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The impact of the euro on trade: two decades into monetary union

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Contents

Abstract

The consensus back in 2008 – ten years after the introduction of the euro – was that the adoption of a common currency had made a limited impact of around 2% in total on the trade flows of the first wave of euro area countries (Baldwin et al., 2008). Since then, six more countries have joined the euro area, and firms have internationalised their production processes. These two phenomena are interrelated and may have changed the way the common currency affects the euro area economy. Therefore, with the common currency now into its third decade – and with more countries queuing to adopt it – this paper revisits the trade effects of the euro, focusing on the newer euro adopters (i.e. those countries that have adopted the euro since 2007) and their interaction with the first wave of euro area members via supply chains. The contribution of the paper is twofold. First, it revisits the estimated aggregate impact of the euro on euro area trade, as well as on trade within and between the two waves of adopters. Data on bilateral flows between 1990 and 2015 for an extended sample of countries to estimate a gravity equation indicate a significant trade impact, ranging between 4.3% and 6.3% in total on average, with the magnitude being the highest for exports from the second wave of adopters to the first wave of adopters. If a synthetic control approach (Abadie and Gardeazabal, 2003; Abadie et al., 2010) is used instead, the estimated gains associated with euro adoption are greater. In particular, exports of both intermediate and final products from countries belonging to the first wave of euro adopters to those belonging to the second wave are estimated to have increased by about 30% using this approach. The second contribution made by this paper relates to the channels through which trade might be affected by a currency union. This question is explored by looking separately at trade in intermediate goods and final products. While we find that trade gains were mainly driven by trade in intermediate goods among countries that adopted the currency earlier (5.3%), our results also show that the euro had a positive effect on the exports of final products from the second wave of adopters to other euro area countries. This effect is as high as 10.6% with the gravity model and 32% with the synthetic control approach. One of the reasons for the difference in the range of estimates between the two approaches might be that the gravity model can control for unobserved characteristics via fixed effects, while the synthetic control approach may fail to do so. These results suggest that the euro facilitated the establishment and expansion of international production chains in Europe. In turn, this is likely to have increased business cycle synchronisation in the euro area and to have supported market access for later adopters.

Keywords: euro, trade flows, global value chains, gravity equation, synthetic control approach

JEL codes: F14, F15

Non-technical summary

It is now more than two decades since the euro was introduced. A number of economies have adopted the single currency in the intervening years, and further countries are in the queue. Against this backdrop, a quantitative reassessment of the euro's impact on trade is of particular interest, especially given that production processes have become increasingly internationalised.

Over the last 20 years, euro area economies have become more and more open to trade and integrated into cross-border supply chains, most notably within the euro area. The Single Market and the common currency have undoubtedly contributed to this trend.

The aim of this paper is to estimate the impact of the euro on bilateral export flows (i) among the first wave of euro area countries, (ii) among the second wave of euro area countries and (iii) between the two groups, taking into account their pan-European contribution to global value chains. To this end, two different estimation methods are applied. First, a gravity equation is estimated with a saturated set of fixed effects using the Poisson pseudo-maximum likelihood estimator. The results are then compared with those derived by applying the synthetic control method, which estimates what bilateral trade flows in euro area economies would have been had these countries not adopted the single currency.

We show the relationship between the emergence of international production chains, which are particularly pervasive in the European Union, and the adoption of the euro by a further set of countries from 2007 onwards. In reducing trade costs more for firms with internationally fragmented production chains than for others, euro adoption may indeed have boosted regional production chains.

By looking at intermediate as well as final goods, the paper provides new evidence that the euro has facilitated trade creation, business cycle synchronisation and the emergence of value chains within the euro area. In this way, the paper contributes to the debate on the endogeneity of optimum currency areas. Our main finding is that the euro has fostered export flows between the first wave of euro area countries and subsequent euro adopters. In particular, the countries in the first wave have increased their exports of both final goods and intermediate inputs to countries joining later, whereas these newer members have increased their exports of final goods.

1 Introduction

The year 2019 marked the 20th anniversary of the introduction of the euro. The adoption of a common currency introduced by the Treaty on European Union (known as the “Maastricht Treaty”) was a key step in the establishment of Economic and Monetary Union (EMU). As the process of European integration advanced towards the establishment of the Single Market, a common currency became essential. In particular, a common currency would bring the benefits of reducing transaction costs, removing nominal exchange rate volatility and hedging costs, and increasing price transparency across countries (cf. Mundell,1961 and subsequent literature, e.g. McKinnon, 1963 and Kenen, 1969, on optimum currency area theory[1]).

1.1 An overview of the literature

By decreasing transaction costs, a European common currency should in principle facilitate trade. The process of European integration delivered a common framework which addressed consumer and labour protection, providing common product standards and production rules. Together with a common currency and a monetary union, all these factors facilitated the market integration of European countries by lowering trade-related costs. However, the European integration process came about during a phase of profound transformation in the global economy, with an unprecedented move towards the opening up of markets for both advanced and emerging economies. In 1995, the World Trade Organization was established, and a great many countries joined over the subsequent decade. This led to a reduction in trade barriers and the opening up of new markets to the global economy, most notably China. Meanwhile, five Member States of the European Union had already signed the first Schengen Agreement in 1985 intended to gradually abolish border checks, thus forming a free trade area. It therefore remains therefore difficult to evaluate the effect of the euro on the trade flows of euro area countries in isolation. The topic is the subject of an exceptionally prolific stream of policy and academic analysis, sometimes leading to contrasting evidence.

Before the launch of EMU, many academics and politicians debated whether the euro area was – or would endogenously become – an optimum currency area (OCA). Mongelli (2002, 2008) reviews the various properties of an OCA: price and wage flexibility, mobility of resources (including labour), business cycle synchronisation and economic openness. This paper focuses on the openness property in OCA theory. In very open economies, the nominal exchange rate is less

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[1] The literature on the notion of an optimum currency area began almost half a century ago, following the seminal contribution of Mundell (1961). The conditions for an optimum currency area include the existence of price and wage flexibility, mobility of input factors, financial and fiscal integration, similarity of inflation rates and business cycle synchronisation. Although there was general consensus prior to the introduction of the euro on the fact that the euro area was not yet fulfilling all of these conditions, it was also believed that the introduction of a common currency could boost trade and contribute to creating an optimum currency area ex post. However, the empirical evidence on whether this has been the case is rather mixed, as reviewed in the main text.

useful as an adjustment instrument because shocks are more likely to be transmitted to the domestic economy through the price of tradable goods. Some authors[2] thought that economic convergence towards an OCA might even happen endogenously through an increase in trade.

Pre-euro trade literature largely shared this positive view, arguing that, on average, joining a common currency would be associated with an increase in trade. Before the introduction of the euro, its potential impact was generally inferred by looking at already existing common currencies among countries across the world. The seminal work of Rose (2000), based on gravity regressions including geographical and institutional controls with data every fifth year between 1970 and 1990, found that the level of trade between two countries sharing a currency was up to three times higher than the level of trade between countries with no common currency. Ensuing literature highlighted the need to control for additional determinants of bilateral trade, such as the relative level of trade barriers or unobservable factors which are country and time-specific. Taking these considerations into account, and assuming symmetry between entries and exits of currency unions, Glick and Rose (2002) estimated the effect of a common currency to be lower but still very high (about a 100% increase). However, as pointed out in Micco et al. (2003), results for other currency unions may not directly apply to the case of the euro, as they concern poor or very small economies which are not fully comparable with those of euro area countries.

Post-1999 literature tempered the optimism: the evidence on the actual trade impact of the euro is not robust to different econometric specifications and data samples and has led to mixed results. A meta-analysis by Glick and Rose (2015, 2016) and Rose (2017) combines data from existing studies. It finds that increasing the time span and expanding the set of countries tends to deliver a higher estimated impact of the introduction of the euro on trade. However, other methodological aspects have been called into question, and several papers have addressed issues such as the presence of zero trade flows, heteroskedasticity in the sample and robust inference, finding an estimated non-significant effect of the euro.[3] In a paper published to mark the tenth anniversary of the single currency, Baldwin et al. (2008) conclude that the impact of the euro on trade is small but significant, at about 2%. In addition, many papers report heterogeneous currency effects along several dimensions, including country size, differences between “core” and “peripheral” euro area member countries,[4] variety of products and productivity of firms. Among these studies is the work carried out by Chen and Novy (2018), who argue that trade effects are larger for those countries starting with a relatively lower level of bilateral trade. Finally, Berthou and Fontagné (2008) were the first to adopt a firm-level approach, measuring the impact of EMU to find that the single currency had a positive effect on the number of French exporting firms (extensive margin).

[2] Frankel and Rose (1998).

[3] See **Box 1** for methodological details.

[4] Miles and Vijverberg (2018) and Belke et al. (2017) look at old euro area countries and find increased synchronization among core euro area countries, but less among peripheral ones. Matesanz et al. (2017) challenge this duality between core and peripheral countries, arguing in favour of the presence of different clusters.

Other studies have expanded the analysis and looked at the trade impact of the whole process of European regional integration, of which monetary union is just one step among others. While evolving from a free trade area to a customs union, and then to a common market, the European Union witnessed a very significant deepening of intra-regional trade among its Member States. Hence, in the case of Europe, the relevant time horizon extends beyond the establishment of EMU and covers the whole process of institutional integration. Empirical evidence supporting this conclusion is provided in Agur et al. (2005) and in Dorrucci et al. (2005).

1.2 Contribution of the paper and key findings

This paper makes two contributions to this literature. First, it estimates the impact of the euro on bilateral export flows of the first and the second waves of euro adopters separately using two different methodologies. The first wave of adopters refers to countries which had joined the euro by 2001, whereas the second wave of adopters comprises those countries which have joined the euro since 2007.[5] Two decades on from the introduction of the euro, with a number of economies joining the common currency in the intervening years and further countries in the queue to adopt it, it is of particular interest now to revisit the topic of the euro's effect on trade, especially given that production processes have become increasingly internationalised.[6] A first contribution of the paper is to estimate separately the trade impact of the euro on bilateral flows (i) among the first wave of euro area countries, (ii) among the second wave of euro area countries and (iii) between the two. To this end, two different estimation methods are applied. In particular, a gravity equation is estimated with a saturated set of fixed effects using the Poisson pseudo-maximum likelihood (PPML) estimator. The results are then compared with those derived by applying the synthetic control method, which estimates what bilateral trade flows in euro area economies would have been had these countries not adopted the single currency.

The second way in which this paper contributes to the literature is that it takes account of the pan-European contribution to global value chains (GVCs) by distinguishing between trade in intermediate and final goods. The separate analysis of the impact of the euro on trade in intermediate and final goods provides information about the channels through which trade might be affected by a currency

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5 Unless specified otherwise, throughout the paper the countries referred to as "first-wave" or "old" euro area countries are Belgium, Germany, Ireland, Greece, Spain, France, Italy, Luxembourg, Netherlands, Austria, Portugal and Finland. Those referred to as "second-wave" or "new" euro area countries are Slovenia (which joined in 2007), Cyprus, Malta (both 2008), Slovakia (2009), Estonia (2011), Latvia (2014) and Lithuania (2015).

6 The empirical literature, including studies of countries that joined the euro area more recently, is quite scarce and shows mixed results. Mensah (2017) finds a significant and large impact of about 50-60% for "new" countries and a negative and non-significant effect for "old" countries. Based on firm-level data for Estonia and Slovakia until 2015, Lalinsky and Merikull (2018) find a significant impact of about 14% on the latter and a non-significant impact on the former, suggesting that the difference between the two countries is driven by the pre-euro currency arrangements. Papers with a shorter post-euro time series, such as Cieślik et al. (2012), find that the euro did not imply a positive effect on export volumes for "new" euro area countries, suggesting that the euro's impact might have taken some time to feed through. Mika and Zymek (2018), meanwhile, find a non-significant impact.

union. We also explore whether there has been trade diversion[7] from – or creation of trade to – other countries out of the euro area.

Our dataset covers bilateral trade flows between 190 countries over the period 1990-2015. We estimate the trade impact of the euro by applying two different methodologies. First, we estimate a state-of-the-art gravity equation with a saturated set of fixed effects using the recommended PPML estimation method in order to account for zero trade flows[8] and heteroscedasticity. Second, we apply the synthetic control method of Abadie and Gardeazabal (2003) to measure the gains relative to a hypothetical counterfactual capturing bilateral trade flows in euro area economies had they not adopted the single currency.

Our results show that the euro increased trade among the first wave of countries adopting the single currency. The gravity model results show that after the introduction of the euro, bilateral exports among the first wave of euro area countries increased by around 5.5% on average between 1995 and 2015, a small but significant positive impact. The synthetic control approach shows an increase in exports of about 10%, which is somewhat higher than for similar pairs of countries not sharing a common currency (non-treated).

In addition, we find a positive and significant impact of the euro on trade between the first and the second waves of euro adopters. According to our gravity equation estimations, bilateral exports between the first and second waves of euro area countries were between 4% and 6% higher after euro adoption. Bilateral trade among new euro area countries also increased, rising by about 5%. The results from the synthetic control approach estimations go in the same direction, i.e. they are qualitatively similar to those from the gravity approach, although quantitatively they are significantly higher, with a trade impact of between 15% and 20%.

The positive effect of the euro on trade is the result of an increase in the exchange of both intermediate and final products between euro area countries, which is consistent with the emergence of GVCs. According to the gravity model, the euro had a positive effect on trade in intermediate products among the first-wave countries (5.3%). It had an even larger impact on second-wave countries' exports of final products to other euro area countries (effect as high as 10.6%). The synthetic approach results show that the first wave of euro adopters significantly increased their exports of both final and intermediate products to the second wave.

To the extent that the euro facilitates the emergence of GVCs within the euro area, EMU can indeed be considered a key factor reinforcing OCA endogeneity. The process of integration into a common currency area has allowed firms in the euro area to efficiently set up cross-border production structures and hence increase their international competitiveness. This integration has contributed towards increasing business cycle synchronisation in the euro area, as shocks are

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[7] See Dai et al. (2014) in the context of regional trade agreements.

[8] Zero trade flows are a common consequence of rounding in bilateral trade data, for instance when trade flows are expressed in millions.

transmitted through production chains.[9] In this sense, the euro area has come closer to being an OCA as described in the seminal paper by Mundell (1961) and subsequent literature.

Although our results are robust to the use of different techniques and to a battery of different tests, a note of caution is needed. As highlighted in Agur et al. (2005), Dorrucci et al. (2005) and Baldwin et al. (2008), the European integration process that started in the 1960s is long-term and still ongoing, which means that the euro effect may capture, at least partially, a delayed effect of measures aimed at increasing market integration via the Single Market. In addition, euro adoption by the second wave of countries (2007-15) came relatively shortly after their accession to the European Union in 2004 and materialised in the years surrounding the global trade collapse of 2009, making it difficult to disentangle the effect of the common currency. We have tried to address methodological issues arising in previous analyses and account for many of these confounding factors. However, we cannot fully rule out the possibility that they may still drive some of our results.

The paper is structured as follows. The next section provides a descriptive overview of developments of intra- and extra-euro area trade since the introduction of the euro in 1999. Section 3 estimates a gravity equation using the PPML estimator and a saturated set of fixed effects. Section 4 explores the impact of the euro on trade using the synthetic control approach and discusses the results. The conclusion of the paper is set out in Section 5.

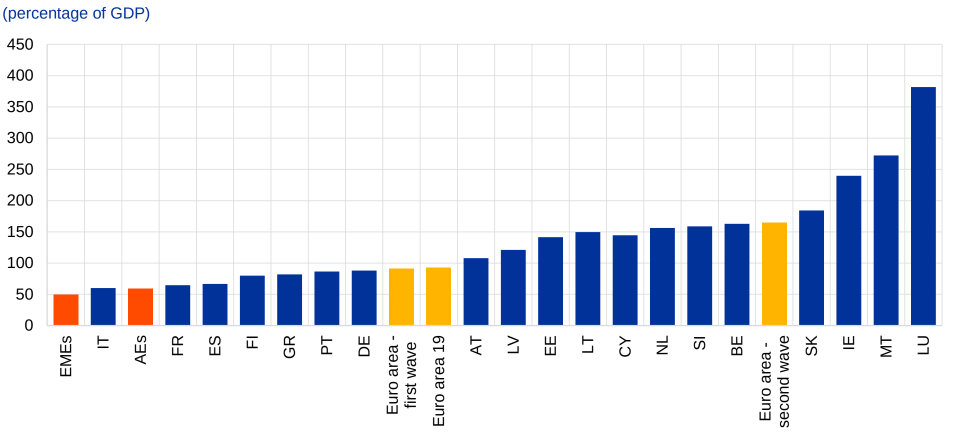
9 See Duval et al. (2016), de Soyres (2016) and Di Giovanni et al. (2018).

2 Trade in the euro area: main trends over the past two decades

Trade is of paramount importance for euro area countries. The euro area as a whole and its member countries are characterised by a high degree of openness. Total (intra- and extra-euro area) imports and exports constituted about 93% of euro area GDP in 2019. The average trade openness of the euro area is more than 50% higher than that of the other advanced and emerging economies (see Chart 1).[10] Within the euro area, the second wave of euro adopters are, on average, smaller economies that are more open to international trade. While, for other advanced and emerging economies, trade openness has remained quite stable in the last two decades, it has increased substantially for the euro area, rising from 61% in 1999 to 93% in 2019 (see Chart 2). It is also interesting to note that trade openness increased even more in the countries that joined the euro in the period 2007-15, rising from an already high level of 105% to 164% (see Chart 2).

