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Benefits of EMU Participation

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Publication date:
2017

Document Version
Early version, also known as pre-print

Link to publication in Tilburg University Research Portal

Citation for published version (APA):
Verstegen, L., van Groezen, B., & Meijdam, L. (2017). *Benefits of EMU Participation: Estimates using the Synthetic Control Method*. (CentER Discussion Paper; Vol. 2017-032). CentER, Center for Economic Research.

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Discussion Paper

No. 2017-032

BENEFITS OF EMU PARTICIPATION: ESTIMATES USING THE SYNTHETIC CONTROL METHOD

By

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28 August 2017

ISSN 0924-7815
ISSN 2213-9532

Benefits of EMU Participation:

Estimates using the Synthetic Control Method*

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August 2017

Abstract

This paper investigates quantitatively the benefits from participation in the Economic and Monetary Union for individual Euro area countries. Using the synthetic control method, we estimate how real GDP per capita would have developed for the EMU member states, if those countries had not joined the EMU. The estimates show that most countries have profited from having the euro, though the crisis leads to negative effects of EMU membership. The PIGS countries, in particular, would have been better off if they had not been an EMU member during the crisis, however, Greece, Portugal and Spain experienced the largest benefits of EMU participation in the pre-crisis period.

JEL classification: C23, E65, F33, F36, F43, F45

Keywords: Economic Growth, Euro Area, Synthetic Control Method, Monetary Union

*We thank participants at the WIEM 2017 in Warsaw, the 2017 RES Symposium of Junior Researchers in Bristol, and the seminar participants at the Netherlands Bureau for Economic Policy Analysis and at Tilburg University for useful comments and discussions.

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1 Introduction

The success of the Economic and Monetary Union has been widely debated. Many economists, as well as the public, wonder whether the introduction of the euro and participation in the EMU has brought prosperity to the individual members, or whether it actually has had negative consequences for the euro adopters.

Even before the introduction of the EMU, and the euro included, the success of the Euro area as a monetary union was questioned. Economists argued that the EMU did not satisfy the requirements as described in the Optimum Currency Area literature that would help the Euro area to be a successful currency union in terms of GDP and trade, for example. For individual countries, the cost of joining a monetary union is to give up the ability to use monetary policy to cope with (asymmetric) shocks. These costs are amplified in unions without sufficient labor mobility and a risk sharing mechanism to cope with asymmetric shocks, exactly two elements that are missing in the Euro area.

In the wake of the recent economic crisis in Europe, the discussion about the viability of the EMU has revived in most Eurozone countries. The Delors Report (Delors (1989)) and the 'One market, one money' report (Commission of the European Communities (1990)) predicted that the adoption of the euro would move the Euro area to a higher growth path. The question remains whether the individual Euro area countries really have benefited from the euro and the common monetary policy. With respect to the future of the Economic and Monetary Union, it is important that member countries are mostly benefiting from their participation in this currency union. A useful extension of this analysis would be to understand the determinants of the benefits or losses from participation in the EMU. A deeper understanding of this can help to take steps to bring the Euro area closer to an optimum currency area.

This paper tries to contribute to this discussion by estimating the effects of having the euro and participating in the EMU for individual member countries. In order to identify a causal relationship, we need to find a counterfactual, given by the answer to the question: "What would have been the level of GDP per capita in a country had it not joined the EMU?" Of course, this counterfactual does not exist and the construction of a credible counterfactual GDP series for each country is difficult. By using the synthetic control method, pioneered by Abadie

and Gardeazabal (2003), we aim to construct robust counterfactual GDP series to examine the impact of participation in the EMU in terms of real GDP per capita. The data-driven procedure of this method builds a counterfactual as a weighted combination of countries, such that the synthetic counterfactual's characteristics best match those of the country of interest in the period before the introduction of the EMU.

A great advantage of this method compared to the commonly used fixed effects regression is that the effect of EMU participation can vary over the period after the introduction of the EMU. Therefore, the research question for this part of the analysis does not only focus on the individual benefits and losses of the euro for the member states, but also investigates how these benefits or losses might change over time.

In contrast to the beliefs of many, our results show that most countries have benefited from their participation in the EMU, an effect that is even significant for Austria, Belgium, the Netherlands and Spain. The only country that initially experiences a loss from having the euro is Italy. Participation in the EMU was proven to be anticipated already two years before the official introduction of the euro in 1999. Moreover, the benefits and losses from EMU participation vary a lot over time. Until 2008, the year in which the financial crisis started, all countries except Italy were profiting from their EMU membership. However, during the crisis period many countries would have been better off if they had not been in the monetary union, especially Greece, Italy and Spain.

The impact of participation in the EMU is quite heterogeneous across countries, which logically leads to the follow-up research question of this paper: "Which economic determinants are important for the losses or benefits of being part of the Euro area?" For this exercise, we run OLS regressions on the estimated payoffs from EMU membership, relating them to several potential determinants. The main drivers of the estimated effect of EMU participation are trade openness, competitiveness, fiscal stance, labor market flexibility and migration.

The rest of the paper is organized as follows. Section 2 briefly discusses the relevant literature in this field. Section 3 presents the synthetic control method and potential issues with this method, a comparison to the fixed effects method and a description of the data. Section 4 shows the estimated payoffs of EMU participation for individual member countries and the variation

in these estimates over different periods in time as well as the potential determinants of the benefits and losses of individual countries. Section 5 presents statistical inference on the results and the differences and similarities of the synthetic control method and the fixed effects method for this analysis. Section 6 concludes.

2 Related literature

This paper attempts to estimate the impact of participation in the EMU and having the euro on per capita GDP for individual countries within the Euro area. Several papers have investigated the euro effect on trade rather than per capita GDP. For example, Frankel and Rose (2002) quantify the implications of having a common currency, using data for more than 200 countries. They first estimate that belonging to a currency union triples trade with other members of the currency union. Then they find that an increase of one percent in trade raises income per capita in that country by at least 0.33 percent. The two estimates combined leads them to conclude that there are beneficial effects of currency unions through a positive trade effect. There are more early papers on this topic, such as Barr et al. (2003), Micco et al. (2003) and Flam and Nordström (2006), that all report sizable and significantly positive trade effects of the euro. Baldwin et al. (2008) find that the euro has promoted trade and foreign direct investment significantly, and identify the relative price channel and the newly-traded goods channel as the main channels for this effect. On the other side of the literature, papers by, amongst others, Mancini-Griffoli and Pauwels (2006), Berger and Nitsch (2008) and Santos Silva and Tenreyro (2010) conclude that the effect of the euro on trade is not significantly different from zero.

Rather than estimating the effect of the euro on trade, there also exist papers trying to capture the effect of the euro on GDP or income for the whole Euro area. In the paper by Drake and Mills (2010) for example, Euro area GDP is decomposed into trend components and cyclical components. The authors find that the trend growth of Euro area real GDP has been reduced by the introduction of the euro. Using a VAR approach with the US as counterfactual, Giannone et al. (2010) show that Euro area per capita GDP growth is not different from what is expected based on pre-EMU economic structure and the US business cycle. The inability of the literature to agree upon the impact of the euro and the EMU on GDP is to a large extent related to the difficulty of establishing a reliable counterfactual by using the right method.

Our paper will use the synthetic control method to estimate the effects of EMU participation on real GDP per capita. This method was pioneered by Abadie and Gardeazabal (2003), who used the approach to identify the impact of terrorist conflict in the Basque Country on GDP per capita. Moreover, this methodology has been used in Abadie et al. (2010) and Abadie et al.

(2015) to estimate the effects of a tobacco control program in California as well as the economic impact of the German reunification. In the paper by Campos et al. (2014), the synthetic control method is used to analyze the gains from membership in the European Union. They find large benefits from EU membership (except for Greece), though these differ across countries and over time.

