08
Adjacency	0.1939394	.3954281	0	1
Common language	0.0909091	.2875133	0	1
GDP	6.51e+08	8.13e+08	1.12e+07	3.88e+09
Distance	1330.004	663.6134	120	3366

Note: 4,290 observations in total; 55 country pairs with two observations each year for imports and exports. Trade and GDP measured in current thousand US-Dollars. Distance in kilometers. Common language takes on one if countries share common official or primary language. Adjacency takes on one if countries are contiguous.

6 Empirical Results

If exchange rate volatility is one of the main impediments to international trade and considering Denmark's success to consistently maintain a fixed exchange rate against the Euro, we should not be able to find a significant gap between actual and synthetic trade flows. For our analysis we differentiate between Danish imports from EMU countries and exports to EMU countries. Our specification includes all pre-treatment lags (1977-1998) and the four predictor variables as discussed in the previous chapter.[7] This setup allows us to draw conclusions about intra currency union trade following a potential Danish Euro accession.

Figure 1 contains results for Danish exports, imports, and total trade with EMU countries. The vertical dashed line marks the treatment period, that is 1999, the dashed

[6] We do not observe significant differences in our results when excluding Germany from the donor pool.

[7] We employ different specifications regarding the use of pre-treatment lags and gravity variables for the donor pool and results remain very similar. All results in the present paper are based on the specification with all pre-treatment lags and the four gravity variables, namely GDP, distance, language and adjacency.

line indicates synthetic Denmark had it introduced the Euro in 1999 while the solid line depicts actual observed trade flows in the respective period. For Danish imports, synthetic and actual trade flows follow each other closely, indicating that the matching process has been successful, and we have a good pre-treatment fit. After the treatment takes place, synthetic trade flows diverge substantially from the actual trade flows starting in 1999. The treatment effect of non-integration is -18%, meaning that between 1999 and 2015 yearly Danish imports from EMU countries were 18% lower than what they could have been had Denmark joined the Euro in 1999.

Similar to Danish imports from the EMU, Danish exports exhibit a good pre-treatment fit indicting that the matching process has been successful, and we are able to draw conclusions from our synthetic counterfactual. Once the Euro has been introduced in 1999, synthetic and actual trade flows do not diverge to the same extent as for imports. Over the period 1999 to 2015, actual Danish exports to EMU countries are 3% lower than what the synthetic counterfactual suggests. It can further be noted here that as Danish imports to the EMU surpass Danish exports from the EMU, the treatment effect in terms of absolute Dollar values is significantly higher for imports than for exports.

Lastly, we combine the obtained results for imports and exports to study how total Danish with the EMU would have developed. Following the aggregate dynamics of Danish imports and exports, total trade displays a good pre-treatment fit and synthetic trade flows diverge from actual trade flows once the Euro had been introduced in 1999. As follows from the previous analysis, the divergence is mainly driven by Danish imports from the EMU and the total treatment effect of monetary non-integration for Danish trade is -12% for the period 1999-2015.

We further report p-values for the treatment effect on total Danish trade in figure 2. While there is some heterogeneity in the estimated p-values in the first few periods after the Euro had been introduced, p-values indicate high statistical significance for all following periods. P-values are obtained by running in-space placebos and comparing the main effect with the effect of in-space placebo treated units (Galiani and Quistorff, 2017).

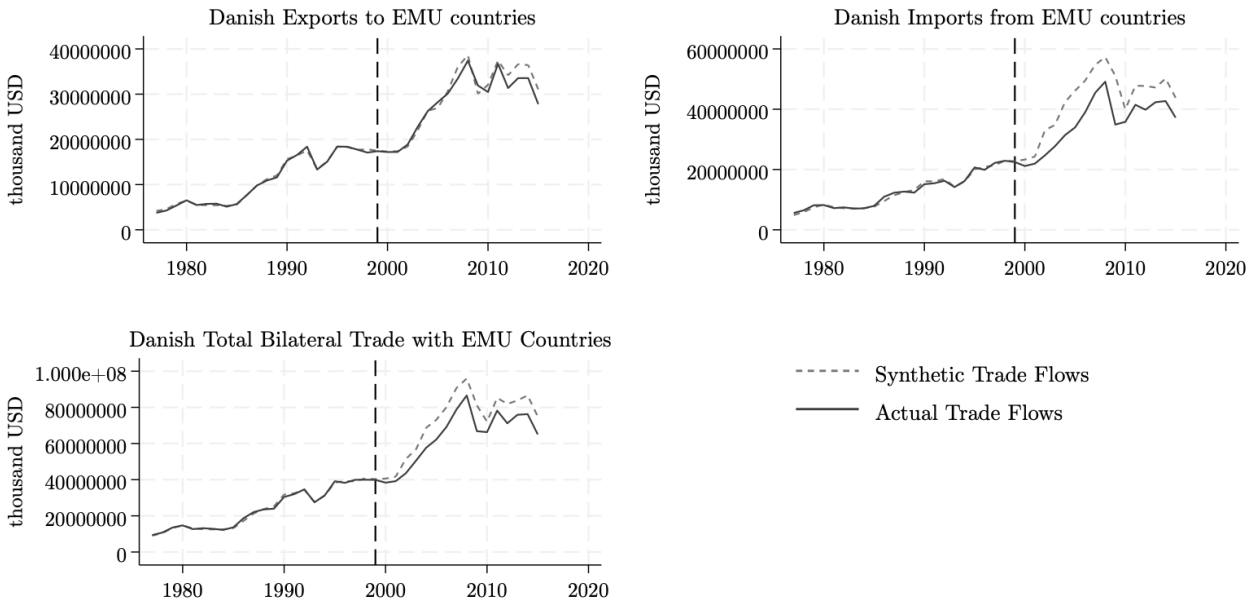

Figure 1: Synthetic Danish Imports, Exports and Total Trade

Note: All pre-treatment lags and gravity variables in the donor pool. Results obtained using synth2 in Stata (Yan and Chen, 2023).

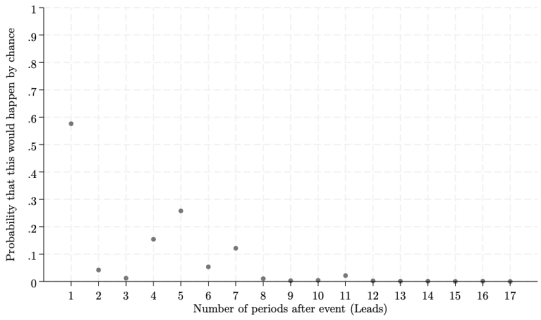

Figure 2: p-values for Danish Total Trade with EMU

Note: p-values obtained using synth_runner in Stata. p-values calculated by comparing the main effect to placebo in space estimates (Galiani and Quistorff, 2017).

Table 4 reports the percentage differences between actual and synthetic imports, exports, and total trade for the 10 country pairs under investigation in the pre-1999 and post-1999 period. As already shown in figure 1, we observe a good pre-treatment fit and differences for imports, exports and total trade are close to zero in the pre-1999 period. A negative value indicates that the synthetic value is higher than the actual observed value and vice versa for positive values. For imports differences are negative for all countries besides Spain, meaning that Danish imports from all countries except

Spain would have been higher had Denmark adopted the Euro in 1999. The biggest effect can be seen for imports from southern European countries, in particular Portugal, France, and Italy. Country specific results for exports exhibit a higher degree of heterogeneity with positive treatment effects for Germany, Spain, Ireland, and the Netherlands. The biggest negative effects can be observed for Belgium, Austria, and Italy. Finally, total trade combines exports and imports and shows that treatment to monetary non-integration for Denmark affects trade with Portugal, Italy, and France the most. Further graphical illustrations for country pair specific imports and exports can be found in the appendix in figure A.3 and A.4.