Chart 1

Trade openness in 2019



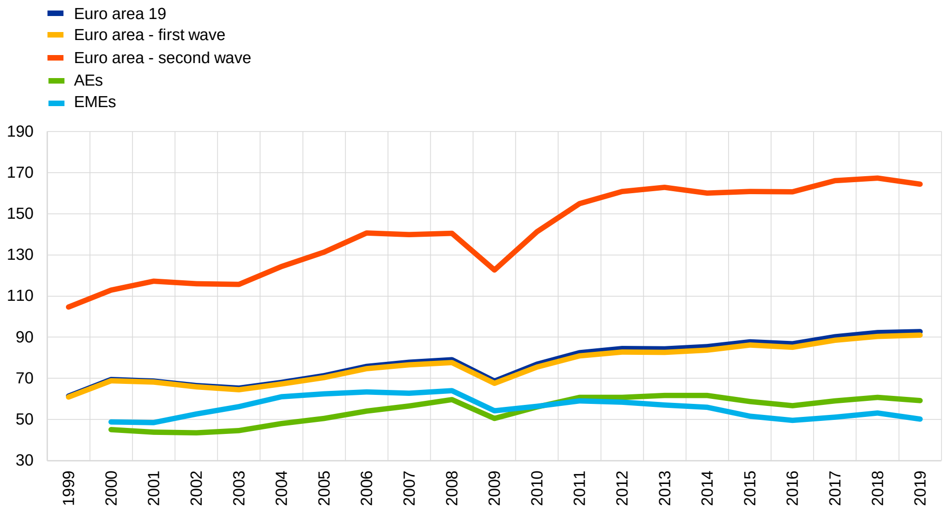
Sources: Eurostat and IMF World Economic Outlook.
Notes: Trade openness is defined as the ratio between nominal trade in goods and services (the sum of exports and imports) and nominal GDP. For the euro area, exports and imports comprise intra- and extra-euro area flows. AEs stands for advanced economies, and EMEs stands for emerging market economies, as defined by the IMF.

10 Trade openness is defined as the ratio between nominal trade in goods and services (the sum of exports and imports) and nominal GDP. For the euro area, exports and imports comprise intra- and extra-euro area flows.

Chart 2

Trade openness over time

(percentage of GDP)



Sources: Eurostat and IMF World Economic Outlook.
Notes: Trade openness is defined as the ratio between nominal trade in goods and services (the sum of exports and imports) and nominal GDP. AEs stands for advanced economies, and EMEs stands for emerging market economies, as defined by the IMF.

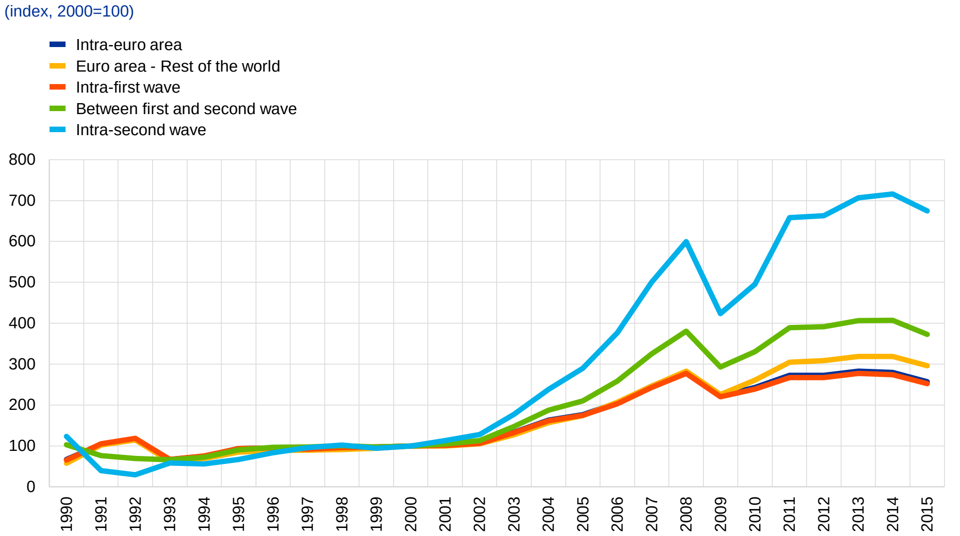
The Single Market and monetary integration are key factors behind the increasing trade openness of the euro area. Leaving aside specific structural issues such as the size of the economies involved, the trade openness of euro area countries has undoubtedly benefited from the integration process, both within the euro area and with the other members of the European Union. Access to the Single Market and the adoption of the *acquis communautaire*, with the removal of trade barriers and the harmonisation of regulations and standards across Europe, as well as the elimination of exchange rate risk brought about by the single currency, have fostered trade integration and encouraged countries' participation in the pan-European and global supply chains.

Since the inception of Economic and Monetary Union, euro area countries have been increasingly trading with each other, albeit with a major disruption brought about by global factors in 2009. Chart 3 shows that the pattern of trade growth among euro area countries was broadly flat from 1990 to 2000, increasing by only 4.5% over the decade. After the introduction of the euro, and up until 2015, both intra- and extra-euro area trade increased almost threefold, despite the negative shock in 2009. Within the euro area, the evolution of trade growth for countries belonging to the second wave of euro adoption has been impressive. Trade growth involving these countries accelerated markedly in the period from 2004 (EU accession) until the global financial crisis. When looking at the period 2000-15 as a whole, intra-second-wave trade and trade between first and second-wave countries increased by factors of 6.7 and 3.7 respectively.

Euro area countries – especially those that joined at a later stage – are witnessing a slowdown in the pace of trade integration globally. After a sluggish recovery following the global financial crisis, countries' trade openness has been plateauing in recent years (see Chart 2). While the euro area as a whole appears more resilient, the countries belonging to the second wave of adopters seem to be following the global downward trend (see also Chart 3). Shortening of global value chains, localisation of production closer to final demand, emerging market rebalancing towards a more domestically oriented model and a generalised rise in trade barriers are at the root of these developments.[11]

Chart 3

Euro area trade



Sources: Eora database and authors' calculations.
Note: Trade is the sum of nominal imports and exports.

In the last two decades, euro area trade in services has grown faster than trade in goods (Chart 4). The role of services in production, exports and sales has been increasing over time (a phenomenon called "servicification"[12]), especially when it comes to value added content in the form of input to production or in product bundles. Chart 4 shows that euro area trade reflects this trend. Since the turn of the last decade, growth in euro area services trade has substantially outpaced growth in goods trade.

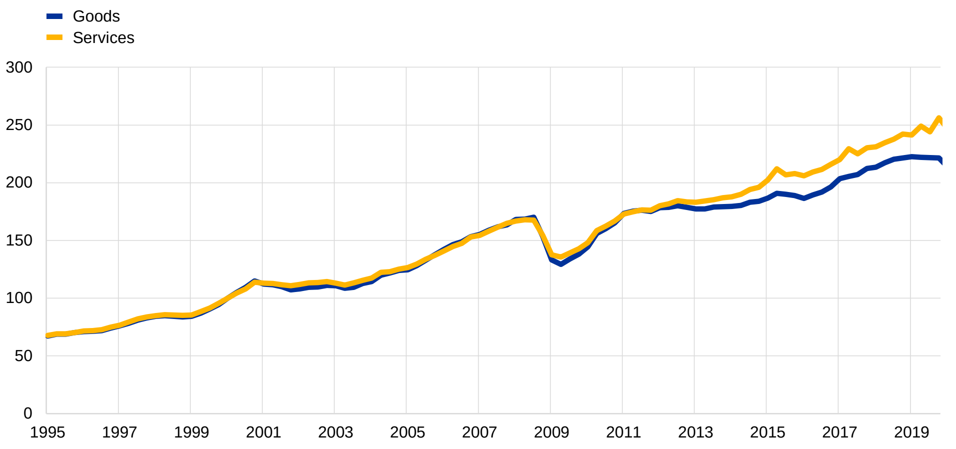
[11] See ECB (2016).

[12] See National Board of Trade Sweden (2016).

Chart 4

Euro area trade – goods vs services

(index, 2000Q1=100)



Sources: Eurostat and authors' calculations.
Notes: Trade is the sum of nominal imports and exports. Last observation: 2019Q4.

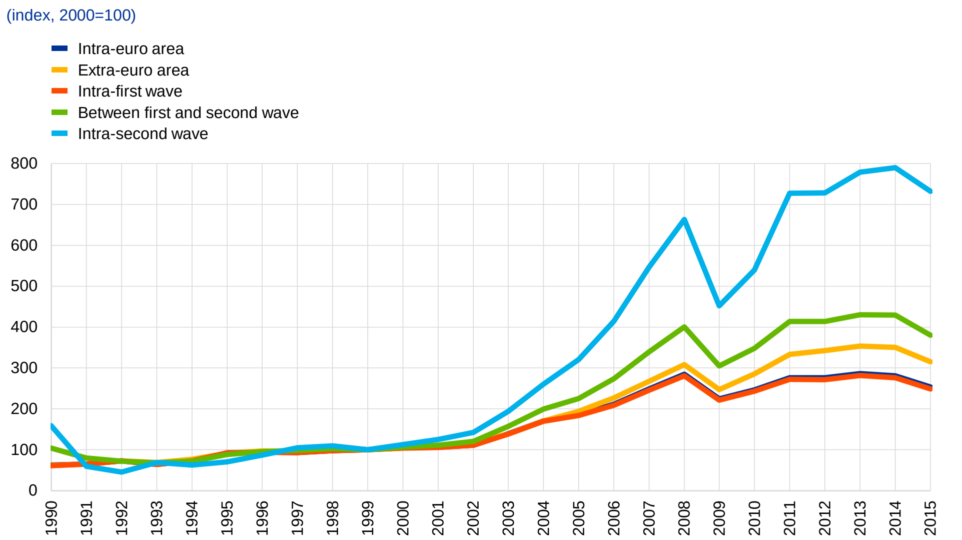
Trade in services has expanded particularly strongly in countries belonging to the second wave. The aggregate expansionary trend in services trade is mostly attributable to deepening trade ties with extra-euro area partners. This is partly due to the opening up of emerging market economies, which rely more on imported services than on domestic services[13]. This trend is also reflected in intra-euro area trade, with countries belonging to the second wave of adopters witnessing a tremendous expansion in services trade within the euro area (see Chart 5). This is particularly valuable in the context of GVCs, as services act both as a propeller of value creation and as a precondition for the existence of these chains, facilitating interconnections via transport and telecommunication.[14]

13 See Lanz and Maurer (2015).

14 See Miroudot and Cadestin (2017).

Chart 5

Euro area trade in services



Sources: Eurostat and authors' calculations.
Note: Trade is the sum of nominal imports and exports.

The euro area is very highly integrated into GVCs and, most notably, into area-wide supply chains. The globalisation of production has been an increasingly pervasive phenomenon in recent decades. Efficiency motives have driven firms to break down production processes into multiple stages that take place across several countries. This is clearly reflected in the intensification of cross-border foreign direct investment (FDI) activity globally and within the euro area.[15] The international relocation of production processes has been particularly noticeable for the euro area, where, compared with the world average, GVC participation is remarkably high (see Chart 6).[16] Most importantly, euro area countries are much more integrated into euro area supply chains than into supply chains with the rest of the world (red line and green line respectively). In addition, intra-euro area supply chains have been more resilient during the global financial crisis and the global trade slowdown.[17]

[15] Between 2000 and 2016, the share of FDI stock in global GDP increased from 22% to 35%. In 2000, EU countries represented 85% of euro area inward FDI and are still the major source of euro area FDI, albeit to a lesser degree with the rise of emerging market economies. For more details, see Carril-Caccia and Pavlova (2018).

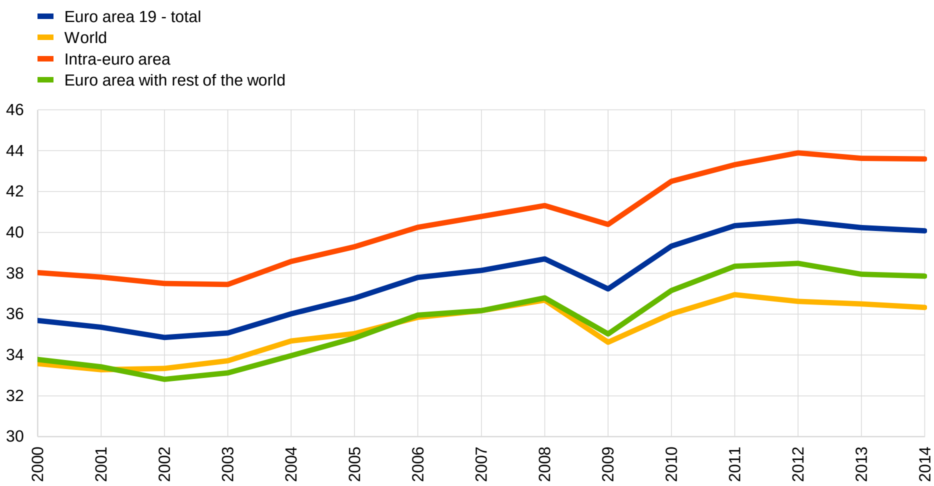
[16] By "GVC participation", we mean the proportion of the gross exports of euro area economies (or the euro area taken as a whole) that is absorbed by two components: (i) the domestic value added embedded in third-country exports (forward, or "upstream" GVC participation) and (ii) the foreign value added embedded in own exports (backward, or "downstream" GVC participation).

[17] For further insights into the economic implications of GVCs for the euro area, see ECB (2019).

Chart 6

The euro area's participation in global value chains

(percentage of gross exports)

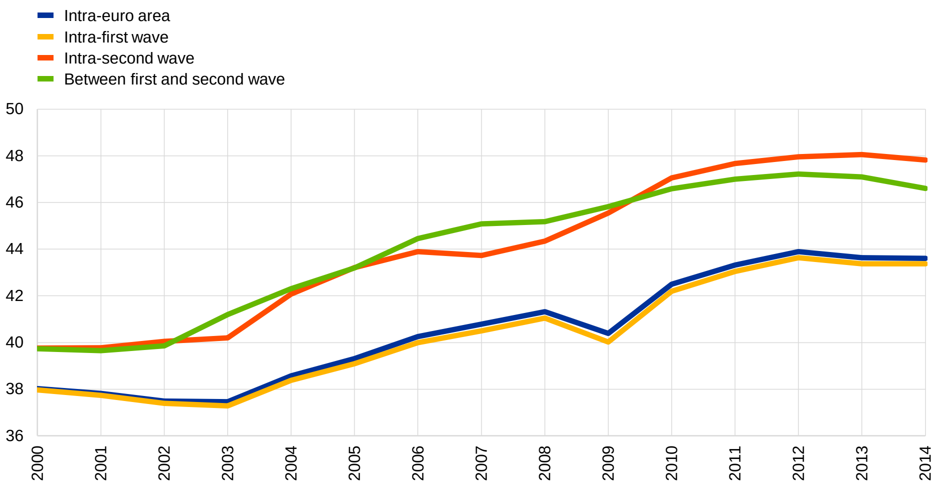


Source: World Input-Output Database (WIOD), 2016 release.
Note: Global value chain participation is computed as the sum of forward (upstream) and backward (downstream) participation as a share of total exports.

Chart 7

Global value chain participation within the euro area

(index, 2000=100)



Source: WIOD, 2016 release.
Note: Global value chain participation is computed as the sum of forward (upstream) and backward (downstream) participation as a share of total exports.

With their participation in the pan-European production chains, countries belonging to the second wave of euro adopters carry out more "downstream" activities, meaning that they incorporate a relatively high share of foreign value added into their exports. The (re)location of some labour-intensive stages of production from large euro area countries to the central and eastern European economies has been driven to a significant extent by the relatively low labour costs of these economies. As a result, the foreign content of production in central and eastern European economies is larger than the value added that they supply to other countries. This means that in aggregate terms, the second-wave euro adopters tend to lie more downstream in the global production chain than the old euro area members (see Chart 8). The results for the aggregate are confirmed by the analysis of each EU country's position within the GVC. With a few exceptions (Ireland, Luxembourg and Malta)[18], the GVC position of countries that adopted the euro at a later stage is much further downstream than that of other euro area countries (see Chart 9).[19]

Trade and supply chain integration within the euro area has boosted business cycle synchronisation; at the same time, export specialisation in certain industries could pose some challenges. While increasing trade integration within the euro area can foster business cycle synchronisation of euro area countries,[20] this high degree of specialisation can present challenges to the process of synchronisation, as it exposes highly specialised countries to industry-specific shocks.[21] For instance, the car industry is predominant in some central European countries, whereas Baltic countries have become extraordinarily involved in service sector exports. However, recent literature has shown that given the increasing complexity of products and production processes, even industry-specific shocks are likely to be transmitted through supply chains across industries, both within the same country and across countries.[22] Another consequence of the increased interconnectedness of the European economies is their vulnerability to physical barriers capable of preventing the free circulation of goods and people. Indeed, as the current coronavirus (COVID-19) crisis is showing, the economic cost of travel limitations is likely to be inflated by the interdependence of European economies.

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18 The particularly downstream position of Ireland, Luxembourg and Malta owes more to their role as international financial centres than to actual production chain linkages.

19 In the case of Ireland, Luxembourg and Malta, the particularly downstream position is related to the predominant role of foreign value added originating from the United States and the United Kingdom and to the role of activity carried out by multinational enterprises (see Sondermann et al., 2019).

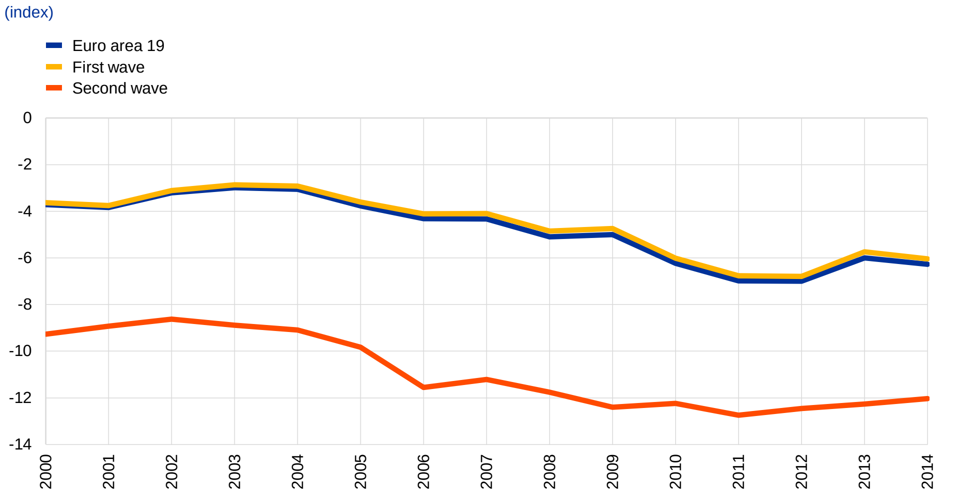
20 Departing from the seminal work of Frankel and Rose (1998), Duval et al. (2016) argue that value added trade in particular has a positive impact on business cycle synchronisation.