With regards to the impact of the euro introduction on GDP, there have been few papers using the synthetic control method. One example is the paper by Gomis-Porqueras and Puzzello (2015), who estimate the effect of joining a monetary union on GDP per capita for six of the early adopters of the euro. They find that Belgium, France, Germany and Italy would have had higher levels of GDP per capita if they had not joined the EMU, whereas the euro effect is positive for Ireland. For the Netherlands, the impact of the euro on income is negligible. In the paper by Fernández and García-Perea (2015), the focus is on the Euro area as a whole, for which there is only a small positive effect of the adoption of the euro which turns negative afterwards.

The contribution of our paper to the literature is fourfold. Firstly, our focus is on the individual Euro area countries. Therefore, the counterfactual we are aiming for reflects the situation in which the individual member would not have joined the EMU, and not the situation in which the EMU would not have existed. We believe that the estimates produced by the synthetic control method are more suitable to provide an answer to this counterfactual question, rather than the question what GDP would have been if there had not been a monetary union at all.

Secondly, a broader data collection allows us to cover a longer period of time before the introduction of the euro. Next to that, more countries and more predictors for real GDP per capita are included in the analysis, all of which will improve the chances of creating a good counterfactual match. Participation within the EMU might have been anticipated, which we will take into account by starting the estimation some years before the introduction of the euro.

Thirdly, we study the different periods after the introduction of the EMU to analyze how the EMU effect might vary over time. An interesting extension is that we estimate the differential impact of the crisis on EMU members relative to non-EMU countries.

Finally, we provide a methodological contribution by making an explicit comparison between the

synthetic control method and the fixed effects panel data regression, which is the most commonly used method in the literature. Using estimates from a fixed effects regression, counterfactuals are built using two approaches, and these are compared to the synthetic counterfactuals. The results show that the fit of the counterfactual to the EMU country in the pre-EMU period is actually much better when we use the synthetic control method compared to the fixed effects method.

3 Synthetic Control Method

Answering the question "What would have been the growth path of GDP per capita in a country, had it not joined the EMU?" is difficult, because of issues related to endogeneity, measurement errors, omitted variables and causality. In order to investigate the effects of EMU participation empirically, we build counterfactuals for each of the Euro area countries separately, using the synthetic control method pioneered by Abadie and Gardeazabal (2003) and further explored by Abadie et al. (2010, 2015).

3.1 Methodology

A simple comparison of the time path of GDP for the members and non-members would reflect the effect of participating in the EMU, but also the differences in predictors of GDP before the introduction of the euro. The synthetic control method tries to identify only the first effect by comparing the growth path of GDP for a given country to the growth path for a synthetic control group. This synthetic control resembles relevant economic characteristics of the country of interest before the introduction of the euro. This method is based on the presumption that a weighted combination of comparison units, the 'counterfactual' EMU country not participating in the EMU, does better in reproducing the EMU country than a single control unit.

In order to construct this synthetic control, the method searches for a weighted combination of control countries that is chosen to closely match the treated country for a set of predictors of GDP. The growth path for GDP per capita of the synthetic control is the estimate of the counterfactual, that is, the growth path of the Euro area country if the country had not joined the EMU. The growth path of this synthetic control is compared to the actual growth path of the Euro area country to find the effect of participation in the EMU. This procedure is repeated for every single EMU country to find the country-specific benefit or loss from being in the EMU.

More formally[1], there is a sample of $J+1$ countries indexed by j, in which country $j = 1$ is the EMU country of interest and countries $j = 2$ to $j = J+1$ are potential control countries, which is called the donor pool. The sample is assumed to be a balanced panel where all units are observed

[1]The notation in this section is similar to the notation in Abadie et al. (2015).

for each period $t = 1, ..., T$. Moreover, we assume that the intervention, e.g. the introduction of the euro, takes place in period $T_0 + 1$, such that T_0 is the number of preintervention periods and T_1 (with $T_0 + T_1 = T$) is the number of postintervention periods.

For each country j and time t we observe Y_{jt}, the outcome of interest. For the EMU country of our interest we observe Y_{1t} for the whole postintervention period, but we would also like to gain knowledge about the unobserved Y_{1t}^N, the outcome for this country if it had not been subject to the intervention. With this knowledge, the effect of the intervention on this EMU country can be estimated by:

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

The counterfactual Y_{1t}^N is now given by the GDP path of the synthetic control.

The synthetic counterfactual or control is defined as a weighted average of the units in the donor pool. The set of weights is given by $W = (w_2, ..., w_{J+1})$, in which $0 \leq w_j \leq 1$ and $\sum_{j=2}^{J+1} w_j = 1$. A donor country can be given at least a zero weight and at maximum 100 percent weight, and all weights should sum to one. For each EMU country we will construct a different synthetic counterfactual and hence the weights for the countries in the donor pool will most likely be different across the EMU countries.

The selection of the control units is a step of crucial importance. The weights for the synthetic control should be chosen in such a way that the 'counterfactual EMU country' most closely resembles the actual EMU country before the introduction of the euro. The preintervention characteristics of the EMU country are captured in the $(k \times 1)$ vector X_1. The $(k \times J)$ matrix X_0 contains the values of the same variables for the units in the donor pool. Preintervention values of the outcome variable, which is GDP in this case, may also be included in X_0 and X_1.

The data-driven procedure to choose the synthetic control W^* is to minimize the difference between the preintervention characteristics of the country of interest and the synthetic control, given by the vector $X_1 - X_0 W$. For $m = 1, ..., k$, the value of the m-th variable for the EMU country is given by X_{1m}, whereas the values of this variable for the donor pool are given by the

$(1 \times J)$ vector X_{0m}. Then we choose $W^* = (w_2^*, ..., w_{J+1}^*)$ that minimizes:

$$\sum_{m=1}^{k} \upsilon_m (X_{1m} - X_{0m}W)^2 \tag{2}$$

The weights $V = \upsilon_1, ..., \upsilon_k$ reflect the relative importance assigned to each of the k variables within X_1 and X_0. There are several methods for choosing the υ_m weights, which will influence the mean square error of the estimator, given by:

$$\frac{1}{T_0} \sum_{t=1}^{T_0} \left(Y_{1t} - \sum_{j=2}^{J+1} w_j^* Y_{jt} \right)^2 \tag{3}$$

The choice could be based on a subjective measure of the relative importance of the predictors. In most cases however, the choice of V is data driven. One possibility is to let the weights be determined by a first step regression. Alternatively, we choose V such that W minimizes the mean square prediction error (MSPE) over a pre-specified set of pre-euro periods. That is, these weights are chosen so that the per capita GDP path of the EMU country is best reproduced by the resulting counterfactual EMU country. This involves a nested optimization problem, in which each choice of the vector of predictor weights V implies a choice of W, the weights for the donor countries, which then implies a value for the MSPE.

The postintervention values of the outcome variable for the EMU country are collected in the $(T_1 \times 1)$ vector $Y_1 = (Y_{1T_0+1}, ..., Y_{1T})'$, whereas the $(T_1 \times J)$ matrix Y_0 contains the postintervention values for the donor pool. The counterfactual path for the EMU country is the GDP path of the synthetic control, which is given by the vector $Y_1^N = Y_0 W^*$. Hence, the estimated effect of the introduction of the euro is given by the difference between the postintervention outcomes of the EMU country and the synthetic control, which is $Y_1 - Y_0 W^*$. Similarly, the synthetic control estimator of the effect of participation in the EMU is given by:

$$\tau_{1t} = Y_{1t} - \sum_{j=2}^{J+1} w_j^* Y_{jt} \tag{4}$$

for all postintervention periods $t \geq T_0$.