Table 4: Difference between actual and synthetic trade (in %)

% Diff actual vs synth.	**AUT**	**BEL**	**DEU**	**ESP**	**FIN**	**FRA**	**IRL**	**ITA**	**NLD**	**PRT**
Imports										
1977-1998	-2.50	0.58	0.46	0.03	2.25	1.81	-1.71	1.50	0.52	0.65
1999-2015	-4.95	-11.82	-6.98	13.47	-21.20	-35.61	-8.50	-31.29	-27.76	-46.78
Exports										
1977-1998	-1.48	-1.27	-0.63	0.31	0.30	-0.19	-2.70	-1.34	0.15	-1.23
1999-2015	-30.71	-23.71	1.01	18.87	-3.48	-13.05	50.83	-23.48	19.07	-21.92
Total trade										
1977-1998	-2.01	-0.12	-0.05	0.20	1.43	0.78	-2.12	-0.07	0.38	-0.86
1999-2015	-18.03	-16.16	-3.71	16.73	-12.37	-25.70	12.84	-27.84	-15.40	-36.84

Note: Percentage difference of actual and synthetic Danish imports, exports and total trade for all country pairs including Denmark for pre- and post-treatment period. Results obtained using synth2 in Stata (Yan and Chen, 2023).

7 Robustness Checks

The results presented in the previous chapter suggest a substantial impact on Danish trade following its decision to not join the Euro area in 1999. While the impact is moderate but non-negligible for exports with a treatment effect of -3%, imports from the EMU show a substantial treatment effect of -18%. In this chapter we make use of in-time and in-space placebo tests as well as two different difference-in-differences estimators to further underpin the validity of our previously presented results.

7.1 In-Time Placebo

Following Saia (2017), we perform an in-time placebo test where we assign the treatment of non-integration ten years earlier in 1989. In-time placebo tests offer a robust method to assess the validity of treatment effects and explore potential anticipation effects. If our results are valid, we should not be able to observe any significant divergence of synthetic and actual trade flows after 1989 since this would indicate that our obtained results are not necessarily due to the treatment of non-integration (Abadie, 2021). Assigning the placebo treatment to 1989, reduces our pre-treatment period to a twelve-year period from 1977 to 1988. Figure 3 presents results for the described in-time placebo where the placebo treatment in 1989 is indicated by the first dashed line and the real treatment in 1999 by the second dashed line. Synthetic and actual trade do not diverge substantially after the placebo treatment until the actual treatment. Once the actual treatment of non-integration takes place in 1999, synthetic and actual trade flows start to diverge, with a higher rate of divergence for Danish imports from EMU countries. These results show that there are no large-scale anticipatory effects and firms are unlikely to have adjusted and redirected trade flows including Denmark in the run-up to Euro introduction. This further proves the validity of our research design and that the observed treatment effect can be attributed to the introduction of the common European currency.

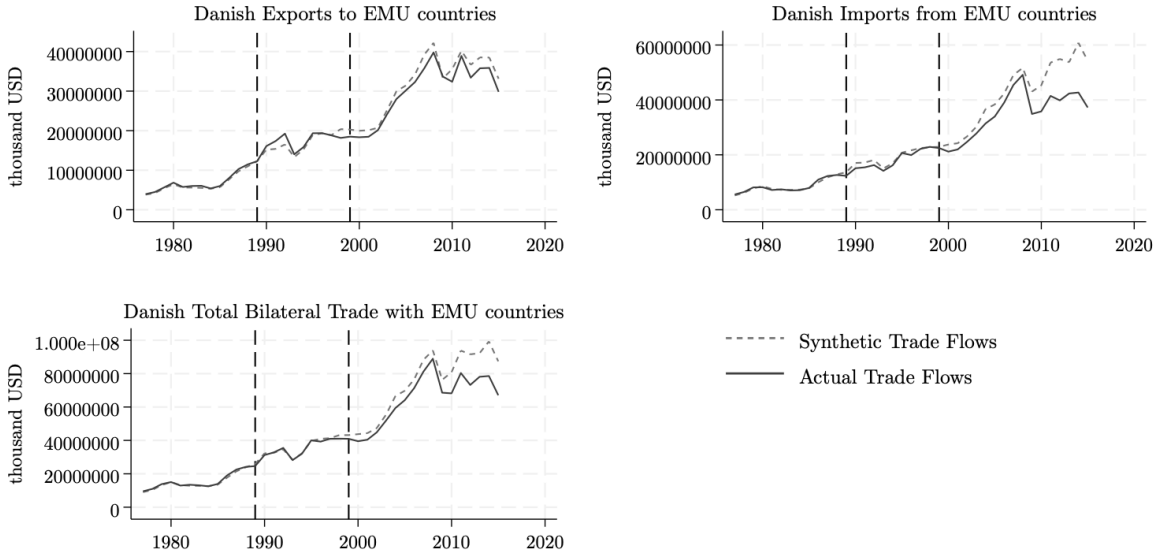

Figure 3: In-Time Placebo Test for Treatment Year 1989

Note: All pre-treatment lags and gravity variables in the donor pool. Results obtained using synth2 in Stata (Yan and Chen, 2023).

7.2 In-Space Placebo

Furthermore, we implement a placebo in-space test where we assign the treatment of non-integration to a country other than Denmark. By assigning the treatment to a country that is non-treated to monetary non-integration, we can further validate our results for the treated unit. If there are observable treatment effects for the placebo treated unit, the treatment effect is not uniquely attributable to the introduction of the Euro and other, unobserved factors might come into play (Gabriel and Pessoa, 2020). As for our placebo treated unit, we choose Finland. Finland seems to be a reasonable choice in this setting as Denmark and Finland are similar in population size and GDP. Furthermore, they are both part of the Nordic countries located in the northern part of Europe and share an overall similar culture and societal values. If the observed trade effect for Denmark is due to the decision not to join the Euro, we should not be able to see any effect for Finland when assigning the treatment of monetary non-integration to Finland.

Figure 4 contains results for the placebo in-space exercise where Finland is treated to monetary non-integration. As for the donor pool we exclude Denmark which leaves us with 9 treated country pairs. The figure exhibits a good pre-treatment fit indicating

a successful matching process. After the treatment to non-integration in 1999 synthetic and actual trade do not diverge substantially which highlights the validity of our previously obtained results. Only once the financial crisis hits in 2008/09 actual and synthetic trade flows diverge. This can be due to many factors as the great financial crisis and the following sovereign debt crisis put a lot of stress on the economies in the Eurozone and does therefore not necessarily invalidate our results. The similar trajectory of actual and synthetic trade flows after the treatment helps to rule out that the observed treatment effect for Denmark is due to randomness and can be clearly attributed to the introduction of the Euro, underpinning the validity of our estimates.

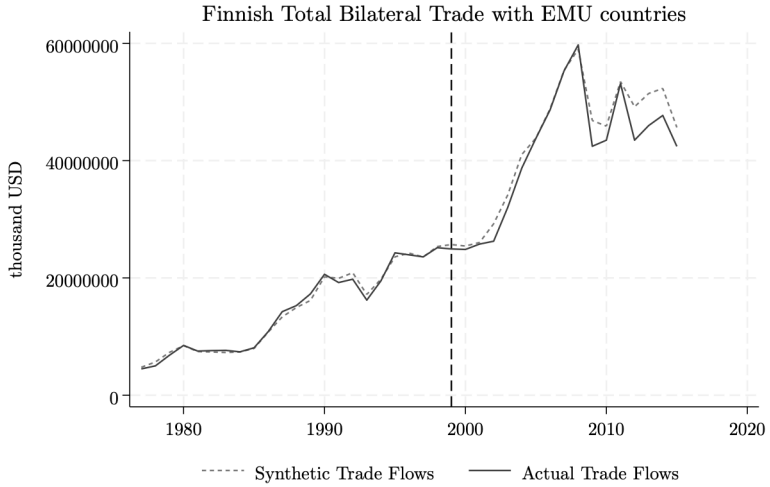

Figure 4: Placebo In-Space using Finland as Treated Unit

Note: All pre-treatment lags and gravity variables in the donor pool. Results obtained using synth2 in Stata (Yan and Chen, 2023).