21 See Alesina et al. (2002).

22 See Carvalho (2014) for suggestive evidence and Atalay (2017), who provides a theoretical framework for the argument.

Chart 8

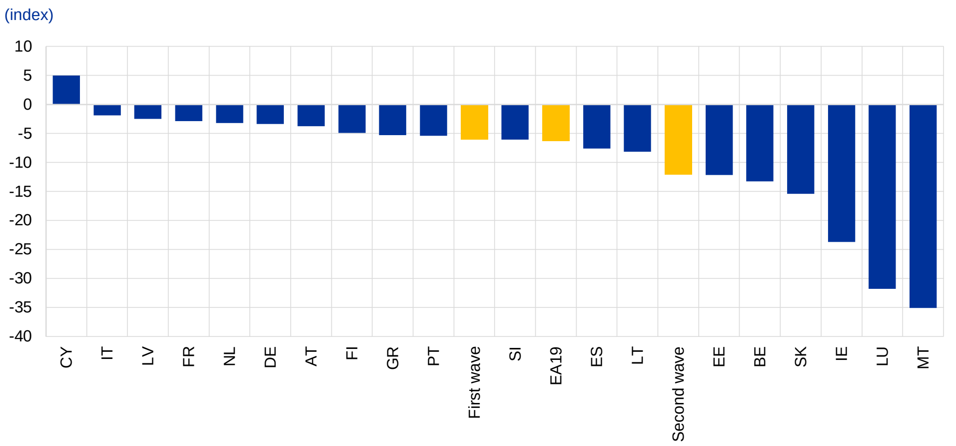
Global value chain position over time



Source: WIOD, 2016 release.
Note: A value above (below) 0 indicates an upstream (downstream) position.

Chart 9

Global value chain position in 2014 by country and wave

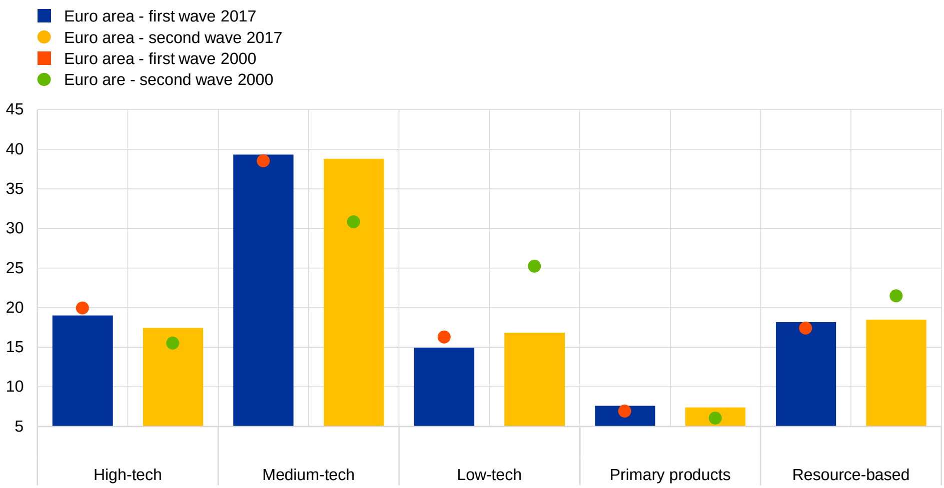


Source: WIOD, 2016 release.
Note: A value above (below) 0 indicates an upstream (downstream) position.

Chart 10

Technology content of exports, 2000-2017

(percentage of total exports)



Source: Authors' calculations based on UN Comtrade data.
Notes: Exported products are clustered according to the Lall (2000) classification (SITC rev.3), converted here into the six-digit "harmonised system" (accounting for the changes that occurred in 1996, 2002, 2007, 2012 and 2017).

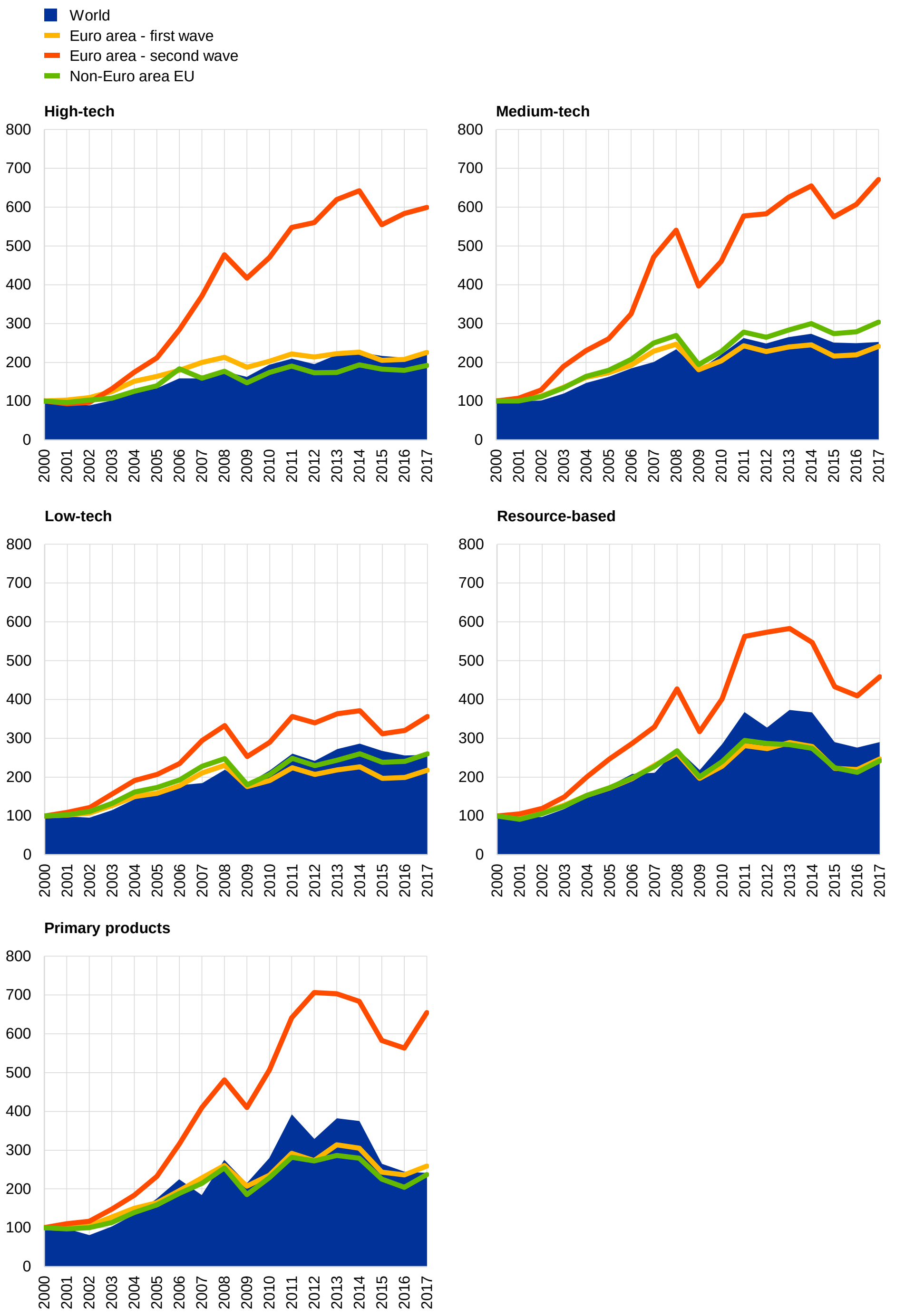
Medium-technology products play a major role in euro area exports. Chart 10 shows a breakdown of exports according to their degree of technological sophistication. Final products are clustered into five mutually exclusive technological categories, namely high-tech (including electronics, pharmaceuticals and aerospace), medium-tech (e.g. automotive products, chemicals and industrial machinery), low-tech (e.g. textile fabrics, clothing, furniture and plastic products), primary (e.g. fresh fruit/meat, wood and crude petroleum) and resource-based products (e.g. prepared fruit/meat, wood products and petroleum products). For both the first and second waves of euro area countries, exports are mainly medium-technology products, representing almost 40% of total exports in 2017, followed by high-tech and resource-based products (about 19%).

Despite starting from low levels, over the past two decades the new euro area member countries have significantly increased their market share across all product categories. Compared with the year 2000, the share of medium-tech exports had increased significantly in the new euro area countries by 2017 (jointly with a reduction of low-tech exports), while it had remained broadly constant over time in the old euro area countries (see Chart 11).

Chart 11

Export share by technological content, 2000=100

(EUR billions)



Source: Authors' calculations based on UN Comtrade data.

3 The impact of the euro on trade: a gravity equation approach

3.1 The gravity equation approach

In what follows, the gravity equation[23] is applied to the analysis of the euro's effect on euro area countries' trade flows, focusing in particular on (i) integration into supply chains and (ii) trade between the first and second waves of euro adopters. The aim of this analysis is to understand whether the common currency has facilitated the exchange of goods and services among euro area member countries and whether it supported their integration into regional production chains.[24] In addition, it is reasonable to think that a currency would be more effective in fostering trade between country pairs which did not trade intensively before the establishment of the common currency; this could suggest the existence of heterogeneous effects within the currency area.[25] As shown by the descriptive analysis in Section 2, it is apparent that growth in trade between countries belonging to the euro area intensified at a faster pace than across countries outside the euro area – even more so when the second wave of euro adopters is considered. But it is not clear to what extent this closer integration was fostered by the euro in particular, beyond the effect of joining the Single Market and other trade agreements, as well as any other possible determinants of bilateral trade, be they pair-specific or country-specific. The gravity equation framework offers the possibility of controlling separately for the trade impact of the common currency and other determinants.

23 The gravity model is the standard, workhorse econometric framework for the assessment of the impact of a monetary union on trade. The approach consists in relating trade flows between two countries to their main determinants, which can be either specific to the two countries as a pair or specific to each of the two countries. For example, the level of economic activity of the countries can be thought to be positively related to the quantity of products that the two countries trade. Some physical barriers, such as the distance between the two countries or their historical commonalities, can negatively and positively influence their trade respectively. At the same time, structural or cyclical changes undergone by each of the two countries, such as accession to the World Trade Organization or a financial crisis, are determinants for the quantity of products they supply or demand internationally. Finally, a common institutional and monetary framework can enhance trade between two countries by decreasing trade-related costs. Therefore, in the specific case of the euro area countries, the Single Market and the monetary union should have a positive effect on the trade flows between their members. For further methodological details regarding the gravity model, please refer to Box 1.

24 In a gravity framework, Carril-Caccia and Pavlova (2018) investigate the role of the euro in fostering foreign direct investment (FDI) flows between member countries. They find that joining the EU increases FDI inflows by 43.9% and adopting the euro has an incremental effect of 20%. This is particularly relevant to our analysis: FDI is conducive to global value chain trade as it lays the foundations for international production networks and trade.

25 Chen and Novy (2018) find that the effects of currency unions are highly heterogeneous, both across and within country pairs, and are higher in particular for pairs with a lower level of bilateral trade (measured as a share of their total trade).

Box 1
The gravity model

The gravity equation has been the workhorse model for the empirical analysis of the determinants of bilateral trade, following the seminal work of Tinbergen (1962). The original idea underlying this approach consisted in relating the trade flows between two countries to their "mass" (represented by their activity) and their distance. As the methodology developed, it became a way to model bilateral trade with its main bilateral and country-specific determinants, including currency unions.

Over the years, the empirical assessment and the quantification of the effect of currency unions has been the subject of lively debate. Strikingly, Rose (2000) found that sharing a common currency more than tripled trade between the countries involved. However, later reassessments concluded that the initial estimates of the common currency effect might have been overstated and that the results depended crucially on the econometric specification and the sample selected (see e.g. Baldwin, 2006 and Glick and Rose, 2015 and 2016 for an overview). Best practice is to control for (i) the barriers to trade that each country faces with all its trading partners (this is known as "multilateral resistance") by including time-varying exporters and importer fixed effects and (ii) unobservable barriers to trade by including time-invariant pair fixed effects.[26] This leads to the following econometric specification, which also has a theoretical foundation[27]:

$$ln\, X_{ijt} = \lambda_{it} + \psi_{jt} + \mu_{ij} + \beta' \boldsymbol{z}_{ijt} + \gamma CU_{ijt} + \varepsilon_{ijt}$$

where X_{ijt} denotes exports or imports between country *i* and country *j* at time ***t***, λ_{it} and ψ_{jt} denotes country-time fixed effects, μ_{ij} denotes pair fixed effects, $\boldsymbol{z}_{ijt}$ is a vector including a set of bilateral and time-varying control variables, such as dummies for regional trade agreements, and finally CU_{ijt} is a dummy taking value 1 if countries *i* and *j* are in a currency union at time ***t***. It is important to highlight that the country-time fixed effects make it possible to control for all country characteristics that vary over time and for any country-time variables that may have been omitted (such as GDP, price levels, etc.).

Considering a broad sample has advantages, of course, but also comes with costs. When including such an extensive set of dummies, it is essential to consider as many years and as many countries as possible in the sample in order to have enough degrees of freedom.[28] However, including small countries brings heteroskedasticity into the sample, because their trade and underlying determinants change structure over time and are more volatile. This makes the ordinary least squares (OLS) estimation inconsistent (Santos Silva and Tenreyro, 2006, 2011)[29], and consequently the estimated effect of a currency union is inflated. A solution to this issue is to estimate the gravity equation with the Poisson pseudo-maximum likelihood (PPML) estimator.[30] Larch et al. (2019)

[26] See Anderson and Van Wincoop (2003), Baldwin and Taglioni (2007), Baier et al. (2007) and Glick and Rose (2016) for a review.

[27] See Arkolakis et al. (2012).

[28] See Glick and Rose (2016) and Rose (2017).

[29] Santos Silva and Tenreyro (2006, 2011) find that the OLS estimator of a log-linearised gravity equation is inconsistent, as the variance of the error term ε_{ijt} and its expected value depend on the regressors, and this violates the condition for consistency of OLS.

[30] The method consists in estimating the gravity regression with pseudo-maximum likelihood in its multiplicative form (in contrast with the logarithmic form in the equation above): $\mathrm{X_{ijt}} = \exp\left(\lambda_{it} + \psi_{jt} + \mu_{ij} + \boldsymbol{\beta}' \mathbf{z}_{ijt} + \gamma \mathrm{CU}_{ijt}\right) + \nu_{ijt}$. Apart from delivering estimates consistent with heteroscedasticity, this method also solves the issue of including zero observation in the estimation sample, which often results from rounding.

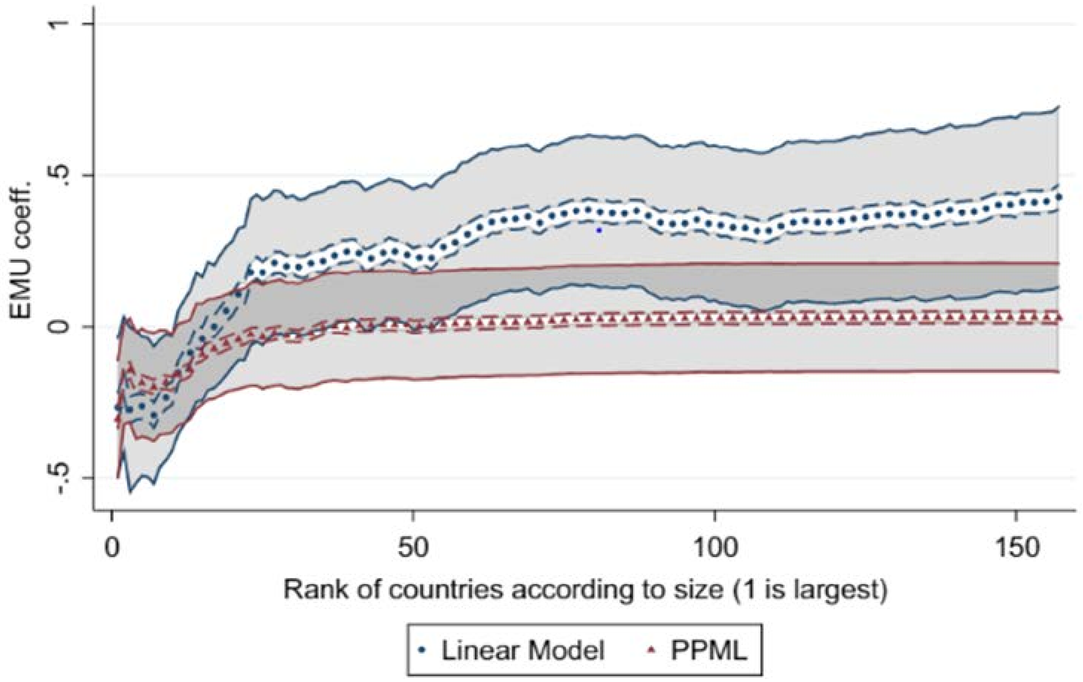
show that while with OLS the estimated effects increase if more small countries are added to the sample, with PPML the estimate increases up to a point but then stays stable, regardless of the addition of small countries (see Chart A).

Chart A

OLS and PPML estimates of EMU coefficient

As smaller countries are added

(units, axis description)



Source: Larch et al. (2019).
Notes: The grey area delimits 95% confidence bands with standard errors clustered by exporter, importer and year. The white area delimits 95% confidence bands with robust standard errors. “Country 1” is EU countries and “country 157” is a group of 31 countries without GDP data. See Larch et al. (2019) for further details.

Finally, proper inference is essential for assessing the significance of the currency effects. While the standard robust error corrections deliver point estimates measured with high precision, Larch et al. (2019) show that inference with multi-way clustering (over all possible panel dimensions) leads to more conservative estimates and often to non-significant results (see Chart A).