3.2 Potential issues

In order to identify the true effect of EMU participation for the Euro area countries, the synthetic control method entails two main identification assumptions. Firstly, the variables that are included in the preintervention characteristics in matrices X_0 and X_1 cannot be variables that anticipate the effects of EMU participation, but should include variables that are able to approximate the GDP path of the EMU member. Although it is hard to rule out any anticipation effects that the introduction of the EMU might have had, we will include different intervention years in our analysis, so-called in-time placebo tests, to investigate the existence of anticipation effects. If anticipation effects exist, then the effect of EMU participation will be estimated for the year in which the anticipation starts. The second assumption requires that countries in the donor pool should not be affected by the intervention. It is important to realize that the intervention is not the introduction of the EMU itself, but the participation of a country in the EMU. The counterfactual that we would like to estimate is for the situation that the country had not joined the EMU, and not for the situation that the EMU had not existed. The countries in the donor pool may be affected by the introduction of the EMU, so spillover effects of the introduction of the EMU could exist. However, if the EMU country had not joined the monetary union, it would have also been affected by the introduction of the euro. Hence we assume that these spillover effects for the EMU countries would have been the same as the spillovers for the control countries, had the EMU countries not joined the EMU. If the spillover effect to these countries would be even larger, and of the same sign as the benefit or loss, then the estimated effect might underestimate the true effect of EMU participation.

Choosing the donor pool requires great care. Countries that have been subject to large country-specific structural shocks to GDP should be excluded from the donor pool, if those shocks would not have affected the EMU country if it had not been a Euro area member. Besides, the donor pool should be restricted to countries with similar characteristics as the EMU countries to avoid interpolation biases and overfitting. The problem of overfitting occurs when the preintervention characteristics of the country of interest artificially match the idiosyncratic variations in the sample data. One could say that the model is too complicated for the dataset. Therefore, we start by using a large donor pool of countries for the synthetic control method, and then we limit the donor pool to a small subset of 14 countries that are more comparable to the EMU

members. Moreover, we perform an in-sample forecast to detect the extent to which overfitting might pose a problem.

Even when the preintervention characteristics and the donor pool are carefully selected, the question remains whether the difference between the actual and synthetic growth path of the EMU country really reflects the effect of EMU membership rather than the inability to reproduce a counterfactual growth path for this country if it would not have joined the EMU. To address this question, a first check is to compare the behavior of the outcome variable of the country of interest and the synthetic control in the periods before the intervention. If these two series behave similarly, then the gap in the outcome variable between the two series after the intervention can be interpreted as a difference that arises because of the introduction of the EMU. As a second check, we will use a difference-in-differences approach to assess statistical significance by estimating confidence intervals for the estimated benefits and losses of EMU participation. Moreover, we will conduct placebo tests. The idea behind these falsification exercises is that one cannot be confident about the estimated effect of EMU participation if similar effects would be obtained for countries that have not joined the EMU. If the synthetic control method would estimate large effects if the intervention was applied to countries in the donor pool, a so-called in-space placebo test, we would not be confident about the estimated causal effect. Placebo tests in space can also be used for statistical inference. In particular, one could create a range of placebo effects by applying the synthetic control method to every potential donor country to find the estimated effect of the placebo intervention. The estimated effect of EMU participation can be evaluated against this range of placebo effects, for each of which the ratio of post- to pre-EMU RMSPE is calculated. If this ratio for the EMU member is larger than any of the ratios for the placebo effects, the estimated benefit or loss for the EMU member can be considered significant. Finally, confidence intervals based on subsamples of the donor pool are used for statistical inference on the EMU effect. We construct 50 counterfactuals, for which we randomly draw a subsample of the control countries to be in the donor pool. The synthetic control method is applied to these 50 counterfactuals, which leads to a distribution for the effect of EMU participation for each country.

3.3 Comparison to fixed effects regression

The construction of a counterfactual as a linear combination of real GDP per capita of control countries, as the synthetic control method does, might appear as an unusual method. However, regression methods also use a weighted combination of the outcome variable of control countries, with coefficients summing to one. There is a large difference, however, as regression methods do not impose the restriction on these coefficients that they have to be between zero and one. The regression weights may take on negative values or coefficients may be greater than one. Hence, a regression-based approach allows for extrapolation outside the support of the data. This means that even if the GDP predictors for the EMU country cannot be approximated by a weighted average of the GDP predictors of the donor pool countries, regression weights would extrapolate to produce a perfect fit. A related advantage of the synthetic control method is that these weights for the control countries are explicitly calculated, whereas the regression weights for fixed effects regressions are usually not reported.

The synthetic control method also has advantages in terms of required data. Time-invariant variables could be used as predictors for the outcome variable, whereas the fixed effects regression method does not allow for time-invariant variables. Besides, building a counterfactual using the fixed effects method requires that none of the predictors have missing values in the years before the intervention as well as all the years after the intervention. On the contrary, the synthetic control method could still use variables for which there are missing observations, as long as there are is at least one observation for the period before the intervention year.

Furthermore, a big advantage of the synthetic control method compared to the fixed effects method is that the effect of the intervention does not need to be constant over the period after the intervention. The synthetic counterfactual shows the time path of GDP over time, and does not limit the analysis to the average effect over a period of time. In this way, the synthetic control method allows us to not only compute the average EMU effect but also to compare the benefit or loss an individual country may have from EMU participation over different periods after 1997. This feature of the method is particularly interesting for comparing the EMU effect for the periods before the financial crisis and the recession period itself.

3.4 Data

The synthetic control method is used to analyze the effect of the introduction of the euro for the early members of the Economic and Monetary Union, as we leave out the late adopters because of data availability, as well as Luxembourg because of the difficulty to find a reliable counterfactual. Hence, we will report on the effects of EMU participation for Austria, Belgium, Finland, France, Germany, Greece, Ireland, Italy, the Netherlands, Portugal and Spain. We will collect country-level panel data for these countries as well as for a large sample of 39 potential countries (see Appendix 1 for details). The data is gathered for the period between 1960 and 2015, though the estimation period will be shorter as we will see later, for the main reason that this optimizes the matching process.

The outcome variable is real GDP per capita, measured in constant 2005 U.S. dollars. For the pre-EMU characteristics, economic growth predictors such as inflation, trade, labor force participation, unemployment, schooling, migration and several financial and political variables are used.[2] A list of all variables used in the analysis is provided in Appendix 1, along with the source of the data. The main source for this dataset is the World Bank database.

Data availability is the main reason to leave countries out of the analysis. This also holds for the late adopters of the euro, as these countries lack observations for certain variables in the early 1990s. The choice of countries within the donor pool is also driven by data availability, and upfront no countries are excluded from the analysis. In comparison to Fernández and García-Perea (2015) and Gomis-Porqueras and Puzzello (2015), we prefer to observe the matches that the synthetic control method comes up with in order to see which countries in the large donor pool are actually close to the EMU members. Then, by leaving out countries that miss data on important variables, or might have experienced large structural shocks or were not part of the synthetic control in the large pool, we limit the donor pool to a smaller subset. The small donor pool consists of countries that are most important in the synthetic controls for the large donor pool as well.

[2]The use of the word 'predictor' might seem confusing as economic growth is likely to be correlated with, and not necessarily caused by, these macroeconomic variables. However, one must bear in mind that we use pre-EMU values of these variables to find the counterfactual growth path after the introduction of the EMU which explains the use of the word 'predictor'. Endogeneity issues do not play a role here, as these so-called predictors are only used to find control countries that match well to the EMU country, and not to find a causal relationship between GDP and these variables.

4 Benefits or losses for individual countries

Using the methodology presented in the previous section, the individual gains and losses of EMU participation are estimated for both a large and a smaller donor pool of countries. We study possible anticipation effects concerning the introduction of the EMU, as well as the differential impact of the 2008 economic crisis on EMU member countries relatively to non-EMU member countries. Furthermore, we investigate the main drivers behind the gains and losses for the EMU members.