7.3 Difference-in-Differences

We provide further evidence by supplementing our SCM results with Difference-in-Differences (DiD) estimates. As our focus in this study is on countries that adopted the Euro in 1999, we do not need to worry about staggered treatment and potential biases that can arise because of that (Baker, Larcker and Wang, 2022). We proceed to estimate the following two-way fixed effects DiD model (Persson, Soegaard & Tärneberg, 2022):

$$ln\,(T_{i,j,t}) = \beta_0 + \beta_1\, ln\big(GDP_{i,t} * GDP_{j,t}\big) + \beta_2\, ln\big(dist_{i,j}\big) + \beta_3(DNK \times Post99) + \eta_t + \rho_{i,j} + \varepsilon_{i,j,t}$$

Where $\ln(T_{i,j,t})$ is the log trade between country i and j in period t; $\ln\big(GDP_{i,t} * GDP_{j,t}\big)$ is the log of the product of the GDP of the two countries i and j; $\ln\big(dist_{i,j}\big)$ is the log of the distance between the two countries i and j; and $(DNK \times Post99)$ is the interaction term between a Denmark dummy and a dummy for the period after 1999, that is 2000-2015. The coefficient β_3 is the treatment effect of interest and measures the potential loss in trade Denmark is facing due to the decision to stay out of the Eurozone. In addition, η_t and $\rho_{i,j}$ are time respectively country pair fixed effects that control for unobserved time and unit invariant characteristics.

Column 1 in table 5 reports estimates for Danish imports. As the previous SCM results suggest, the coefficient (DNK x Post99) is negative and statistically significant at the 1% level. The estimate for imports in column 1 (-0.187) suggests a treatment effect of non-integration of -17.1% for Danish imports from the EMU.[8] The treatment effects of non-integration for exports (-0.121) and total trade (-0.153) are -11.3% and -14.2% respectively. While the DiD estimate for exports suggest a higher treatment effect than the SCM estimate with -3.1%, the DiD estimate for imports is close to the SCM estimate of -17.9%. Overall, while the SCM estimate for total trade is -11.9%, the DiD suggests a slightly higher treatment effect of -14.2%. In summary, it can be stated that the obtained DiD estimates support the validity of our SCM exercise and suggest an even slightly larger treatment effect of monetary non-integration on Danish trade with the EMU.

To further investigate potential time-varying effects of the Euro on Danish trade, we split the treatment period into three different subperiods, specifically 1999-2004,

[8] We use the following formula to obtain the percentage effect of non-integration: 100*[exp (DNK x Post99) - 1].

2005-2009, and 2010-2015 as depicted in table 6.[9] This regression setup allows us to see if there are any differences in the magnitude of the treatment effect in different periods. For exports, the estimated coefficient for period one and two is identical and increases substantially in the third period. As for imports and total trade, estimated coefficients increase gradually over time. Like the results in table 5, the treatment effect for imports is higher than for exports in all periods.

Our DiD results are overall in line with our findings using the SCM and provide further validation of the previous results. However, the DiD suggests a larger effect of monetary non-integration on trade especially for exports as compared to the SCM. This could be traced back to the different approaches each method uses in order to determine the treatment effect. While the DiD constructs the counterfactual by averaging over unaffected units, the SCM uses a more systematic approach by employing matching techniques and assigning different weights to the unaffected units (Abadie, 2021). On the other hand, the DiD allows to incorporate time and unit fixed effects which is not possible within the SCM framework.

Table 5: DiD Regression Results

VARIABLES	(1) Imports	(2) Exports	(3) Total Trade
log(Dist)	-0.402***	-0.281*	-0.373**
	(0.148)	(0.148)	(0.146)
DNK x Post99	-0.187***	-0.121***	-0.153***
	(0.0255)	(0.0223)	(0.0222)
log(GDP x GDP)	0.784***	0.778***	0.791***
	(0.0358)	(0.0358)	(0.0343)
Constant	-13.30***	-13.94***	-13.79***
	(1.629)	(1.631)	(1.579)
Observations	3,900	3,900	4,290
R-squared	0.963	0.964	0.963

Note: Robust standard errors in parentheses; *** p<0.01, ** p<0.05, * p<0.1; including time (year) and country pair fixed effects. Dependent variable in log.

[9] Furthermore, we drop the time fixed effect to control for individual years and find that coefficients for years just before the Euro introduction (1996, 1997 & 1998) are positive and non-significant (p >0.1). This further proves the absence of anticipatory effects and adjusted firm behavior.

Table 6: DiD Regression Results by Subperiods

VARIABLES	(1) Imports	(2) Exports	(3) Total Trade
log(dist)	-0.402***	-0.281*	-0.373**
	(0.148)	(0.148)	(0.146)
DNK x (99–04)	-0.163***	-0.0998***	-0.131***
	(0.0326)	(0.0352)	(0.0334)
DNK x (05–09)	-0.187***	-0.0970***	-0.141***
	(0.0385)	(0.0318)	(0.0333)
DNK x (10–15)	-0.207***	-0.158***	-0.182***
	(0.0387)	(0.0344)	(0.0328)
log(GDP x GDP)	0.784***	0.779***	0.791***
	(0.0358)	(0.0358)	(0.0343)
Constant	-13.30***	-13.95***	-13.80***
	(1.629)	(1.630)	(1.578)
Observations	3,900	3,900	4,290
R-squared	0.963	0.964	0.963

Note: Robust standard errors in parentheses; *** p<0.01, ** p<0.05, * p<0.1; including time (year) and country pair fixed effects. Dependent variable in log.

7.4 Synthetic Difference-in-Differences

Lastly, we turn to the synthetic difference-in-differences (SDiD) estimator to further supplement our robustness checks. The SDiD combines both elements from the classic DiD and the SCM and is based on parallel trends compared to common trends as with the SCM. Therefore, we do not aim to generate a close fit of synthetic and actual trade flows in the pre-treatment period but rather parallel trends that are allowed to differ in their level. The SDiD approach was introduced by Arkhangelsky et al. (2021) and uses time and unit fixed effects while also assigning weights for units and time. As the SDiD combines both elements from the previously presented SCM and DiD approaches, being able to reproduce our results with the SDiD significantly highlights the strength of our estimates. We will not further discuss the SDiD in detail at this point as it is solely used as a supplementary robustness check, but the interested reader may be referred to Arkhangelsky et al. (2021) and Clarke et al. (2023) for a further discussion of the SDiD.

Figure 5 shows our SDiD results where the dashed line indicates the constructed control unit and the solid line the actual treated units, that is Danish imports and exports respectively. Differences in the trends post-1999 describe the treatment effect of the intervention. The x-axis measures values for imports and exports in current thousand US-Dollar in log. Due to the constructed parallel trends, the treatment effect is harder to observe visually as lines do not diverge as clearly as under the common trends assumption.

The left graph shows Danish imports from the EMU and suggests a treatment effect of -11.4% for monetary non-integration. As p-values are based on large-sample approximations we run several iterations and observe statistical significance with p-values smaller than 0.05. While the SCM and DiD show treatment effects of -17.9% and -17.1% respectively, the SDiD estimate is smaller, with -11.4%, but confirms the overall negative trade effect of monetary non-integration.

The graph on the right-hand side in figure 5 depicts Danish exports to EMU countries. The treatment effect is close to zero and there is no statistical significance observable on conventional levels. While the DiD estimate suggests a treatment effect of -11.3% for exports and the SCM -3.1%, the SDiD falls out of line here with a non-significant treatment effect close to zero. However, the SDiD estimates should merely be seen as a further addition to the presented SCM and DiD results as it goes beyond the scope of the present paper to further elaborate on the SDiD approach and its shortcomings and advantages. Overall, it can be concluded that the SDiD supports our findings for Danish imports but stands in contrast with our findings for Danish exports to the EMU.