For our analysis we rely on Eora, a global supply chain database structured around a multi-region input-output tables model (see Annex 1). The advantage of this database is that it provides a time series of detailed input-output tables connecting 190 countries between 1990 and 2015 – a larger number of observations than in other widely used databases. This helps us estimate the gravity equation correctly (see Box 1).[31] The fact that data are available from 1990 also allows for a

31 A sample with a large number of cross-sectional and time observations allows us to have enough degrees of freedom, which is crucial when using a model with a comprehensive set of fixed effects. In addition, having enough pre-euro observations makes it possible to identify the euro effect, especially in the case of the first wave of adopters.

long enough "pre-treatment" period for the first wave of euro adopters (1999-2001) in the synthetic control analysis presented in the next section.

3.2 Results

The estimation results show that the euro promoted trade between euro area countries, in particular in intermediate products, and therefore fostered the creation/intensification of cross-border supply chains (Table 1, columns (1), (4) and (7)). In a regression controlling for (i) EU membership, (ii) currency unions and regional trade agreements (RTAs) other than those of the euro and the EU and (iii) unobserved country-time and pair-specific developments, the effect of the euro on trade appears to be statistically significant at around 6%[32] (column (1)).[33] By decomposing total exports into exports of intermediate products, which are intuitively associated with multi-stage production processes[34] (column (4)), and exports of final products (column (7)), it is possible to observe that on average, taking all euro area countries into consideration, the euro's effect on total exports[35] is mostly driven by exports of intermediates (5.3% versus a non-significant effect on trade in final goods). For total and intermediate exports, the positive effect of euro adoption on trade is greater than that of belonging to the Single Market[36] or to other currency unions and RTAs. It is also interesting to notice that RTAs tend to have a positive and significant effect for trade in intermediate products, whereas the currency unions have such an effect for trade in final products.

The results highlight that the common currency has fostered value chain creation among countries that adopted the euro at an early stage. Aggregate results pooling all euro area countries together can actually mask heterogeneous effects across waves of adoption. The regressions results in Table 1 make it possible to disentangle the results and look separately at the effect of the euro on trade between specific sub-groups of countries (columns (2) and (3)), as well as breaking the findings down into different types of product traded (intermediate or final goods). The point estimates of the impact of the euro on different combinations of country groups and for different types of product are shown in Chart 12. The estimated effect of the euro on total trade (intermediate and final goods) is similar for trade among first-wave countries and trade among second-wave countries (5.4% and 5.3% respectively). However, total exports from the second wave to the first wave of euro

32 Following the regression specification illustrated in Box 1, here and in what follows, the effect of each dummy variable is computed as exp(coeff)-1.

33 To ensure comparability of results, our gravity equation follows the specification adopted in Larch et al. (2019) and Glick and Rose (2016).

34 See Johnson and Noguera (2012). On the effects of global value chain integration on the euro area, see ECB (2019).

35 Total exports are calculated as the sum of final and intermediate exports.

36 The effect of EU integration is taken into account by the inclusion of the EU dummy as well as a variable for existing bilateral RTAs (hence also including EU agreements with other countries). Differently from previous results in the literature, the EU variable does not turn out to be significant, most probably because, in this analysis, the sample starts in 1990, whereas the process of EU integration started some decades earlier – at least for the first EU Member States. It is worth noting that for the second-wave countries in particular, the Single Market is likely to have been a major contributor to market integration and convergence in prices and activity. A different specification focusing on the differential effects of the EU could help in identifying and quantifying the benefits of EU integration.

adopters increased by more than those from the first wave to the second wave of adopters (6.3% and 4.3% respectively – see left panel of Chart 12 and column (3)). By looking separately at the effect of the euro on trade in intermediate and final products (middle and right panels of Chart 12, corresponding to columns (6) and (9) respectively), it is possible to conclude that the euro positively affected trade in intermediate products between countries belonging to the first wave of adoption (an increase of around 5.3%). This suggests that the euro area fostered the creation of cross-border supply chains in the block of countries which joined the euro at the outset.

Table 1

The effect of the euro on trade – Poisson pseudo-maximum likelihood regressions

(sample 1990-2015)

Variables	(1) Total exports	(2) Total exports	(3) Total exports	(4) Intermediate exports	(5) Intermediate exports	(6) Intermediate exports	(7) Final exports	(8) Final exports	(9) Final exports
euro	0.058***			0.052**			0.007		
	(0.021)			(0.023)			(0.025)		
euro (first wave)		0.043*	0.053**		0.055**	0.052**		-0.006	-0.004
		(0.024)	(0.021)		(0.024)	(0.022)		(0.031)	(0.028)
euro (second wave)		0.046**	0.052**		0.036	0.033		0.049**	0.048**
		(0.022)	(0.021)		(0.024)	(0.022)		(0.023)	(0.021)
euro (first-second wave)		0.045**			0.030			0.061**	
		(0.022)			(0.023)			(0.028)	
euro (first to second wave)			0.042**			0.023			0.033
			(0.021)			(0.023)			(0.028)
euro (second to first wave)			0.061**			0.028			0.101***
			(0.028)			(0.028)			(0.029)
eu	-0.020	-0.024	-0.016	-0.011	-0.008	-0.006	-0.029	-0.023	-0.026
	(0.019)	(0.020)	(0.018)	(0.020)	(0.020)	(0.019)	(0.022)	(0.023)	(0.022)
other currency unions	0.046**	0.035*	0.042**	0.033	0.032	0.030	0.039**	0.035*	0.037**
	(0.018)	(0.020)	(0.017)	(0.021)	(0.021)	(0.020)	(0.018)	(0.020)	(0.017)
other RTAs	0.018**	0.015**	0.018**	0.016*	0.016*	0.016*	0.011	0.011	0.011
	(0.007)	(0.008)	(0.007)	(0.009)	(0.009)	(0.009)	(0.008)	(0.008)	(0.008)
Observations	914,056	914,056	914,056	914,056	914,056	914,056	914,056	914,056	914,056
R-squared	0.999	0.999	0.999	0.999	0.999	0.999	0.999	0.999	0.999

Sources: Eora database, Larch et al. (2019) and authors' calculations.
Notes: The dependent variable is bilateral exports between two countries at time *t* of total products (final + intermediate, columns (1)-(3)), intermediate products (columns (4)-(6)) and final products (columns (7)-(9)). The dummy *euro (first wave)* takes value 1 if at time *t* both trade partners belong to the first wave of euro adopters and zero otherwise. The dummy *euro (second wave)* takes value 1 if at time *t* both trade partners belong to the second wave of euro adopters and zero otherwise and *euro first-second wave* takes value 1 if at time *t* one of the two trade partners belongs to the first wave of euro adopters and the other to the second wave and zero otherwise. The dummy *EU* is equal to one if at time *t* both trade partners belong to the European Union, irrespective of whether they belong to the euro area. The dummy *other currency unions* is equal to one if at time *t* country *i* and country *j* belong to a currency union which is not the euro area. The dummy *other RTAs* is equal to one if at time *t* country *i* and country *j* are in a regional trade agreement that is not a currency union and is not the European Union. Equations are estimated with Poisson pseudo-maximum likelihood panel regressions (see Larch et al. 2019) and include pair, exporter-time and importer-time fixed effects; standard errors are clustered by exporter, importer and year (multi-way clustering). The regressions also include a pair-time trend. For further reference, see Box 1.

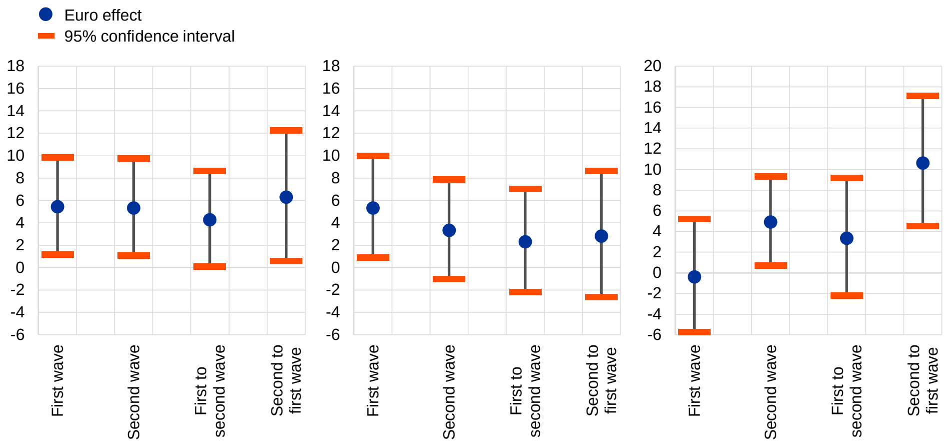
At the same time, the euro has opened up markets for final products from the second wave of adopters. The results in column (9), as illustrated in the right panel of Chart 12, show that the euro facilitated the market access of the second wave of adopters. Indeed, in the regression for trade in final products, the euro effect is significant for those exchanges involving the second wave of adopters. The effect is as large as 10.6% for exports from the second to the first wave of adopters. This result partly confirms the evidence of second-wave countries occupying a relative downstream position in pan-European supply chains (Section 2). It is also in line with anecdotal evidence on the relocation of plants from euro area countries to central eastern European countries, based on cost-saving arguments (see, for example, IMF, 2003).

Chart 12

Effect of the euro on trade according to a gravity model

Effect on total, intermediate and final trade

(percentage)



Sources: Eora database, Larch et al. (2019) and authors' calculations.
Notes: Trade effects are calculated as *(exp(coeff)-1)x100* where *coeff* are the coefficients shown in Table 1, in the most complete specification (columns (3), (6) and (9) respectively).

4 The impact of the euro on trade: a synthetic control approach

4.1 The synthetic control approach

In this section, we investigate whether the results discussed in the previous section are confirmed when applying a different estimation method, namely the synthetic control approach. The rationale behind this method is to estimate the bilateral exports of euro area economies had these countries not adopted the single currency. More specifically, we compare the bilateral export flows of the "treated units" (the first and second waves of euro area countries) with those of a counterfactual "control group" showing how outcomes would have differed in the absence of the "treatment" (euro adoption). While the intuition behind this method is straightforward, the challenge is to properly define the set of potential control units (or "donor pool") to construct the counterfactual: any observed difference in trade performance from the time of treatment can be ascribed to the adoption of the euro only to the extent that the pre-treatment match between the actual and the counterfactual is adequate. As a robustness check, we replicate the analysis applying a non-parametric extension of the synthetic control as developed in Cerulli (2017).[37] More detail on the methodology is provided in Box 2.

Box 2
The synthetic control method

In our analysis we apply the synthetic control methodology of Abadie and Gardeazabal (2003) and Abadie at al. (2010) and, as a robustness check, a non-parametric extension developed in Cerulli (2017). The synthetic control method is an extension of the difference-in-differences method. It proves particularly helpful when none of the potential control units, taken alone, replicates closely enough the behaviour of the treated unit before the event takes place – in which case the parallel trend hypothesis is violated, and standard difference-in-differences methods produce biased estimates. In addition, the synthetic control method makes it possible to disentangle the effect of a policy (occurring at a certain time t and remaining in place afterwards) in the presence of a relatively small number of cross-sectional units – as in the case of aggregate entities, such as countries or regions – but a long longitudinal dimension. The novelty of the method is that it constructs a weighted average of the potential controls, in turn allowing the construction of a "synthetic counterfactual" approximating the same trend during the pre-treatment period of the unit exposed to the intervention. In particular, the weights are chosen in such a way as to minimise the distance between treated and control series in terms of the outcome of interest (export flows) during the pre-treatment period, as well as other possible determinants of the post-treatment outcome.

Formally, the estimator of the causal effect of the policy (in our analysis, the adoption of the euro) is defined as the difference between the outcome (bilateral exports) $\boldsymbol{y}_1$ observed in the treated unit (belonging to either the first wave or the second wave of euro adoption) over a time horizon of

[37] Results are shown in Annex 3.

length T and a counterfactual scenario of potential bilateral exports $\boldsymbol{y}_1^*$ had the euro not been adopted. The latter is generated by applying to a (T x J) matrix $\boldsymbol{y}_0$ of the time series of bilateral exports in J potential comparison units (i.e. countries not exposed to the policy) a (Jx1) vector of weights. Formally,

$$\boldsymbol{y}_1^* = \boldsymbol{y}_0 \boldsymbol{w}^*$$

$$wj \geq 0 \text{ for } j=1,\ldots,J \; ; \quad \sum_{j=1}^{J} wj = 1$$

Given an $\boldsymbol{x}_1$ vector of N predictors of the variable of interest observed in the treated country and, in the same vein, an (N x J) matrix $\boldsymbol{X}_0$ of the same predictors observed in the donor pool, $\boldsymbol{w}^*$ minimises the following expression over the pre-treatment period

$$D(\boldsymbol{w}) = (\boldsymbol{x}_1 - \boldsymbol{X}_0 \boldsymbol{w})' \mathbf{V} (\boldsymbol{x}_1 - \boldsymbol{X}_0 \boldsymbol{w})$$

where **V** is a diagonal matrix with non-negative components reflecting the relative importance of the different predictors of exports. In our analysis, the set of predictors includes the traditional ones in the literature as well as some novel ones. The traditional ones include GDP, population and trade openness, as well as a linear approximation of the multilateral trade resistance terms (Anderson and van Wincoop, 2003) taken from Baier and Bergstrand (2009a, 2009b) and also used in Saia (2017), such as distance, contiguity and common language.[38] In addition, we include in the matching exercise some novel variables, namely the share of manufacturing in value added, financial openness and the number of years passed between accession to the European Union and the adoption of the euro.

As the database is structured at the bilateral level, each observation is a bilateral export flow for a given pair of countries in a given year. Therefore, when needed, we either sum the values of the variables for the two countries or take a weighted average. In the case of the population predictor, for example, this means that for the trade flow between country i and country j in a given year, we take the sum of the population of both countries. We follow this procedure for GDP, population, area (in square kilometres) and trade openness – measured as the sum of export and imports over GDP. We take the sum of the first two and the weighted average of the others. Table 9 in Annex 2 shows that the average values in the pre-treatment period of the output variable, bilateral trade and each of the matching characteristics used to obtain the synthetic counterfactuals are very similar. Given the large donor pool used for each synthetic counterfactual and the wide range of determinants used to estimate the optimal weights given to each pair of countries in that pool, the results of the exercise are reassuring.

A recent extension of the synthetic control method estimates the weights non-parametrically using a kernel vector distance approach (Cerulli, 2017). In particular, for each year, given a certain bandwidth h, a matrix of weights proportional to the distance between the N covariates $\boldsymbol{x}$ observed for the treated unit and the untreated units is computed on the basis of a specific kernel function K.

[38] Where $BV\,X_{ij} = X_{ij} - \frac{1}{N}\sum_{m=1}^{N} X_{mj} - \frac{1}{N}\sum_{k=1}^{N} X_{ik} + \frac{1}{N^2}\sum_{m=1}^{N}\sum_{k=1}^{N} X_{mk}$ and X represents lnDIST (i.e. the log of the bilateral distance between the two countries i and j, for a total of N countries), CONTIG (i.e. a contiguity dummy) and LANG (i.e. a dummy that takes value 1 if a language is spoken by at least 9% of the population in both countries), as in Saia (2017).

Formally, the weights used to generate the counterfactual time pattern of a treated unit i are computed as

$$w_{t,j}^{i}(h)=\mathrm{K}\left(\frac{|x_{t,i}-x_{t,j}|}{h}\right) \quad \text{for } j=1,\dots,J$$

and are eventually averaged over time. The optimal bandwidth is estimated computationally by forming a grid of possible values for h and selecting the one that minimises the root mean squared prediction error over the grid.

The treated units are two groups of euro area countries, namely the first wave and the second wave of euro adopters, each averaged in order to create a "representative" aggregate entity. Each entity is constructed ex ante[39] as a weighted average of the corresponding group of countries, taking their GDP as the weight in each case.[40] One difficulty regarding the second wave of adopters is that it includes countries which adopted the euro in different years.[41] This means there is no common "treatment year" that could be assigned to the computed ex ante aggregate.[42] After excluding Estonia, Latvia and Lithuania due to the time coverage of the dataset, we are left with the four euro area members that adopted the single currency between 2007 and 2009. In the econometric exercise, this narrower group (Cyprus, Malta and Slovakia and Slovenia) defines the second-wave country group, and the synthetic simulation is run three times, each time assuming a different treatment year between 2007 and 2009. The charts shown in the text are the result of averaging the three resulting actual and counterfactual bilateral flows.[43]

Each treated unit is compared with two possible counterfactuals: trade between similar pairs of non-euro area countries and trade between similar pairs of euro area and non-euro area countries. The first synthetic counterfactual is constructed as a convex combination of bilateral trade between non-euro area countries.[44] It provides information about how much more (or less) two euro area countries (in the first or second wave) trade relative to two non-euro area countries that are otherwise very similar. The second counterfactual is constructed by averaging bilateral exports between comparable euro area and non-euro area countries. The purpose is to quantify the gains in trade between two euro area

39 An alternative approach would be an ex post aggregation, i.e. producing a synthetic counterfactual for each of the 240 euro pairs in our dataset and then aggregating up the impact of the euro on each pair; this is the approach followed in Saia (2017). The full set of results based on the ex post aggregation is shown in Annex 3, Section 8.1.

40 This approach is especially suitable for the second wave of euro adopters, since they are all small countries and have quite similar-sized economies.

41 Slovenia in 2007, Cyprus and Malta in 2008, Slovakia in 2009, Estonia in 2011, Latvia in 2014 and Lithuania 2015.

42 Note that when we aggregate ex ante the first wave of euro adopters, we do not include Greece given that it joined the euro in a different year (2001 versus 1999 for the rest of the first wave of countries). Even so, results do not change significantly when Greece is included in the analysis.

43 The full set of results assuming each time a different treatment year is shown in section 8.2 of the Annex. In all cases results are very similar. An alternative could have been to rescale the years of entry to zero for each country. However, the entry year coincided with the crisis for some countries, and not for others, which introduced noise into the aggregation.

44 Non-euro area countries include all countries that are never part of the euro area in any of the years of our sample. This means that we also exclude countries which adopt the euro at a later stage, even if at time t they could be classified as "non-euro area". Annex 2 shows the weight given to each pair of countries to construct each of the counterfactuals.

countries relative to the bilateral trade that would take place between a similar pair of countries, including one belonging to the euro area and one outside the euro area. Note that, in the latter case, the dynamics could be affected by trade diversion from euro area to non-euro area countries. The covariates chosen in the exercise are discussed in Box 2. The donor pool available to construct the first synthetic counterfactual consisted of 2,600 country pairs; to construct the second type of counterfactual – euro area to non-euro area trade – the pool consisted of 1,700 country pairs. While the use of such a large database is helpful for constructing an adequate counterfactual, it also poses some technical problems, as the built-in routines are prepared to handle a much smaller set of countries in the donor pool. Section 8.3 in Annex 2 shows the details of how we handled these technical difficulties.