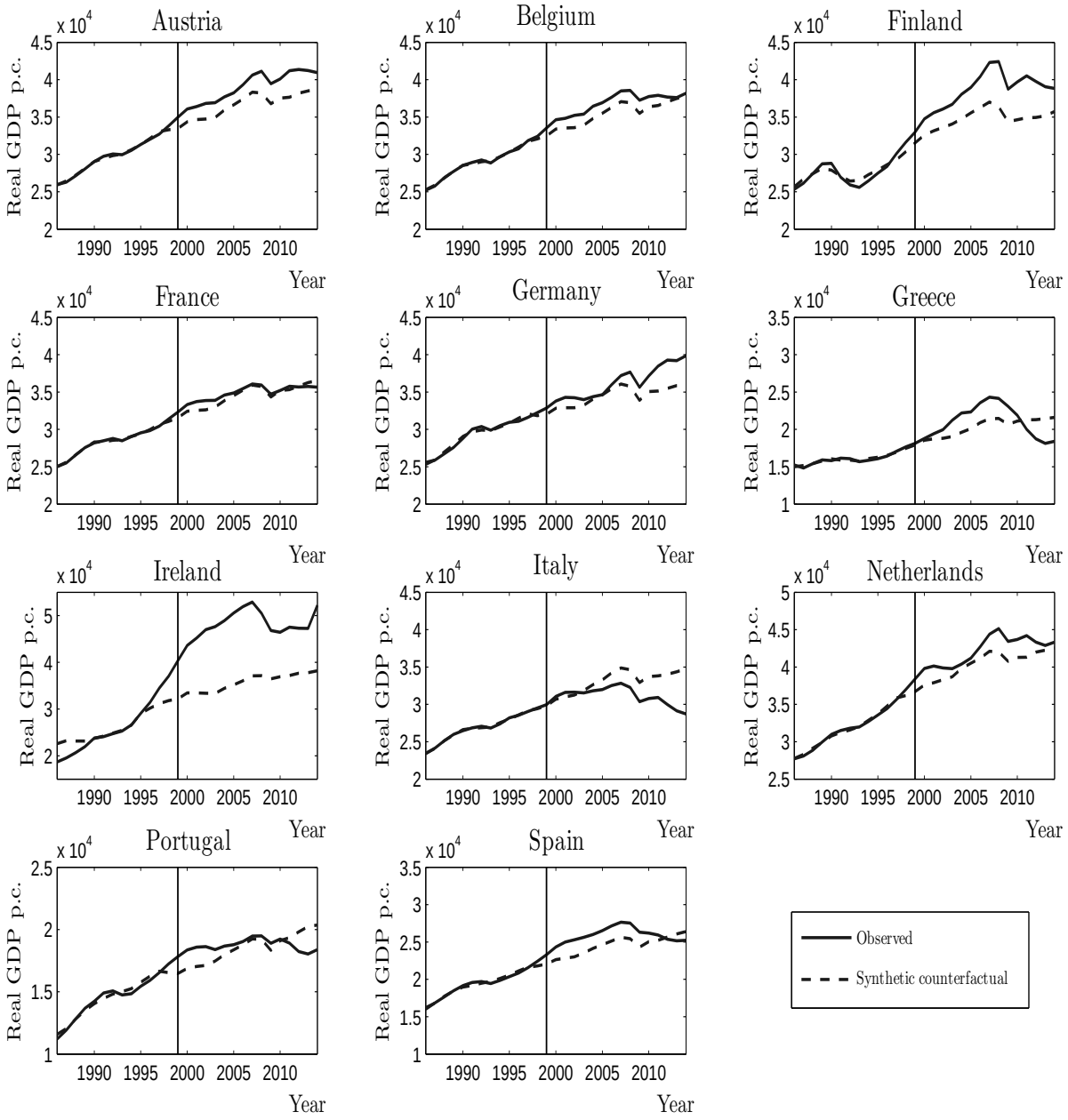
4.1 Starting from a large donor pool...

For the 11 individual member countries of the EMU a synthetic counterfactual is built based on a large donor pool of countries. This donor pool consists of 39 countries in Europe, Oceania and North America as well as Asia, Africa and South America, as to make this set as broad as possible given the data limitations. The synthetic weights in the counterfactual are displayed in table A.1. The synthetic counterfactual is estimated using data from 1986 until 1996.[3] Figure 1 displays the observed series for real GDP per capita and the synthetic counterfactual for the individual member countries of the EMU.

For most EMU countries, the synthetic counterfactual tracks very well real GDP per capita before the introduction of the EMU in 1999, which is an important factor in establishing the validity of the result. The difference between the observed series and the synthetic counterfactual after 1999 is the effect of participation in the EMU, and is positive if the observed real GDP per capita lies above the line of the synthetic counterfactual. Our estimates show that most countries experienced a positive effect of having the euro over the whole period between 1999 and 2014. An interesting observation is that Greece, Portugal and Spain experience a benefit of being in the EMU first, whereas this turns into a loss during the 2008 economic crisis. According to these results, Italy would have been better off had it not introduced the euro, whereas the effect for France appears to be not significantly different from zero. Ireland is an exceptional

[3] As a robustness check, we repeat the analysis for the small donor pool with intervention year 1997 using different starting years of the estimation period. The EMU effect does not differ substantially between the estimations based on starting year 1980 until starting year 1990 for most countries. However, for Belgium, Germany, Greece, Portugal and Spain there are some quantitative differences for the average effect when a different starting year is chosen.

Figure 1: Real GDP per capita: Observed vs synthetic counterfactual



case in this analysis, as the country has gone through a period of specific high growth rates in the 1990s and 2000s, which many attribute to a large extent to foreign direct investment and foreign multinationals. This makes it fairly hard to find a reasonable counterfactual, the estimated EMU effect for Ireland should therefore be considered as largely overestimated.

4.2 ... to a smaller donor pool with more GDP predictors

In constructing a solid counterfactual, it is important that the combination of control countries matches well on the GDP path before the introduction of the EMU, as well as on the economic predictors of GDP. For that reason, we move to a smaller donor pool which enables us to include more GDP predictors as for these countries more data is available. Another advantage of using this smaller donor pool is that these control countries are more comparable to the EMU countries, which makes us confident that no structural changes in these countries trouble the view that the estimated EMU effect gives.[4] This small donor pool consists of 14 countries, namely Australia, Canada, Chile, Denmark, Iceland, Japan, Mexico, New Zealand, Norway, Sweden, Switzerland, Turkey, United Kingdom and United States. As table A.1 shows, these countries were already important control countries for the results in the previous section.

From figure 2 it appears that the estimated EMU effect is similar for most countries when we adjust the donor pool to a smaller subset of countries. The only exception here is Finland, that seems to benefit less from being in the EMU than before. An important observation in both figure 1 and 2 is that the effect of EMU participation seems to start earlier than 1999 for most EMU members. These so-called anticipation effects might arise as consumers, firms and also governments anticipate the introduction of the euro in advance and start to behave accordingly. Taking anticipation effects into account can be done by applying the synthetic control method to a different year, and using the period until that year as basis for the matching. In this case, we will use the year 1997, since it appears that the EMU effect sets in at this time for most EMU members.

Figure 3 shows that except for Ireland, the synthetic control method for intervention year 1997

[4]The smaller donor pool indeed matches better on the economic predictors of real GDP per capita than the large donor pool, as the average distance between the predictors of the EMU country and its synthetic control is smaller.