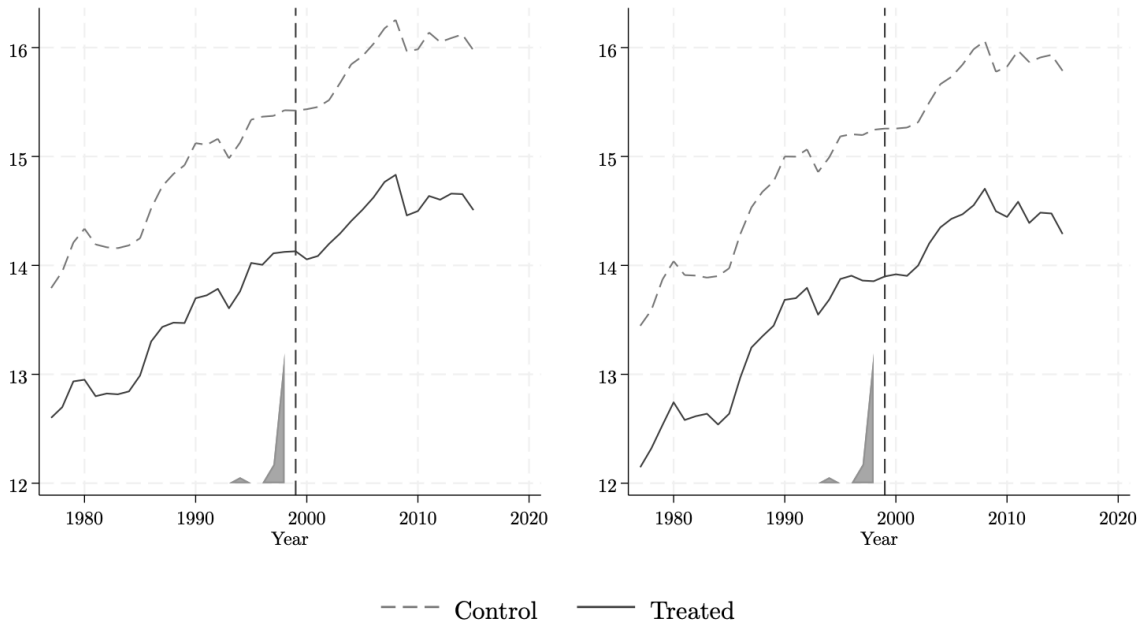

Figure 5: Synthetic Difference-in-Differences for Danish Imports and Exports

Note: Figure 5 shows Danish imports from the EMU on the left-hand side and exports to the EMU on the right-hand side. Trade values (thousand USD) on the x-axis in log. Results obtained using SDID in Stata. Grey area represents time specific weights assigned by SDID (Clarke et al., 2023)

8 Conclusion

Creating a European currency union can be seen as one of the major steps towards economic integration in Europe. To date, the Euro has established itself as one of the major global currencies, just falling short to the US-Dollar, and does hence play an important role in international transactions and cross-border trade.

Our paper employs the Synthetic Control Method (SCM) to study the effect on Danish trade with the initial members of the European Monetary Union (EMU) if Denmark would have adopted the Euro in 1999. In other words, we investigate the trade effects of monetary non-integration for Denmark. We do not find altogether robust results when it comes to exports. Indeed, the two synth approaches point in the direction of a small or even insignificant result for exports, even though the methodologically weaker DiD model finds a significant effect. By contrast, we find strikingly robust results for imports, and all estimation approaches yield the same outcome; non-integration had a strong negative effect on Danish imports despite its fixed exchange rate against the Euro.

Circling back to the theoretical considerations about currency unions and trade, the literature suggests that joining a currency union leads to higher trade flows due to lower transaction costs and reduced exchange rate volatility. Although Denmark did not join the Euro in 1999, they have successfully maintained a stable peg, largely eliminating this risk of exchange rate volatility. In doing so, Denmark has in effect achieved one of the primary benefits of a currency union whilst operating outside of one. Considering this, one would expect the absence of any significant trade effects due to Denmark's decision of monetary non-integration. Our results, however, run contrary to these assumptions; our SCM estimates suggest that Danish trade with members of the EMU is 12% lower than it could have been between 1999 and 2015 and that this effect is mainly driven by Danish imports from EMU countries.

As for the empirical strand of literature, Saia (2017) comes closest to our research, studying the trade effects for the UK of not joining the Euro. He concludes that trade flows between the UK and members of the Eurozone would have been 16% higher if the UK had adopted the Euro in 1999. This estimate falls into line with our provided results and suggests that there is more behind the positive trade effects of currency unions than simply the elimination of exchange rate volatility. It is worth noting that while Saia's estimates are slightly larger than our own, this is not necessarily surprising. The UK and Denmark are, after all, quite different countries. Whereas the mainland UK shares no common borders with EU states, Denmark does, and is positioned much more centrally within the Eurozone. Additionally, the Krone and Pound Sterling also differ quite significantly; with the latter being the fourth most traded currency in the world, it is safe to say that both currencies are subject to starkly different dynamics on international markets (ECB, 2023). Considering this, a difference of approximately -4% is not beyond one's reasonable expectations.

Overall, we can conclude that our study provides further evidence for positive trade effects when joining a currency union, supplementing this existing literature by providing another case study and strengthening previous results. Moreover, since Denmark is the only European country that has kept a successful peg against the Euro since 1999, investigating Danish trade allows us to study the extent to which a fixed

exchange rate regime might impact exports and imports. It is important to state clearly, once more, that the security and long-term success of this peg has served to mitigate against exchange rate volatility, one major concern when considering trade. If we accept that Denmark's trade would have been greater under Eurozone membership, we must also accept that this difference in actualised trade would have been for reasons unrelated to exchange rate volatility. Though we cannot say for certain what mechanisms are at play, one may conclude, definitively, that despite all else, currency union status does, in fact, matter for trade integration.

Of course, we cannot say how Danish trade with the rest of the world would have developed if Denmark had joined the Euro, with the potential for trade diversion here being a key consideration when examining extra-EMU trends in the Danish trade balance. This is, however, simply beyond the scope of our study; we are looking, specifically, at how monetary non-integration affects trade with aligned currency unions, rather than aiming to provide a broader picture of Danish trade patterns.

Our findings, overall, underscore the pivotal role of monetary integration in enhancing trade relations within Europe, confirming that the benefits of a shared currency extend beyond simplifying transactions or mitigating risk but rather in serving to fundamentally enhance economic integration. As Europe continues to evolve economically, the findings from our research on Denmark provide crucial insights for policymakers and economists considering the broader implications of currency integration for trade partnerships and sustainable economic growth.

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Appendix

Table A.1: Denmark Main Trading Partners (2007-2023)

Country	**Share of Exports (in %)**	**Country**	**Share of Imports (in %)**
Germany	15.48%	Germany	20.98%
Sweden	11.67%	Sweden	12.57%
USA	7.93%	Netherlands	7.87%
United Kingdom	7.03%	China	7.41%
Norway	6.31%	Norway	5.14%
Netherlands	5.13%	United Kingdom	4.15%
China	3.85%	Poland	3.74%
France and Monaco	3.66%	Italy	3.52%
Poland	3.49%	USA	3.29%
Italy	2.57%	Belgium	3.23%
Finland	2.32%	France and Monaco	3.19%
Spain	2.17%	Spain	1.68%
Japan	1.94%	Czech Republic	1.50%
Belgium	1.60%	Finland	1.47%
Russia	1.18%	Russia	1.38%
Czech Republic	0.97%	Turkey	1.05%
Australia	0.96%	Ireland	0.99%
Switzerland	0.93%	Austria	0.94%
Canada	0.89%	South Korea	0.84%
Hongkong	0.86%	India	0.83%
Ireland	0.85%	Switzerland	0.81%
Turkey	0.85%	Hungary	0.77%
South Korea	0.79%	Lithuania	0.69%
Brazil	0.72%	Bangladesh	0.63%
Austria	0.70%	Greenland	0.56%
Saudi Arabia	0.66%	Latvia	0.56%
Hungary	0.60%	Taiwan	0.51%
Singapore	0.60%	Japan	0.48%
Greenland	0.50%	Thailand	0.47%

Note: Main trading partners of Denmark in the period 2007-2023 in percent of total exports and imports respectively. Grey indicates countries that have adopted the Euro in 1999. Source: Statistics Demark (2024).