4.2 Results: the impact of the euro on exports from the second wave of euro adopters

Turning to the results, total exports from the second wave of euro adopters to euro area countries started deviating from both counterfactuals as early as in 2007. Chart 13 compares the dynamics of bilateral exports between the representative group of recent euro adopters and the entity averaging all euro area countries (the treated pairs) with that of the two counterfactuals described above. It shows that the treated and non-treated units move closely in step until 2007. After 2007 – and particularly after the great trade collapse in 2009 – trade between euro area countries starts deviating from that of the two counterfactuals, being 10% higher than trade between non-euro area countries and 14% higher than trade between euro area and non-euro area countries. Table 2 quantifies the graphical results by showing the average trade differences in percentage terms between the trade of the treated unit and the two counterfactuals, before and after the treatment (the adoption of the euro).[45] For the exercise to make sense, the average difference in trade between the treated and non-treated units in the pre-treatment period should be close to zero. This would mean that the pre-treatment match has been successful, so that in the absence of the euro the treated and counterfactual pairs have similar trade developments. In this case, the average percentage trade difference between the treated pairs and the controls in the post-treatment period gives an estimation of the average impact of the euro on trade flows.

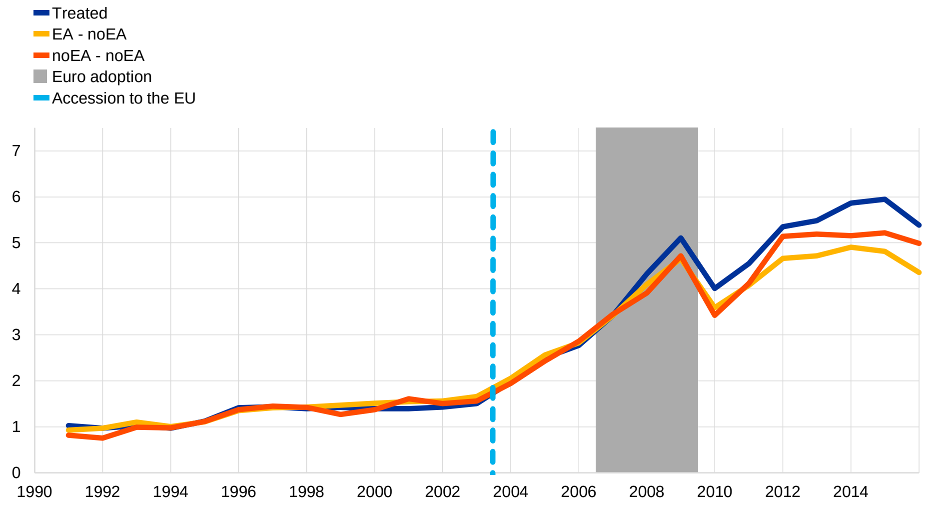
[45] To this end, we first computed the average difference in percentage terms over the pre-treatment period and the post-treatment period for simulations with three different years of adoption (2007, 2008 and 2009). We then calculated the average of the results from the three simulations. Note that mathematically, this is different from first averaging the synthetic trade from the three simulations and then calculating the difference versus the observed trade in percentage terms. However, in practice it did not change our results by much.

Chart 13

Dynamics of total exports from second-wave to all euro area countries

Parametric synthetic control

(bilateral exports of total goods in millions)



Sources: Authors' calculations based on the Eora database, GeoDist database, World Economic Outlook database, World Development Indicators database, Chinn and Ito (2006).

Table 2

Difference between actual and synthetic aggregate trade flows from second-wave to all euro area countries

(% difference)

	Total trade		Intermediate goods trade		Final goods trade	
	Pre	Post	Pre	Post	Pre	Post
EA-noEA	-0.44	13.96	-0.01	12.57	-2.61	30.98
	(6.870)	(5.07)	(5.881)	(6.10)	(9.098)	(8.159)
noEA-noEA	2.36	9.62	2.24	8.17	6.24	24.62
	(10.69)	**(4.36)**	**(7.999)**	**(3.89)**	**(14.12)**	**(4.84)**

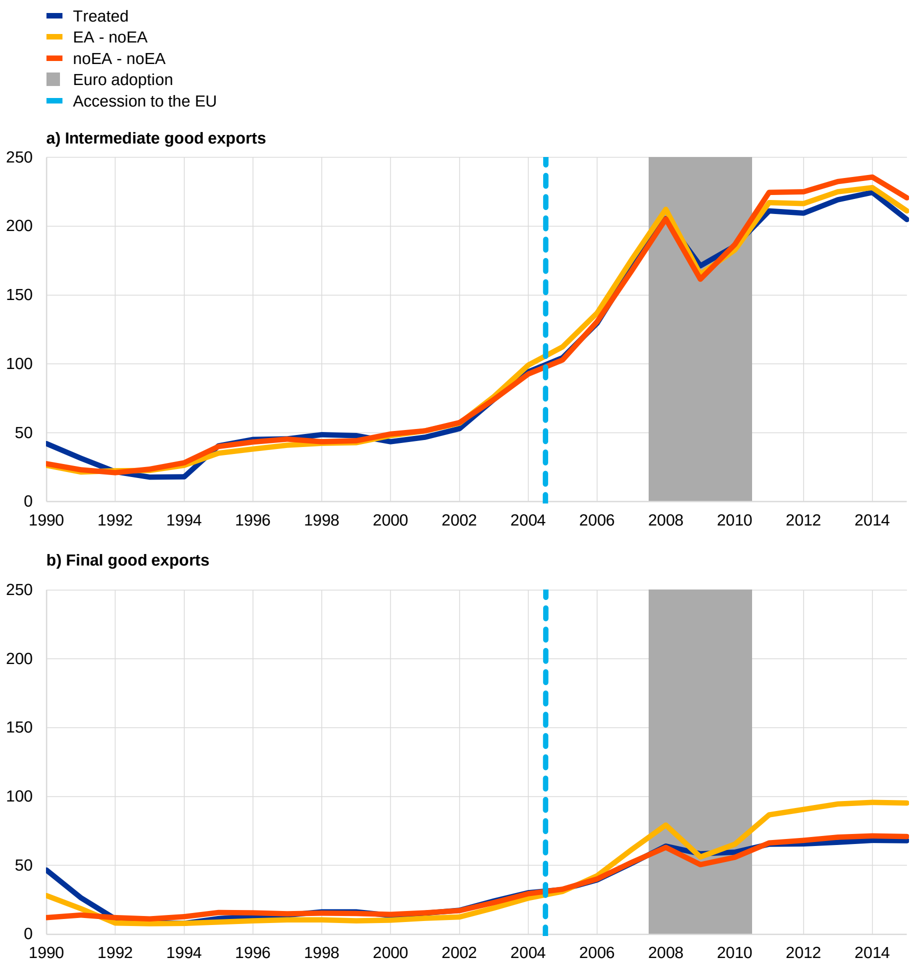
Note: The pre-treatment period is defined as the average of the periods 1990-2007, 1990-2008 and 1990-2009. The table shows the average percentage deviation of the treated pair relative to the counterfactual country pair in the pre-treatment and post-treatment periods. In parentheses we show the standard deviation of yearly differences within each period.

The increase in bilateral exports from the second wave of euro adopters to all euro area countries is solely driven by exports of final goods to the first wave. Chart 14 looks at exports among the second wave of euro adopters, whereas Chart 15 depicts the dynamics of exports from the second wave to the first wave of euro adopters. After euro adoption, bilateral exports among second euro adopters were not different from those among non-euro area countries and were slightly below those between euro area and non-euro area countries, the latter possibly reflecting trade diversion towards non-euro area countries. The "Total trade – post-treatment" column in Table 3 confirms that in the post-treatment period, export flows between second-wave euro adopters were 15% below trade flows between similar pairs of euro area and non-euro area countries, and non-significantly different from similar pairs of non-euro area countries (difference of 2.7%).

Chart 14

Dynamics of final and intermediate exports among the second wave of euro adopters

(bilateral exports of intermediate and final goods in thousands)



Sources: Authors' calculations based on the Eora database, GeoDist database, World Economic Outlook database, World Development Indicators database, Chinn and Ito (2006).

Table 3

Difference between actual and synthetic aggregate trade flows from second-wave to second-wave euro area countries

(% difference)

	Total trade		Intermediate goods trade		Final goods trade	
	Pre	Post	Pre	Post	Pre	Post
EA-noEA	6.98	-15.19	4.07	-1.58	27.11	-21.60
	(24.32)	(4.98)	(22.22)	(2.70)	(25.64)	(10.92)
noEA-noEA	14.94	2.70	2.58	-3.94	22.07	1.90
	(39.29)	**(4.78)**	**(22.63)**	**(3.83)**	**(78.29)**	**(6.32)**

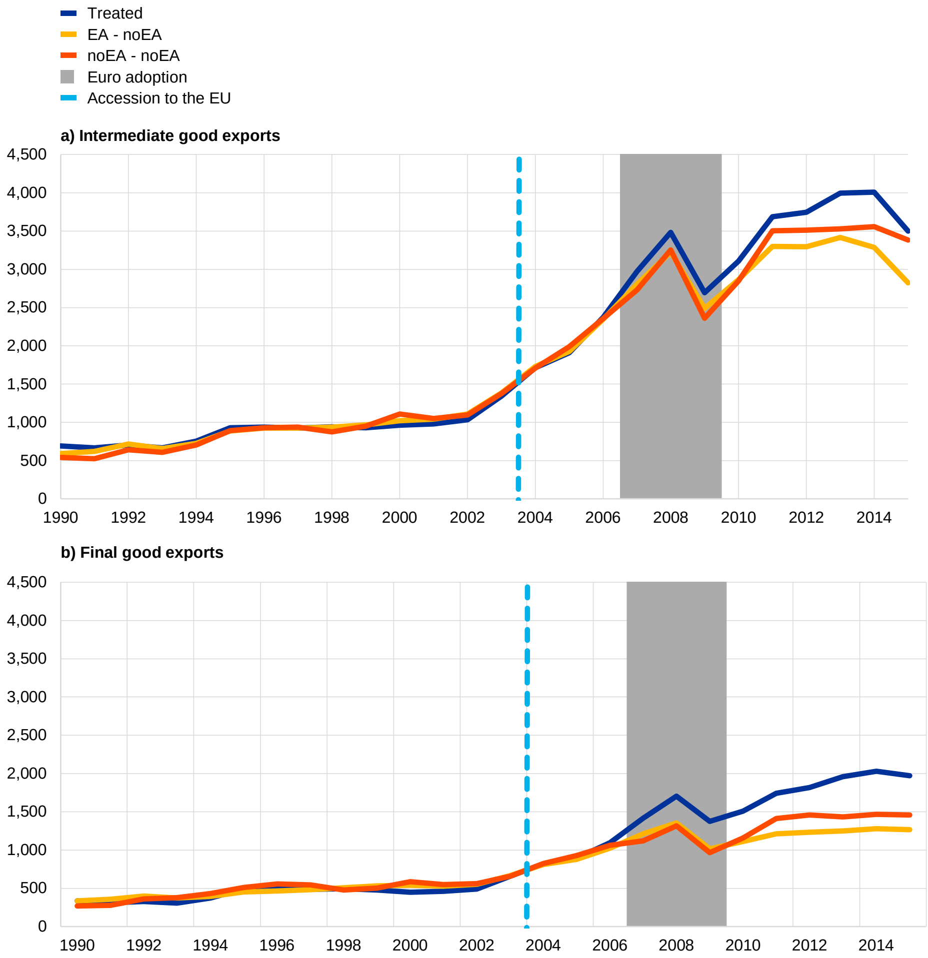
Notes: The pre-treatment period is defined as the average of the periods 1990-2007, 1990-2008 and 1990-2009. The table shows the average percentage deviation of the treated pair relative to the counterfactual country pair in the pre-treatment and post-treatment periods. In parentheses we show the standard deviation of yearly differences within each period.

By contrast, exports from second-wave to first-wave countries increased substantially after euro adoption (see Chart 15 and Table 4). The main driver was exports of final products, which were 32% higher than bilateral flows between two similar non-euro area countries and 48% higher than trade between euro area and non-euro area countries after euro adoption ("Final goods trade – Post" column in Table 4). By contrast, the gain in exports of intermediates was relatively low, i.e. 9% higher than in similar non-euro area country pairs after the treatment year and 15% higher than in similar euro area to non-euro area country pairs ("Intermediate goods trade – Post" column in Table 4). These results are very much in line with those from the gravity estimation in the previous section.

Chart 15

Dynamics of final and intermediate goods exports from second-wave to first-wave euro area countries

(bilateral exports of intermediate and final goods in thousands)



Sources: Authors' calculations based on the Eora database, GeoDist database, World Economic Outlook database, World Development Indicators database, Chinn and Ito (2006).

Table 4

Difference between actual and synthetic aggregate trade flows from second-wave to first-wave euro area countries

(% difference)

	Total trade		Intermediate goods trade		Final goods trade	
	Pre	Post	Pre	Post	Pre	Post
EA-noEA	-0.64	20.38	1.10	15.13	-1.50	47.88
	(5.667)	(5.44)	(5.776)	(6.20)	(12.70)	(10.25)
noEA-noEA	0.21	12.42	4.03	8.92	-1.31	32.38
	(11.62)	**(4.70)**	**(10.66)**	**(4.03)**	**(15.49)**	**(6.75)**

Notes: The pre-treatment period is defined as the average of the periods 1990-2007, 1990-2008 and 1990-2009. The table shows the average percentage deviation of the treated pair relative to the counterfactual country pair in the pre-treatment and post-treatment period. In parentheses we show the standard deviation of yearly differences within each period.

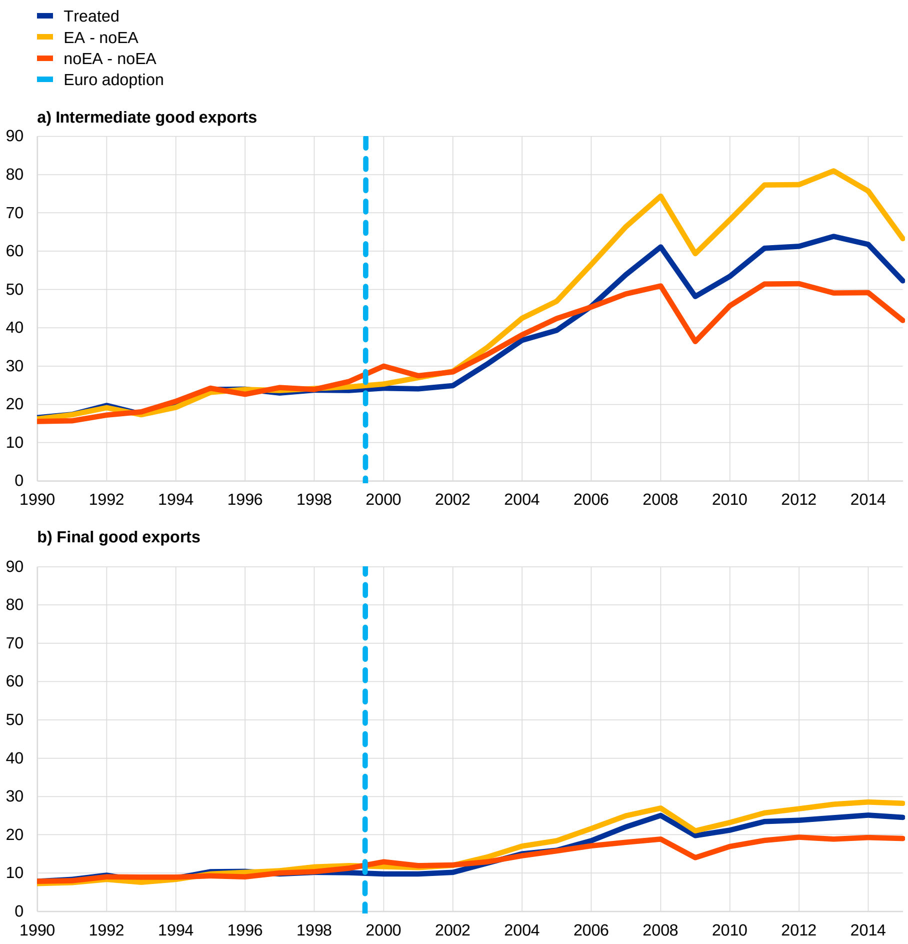
4.3 Results: the impact of the euro on exports from the first wave of euro adopters

The euro increased exports among the first wave of euro area countries when compared with similar non-euro pairs, but not relative to similar euro area to non-euro area pairs (Chart 16 and Table 5). Turning to the results where the aggregate old euro area is the origin of the export flows, we find that exports among the first euro area countries, particularly in intermediates, were lower after euro adoption than bilateral exports between euro and non-euro area countries. This means that, after euro adoption, trade flows between earlier euro members and non-euro area members increased by more than trade among earlier euro area countries. By contrast, when compared with trade between two similar non-euro area country pairs, the adoption of the euro led to increases in trade among the first wave of euro members of 8% and 13% for intermediate and final goods respectively (the “Intermediate goods trade – Post” and “Final goods trade – Post” columns in Table 5). Again, the increase in trade of both intermediate and final goods among first-wave adopters after euro adoption, relative to non-euro area countries, is very much in line with that that found in the previous section. Additionally, the synthetic control approach results show the existence of substantial trade diversion from euro area countries to non-euro area countries after euro adoption.

Chart 16

Dynamics of final and intermediate exports among first-wave euro area countries

(bilateral exports of intermediate and final goods in millions)



Sources: Authors' calculations based on the Eora database, GeoDist database, World Economic Outlook database, World Development Indicators database, Chinn and Ito (2006).