Figure 2: Real GDP per capita: Observed vs synthetic counterfactual for small donor pool

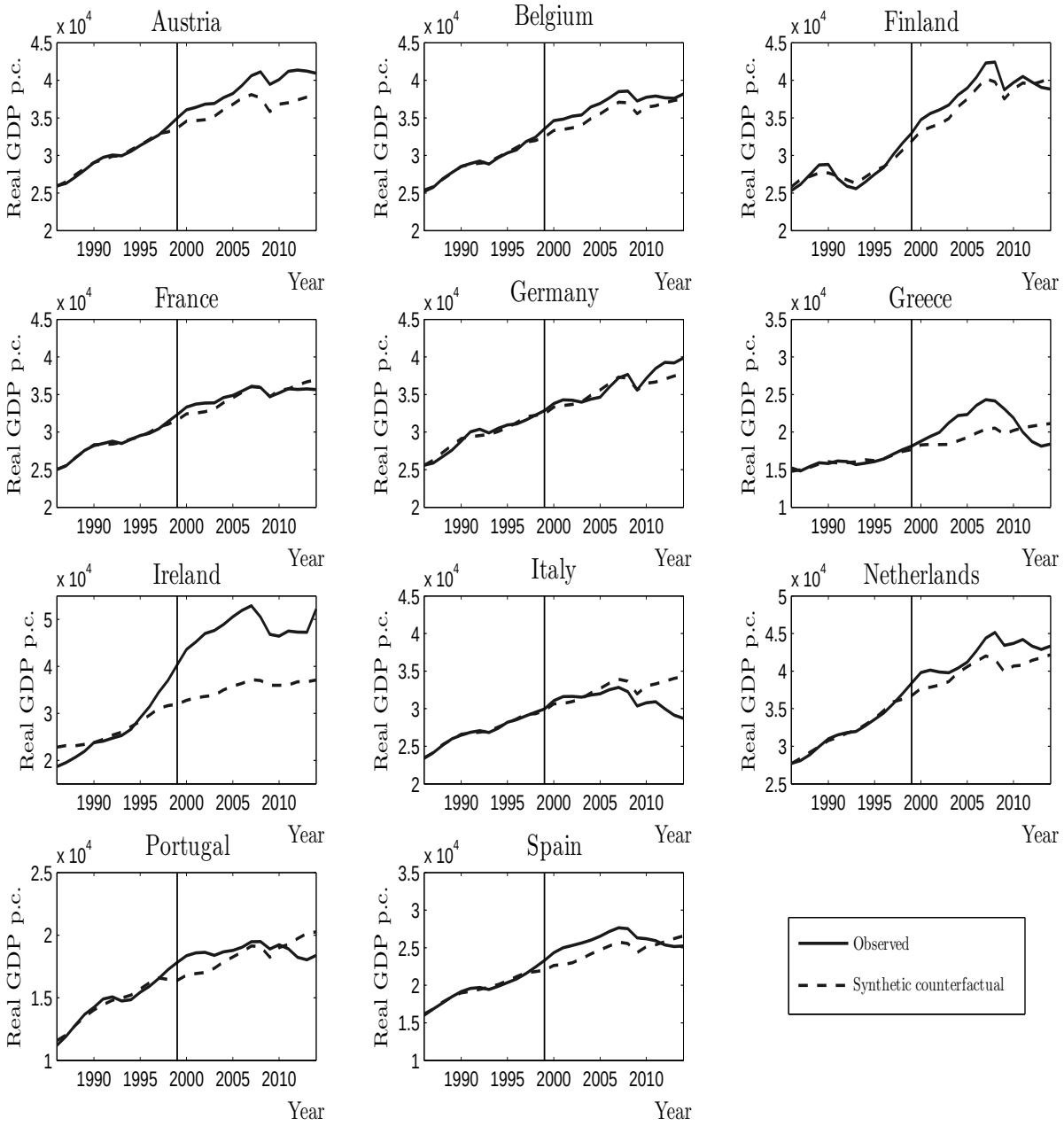
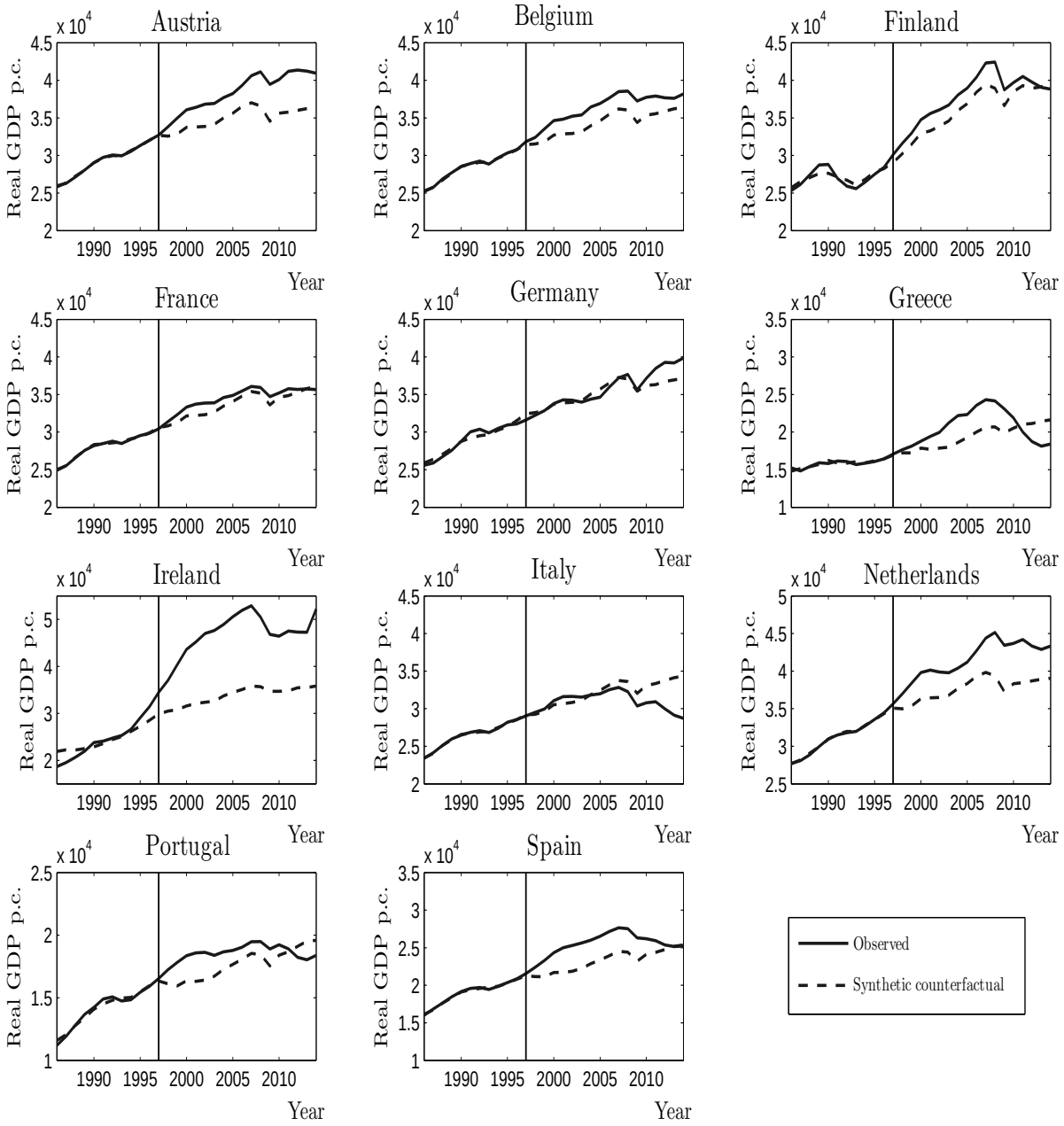


Figure 3: Anticipation effects: Observed vs synthetic counterfactual for small donor pool



captures the introduction of the euro quite well. It is still clear that Austria, Belgium, Finland, the Netherlands and Spain have benefited from participation in the EMU, and the loss for Italy is also undisputed. Portugal and Greece started off by profiting from the euro, but around the economic crisis the effect is reversed. For France, hardly any effect of EMU participation is observed, whereas Germany appears to be only profiting during and after the crisis. As we discussed before, the case of Ireland is particular because of its rapid economic growth related to foreign direct investment which makes it hard to find a good match for Ireland in any case.