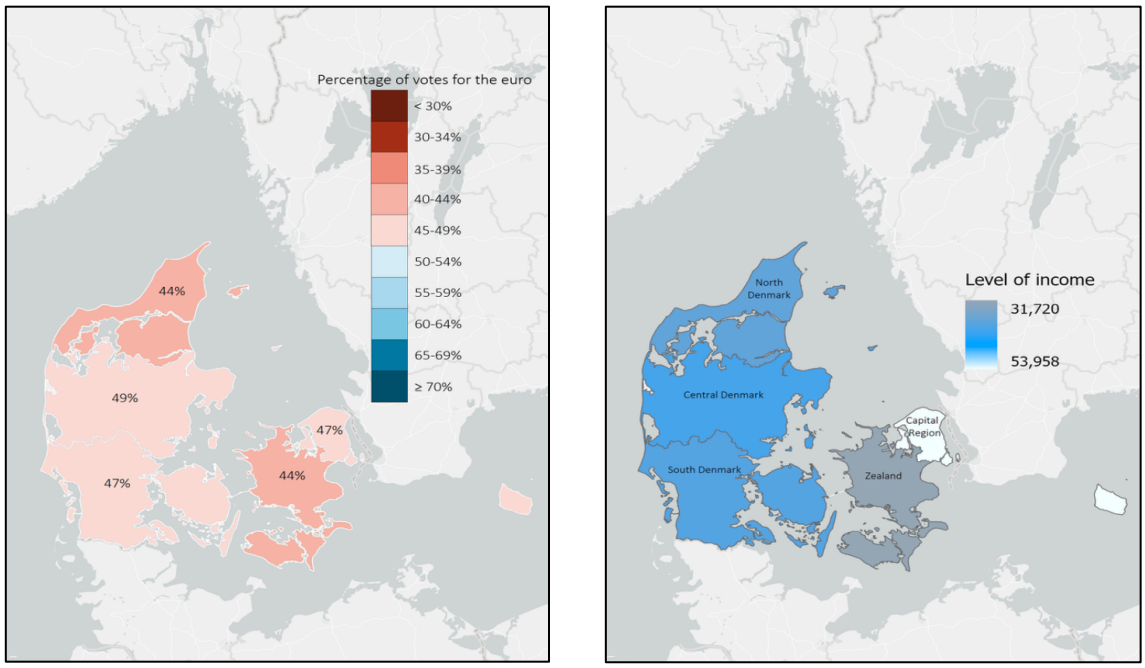

Figure A.1: Voting behavior in Danish referendum regarding Eurozone accession by region and corresponding income levels (taken from Cho and Wong (2021))

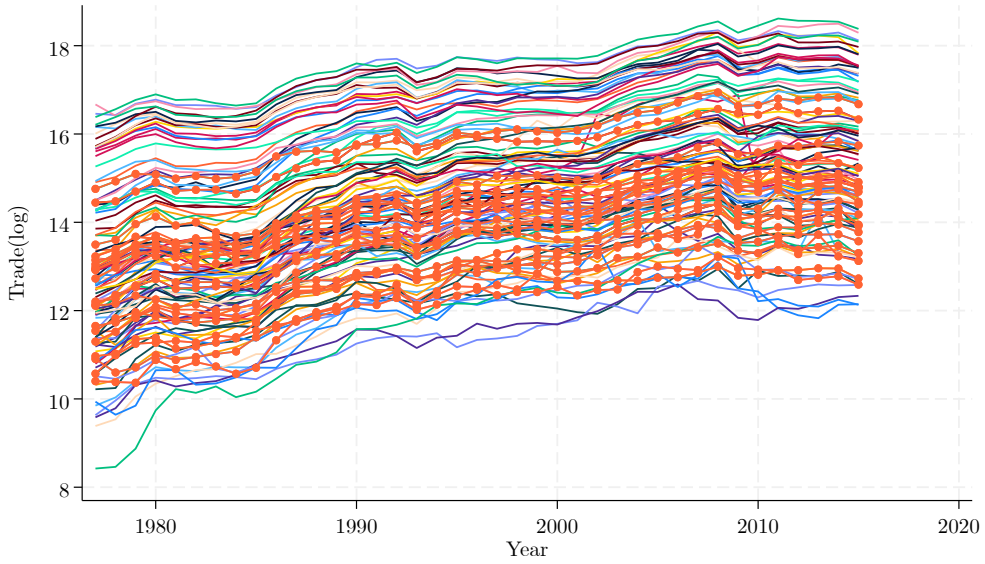

Figure A.2: All observed trade flows in log (dotted orange lines mark trade flows where Denmark is involved)

Table A.2: Weights for Exports

Country Pair	Identifier	AUT/DNK	BEL/DNK	DEU/DNK	ESP/DNK	FIN/DNK	FRA/DNK	IRL/DNK	ITA/DNK	NLD/DNK	PRT/DNK
AUT/BEL	1	0.031	0	0	0	0	0	0	0	0	0
AUT/DEU	2	0	0	0	0	0	0	0	0	0	0
AUT/DNK	3	0	0	0	0	0	0	0	0	0	0
AUT/ESP	4	0	0	0	0	0	0	0	0	0	0
AUT/FIN	5	0	0	0	0	0	0	0	0	0	0
AUT/FRA	6	0	0	0	0	0	0	0	0	0	0
AUT/IRL	7	0.373	0.28	0	0.258	0	0	0	0	0	0.135
AUT/ITA	8	0.02	0.012	0	0	0	0.048	0	0	0	0
AUT/NLD	9	0	0	0	0	0	0	0	0	0	0
AUT/PRT	10	0	0	0	0.52	0	0	0	0	0	0.143
BEL/AUT	11	0	0	0	0	0	0	0	0	0	0
BEL/DEU	12	0	0	0	0	0	0	0	0	0	0
BEL/DNK	13	0	0	0	0	0	0	0	0	0	0
BEL/ESP	14	0	0	0	0	0	0	0	0	0	0
BEL/FIN	15	0	0.147	0	0	0	0	0	0	0	0.003
BEL/FRA	16	0	0	0	0.002	0	0	0	0	0	0
BEL/IRL	17	0	0	0	0	0.025	0	0	0	0	0
BEL/ITA	18	0	0	0	0	0	0	0	0	0	0
BEL/NLD	19	0	0	0	0	0	0	0	0	0	0
BEL/PRT	20	0	0	0	0	0	0	0	0	0	0
DEU/AUT	21	0	0	0.057	0.002	0	0.003	0	0.015	0	0
DEU/BEL	22	0.002	0.001	0.141	0	0	0	0	0	0	0
DEU/DNK	23	0	0	0	0	0	0	0	0	0	0
DEU/ESP	24	0	0	0.017	0	0	0	0	0	0	0
DEU/FIN	25	0	0.017	0	0	0	0.008	0	0	0	0
DEU/FRA	26	0	0	0	0	0	0	0	0	0	0
DEU/IRL	27	0	0	0	0	0	0	0	0	0	0
DEU/ITA	28	0	0.001	0.028	0	0	0	0	0	0	0
DEU/NLD	29	0	0	0	0	0.003	0	0	0	0	0
DEU/PRT	30	0	0	0	0.008	0	0.034	0	0	0	0
DNK/AUT	31	0	0	0	0	0	0	0	0	0	0
DNK/BEL	32	0	0	0	0	0	0	0	0	0	0
DNK/DEU	33	0	0	0	0	0	0	0	0	0	0
DNK/ESP	34	0	0	0	0	0	0	0	0	0	0
DNK/FIN	35	0	0	0	0	0	0	0	0	0	0
DNK/FRA	36	0	0	0	0	0	0	0	0	0	0
DNK/IRL	37	0	0	0	0	0	0	0	0	0	0
DNK/ITA	38	0	0	0	0	0	0	0	0	0	0
DNK/NLD	39	0	0	0	0	0	0	0	0	0	0
DNK/PRT	40	0	0	0	0	0	0	0	0	0	0
ESP/AUT	41	0	0	0	0	0	0	0	0	0	0
ESP/BEL	42	0	0	0	0.051	0	0	0	0	0	0
ESP/DEU	43	0	0	0	0	0	0	0	0	0	0
ESP/DNK	44	0	0	0	0	0	0	0	0	0	0
ESP/FIN	45	0	0	0	0	0	0	0	0	0	0
ESP/FRA	46	0	0	0	0.002	0	0	0	0	0	0
ESP/IRL	47	0	0	0	0	0	0	0	0	0	0