Table 5

Difference between actual and synthetic aggregate trade flows among first-wave euro area countries

(% difference)

	Total trade		**Intermediate goods trade**		**Final goods trade**	
	Pre	Post	Pre	Post	Pre	Post
EA-noEA	0.56	-13.74	0.29	-16.62	1.35	-11.71
	(4.69)	(3.26)	(2.36)	(4.74)	(9.67)	(2.90)
noEA-noEA	0.47	9.82	1.01	8.36	0.70	13.17
	(6.84)	**(14.98)**	**(7.87)**	**(17.07)**	**(8.65)**	**(20.27)**

Notes: The pre-treatment period is defined as the average of the periods 1990-2007, 1990-2008 and 1990-2009. The table shows the average percentage deviation of the treated pair relative to the counterfactual country pair in the pre-treatment and post-treatment period. In parentheses we show the standard deviation of yearly differences within each period.

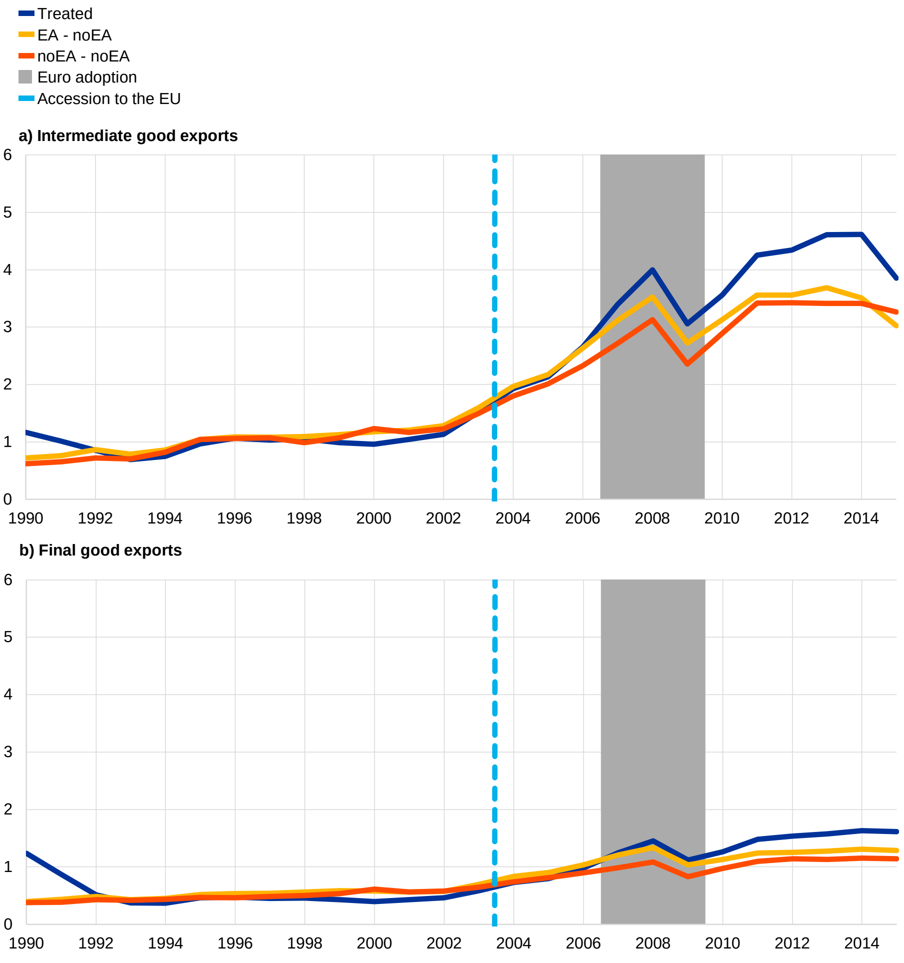
Finally, exports of both final and intermediate products from first-wave to second-wave countries increased significantly after euro adoption (Chart 15

and Table 6). Exports of intermediate products from the first wave to the second wave of euro area countries increased by 22% and 28% respectively relative to a situation where either one or both of the country pairs had not adopted the euro ("Intermediate goods trade – Post" column in Table 6). The corresponding increases were 20% and 37% respectively in the case of final products ("Final goods trade – Post" column in Table 6).

Chart 17

Dynamics of final and intermediate exports from first-wave to second-wave euro area countries

(bilateral exports of intermediate and final goods in millions)



Sources: Authors' calculations on the Eora database, GeoDist database, World Economic Outlook database, World Development Indicators database, Chinn and Ito (2006).

Table 6

Difference between actual and synthetic aggregate trade flows from first-wave to second-wave euro area countries

(% difference)

	Total trade		Intermediate goods trade		Final goods trade	
	Pre	Post	Pre	Post	Pre	Post
EA-noEA	1.90	22.50	0.44	21.84	5.18	20.12
	(32.57)	(7.29)	(18.99)	(6.90)	(57.83)	(6.111)
noEA-noEA	14.95	34.43	9.55	27.75	15.39	37.26
	(22.56)	**(4.02)**	**(25.59)**	**(6.43)**	**(61.80)**	**(4.36)**

Note: The pre-treatment period is defined as the average of the periods 1990-2007, 1990-2008 and 1990-2009. The table shows the average percentage deviation of the treated pair relative to the counterfactual country pair in the pre-treatment and post-treatment periods. In parentheses we show the standard deviation of yearly differences within each period.

These results are robust to a number of tests. We use a placebo test to check for the relevance of euro adoption in driving these results. The first placebo test assumes that the treatment year (year of euro adoption) is 1999 – instead of the average for the period 2007-2009 – for the euro area countries belonging to the second wave and reruns the analysis. The results of this test show a non-significant deviation of the actual relative to the counterfactual trend after the fake treatment year (see Annex 3, Section 8.4).

Results using non-parametric methods to construct the counterfactuals lead to similar results, although they are less precisely estimated. The use of non-parametric methods to construct the weights of each country pair in the donor pool and thus compute the counterfactuals has the advantage of being more data-driven and therefore less dependent on assumptions. However, this is a technique still in development and the pre-treatment period match between the treated and non-treated units is not as good as that obtained with the parametric methods. Despite this, the qualitative results, shown in Annex 3, are consistent with those shown in the main text.

4.4 Discussion of results from the gravity model and synthetic control approach

Results from the gravity equation and the synthetic control approach are qualitatively consistent, although they differ somewhat quantitatively. One of the reasons for the difference in range of estimates between the two approaches is the presence of fixed effects in the gravity model, allowing observed and unobserved characteristics of the countries to be captured. By contrast, the synthetic control approach selects the country pairs for the control group based on observables characteristics. The control group selected as such may fail to reproduce all structural feature and embed all observed and unobserved characteristics of the treated units. Note also that the reference group in the gravity results represents trade flows between non-euro area pairs of countries. In the synthetic control approach exercise, we replicate the same exercise when comparing actual bilateral exports of treated units with those of the counterfactual including non-euro area countries. But using this latter methodology, we carry out a further exercise by comparing trade flows between treated units with those of a second counterfactual which includes one euro area and one non-euro area country. With this in mind, both methodologies show that exports among earlier euro adopters increased by a small but significant amount relative to bilateral exports between non-euro area pairs. The increase was around 5.4% according to the gravity results and about 10% according to the synthetic approach. Trade among new euro area members increased by 5.3% according to the gravity results, but with the synthetic methodology, trade flows were not significantly different from those between non-treated pairs and increased by less than trade flows between euro and non-euro area countries.

Regarding the aggregate effect of the euro, our paper is broadly consistent with the estimates provided by the previous literature. Early models studying the effect of EMU indicate coefficients in a range of 3% (Baldwin and Taglioni, 2004) to 22% (Serlenga and Shin, 2007). Meanwhile, Micco et al. (2003) and Faruqee (2004) report effects of 11% and 8%, respectively. These studies rely on a time series that is broadly of the same length as ours, although they focus on aggregate data, while we can introduce a sectoral breakdown. Even so, as Glick and Rose (2016) argue, the exclusion of EU time trends to control for economic integration prior the common currency and a longer time series might inflate the results. On this basis, the fact that we do not include EU time trends among the covariates used in the synthetic control exercise might partly explain why we obtain more sizeable effects than those obtained with the gravity equation. It is worth mentioning that newer gravity models that corrected more efficiently for the multilateral resistance effect (see Box 1) have managed to obtain greater effects. For instance, Glick and Rose (2016) and Eicher and Henn (2011) report a positive impact of EMU on exports of about 50%. The higher coefficient is mostly attributed to the larger set of countries and the longer time span, which in the second study stretches back to 1950. These differences in the dataset composition probably also justify our relatively low coefficients, despite the fact that we use a comparable methodology. Nonetheless, despite the shorter time frame, our data allow a breakdown of trade by type of good (final and intermediate), thereby enabling the role of value chains to be assessed. In addition, we are able to investigate in greater detail the different effect that trade had on the first and second waves of euro adopters. Both of these novel dimensions of our results are discussed below.

The main result of our analysis is robust to the methodology employed and shows that the euro boosted exports between the first and second waves of euro adopters. By analysing separately the impact of the euro on exports of final and intermediate inputs, we are able to shed some light on the factors explaining this development. With the gravity approach we find that the euro had a positive effect on trade in intermediate products among old euro area countries (of 5.3%). In addition, the euro contributed positively to the export of final goods of late euro adopters, particularly to first-wave euro area countries (4.9% to exports to other second-wave countries and 10.6% to those to first-wave countries). According to the synthetic control approach, the increases in trade flows from the second to the first wave of euro adopters are more sizeable, with an increase in final goods exports of about 30%. Differently to the gravity results, the synthetic control approach finds that exports of both final and intermediate goods from the first to the second wave of euro adopters also increased after euro adoption, rising by 37% and 27% respectively. These results indicate increased economic integration between the different waves of euro adopters, as trade flows – including trade in intermediate goods – between these groups of countries were boosted by the common currency. The results from the synthetic control approach point more explicitly to the role of global value chains in explaining the result, as trade in intermediates also increased between the different waves.

With the synthetic control approach, we also find evidence of trade creation beyond the common currency area. Using the synthetic control approach, we find that exports between euro area and non-euro area countries, the latter mostly belonging to the European Union, expanded after euro adoption. In this regard, the IMF has documented the emergence of supply chains between Germany on the one hand and the Czech Republic, Hungary, Poland and Slovakia on the other. Three out of these four main partner countries belong to the European Union but not to the euro area, which supports our findings.

5 Conclusions

The adoption of the euro by a large number of EU countries – 19 at the time of writing, with the number possibly increasing in the coming years – has been a key step towards greater European integration. This has raised the question of whether the adoption of the euro has in itself triggered an increase in trade across euro area members – a question that has been addressed in an extensive body of literature.

The empirical evidence on optimum currency area endogeneity has so far been inconclusive. Pre-euro empirical evidence on the trade impact of a common currency failed the robustness tests, as the point estimates crucially depended on the sample coverage and the methodology used. Since the introduction of the euro, several studies have found some positive effect, but this is usually small.

With the euro entering its third decade, the aim of this paper is to reassess its impact on trade flows by accounting for two interrelated developments that have occurred over the last 20 years. The first of these developments is the emergence of international production chains, particularly pervasive in the European Union and among euro area countries. The second development is the adoption of the euro by a further set of countries since 2007. We argue that the euro, in reducing trade costs more for firms with internationally fragmented production chains than for others, may have facilitated the establishment or expansion of regional production chains among euro area countries and, in particular, between the first and second waves of euro adopters.

The results, consistent across the two methodologies used in the analysis, show that the euro has fostered additional export flows between the first wave of euro area countries and those joining subsequently. According to the gravity model results, the euro has generated an increase of around 4.3% in export flows between the two sets of euro area countries relative to exports between non-euro area countries. Estimates using the synthetic control approach indicate that the impact was significantly larger, with increases in the range of 30%. Regarding the channels, we find that for both the gravity approach and the synthetic control approach, the adoption of the euro fostered trade from the first wave to the second wave of adopters, an effect which turns out to be similar in magnitude for final and intermediate products. In addition, the analysis finds a pronounced positive euro effect on exports of final goods from second-wave to first-wave euro adopters. This is consistent with the establishment of regional production chains in which second-wave euro area countries are positioned downstream.

Bilateral exports both among the first wave and among the second wave of euro adopters increased by a small but significant amount relative to non-euro area countries. The gravity results show an increase of 5.4% in exports among the first wave of euro members after euro adoption, a greater effect than shown by previous estimates (Baldwin et al. 2008). The synthetic control approach shows an increase of about 10% relative to non-euro area pairs. Trade within the set of newer euro area countries increased by 4.9% after euro adoption according to the gravity model, and by less than 3% according to the synthetic control approach.

We also find strong evidence of trade creation within the European Union. Regional production chains in Europe involved not only newer euro area countries, but also non-euro area countries in the region.

The high degree of integration into international production chains facilitated by the euro is important for increasing business cycle synchronisation in the euro area. One of the conditions for an optimum currency area is the existence of a high degree of business cycle synchronisation. Participation in regional production chains could help in that respect. However, a potential risk to be borne in mind is that if downstream countries specialise too much in certain industries, such as the car industry, they could be subject to sector-specific shocks to a much larger extent. As a consequence, they could eventually decouple from other euro area countries. At the same time, euro area countries are facing a changing scenario that sees regional integration progressing amid stalling trade integration at the global level.

Annex 1: Data appendix

The Eora database

The Eora database is provided by KGM & Associates and gives a time series of detailed input-output tables connecting 190 countries between 1990 and 2015. For each country, different levels of detail concerning the sectoral breakdown are available. We select the most standardised model with 26-sector harmonised classification. Raw data are obtained from a wide array of sources[46] and are presented either in "basic prices" or "purchasers' prices" format. Basic prices reflect the costs of production borne by the producer, while purchasers' prices embed the amount paid by the purchaser. Therefore, the difference between the two lies essentially in transportation costs and net taxes, which are included only in purchasers' prices. For this exercise, we have opted to use the basic prices measure so as to be in line with the OECD and WIOD databases.

The database makes it possible to distinguish between bilateral trade flows in final and intermediate goods. Given the structure of the Eora input-output table, we classify as intermediate (final) exports from country i to country j all imports of country i sourced from country j to meet intermediate (final) demand of country i. We do this for each country in the database and for each year. It is important to note that, given the high number of countries included, the database can account for almost all global trade flows.

Although we use the same database for both the gravity equation and the synthetic control approach, the number of countries included in each differs. The reason is that in the synthetic control analysis, we complement the trade flows with other variables to construct the counterfactuals. These variables are not available for all country pairs, which causes a reduction in the sample size from the 190 countries considered for the gravity equation to 66 countries and 4,290 pairs of countries after the cleaning in the synthetic control approach.

The countries included in the Eora database are as follows: Albania, Argentina, Australia, Austria, Belgium, Bosnia and Herzegovina, Bulgaria, Brazil, Canada, Chile, China, Colombia, Croatia, Cyprus, Czech Republic, Denmark, Egypt, Estonia, Finland, France, Germany, Greece, Hong Kong, Hungary, Iceland, India, Iran, Ireland, Israel, Italy, Japan, Korea, Kuwait, Latvia, Lithuania, Luxembourg, Malaysia, Malta, Mexico, Netherlands, New Zealand, Nigeria, North Macedonia, Norway, Pakistan, Peru, Philippines, Poland, Portugal, Romania, Russia, Saudi Arabia, Singapore, Slovakia, Slovenia, South Africa, Spain, Sweden, Switzerland, Thailand, Turkey, Ukraine, United Arab Emirates, United Kingdom, United States and Venezuela.

[46] The United Nations System of National Accounts, Eurostat, the United Nations Trade Statistics Database (Comtrade), the Institute of Developing Economies (IDE/JETRO) and numerous national agencies.

Data used in the synthetic control approach

For the synthetic control analysis, we included a set of variables to be used to identify a synthetic counterfactual based on the convex combination of the members of the donor pool.

More specifically: distance, area, common language and common border come from CEPII's GeoDist database (Mayer and Zignago, 2011); GDP comes from the World Economic Outlook database of the International Monetary Fund; population comes from the World Development Indicators of the World Bank. Trade openness is computed as the sum of export and imports over GDP.

We also include three additional novel variables. The first, DistanceEUij, measures the average number of years between the entry in the European Union and the adoption of the euro for country i and country j. This variable is included in order to take into account other factors, stemming from only being part of the EU, that could have affected trade – such as the EU customs union – and that could have anticipated or confounded the gains of trade derived from only sharing a currency. The second variable that we include is the share of total value added accruing to the manufacturing sector (World Development Indicators of the World Bank). Finally, we include a proxy of financial openness coming from the Chinn-Ito index (Chinn and Ito, 2006).

Annex 2: Tables

Table 7 and Table 8 below show the weights given to each pair of countries in the control group to create a synthetic country representing the first or second wave of euro adopters. The average value of the output variable in the pre-treatment period is shown in Table 9 and Table 10.

Table 7

Weights of the different pairs of countries used to create the synthetic control for the different groups treated for total trade

	Second wave-second wave		First wave-second wave		Second wave-first wave		First wave-first wave	
	2007		2007		2007		1999	
Rank	Pair	Weight	Pair	Weight	Pair	Weight	Pair	Weight
1	MKD-HUN	0.332	DNK-SWE	0.137	KWT-ROU	0.264	SWE-NOR	0.32
2	MKD-HRV	0.316	CHE-HUN	0.078	DNK-SWE	0.131	JPN-USA	0.18
3	HUN-MKD	0.208	LTU-USA	0.072	KWT-POL	0.077	ALB-NZL	0.146
4	ISR-MKD	0.047	SWE-CHE	0.051	KWT-ISR	0.077	KWT-UKR	0.133
5	MKD-ISL	0.031	HUN-CZE	0.043	ISR-JPN	0.073	SWE-DNK	0.122
6	SGP-KWT	0.029	CZE-HUN	0.043	HKG-JPN	0.073	USA-CAN	0.068
7	SGP-MKD	0.024	KWT-CHE	0.03	KWT-USA	0.058	BIH-NZL	0.03
8	MKD-ALB	0.01	MKD-CHE	0.022	KWT-PER	0.038	NZL-IND	0.002
9	DNK-SWE	0.005	CHE-MKD	0.018	KWT-ARE	0.033		
10			KWT-JPN	0.012	KWT-KOR	0.028		

Notes: Control group: pairs of countries that have not adopted the euro. The year in the table indicates the beginning of the treatment period. Only the ten most important pairs used for the synthetic control are included in the table.