The estimate of the effect of EMU participation is the difference between the observed per capita GDP in the EMU country and in its synthetic counterfactual. Figure 4 plots this yearly EMU effect for the 11 individual member countries. On the one hand, these graphs show that the synthetic counterfactual does quite well in matching the EMU country before 1997, where we would like to see the gap as close to zero as possible. It is clear that the matching process done by the synthetic control method is less successful for Finland, Greece, Ireland and Portugal than for the other countries. On the other hand, the graph shows for the period after 1997 how large the effect of joining the EMU is. The magnitude of the estimated effects is substantial, as is also laid out in table 1. This table reports the average yearly EMU effect over the period between 1997 and 2014 for the EMU country in the second and fourth column. However, for the countries that experience both benefits and losses related to the introduction of the euro, it might be useful to split the period after 1997 into the period until 2007 and the crisis period. These results for the period from 1997 until 2007 are shown in column 3 and 5.

Table 1: Estimated EMU effect on real GDP per capita

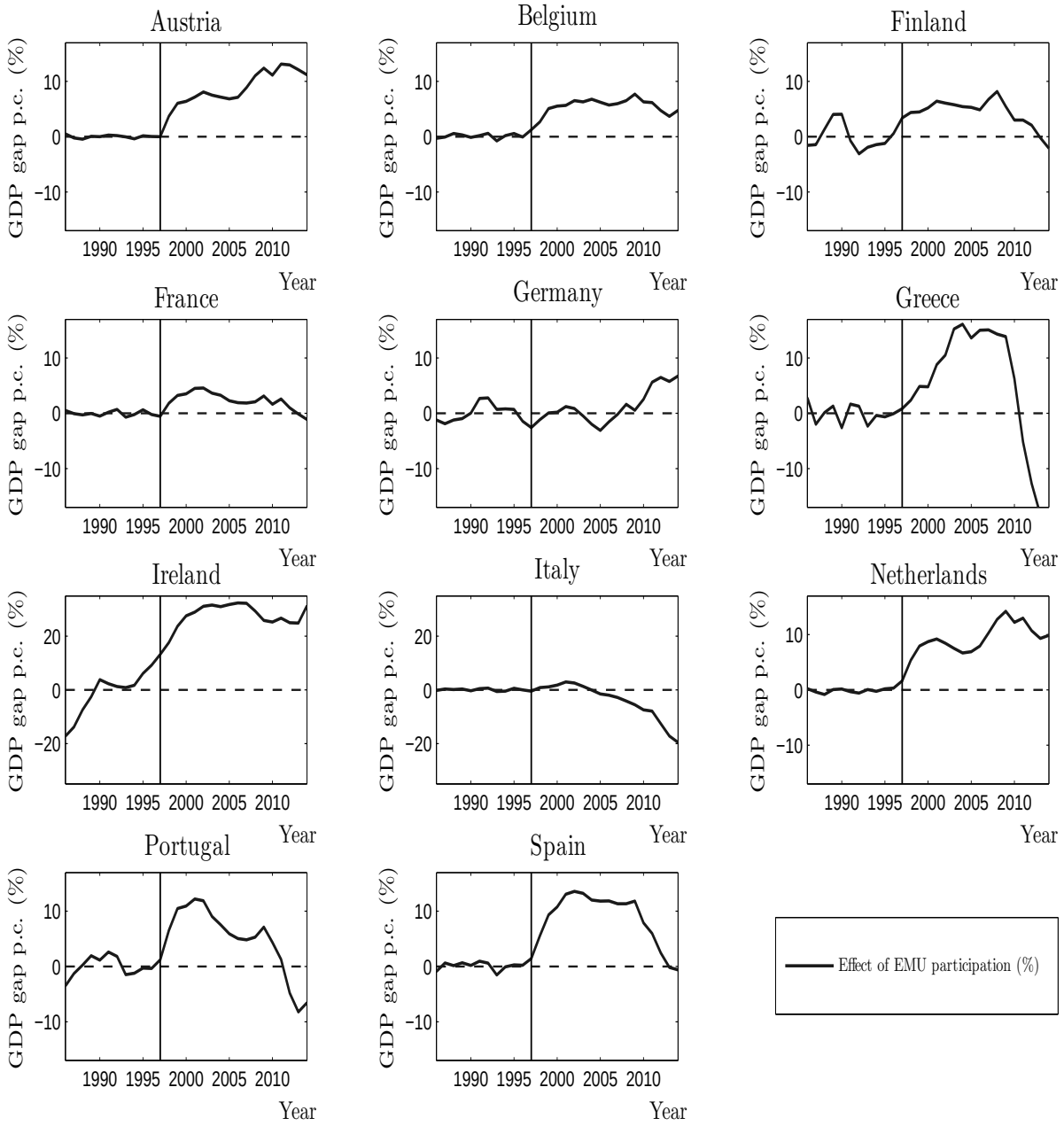
	Effect of EMU in euros		Effect of EMU in %	
	All years	1997-2007	All years	1997-2007
Austria	+3336	+2344	+8.50%	+6.27%
Belgium	+1985	+1876	+5.43%	+5.25%
Finland	+1622	+1933	+4.31%	+5.29%
France	+749	+930	+2.19%	+2.74%
Germany	+470	-268	+1.14%	-0.79%
Greece	+1182	+2111	+4.89%	+9.75%

Ireland	+12892	+12788	+27.23%	+27.41%
Italy	-1170	+97	-3.92%	+0.33%
Netherlands	+3810	+2968	+9.04%	+7.33%
Portugal	+871	+1434	+4.68%	+7.79%
Spain	+2187	+2643	+8.49%	+10.37%

Table 1 confirms the general impression of figure 4. The estimated average effect of participation in the EMU is quite substantial, and positive for all economies except for Italy. For example, Austria had a benefit of 8.5% on average, meaning that its yearly GDP per capita would have been 8.5% lower had it not joined the EMU. The comparison between the whole period and the pre-crisis period displays the interesting fluctuations in the EMU effect over time as we have also seen in figure 4. For Greece, Portugal, and to a lesser extent Spain, the estimated EMU effect is substantially larger when only the period until 2007 is considered compared to the whole period until 2014. For Italy, the story is similar, as it has experienced a small benefit until 2007 but over the whole period there is a sizable loss. The numbers for Germany describe the opposite story, namely that Germany has not benefited until 2007, but since the average over the whole period is positive, it must have gained a lot during the recent crisis. Ideally, we would like to present the estimated average EMU effect during the period 2008-2014, however, using the synthetic counterfactuals as we constructed here would not be appropriate. The synthetic counterfactual for the years between 2008 and 2014 already takes into account everything that has happened before, there is a type of path dependence in the estimated EMU effect. Therefore, we could only evaluate the differential impact of the crisis on EMU member countries compared to non-EMU member countries if we redo this specific exercise using the synthetic control method for an intervention in 2008. The results of this exercise are discussed in section 4.3.

One may be concerned about the forecast error of this method, which might bias the results in the direction of the effect that we find. For that reason, we have split the preintervention period in a training period and an evaluation period. The training period from 1986 until 1992 is used to forecast the values of real GDP per capita for the evaluation period from 1993 until 1996. The results of these in-sample forecasts show that the forecast error is on average small,

Figure 4: Per-capita percentage gap EMU country and synthetic counterfactual



except for Finland, Greece and Ireland.[5] Moreover, for most EMU countries, the forecast error is negative implying that the synthetic control is estimated to be higher than actual GDP.[6] As a consequence, the mostly positive estimates of the EMU effect that we find are not caused by an upward biased forecast error.