ESP/ITA	48	0	0	0	0.003	0.001	0	0	0	0	0
ESP/NLD	49	0	0	0	0	0.001	0	0	0	0	0
ESP/PRT	50	0	0	0	0.013	0.283	0	0	0	0	0.005
FIN/AUT	51	0	0	0	0	0	0	0	0	0	0
FIN/BEL	52	0	0	0	0	0.014	0	0	0	0	0
FIN/DEU	53	0	0	0	0	0	0	0	0	0	0
FIN/DNK	54	0	0	0	0	0	0	0	0	0	0
FIN/ESP	55	0	0	0	0	0	0	0	0	0	0
FIN/FRA	56	0	0	0	0	0.143	0	0	0	0	0
FIN/IRL	57	0	0	0	0	0	0	0.069	0	0	0
FIN/ITA	58	0	0	0	0	0.183	0	0	0	0	0
FIN/NLD	59	0	0	0	0	0	0	0	0	0	0
FIN/PRT	60	0	0.014	0	0	0	0.686	0	0.092	0	0.186
FRA/AUT	61	0	0	0	0	0	0	0	0	0	0
FRA/BEL	62	0	0	0	0	0	0	0	0	0	0
FRA/DEU	63	0	0	0	0	0	0	0	0	0	0
FRA/DNK	64	0	0	0	0	0	0	0	0	0	0
FRA/ESP	65	0	0	0	0	0	0	0	0	0	0
FRA/FIN	66	0	0	0	0	0	0	0	0	0	0
FRA/IRL	67	0	0	0	0	0	0	0	0	0	0
FRA/ITA	68	0	0	0	0	0	0.032	0	0.023	0	0
FRA/NLD	69	0	0	0	0	0	0	0.003	0.02	0	0
FRA/PRT	70	0	0	0	0	0	0.059	0	0	0	0
IRL/AUT	71	0.557	0.427	0	0	0	0	0.441	0.207	0.02	0
IRL/BEL	72	0	0	0	0	0	0	0.008	0.066	0	0
IRL/DEU	73	0	0	0	0	0	0	0	0	0	0
IRL/DNK	74	0	0	0	0	0	0	0	0	0	0
IRL/ESP	75	0	0	0	0	0	0	0.022	0	0	0
IRL/FIN	76	0	0	0	0	0	0	0.038	0	0	0
IRL/FRA	77	0	0	0	0	0	0	0.034	0	0	0
IRL/ITA	78	0	0	0	0	0.043	0	0	0	0	0
IRL/NLD	79	0	0	0	0	0	0	0	0	0	0
IRL/PRT	80	0	0	0	0	0	0	0.332	0	0	0.193
ITA/AUT	81	0	0	0	0	0	0	0	0	0	0
ITA/BEL	82	0	0	0	0	0	0	0	0	0	0
ITA/DEU	83	0	0	0	0	0	0	0	0	0	0
ITA/DNK	84	0	0	0	0	0	0	0	0	0	0
ITA/ESP	85	0	0	0	0	0	0	0	0	0	0
ITA/FIN	86	0	0	0	0	0	0	0	0	0	0
ITA/FRA	87	0	0	0	0	0	0	0	0	0	0
ITA/IRL	88	0	0	0	0	0	0	0	0	0	0
ITA/NLD	89	0	0	0	0	0.303	0	0	0	0	0
ITA/PRT	90	0	0	0	0.081	0	0	0	0	0	0
NLD/AUT	91	0	0	0	0	0	0	0	0	0.595	0
NLD/BEL	92	0	0	0	0	0	0	0	0.02	0.014	0
NLD/DEU	93	0	0.009	0	0	0	0.019	0	0.007	0	0
NLD/DNK	94	0	0	0	0	0	0	0	0	0	0
NLD/ESP	95	0	0	0	0	0	0	0	0	0	0
NLD/FIN	96	0	0	0	0	0	0	0	0	0.037	0
NLD/FRA	97	0	0	0	0	0	0	0	0	0	0

NLD/IRL	98	0	0	0	0	0	0	0	0	0.069	0
NLD/ITA	99	0.017	0	0	0	0	0	0	0	0	0
NLD/PRT	100	0	0.063	0	0	0	0	0.055	0	0.196	0
PRT/AUT	101	0	0	0	0	0	0	0	0.551	0	0.335
PRT/BEL	102	0	0.009	0	0	0	0	0	0	0	0
PRT/DEU	103	0	0.009	0	0	0	0	0	0	0	0
PRT/DNK	104	0	0	0	0	0	0	0	0	0	0
PRT/ESP	105	0	0	0	0	0	0	0	0	0	0
PRT/FIN	106	0	0	0	0	0	0	0	0	0	0
PRT/FRA	107	0	0.011	0	0	0	0.11	0	0	0	0
PRT/IRL	108	0	0	0	0	0	0	0	0	0	0
PRT/ITA	109	0	0	0.555	0.036	0	0	0	0	0	0
PRT/NLD	110	0	0	0.202	0.024	0	0	0	0	0.068	0

Table A.3: Weights for Imports

Country Pair	Identifier	DNK/AUT	DNK/BEL	DNK/DEU	DNK/ESP	DNK/FIN	DNK/FRA	DNK/IRL	DNK/ITA	DNK/NLD	DNK/PRT
AUT/BEL	1	0	0	0	0	0	0	0	0	0	0
AUT/DEU	2	0	0	0	0	0	0	0	0	0	0.019
AUT/DNK	3	0	0	0	0	0	0	0	0	0	0
AUT/ESP	4	0	0	0	0	0	0	0	0	0	0.054
AUT/FIN	5	0	0	0	0	0	0	0	0	0	0
AUT/FRA	6	0	0	0	0	0	0	0	0	0	0
AUT/IRL	7	0	0	0	0	0	0	0	0	0	0
AUT/ITA	8	0	0	0	0	0	0	0	0	0	0
AUT/NLD	9	0	0.022	0	0	0	0	0	0	0.084	0
AUT/PRT	10	0	0	0	0	0	0	0	0	0	0.179
BEL/AUT	11	0	0	0	0.032	0	0	0	0.174	0	0
BEL/DEU	12	0	0	0	0	0	0	0	0	0	0
BEL/DNK	13	0	0	0	0	0	0	0	0	0	0
BEL/ESP	14	0	0	0	0	0	0	0	0	0	0
BEL/FIN	15	0	0	0	0	0	0	0	0.079	0	0.04
BEL/FRA	16	0	0	0	0	0	0	0	0	0	0
BEL/IRL	17	0	0.049	0.322	0.021	0	0.139	0	0.165	0.166	0
BEL/ITA	18	0	0	0	0	0	0	0	0	0	0
BEL/NLD	19	0	0	0	0	0	0	0	0	0.021	0
BEL/PRT	20	0	0	0	0	0	0	0	0	0	0
DEU/AUT	21	0	0	0	0	0	0	0	0	0	0
DEU/BEL	22	0	0	0	0	0	0	0	0	0	0
DEU/DNK	23	0	0	0	0	0	0	0	0	0	0
DEU/ESP	24	0	0	0	0	0	0	0	0	0	0
DEU/FIN	25	0	0	0	0	0	0	0	0	0	0
DEU/FRA	26	0	0	0	0	0	0	0	0	0	0
DEU/IRL	27	0	0	0	0.012	0	0	0	0	0	0