Table 8

Weights of the different pairs of countries used to create the synthetic control for the first wave to second wave treatment group for total trade depending on the year when the treatment starts

Pair	**2007**		**2008**		**2009**	
Rank	Pair	Weight	Pair	Weight	Pair	Weight
1	KWT-ROU	0.264	KWT-CHE	0.174	KWT-JPN	0.188
2	DNK-SWE	0.131	KWT-USA	0.111	ISR-CHE	0.087
3	KWT-POL	0.077	DNK-SWE	0.107	ISR-MKD	0.07
4	KWT-ISR	0.077	KWT-ROU	0.084	ISR-TUR	0.063
5	ISR-JPN	0.073	KWT-ISR	0.083	KWT-CHE	0.06
6	HKG-JPN	0.073	MKD-ROU	0.071	HKG-JPN	0.059
7	KWT-USA	0.058	KWT-UKR	0.065	DNK-SWE	0.047
8	KWT-PER	0.038	KWT-ARE	0.033	KWT-ARE	0.045
9	KWT-ARE	0.033	SGP-JPN	0.03	CHE-CZE	0.041
10	KWT-KOR	0.028	CHE-DNK	0.02	MKD-ISR	0.038
11	CHE-HRV	0.015	KWT-POL	0.02	CHE-ISR	0.034
12	ISR-NZL	0.008	SGP-MYS	0.012	MKD-ROU	0.03
13	CHE-CZE	0.007	MKD-POL	0.01	ISR-KWT	0.027
14	ISR-POL	0.002	KWT-IRN	0.007	KWT-PER	0.022
15	ISR-MKD	0.002	ISR-ROU	0.007	CHE-CAN	0.021
16	KWT-IRN	0.002	ISR-AUS	0.006	SGP-AUS	0.012
17	KOR-JPN	0.002	ALB-ROU	0.005	HKG-USA	0.009
18	LTU-USA	0.002	CHE-HRV	0.005	KWT-POL	0.008
19	SGP-AUS	0.002	ISR-POL	0.005	KWT-UKR	0.007
20	KWT-NOR	0.001	ISR-TUR	0.004	CZE-CHE	0.005

Notes: Control group: pairs of countries that have not adopted the euro. Only the 20 most important pairs used for the synthetic control are included in the table.

Table 9

Average value of the output variable in the pre-treatment period depending on the treatment group

	Second wave-second wave		First wave-second wave		Second wave-first wave		First wave-first wave	
	2007		2007		2007		1999	
	Treated	Synthetic	Treated	Synthetic	Treated	Synthetic	Treated	Synthetic
Total trade	73,434	70,719	1822388	2072606	1614342	1715996	29789036	29462282
Area	48,682	76,513	695477.2	388359.5	59549.22	43170.63	689447.5	1845173
Saia's transformation of contiguity	-0.10	-0.10	-0.07569	-0.08409	-0.0501	-0.04961	0.331952	0.332304
Saia's transformation of distance	0.08	0.08	0.415273	0.303349	0.372857	0.335385	-0.0394	-0.04229
Saia's transformation of common language	0.17	0.18	0.141573	0.144873	0.14517	0.14521	0.19232	0.159643
GDP	47,301	62,668	1440073	1610502	1441359	1510599	2593403	2842258
Population	5975	9547	57936.62	48073.13	57721.31	56410.98	107582.1	105672.5
Time period between accession to the EU and adoption of the euro	4.06	0.00	6.540932	0	6.430489	0	8.718297	0
Value added of the manufacturing sector	18.33	18.50	18.02529	18.26499	18.14387	18.26381	18.38127	18.36407
Financial openness index	-0.18	-0.12	1.138519	1.291982	1.198864	1.235635	1.892759	1.794673

Notes: Control group: pairs of countries that have not adopted the euro. The year in the table indicates the beginning of the treatment period.

Table 10

Average value of the output variable in the pre-treatment period for the first wave to second wave treatment and synthetic groups depending on the year of treatment

	2007		2008		2009	
	Treated	Synthetic	Treated	Synthetic	Treated	Syntethic
Total trade	1822388	2072606	1979172	2349708	2161939	2672055
Area	695477.2	388359.5	695145	278345.5	694865.1	204863.3
Saia's transformation of contiguity	-0.07569	-0.08409	-0.07497	-0.08191	-0.07434	-0.08468
Saia's transformation of distance	0.415273	0.303349	0.413786	0.291813	0.41245	0.289653
Saia's transformation of common language	0.141573	0.144873	0.141876	0.150749	0.142165	0.151069
GDP	1440073	1610502	1483920	1689157	1534199	1729654
Population	57936.62	48073.13	57907.07	49337.11	57888.39	49048.65
Time period between accession to the EU and adoption of the euro	6.540932	0	6.539347	0	6.537935	0
Value added of the manufacturing sector	18.02529	18.26499	17.96894	18.18506	17.88299	17.98651
Financial openness index	1.138519	1.291982	1.18292	1.334619	1.225467	1.394855

Note: Control group: pairs of countries that have not adopted the euro.

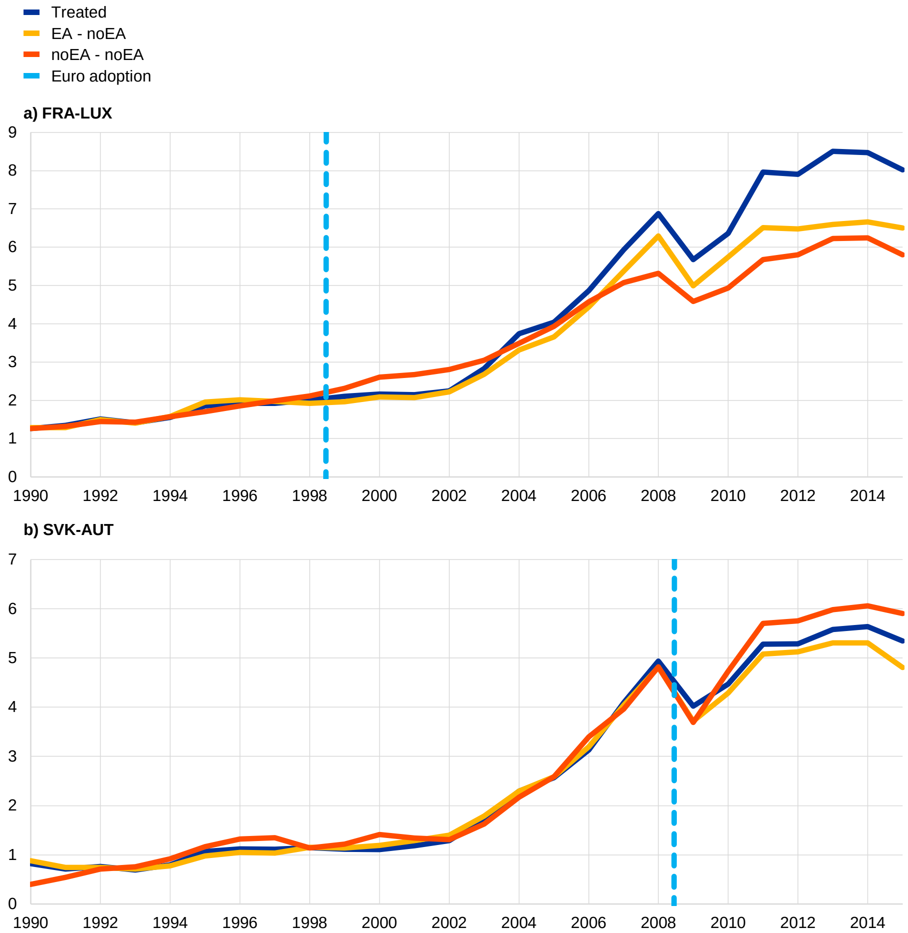
Annex 3: Synthetic control approach – additional results

Ex post aggregation

Chart A.1

Dynamics of total exports from France to Luxembourg and from Slovakia to Austria

(bilateral exports of total goods in millions)



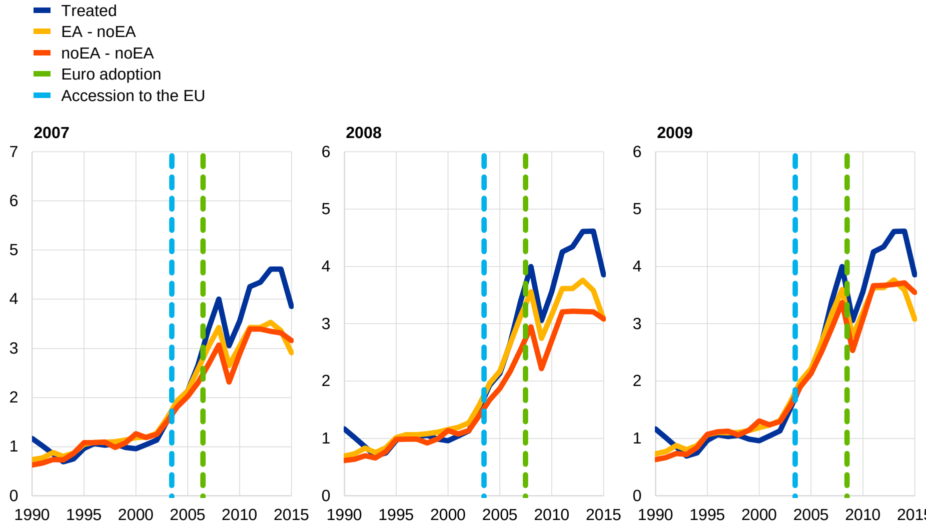
Sources: Eora database, GeoDist database, World Economic Outlook database, World Development Indicators database, Chinn and Ito (2006) and authors' calculations.

Different treatment years for ex ante aggregation of the second-wave euro area countries

Chart A.2

Dynamics of intermediate exports from first-wave to second-wave euro area countries with different years of adoption

(bilateral exports of intermediate goods in millions)

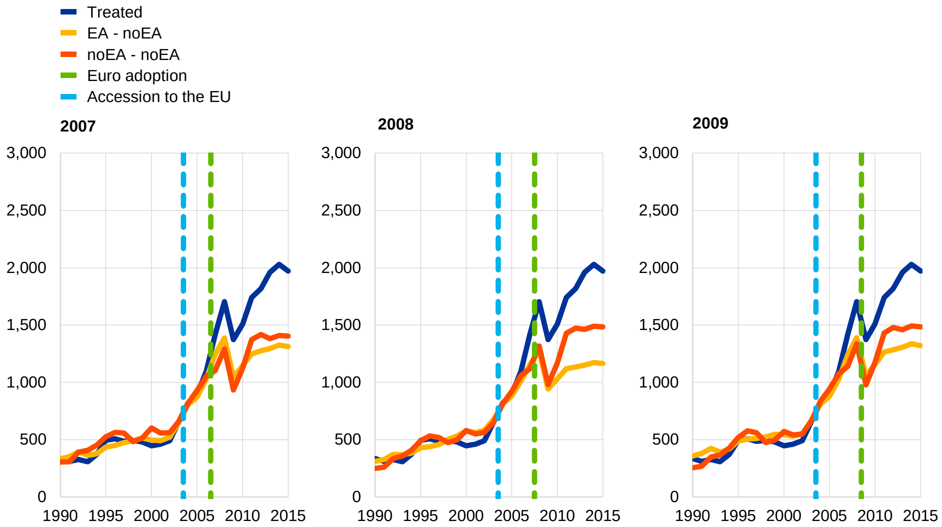


Sources: Authors' calculations based on the Eora database, GeoDist database, World Economic Outlook database, World Development Indicators database, Chinn and Ito (2006).

Chart A.3

Dynamics of final exports from second-wave to first-wave euro area countries with different years of adoption

(bilateral exports of final goods in thousands)



Sources: Authors' calculations based on the Eora database, GeoDist database, World Economic Outlook database, World Development Indicators database, Chinn and Ito (2006).

Making the parametric and non-parametric methods work with a large set of donors

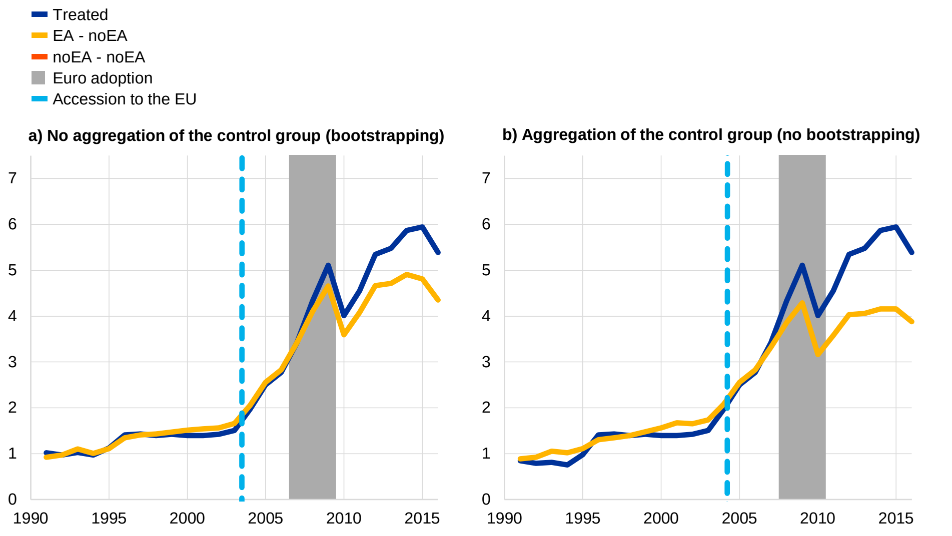
To construct a synthetic counterfactual parametrically, we used the Stata command synth. However, this command has one weakness: it limits the maximum number of observations in the control group to around 1,600 pairs of countries. As mentioned above, we had a pool of 1,700 pairs to construct one of our synthetic counterfactuals (noEA-EA) and a pool of as many as 2,600 pairs to construct a counterfactual for bilateral trade between non-euro area countries (noEA-noEA). We solved this issue by applying a simple random sampling technique with replacement, i.e. a bootstrapping method, to our control group (50 draws for the noEA-EA control group and 150 draws for noEA-NoEA control group). We tested the robustness of our results by aggregating the countries of the second wave of euro adopters for the noEA-EA control group to reduce the sample to less than 1,600 observations and ran the command again without bootstrapping. The results can be seen in Chart A.4 below and are very similar.

To construct the non-parametric counterfactuals, we used the still-in-trial Stata command npsynth. This command does not limit the number of observations in the control group, so we were able to run the command with all country pairs in each donor pool. However, the routine, which is still in its development phase, is very sensitive to the choice of the bandwidth and the type of kernel function. In addition, the optimal bandwidth, which determines which country pairs are "close enough" in their pre-treatment characteristics to be included in the synthetic counterfactual, varies for each of the treated country pairs. In order to overcome this problem, we designed a routine which chooses the optimal bandwidth, defined as the one with the smallest root mean squared prediction error (RMSPE), with a precision of 0.001 for four different types of kernel function (normal, epan, biweight and triangular). The routine included a loop dividing our interval of possible bandwidths into four and calculating the five different RMSPEs associated with the corresponding bandwidths. It then divided the interval into two, centred it on the value of bandwidth giving the smallest RMSPE and restarted the operation until the desired precision was reached. We believe this method is the cleanest possible way to choose the bandwidth and type of kernel function. We applied it every time we implemented the non-parametric method. This allowed us to automatically select the optimal bandwidth and the optimal type of kernel function for each of the treated country pairs.

Chart 18

Dynamics of total exports from second-wave to all euro area countries with and without bootstrapping

(bilateral exports of total goods in millions)



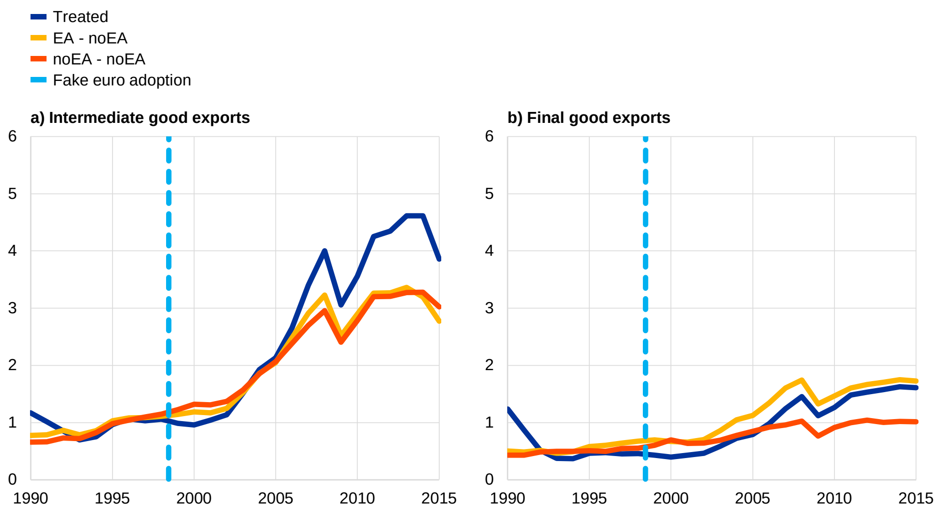
Sources: Authors' calculations based on the Eora database, GeoDist database, World Economic Outlook database, World Placebo tests

The time placebo test reassigns the introduction of the euro to an earlier date to check that the phenomenon observed at the date of interest would not have happened earlier by setting up an earlier date than that used in the synthetic control method. In this connection, we decided to rerun the exercise for the "new" countries, with 1999 as the year of adoption.

Chart A.5

Dynamics of final and intermediate exports from first-wave to second-wave euro area countries with placebo test (euro adoption date = 1999)

(bilateral exports of intermediate and final goods in millions)

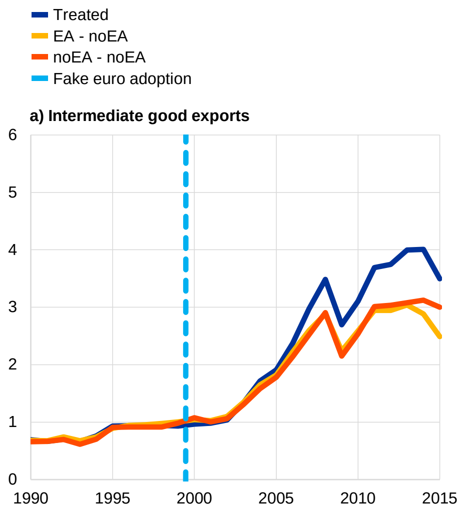


Sources: Authors' calculations based on the Eora database, GeoDist database, World Economic Outlook database, World Development Indicators database, Chinn and Ito (2006).