Another valid concern one may have regarding these results on the EMU effect is the existence of potential spillover effects. It is plausible that the introduction of the EMU in Europe has affected real GDP per capita in other countries included in the donor pool. However, it is important to consider the question we ask in order to find the counterfactual: "What would have been real GDP per capita in the EMU country if it had not become an EMU member?" So the EMU effect that we estimate is the difference between joining and not joining a monetary union that is in any case existent, and not the effect of no monetary union in Europe at all. As long as the countries in the synthetic control are a close match to the EMU country, we expect that this control country will have the same spillover effects as the EMU country in case it had not participated in the EMU. We believe this is very likely to hold, at least for our smaller pool of donor countries. However, even if there are larger positive spillover effects to other countries, the synthetic control would provide an overestimate of the GDP path in case the EMU country had not joined. In that case, the estimated effect of EMU participation would have been underestimated.[7]

4.3 Impact of crisis on EMU countries

In section 4.2 we discussed the benefits and losses of EMU participation for the period until 2014 as well as the shorter period until the start of the crisis. In order to discuss the separate effects of being in the EMU during the crisis period, we use the synthetic control method for the intervention in 2008 with the years between 1997 and 2007 as basis for the matching. The question that needs to be answered to find the counterfactual in this case is: "What would have

[5]The forecast errors are reported in table A.3.

[6]The forecast error over the period 1993-1996 is negative for Belgium, Finland, France, Germany, Greece, Italy, Portugal and Spain.

[7]The donor pool includes EU countries as well, which might bias the results in a certain direction as those are most likely to be experience spillover effects from the participation of a country in the EMU. Therefore, we perform a robustness check in which the synthetic control method is applied for each EMU country to the donor pool with only non-EU countries. As table A.4 shows, the results remain qualitatively and mostly quantitatively similar.

been the level of GDP per capita during the period of the economic crisis if the country had not been in the EMU during the crisis?" Hence, the difference between the observed data and the counterfactual identifies the differential impact of the crisis on EMU countries relative to non-EMU countries.

Figure 5: Real GDP per capita: Observed vs synthetic counterfactual during crisis period

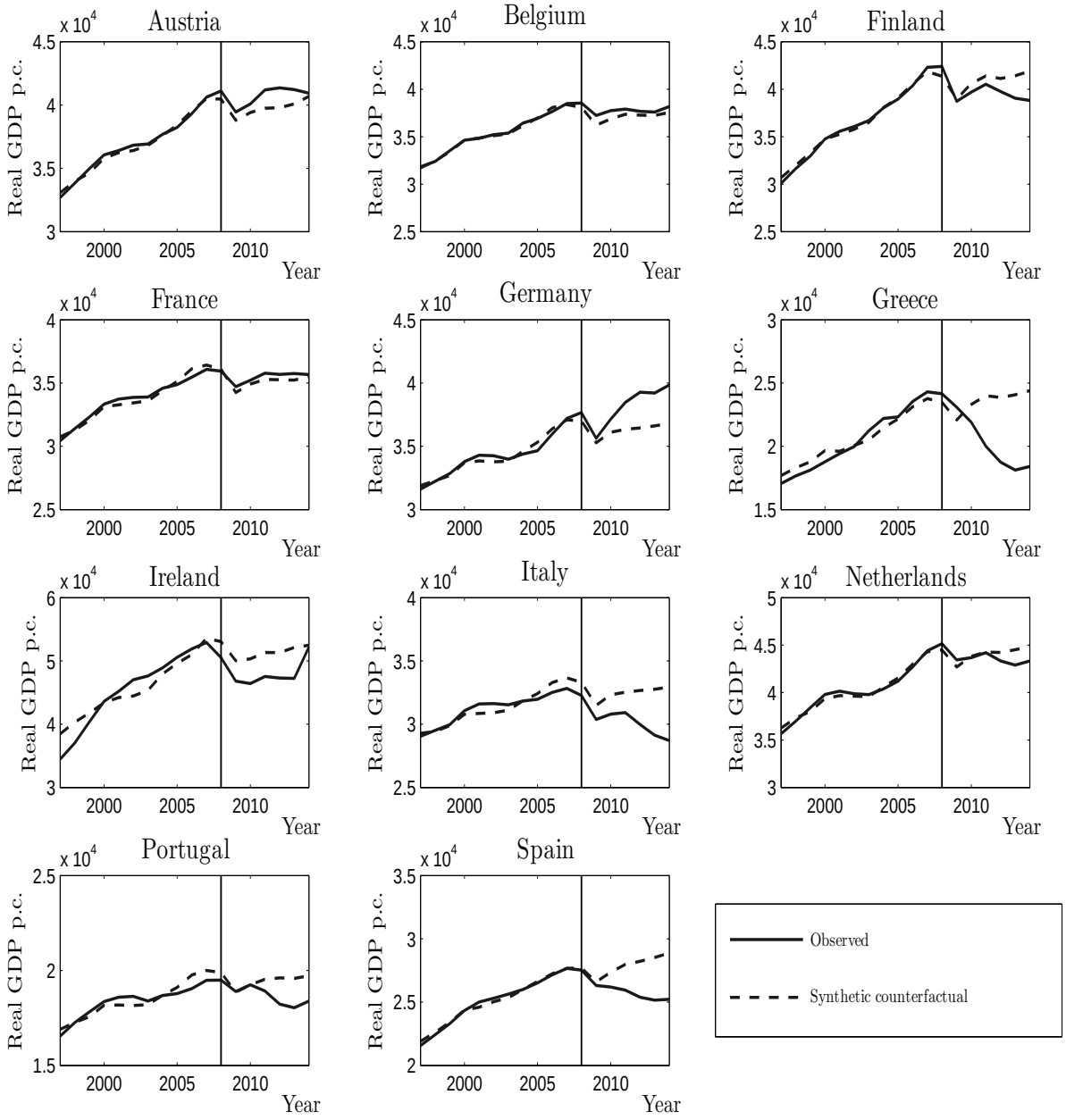


Table 2: Estimated EMU effect during the crisis period

	Effect of EMU in euros	Effect of EMU in %
Austria	+913	+2.23%
Belgium	+613	+1.62%
Finland	-1115	-2.87%
France	+313	+0.88%
Germany	+1810	+4.66%
Greece	-2971	-16.00%
Ireland	-3228	-6.80%
Italy	-2266	-7.61%
Netherlands	-405	-0.95%
Portugal	-749	-4.08%
Spain	-1935	-7.60%

Figure 5 shows the observed GDP series and the counterfactual for the crisis if not being in the EMU for the 11 individual member countries. For Austria and Germany, there is a clear benefit of EMU participation during the economic crisis, whereas the story is not as clear for Belgium and France. For Ireland and the PIGS-countries, Portugal, Italy, Greece and Spain, there is a clear loss associated with being in the EMU during the crisis. The results suggest that these countries would have had higher levels of GDP per capita if they had not been part of the monetary union. The loss is smaller for Finland and the Netherlands, but also these countries seem to have suffered from being in the EMU during the crisis. Table 2 reports the size of the loss or benefit of EMU membership during the 2008 economic crisis. The effects are quite substantial, especially for the PIGS countries. These results are in line with the impressions given by table 1 on this specific period in the history of the EMU.

4.4 What drives the gains and losses?

Understanding the variation in the benefits and losses of EMU participation across countries and over time is important for the current EMU members as well as possible future adopters of the euro. If the main drivers behind the estimated results of the previous sections are identified, steps could be taken to improve the Euro area's features so that the EMU gets closer to an optimum currency area. In this section, we try to identify these main drivers of the results using OLS regressions with the EMU effect as the dependent variable for 11 countries and the years after 1997. The EMU effect is the percentage difference between actual GDP per capita and the synthetic counterfactual as estimated in section 4.2. The variable EMU effect takes on positive values if the country has profited from participation in the EMU and negative values otherwise. A range of potential factors is included as independent variables in the regression, which are related to the literature on the benefits and costs of a monetary union. The goal of this exercise is not to retrieve a causal relationship from the OLS regression, but rather to highlight an important association between the EMU effect and its drivers.