DEU/ITA	28	0	0	0	0.001	0	0.022	0	0	0	0
DEU/NLD	29	0.003	0	0	0.002	0	0.001	0	0.002	0	0
DEU/PRT	30	0	0	0	0	0	0	0.015	0	0	0
DNK/AUT	31	0	0	0	0	0	0	0	0	0	0
DNK/BEL	32	0	0	0	0	0	0	0	0	0	0
DNK/DEU	33	0	0	0	0	0	0	0	0	0	0
DNK/ESP	34	0	0	0	0	0	0	0	0	0	0
DNK/FIN	35	0	0	0	0	0	0	0	0	0	0
DNK/FRA	36	0	0	0	0	0	0	0	0	0	0
DNK/IRL	37	0	0	0	0	0	0	0	0	0	0
DNK/ITA	38	0	0	0	0	0	0	0	0	0	0
DNK/NLD	39	0	0	0	0	0	0	0	0	0	0
DNK/PRT	40	0	0	0	0	0	0	0	0	0	0
ESP/AUT	41	0	0	0	0	0	0	0	0	0	0
ESP/BEL	42	0	0	0	0	0	0	0	0	0	0
ESP/DEU	43	0	0	0	0	0	0	0	0	0	0
ESP/DNK	44	0	0	0	0	0	0	0	0	0	0
ESP/FIN	45	0	0	0	0	0	0	0	0	0	0
ESP/FRA	46	0	0	0	0	0	0	0	0	0	0
ESP/IRL	47	0	0	0	0	0	0	0	0	0	0
ESP/ITA	48	0	0	0	0	0	0	0	0	0	0
ESP/NLD	49	0	0	0	0	0	0	0	0	0	0
ESP/PRT	50	0	0	0	0	0	0	0	0	0	0
FIN/AUT	51	0.116	0	0	0	0.518	0	0	0	0	0
FIN/BEL	52	0	0	0	0	0	0	0	0	0	0
FIN/DEU	53	0	0	0	0	0	0	0	0	0	0
FIN/DNK	54	0	0	0	0	0	0	0	0	0	0
FIN/ESP	55	0	0	0	0	0	0	0	0	0	0
FIN/FRA	56	0	0	0	0	0	0	0	0	0	0
FIN/IRL	57	0	0	0	0	0	0	0.815	0.014	0	0
FIN/ITA	58	0	0	0	0	0	0	0	0	0	0
FIN/NLD	59	0	0	0	0	0	0	0	0	0	0
FIN/PRT	60	0	0	0	0	0	0	0	0	0	0.34
FRA/AUT	61	0	0	0	0	0	0	0	0	0	0
FRA/BEL	62	0	0	0	0	0	0	0	0	0	0
FRA/DEU	63	0	0	0.023	0	0	0	0	0	0	0
FRA/DNK	64	0	0	0	0	0	0	0	0	0	0
FRA/ESP	65	0	0	0	0	0	0	0	0	0	0
FRA/FIN	66	0	0	0	0	0	0	0	0	0	0
FRA/IRL	67	0	0	0	0	0	0	0	0	0	0
FRA/ITA	68	0	0	0	0	0	0	0	0	0	0
FRA/NLD	69	0	0.042	0.276	0	0.067	0.017	0	0.019	0.058	0
FRA/PRT	70	0	0	0	0	0	0	0	0	0	0
IRL/AUT	71	0.599	0	0	0.332	0	0	0	0	0	0

IRL/BEL	72	0	0	0	0	0	0	0	0	0	0
IRL/DEU	73	0	0	0	0	0	0	0	0	0	0
IRL/DNK	74	0	0	0	0	0	0	0	0	0	0
IRL/ESP	75	0	0	0	0	0	0	0.144	0	0	0
IRL/FIN	76	0.276	0.674	0	0.508	0.415	0.495	0	0.222	0	0
IRL/FRA	77	0	0.118	0	0	0	0.174	0	0.098	0.629	0
IRL/ITA	78	0	0	0	0	0	0	0	0	0	0
IRL/NLD	79	0	0	0	0	0	0	0	0	0	0
IRL/PRT	80	0	0	0	0	0	0	0	0	0	0
ITA/AUT	81	0	0	0	0	0	0	0	0	0	0
ITA/BEL	82	0	0	0	0	0	0	0	0	0	0
ITA/DEU	83	0	0	0	0	0	0	0	0	0	0
ITA/DNK	84	0	0	0	0	0	0	0	0	0	0
ITA/ESP	85	0	0	0	0	0	0	0	0	0	0
ITA/FIN	86	0	0	0	0	0	0	0	0	0	0
ITA/FRA	87	0	0	0	0	0	0	0	0	0	0
ITA/IRL	88	0	0	0	0	0	0	0	0	0	0
ITA/NLD	89	0	0	0.109	0	0	0	0	0	0	0
ITA/PRT	90	0	0	0	0	0	0	0.016	0	0	0
NLD/AUT	91	0	0	0	0	0	0	0	0	0	0.008
NLD/BEL	92	0.003	0	0	0	0	0.009	0	0	0	0
NLD/DEU	93	0.004	0	0.033	0	0	0	0	0.012	0	0
NLD/DNK	94	0	0	0	0	0	0	0	0	0	0
NLD/ESP	95	0	0	0.118	0.012	0	0	0	0	0	0
NLD/FIN	96	0	0	0	0	0	0	0	0	0	0
NLD/FRA	97	0	0	0	0	0	0	0	0	0	0
NLD/IRL	98	0	0.03	0.011	0	0	0	0	0	0.042	0.005
NLD/ITA	99	0	0.066	0.107	0	0	0.044	0	0	0	0
NLD/PRT	100	0	0	0	0.08	0	0.098	0	0.002	0	0.098
PRT/AUT	101	0	0	0	0	0	0	0	0	0	0.257
PRT/BEL	102	0	0	0	0	0	0	0	0	0	0
PRT/DEU	103	0	0	0	0	0	0	0	0	0	0
PRT/DNK	104	0	0	0	0	0	0	0	0	0	0
PRT/ESP	105	0	0	0	0	0	0	0.015	0	0	0
PRT/FIN	106	0	0	0	0	0	0	0	0	0	0
PRT/FRA	107	0	0	0	0	0	0	0	0	0	0
PRT/IRL	108	0	0	0	0	0	0	0	0	0	0
PRT/ITA	109	0	0	0	0	0	0	0	0	0	0
PRT/NLD	110	0	0	0	0	0	0	0	0	0	0