Chart A.6

Dynamics of final and intermediate exports from second-wave to first-wave euro area countries with time placebo test (euro adoption date = 1999)

(bilateral exports of intermediate and final goods in millions)



Sources: Authors' calculations based on the Eora database, GeoDist database, World Economic Outlook database, World Development Indicators database, Chinn and Ito (2006).

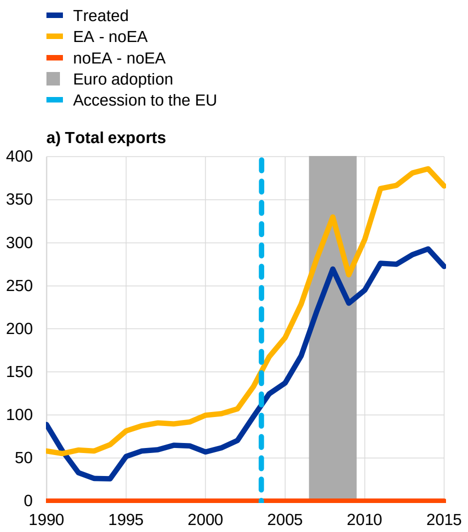
Non-parametric estimation of counterfactuals

In some cases, the synthetic control did not find good matches, resulting in a flat line of synthetic trade. We excluded those results and do not show them here.

Chart A.7

Dynamics of total and intermediate exports from second-wave to second-wave euro area countries with non-parametric synthetic control

(bilateral exports of total and intermediate goods in thousands)

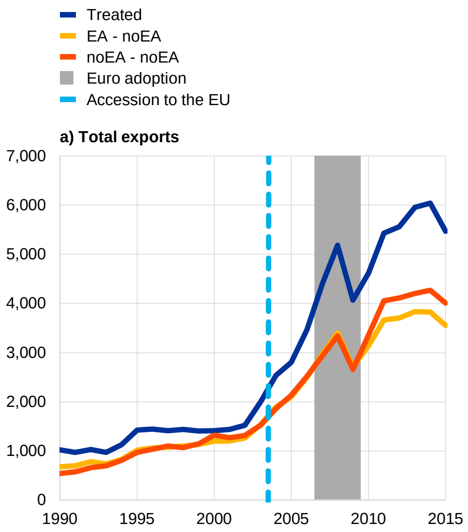


Sources: Authors' calculations based on the Eora database, GeoDist database, World Economic Outlook database, World Development Indicators database, Chinn and Ito (2006).

Chart A.8

Dynamics of total and intermediate exports from second-wave to first-wave euro area countries with non-parametric synthetic control

(bilateral exports of total and intermediate goods in thousands)

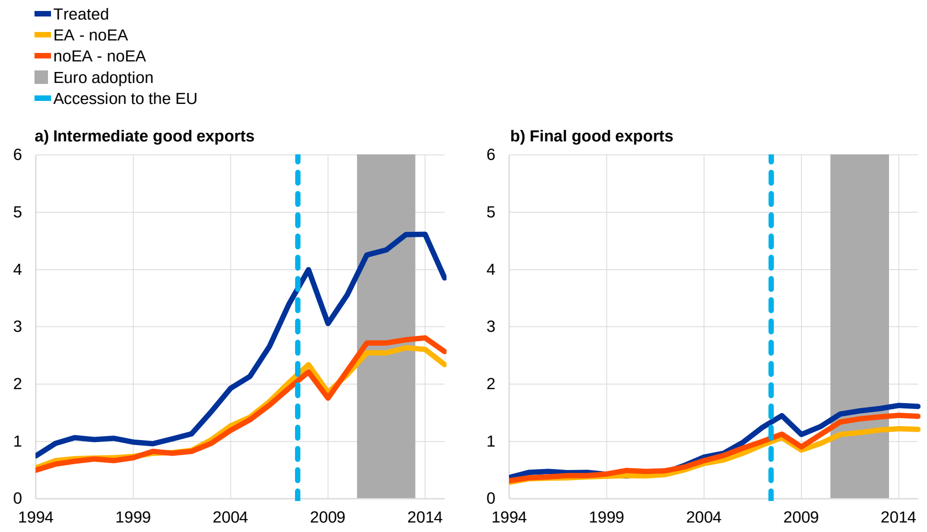


Sources: Authors' calculations based on the Eora database, GeoDist database, World Economic Outlook database, World Development Indicators database, Chinn and Ito (2006).

Chart A.9

Dynamics of final and intermediate exports from first-wave to second-wave euro area countries with non-parametric synthetic control

(bilateral exports of intermediate and final goods in millions)

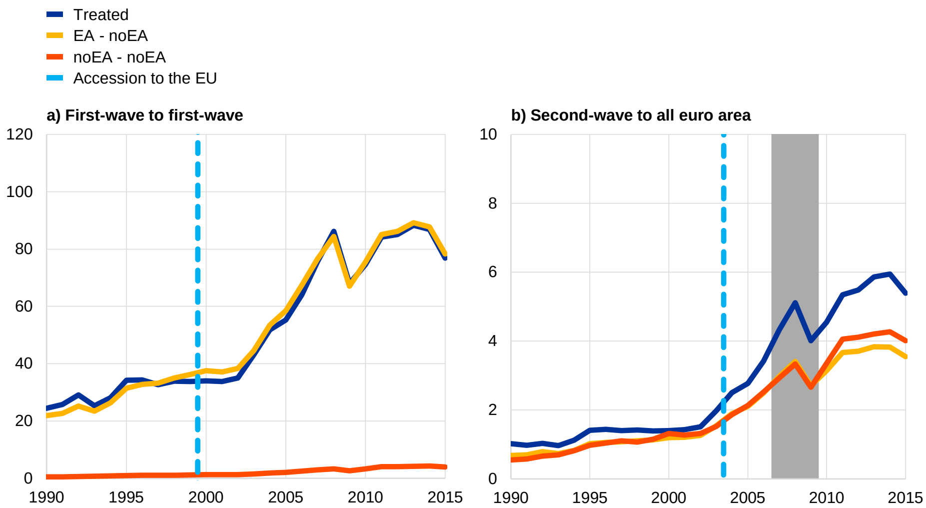


Sources: Authors' calculations based on the Eora database, GeoDist database, World Economic Outlook database, World Development Indicators database, Chinn and Ito (2006).

Chart A.10

Dynamics of total exports from first-wave to first-wave euro area countries and from second-wave to all euro area countries with non-parametric synthetic control

(bilateral exports of total goods in millions)



Sources: Authors' calculations based on the Eora database, GeoDist database, World Economic Outlook database, World Development Indicators database, Chinn and Ito (2006).

References

Abadie, A. and Gardeazabal, J. (2003), “The Economic Cost of Conflict: A Case Study of the Basque Country”, *American Economic Review*, Vol. 93, No 1, pp. 113-132.

Abadie, A., Diamond, A. and Hainmueller, J. (2010), “Synthetic Control Methods for Comparative Case Studies: Estimating the Effect of California’s Tobacco Control Program”, *Journal of the American Statistical Association*, Vol. 105, Issue 490, pp. 493-505.

Agur, I., Dorrucci, E. and Mongelli, F.P. (2005), “What does European institutional integration tell us about trade integration?”, *Occasional Paper Series*, No 40, ECB.

Alesina, A., Barro, R.J. and Tenreyro, S. (2002), “Optimal currency areas”, *NBER Macroeconomics Annual*, Vol. 17, pp. 301-345.

Anderson, J. and van Wincoop, E. (2003), “Gravity with Gravitas: A Solution to the Border Puzzle”, *American Economic Review*, Vol. 93, No 1, pp. 170-192.

Arkolakis, C., Costinot, A. and Rodríguez-Clare, A. (2012), “New Trade Models, Same Old Gains?”, *American Economic Review*, Vol. 102, No 1, pp. 94-130.

Atalay, E. (2017), “How Important are Sectoral Shocks?”, *American Economic Journal: Macroeconomics*, Vol. 9, No 4, pp. 254-80.

Baier, S., Bergstrand, J. and Vidal, E. (2007), “Free Trade Agreements in the Americas: Are the Trade Effects Larger than Anticipated?”, *The World Economy*, Vol. 30, Issue 9, pp. 1347-77.

Baier, S. and Bergstrand, J. (2009a), “*Bonus vetus* OLS: a simple method for approximating international trade cost effects using the gravity equation”, *Journal of International Economics*, Vol. 77, Issue 1, pp. 77-85.

Baier, S. and Bergstrand, J. (2009b), “Estimating the effects of free trade agreements on international trade flows using matching econometrics”, *Journal of International Economics*, Vol. 77, Issue 1, pp. 63-76.

Baldwin, R.   and Taglioni, D. (2004), “Positive OCA Criteria: Microfoundations for the Rose Effect”, *COE/RES Discussion Paper Series*, No 34.

Baldwin, R. (2006), “The euro’s trade effects”, *Working Paper Series*, No 594, ECB.

Baldwin, R. and Taglioni, D. (2007), “Trade Effects of the Euro: a Comparison of Estimators”, *Journal of Economic Integration*, Vol. 22, No 4, pp. 780-818.

Baldwin, R., Di Nino, V., Fontagné, L., De Santis, R. and Taglioni, D. (2008), “Study on the impact of the euro on trade and foreign direct investment”, *Economic Papers* No 321, European Commission.

Belke, A., Domnick, C. and Gros, D. (2017), “Business Cycle Synchronization in the EMU: Core vs. Periphery”, *Open Economies Review*, Vol. 28, Issue 5, pp. 863-892.

Berthou, A. and Fontagné, L. (2008), “The Euro and the Intensive and Extensive Margins of Trade: Evidence from French Firm Level Data”, available at SSRN 1194963.

Carril-Caccia, F. and Pavlova, E. (2018), “Foreign direct investment and its drivers: a global and EU perspective”, *Economic Bulletin*, Issue 4, ECB.

Carvalho, V.M. (2014), “From Micro to Macro Via Production Networks”, *Journal of Economic Perspectives*, Vol. 2, Issue 4, pp. 23-48.

Cerulli, G. (2017), “NPSYNTH: Stata module to implement Nonparametric Synthetic Control Method”, *Statistical Software Components* S458398, Boston College Department of Economics.

Chen, N. and Novy, D. (2018), “Currency Unions, Trade, and Heterogeneity”, *CEPR Discussion Paper*, No 12954.

Chinn, M. and Ito, H. (2006), “What matters for financial development? capital controls, institutions, and interactions”, *Journal of Development Economics*, Vol. 81, Issue 1, pp. 163-192.

Cieślik, A., Michałek, J. and Mycielski, J. (2012), “Consequences of the euro adoption by Central and Eastern European (CEE) countries for their trade flows”, *NBP Working Papers* , No 118, Narodowy Bank Polski.

Dai, M., Yotov, Y.V. and Zylkin, T. (2014), “On the trade-diversion effects of free trade agreements”, *Economics Letters*, Vol. 122, Issue 2, pp. 321-325.

de Soyres, F. (2016), “Value added and productivity linkages across countries”, *Working Paper*, No 209, Oesterreichische Nationalbank.

Di Giovanni, J., Levchenko, A.A. and Mejean, I. (2018), “The Micro Origins of International Business-Cycle Comovement”, *American Economic Review*, Vol. 108, No 1, pp. 82-108.

Dorrucci, E., Firpo, S., Fratzscher, M. and Mongelli, F.P. (2005), “The Path of European Institutional and Economic Integration: What Lessons for Latin America?”, *Journal of Economic Integration,* Vol. 20, No 2.

Duval, R., Li, N., Saraf, R. and Seneviratne, D. (2016), “Value-added trade and business cycle synchronization”, *Journal of International Economics*, Vol. 99, Issue C, pp. 251-26.

European Central Bank (2016), “Understanding the weakness in global trade – What is the new normal?”, *Occasional Paper Series*, No 178.

European Central Bank (2019), “The impact of global value chains on the euro area economy”, *Occasional Paper Series*, No 221.

Eicher, T. S. and Henn, C. (2011), “One money, one market: A revised benchmark”, *Review of International Economics,* Vol. 19, Issue 3, pp. 419-435.

Faruqee, H. (2004), “Measuring the trade effects of EMU”, *IMF Working Paper*, No 04/154.

Frankel, J.A. and Rose, A.K. (1998), “The Endogenity of the Optimum Currency Area Criteria”, *The Economic Journal*, Vol. 108, pp. 1009-1025.

Frankel, J. and Rose, A. (2001), “An Estimate of the Effect of Common Currencies on Trade and Income”, *Working Paper Series*, RWP01-013, Harvard University, John F. Kennedy School of Government.

Glick, R. and Rose, A. (2002), “Does a currency union affect trade? The time-series evidence”, *European Economic Review*, Vol. 46, Issue 6, pp. 1125-1151.

Glick R. and Rose, A. (2015), “Currency Unions and Trade: A Post-EMU Mea Culpa”, *CEPR Discussion Paper*, No 10615.

Glick R. and Rose, A. (2016), “Currency Unions and trade: A post-EMU reassessment”, *European Economic Review*, Vol. 87, Issue C, pp. 78-91.

Johnson, R.C. and Noguera, G. (2012), “Accounting for intermediates: Production sharing and trade in value added”, *Journal of international Economics*, Vol. 86, Issue 2, pp. 224-236.

Kenen, P. (1969), “The Optimum Currency Area: an eclectic view”, In Mundell and Swoboda (eds.), *Monetary Problems of the International Economy*, University of Chicago Press, Chicago.

Lalinsky, T. and Merikull, J. (2019), “The effect of the single currency on exports: comparative firm-level evidence”, *Working Paper Series*, No 2018-10, Eesti Pank.

Lall, S. (2000), “The technological structure and performance of developing country manufactured exports, 1985-98”, *Oxford Development Studies*, Vol. 28, Issue 3, pp. 337-369.

Lanz, R. and Maurer, A. (2015), “Services and global value chains: some evidence on servicification of manufacturing and services networks”, *WTO Staff Working Papers,* ERSD-2015-03.

Larch, M., Schmeißer, A. and Wanner, J. (2019), “A Tale of (almost) 1001 coefficients: deep and heterogeneous effects of the EU-Turkey customs union”, *CESifo Working Paper Series*, No 7498.

Mayer, T. and Zignago, S. (2011), “Notes on CEPII’s distances measures: the GeoDist Database”, *CEPII Working Paper*, No 2011-25.

Matesanz, D., Ferrari H., Torgler, B. and Ortega, G. (2017), “Synchronization and diversity in business cycles: a network analysis of the European Union”, *Applied Economics*, Vol. 49, Issue 10, pp. 972-986.

McKinnon, R. (1963), “Optimum Currency Areas”, *American Economic Review*, Vol. 52, pp. 717-725.

Mensah, I. (2017), “The Euro's effect on trade: an analysis of ‘old’ and ‘new’ EMU members”, *FIW Working Paper Series*, No 179.

Mika, A. and Zymek, R. (2018), “Friends without benefits? New EMU members and the ‘Euro Effect’ on trade”, *Journal of International Money and Finance*, Vol. 83, pp. 75-92.

Micco, A., Stein, E. and Ordoñez, G. (2003), “The currency union effect on trade: early evidence from EMU”, *Economic Policy*, Vol. 18, Issue 37, pp. 315-356.

Miles, W. and Vijverberg, C. (2018), “Did the Euro Common Currency Increase or Decrease Business Cycle Synchronization for its Member Countries?”, *Economica*, Vol. 85, Issue 339, pp. 558-580.

Miroudot, S. and Cadestin, C. (2017), “Services in global value chains: from inputs to value-creating activities”, *OECD Trade Policy Papers*, No 197.

Mongelli, F.P. (2002), “‘New’ views on the optimum currency area theory: what is EMU telling us?”, *Working Paper Series*, No 138, ECB.

Mongelli, F.P. (2008), “European economic and monetary integration and the optimum currency area theory”, *Economic Papers*, No 302, European Commission.

Mundell, R. (1961), “A Theory of Optimum Currency Areas”, *American Economic Review*, Vol. 51, No 4, pp. 657-665.

National Board of Trade Sweden (2016), *The Servicification of EU manufacturing. Building Competitiveness in the Internal Market*.

Rose, A.K. (2000), “One money, one market: the effect of common currencies on trade”, *Economic Policy*, Vol. 15, Issue 30, pp. 8-45.

Rose, A.K. (2017), “Why do Estimates of the EMU Effect on Trade Vary so Much?”, *Open Economies Review*, Vol. 28, Issue 1, pp. 1-18.

Saia A. (2017), “Choosing the open sea: the cost to the UK of staying out of the euro”, *Journal of International Economics*, Vol. 108, Issue C, pp. 82-98.

Santos Silva, J. and Tenreyro, S. (2006), “The log of gravity”, *The Review of Economics and Statistics*, Vol. 88, Issue 4, pp. 641-658.

Santos Silva, J. and Tenreyro, S. (2011), “Further simulation evidence on the performance of the Poisson pseudo-maximum likelihood estimator”, *Economic Letters*, Vol. 112, Issue 2, pp. 220-222.

Serlenga, L. and Shin, Y. (2007), “Gravity models of intra-EU trade: application of the CCEP-HT estimation in heterogeneous panels with unobserved common time-specific factors” *Journal of Applied Econometrics*, Vol. 22, Issue 2, pp. 361-381.

Sondermann, D., Consolo, A., Gunnella, V., Koester, G., Lambrias, K., Lopez-Garcia, P., Nerlich, C., Petroulakis, F., Saiz, L. and Serafini, R. (2019), "Economic structures 20 years into the euro", *Occasional Paper Series*, No 224, ECB.

Tinbergen, J. (1962), "Shaping the world economy: suggestions for an international economic policy", *The Twentieth Century Fund*, New York.

Yi, K. (2003), "Can Vertical Specialization Explain the Growth of World Trade?", *Journal of Political Economy*, Vol. 111, No 1, pp. 52-102.

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