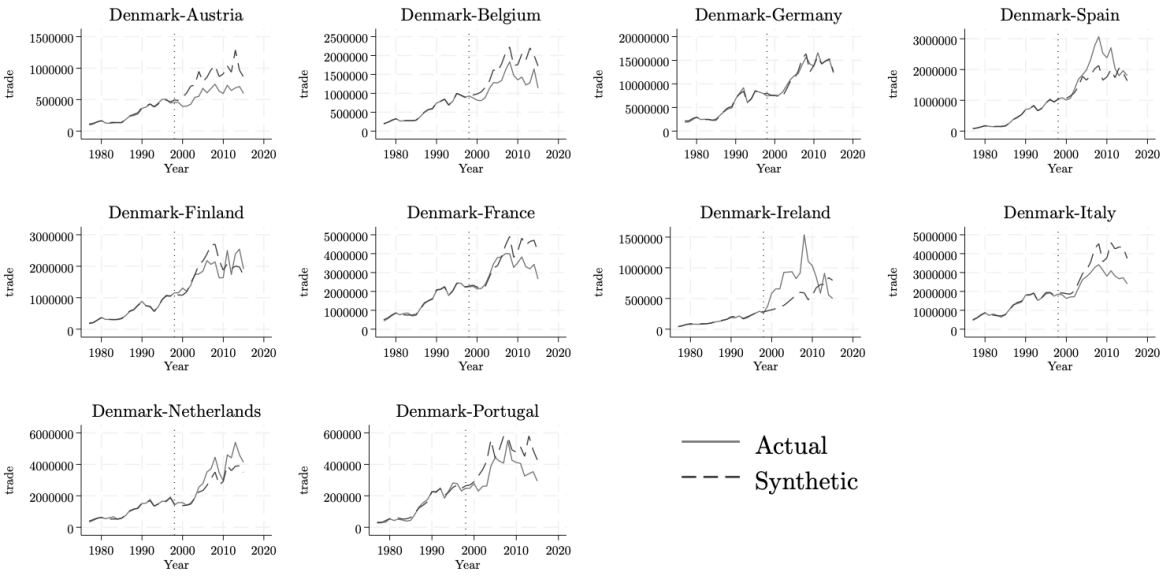

Figure A.3: Synthetic Exports by Country Pair

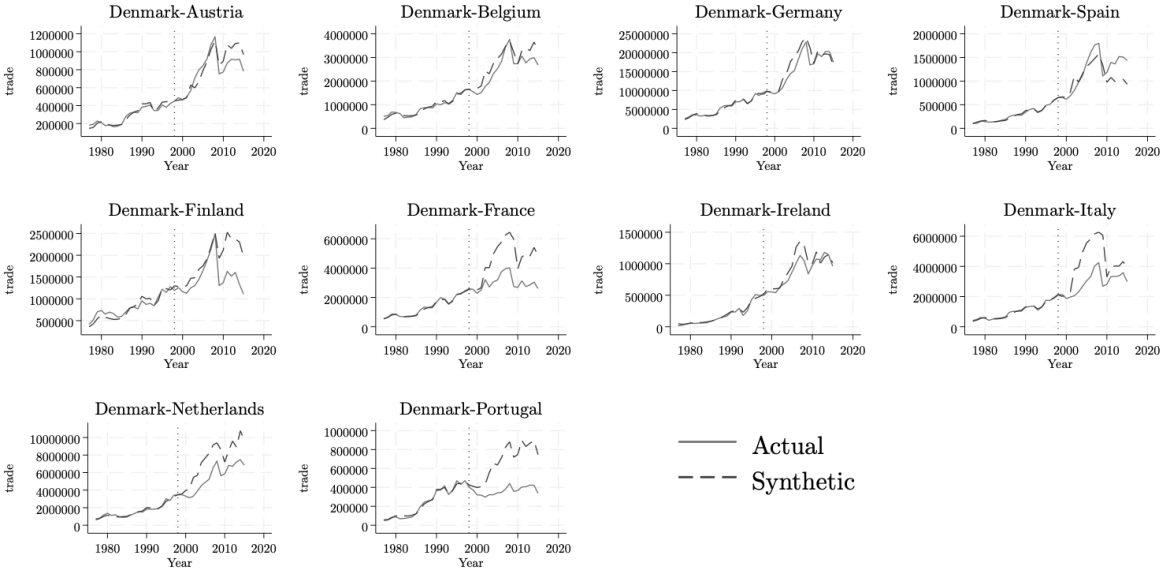

Figure A.4: Synthetic Imports by Country Pair

Table A.4: Differences between synthetic and actual trade flows for Danish imports, exports and total trade by time periods (in %)

Diff. synth vs. actual in %	**1999-2001**	**2002-2004**	**2005-2007**	**2008-2010**	**2011-2013**	**2014-2015**
Imports						
	-6.72	-23.89	-21.26	-19.19	-13.35	-14.96
Exports						
	-0.72	1.74	-1.88	0.96	-6.12	-9.12
Total Trade						
	-4.17	-14.32	-13.83	-11.81	-10.23	-12.51

Table A.5: Actual and Synthetic Danish Imports, Exports and Total Trade (1977-2015)

Year	**Imports**		**Exports**		**Total Trade**	
	Synth	**Actual**	**Synth**	**Actual**	**Synth**	**Actual**
1977	4891837.42	5578116.68	4172868.56	3766172.69	9064705.98	9344289.37
1978	5887104.56	6476980.81	4569466.73	4269859.94	10456571.3	10746840.8
1979	7458489.62	8154786.45	5738313.22	5375585.03	13196802.8	13530371.5
1980	8349186.81	8211151.57	6436931.63	6528020.07	14786118.4	14739171.6
1981	7484483.25	7200548.43	5541259.49	5482504.61	13025742.7	12683053
1982	7172664.61	7445073.5	5455240.53	5729577.23	12627905.1	13174650.7
1983	7061148.85	7055367.35	5435986.16	5779200.4	12497135	12834567.8
1984	7219857.89	7125427.99	5306394.64	5116647.14	12526252.5	12242075.1
1985	7662850.07	7948971.56	5555757.27	5706497.42	13218607.3	13655469
1986	9555781.4	10987371	7693645.44	7677315.42	17249426.8	18664686.4
1987	11469752.5	12315868.4	9796828	9784590.74	21266580.5	22100459.1
1988	12538173.6	12676118.4	11209638	10899518.8	23747811.6	23575637.3
1989	13206949.8	12354328.3	12026203.7	11609312.6	25233153.5	23963640.9
1990	16126603.1	15126609.4	15637470.7	15296069.5	31764073.8	30422679
1991	16094902.1	15459873.2	16429258.8	16556179	32524160.9	32016052.2
1992	16845917.1	16272921.9	17586954.4	18380266.5	34432871.5	34653188.3
1993	14243283.6	14180943.9	13402284.1	13332374.4	27645567.7	27513318.3
1994	16035096.1	16186554.7	15153429.7	15075231.6	31188525.8	31261786.3

1995	20068944.2	20696618.3	18384294.9	18414253.5	38453239.1	39110871.9
1996	20858027.3	19908426.3	18324851.4	18370661.1	39182878.7	38279087.4
1997	21415208.9	22190022.4	17689410.2	17734775.6	39104619.1	39924797.9
1998	22936768.4	22905479.1	17809946.6	17084246.7	40746715	39989725.8
1999	22744477.4	22482145.1	17484403.6	17394783.7	40228881	39876928.8
2000	23299852.2	21171224.2	17324641.6	17200362.4	40624493.8	38371586.6
2001	24313009.8	21973004.4	17380778.4	17218486	41693788.2	39191490.5
2002	33028257.7	24708033.9	18413566.6	18857336.2	51441824.3	43565370.1
2003	34808443.9	27753793.5	21949933.3	22756892.1	56758377.2	50510685.6
2004	42379936.1	31424608.6	26324402.5	26231058.4	68704338.6	57655667
2005	46165399.7	33975645.1	26934743.5	28228248.1	73100143.2	62203893.2
2006	49513819.1	39005994	30619074.5	30134179.5	80132893.6	69140173.6
2007	54737218.9	45453295.4	36037261.2	33469544	90774480.1	78922839.4
2008	57293902.9	49146017.7	38616537.2	37408218.8	95910440.1	86554236.5
2009	51034770.6	34898851.3	30086411.2	31914421	81121181.8	66813272.3
2010	40011183.2	35832995.8	32063117.7	30479802.1	72074300.9	66312798
2011	47801087.3	41467748.9	37454103.6	36729569	85255190.9	78197317.9
2012	47710093.2	39837600.7	34168531.4	31360762.6	81878624.6	71198363.4
2013	47192811.8	42347662.5	36632506.6	33540157	83825318.4	75887819.5
2014	50185634.8	42704708.1	36438799.8	33551062.3	86624434.6	76255770.5
2015	43812194.9	37235211.9	31066824	27807001.8	74879018.9	65042213.7

Note: Actual and synthetic imports, exports and total trade in current thousand US Dollars.