The first factor considered here is trade openness, which we measure by the sum of exports and imports as percentage of GDP. Trade openness influences both the costs and benefits of joining a monetary union. The higher the degree of openness, the more a country might profit from lower transaction costs of trade within the union. Moreover, McKinnon (1963) argues that giving up independent monetary policy is less costly for more open economies, as the aggregate price level is determined to a larger extent by international prices of tradables. So small open economies, like Austria and the Netherlands, are more likely to gain from a fixed exchange rate as these countries are likely to be more open economies. The regression results in table 3 report a positive coefficient for the variable of trade openness, which confirms this story. One could also include the trade balance, being exports minus imports, in the analysis, but this variable is less suited to represent this aspect of the theory. However, in this case, the result would be similar, a country with a higher trade balance will have a more positive or less negative effect of EMU participation.

Table 3: Main drivers behind the effect of EMU participation

	(1)	(2)	(3)	(4)	(5)	(6)
Trade openness	0.0842*		0.0774	0.102*	0.0792*	0.1503*
	(1.81)		(1.58)	(2.14)	(2.09)	(2.06)
Trade balance		0.0804				
		(0.21)				
Public debt	-0.101**	-0.106**		-0.122***	-0.0942***	
	(-2.43)	(-3.01)		(-3.28)	(-4.10)	
Interest rate			-1.009			
on public debt			(-1.24)			
Employment	-1.906	-3.679	-1.925		-1.109	
protection	(-0.96)	(-1.41)	(-0.97)		(-1.26)	
Real unit				-0.448*		-0.510
labor cost				(-1.87)	(-1.43)	
Migration					1.950**	
					(2.35)	
Health						-0.4382
banking sector						(-1.38)
N	187	187	165	197	44	79
R^2	0.431	0.302	0.373	0.467	0.572	0.450

Notes: t statistics in parentheses. Inference: * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$. The dependent variable is the percentage difference between the actual and synthetic series of GDP per capita for each of the 11 EMU countries and each year after the intervention in 1997. Because of their correlatedness, trade balance and trade openness, public debt and the interest rate on public debt, and employment protection and real unit labor costs, are not included at the same time in the analysis. For collinearity reasons, public debt and health of the banking sector are not included simultaneously. No country and year fixed effects are included. Standard errors are clustered.

Fiscal stance of the economy might be important in determining the benefit or loss a country experiences after introducing a common currency. Having a high level of public debt increases the costs of joining a monetary union, as the country loses its ability to use monetary policy to create inflation to reduce the burden of its high debt level. Moreover, apart from not being able to use monetary policy to solve internal issues, the use of fiscal policy might be limited because of lower access to credit and an already high interest rate on public debt. Using either public debt or the interest rate on public debt as a regressor, we find that the coefficient is negative.

This implies that countries with a high debt level, and hence a higher interest rate than other countries, experienced smaller benefits or even losses due to the introduction of the euro.

Mundell (1961) emphasized that labor mobility is crucial for a currency area to work optimally. The loss of independent monetary policy becomes aggravated if there is an asymmetric or country-specific shock in the union and there is no adjustment mechanism in the form of labor moving freely across the countries. Greater openness to migration thus reduces the loss of a fixed exchange rate. A variable for net migration is added to the regression analysis, which is the absolute amount of net migration in percentages.[8] Though we notice that the amount of observations for this regression is reduced by the amount of data available, we still find that a higher degree of migration has a positive effect on the effect of EMU participation.

A related point is the degree of wage flexibility and the rigidity of the labor market. Wage flexibility or less rigid labor markets could dampen the effects of a negative shock on unemployment and GDP. As a measure for the rigidity of labor markets, we use the indicator for strictness of employment protection as provided by the OECD (Organization for Economic Co-Operation and Development). As table 3 shows, countries with less rigid labor markets cope better with external shocks and hence profit more from having a joint currency.

Another factor that we consider is the competitiveness of the country in the monetary union. When a common currency is introduced, differences in competitiveness and strong imbalances in the union cannot be solved by currency adjustments. We include a proxy for competitiveness in the analysis, which is the real unit labor cost as provided by the AMECO database. The coefficient on this variable is significantly negative, which implies that the less competitive an economy is, the more it suffers from being in the EMU.

Finally, the health of the banking sector is taken as a potential related factor to the profitability of joining the monetary union for a country. Member states in which the financial market does not function properly might experience deeper recessions than other countries with a healthier banking sector. As a proxy for the health of the banking sector we take the amount of

[8]Here we do not distinguish between a country receiving many immigrants or where many migrants leave, the degree of openness is affected similarly by both cases.

nonperforming loans as a percentage of total gross loans.[9] Column 6 shows that this coefficient has the expected sign, as the healthier the banking sector is, the more likely it is that the member state profits from its membership.

[9]Data for this proxy of the health of the banking sector is not available for Finland and Greece, and there are years with missing observations for the other countries, such that the amount of observations is reduced to 79.

5 Inference and counterfactuals for fixed effects method

The benefits and losses that were estimated in the previous section are substantial, but whether these results are both significant and truly the result of EMU participation has not been established yet. In this section, we will report different ways of statistical interference of the results on the EMU effect as well as additional robustness checks. Moreover, we provide a clear comparison of the synthetic control method to the fixed effects regression methods, in order to demonstrate the advantages of this method.

5.1 Statistical inference

5.1.1 Ratio of post- to pre-EMU root mean squared prediction error

To discuss the robustness of the results, one could use the difference-in-differences (DID) estimator for the actual versus the synthetic counterfactual series. This method reports on the statistical significance of the average EMU effect for the whole period, and hence it would also be useful to have DID estimates for the period before the crisis as we have seen that the effects in these two separate periods might go in opposite directions. The results for the DID exercise are reported in table A.5 in the appendix. Considering the differential impact of being an EMU member during the crisis, the DID estimator could also be used to identify the significance of the results. Due to the shorter time period considered, as the crisis period here is from 2008 until 2014, significance is slightly harder to attain. The difference-in-difference estimator is applied to the actual and synthetic series as we have seen in figure 5, and the results are reported in table A.6 in the appendix.

Another type of statistical inference for the synthetic control method is the use of placebo tests. These falsification exercises are meant to find out whether the estimated effect by the synthetic control method is truly the effect of EMU participation, or whether a similar effect would be obtained for the control countries. Figure A.2 in the appendix shows for each of the 11 countries in our analysis the estimated EMU effect and the placebo effects for the control countries. Because of a large prediction error, four countries are left out of the analysis, namely

Chile, Iceland, Norway and Switzerland.[10] If the match is not performing well in the period before 1997, the counterfactual for the years after 1997 is likely to be a bad prediction of reality which is detrimental to the reliability of the estimated placebo effect.

The DID estimates, in contrast to the placebo tests, take into account the quality of the match before the introduction of the EMU. On the other hand, the placebo test compares the estimated EMU effect to that of the other control countries, whereas the DID estimates shows the significance based on the own country only. Ideally, one would want to use a method that includes into its measure of significance both the quality of the match as well as the placebo effects on control countries. Moreover, the DID estimates and the placebo tests touch upon the fact that it is harder to obtain statistical significance if the EMU effect is not constant over the period after introduction of the EMU, and might actually go in opposing directions. For that reason, we will report on a measure that does not focus on the significance of the average effect, but rather the cumulative effect over the whole period that might include years with benefits and years with losses, which is the post- to pre-EMU RMSPE ratio.

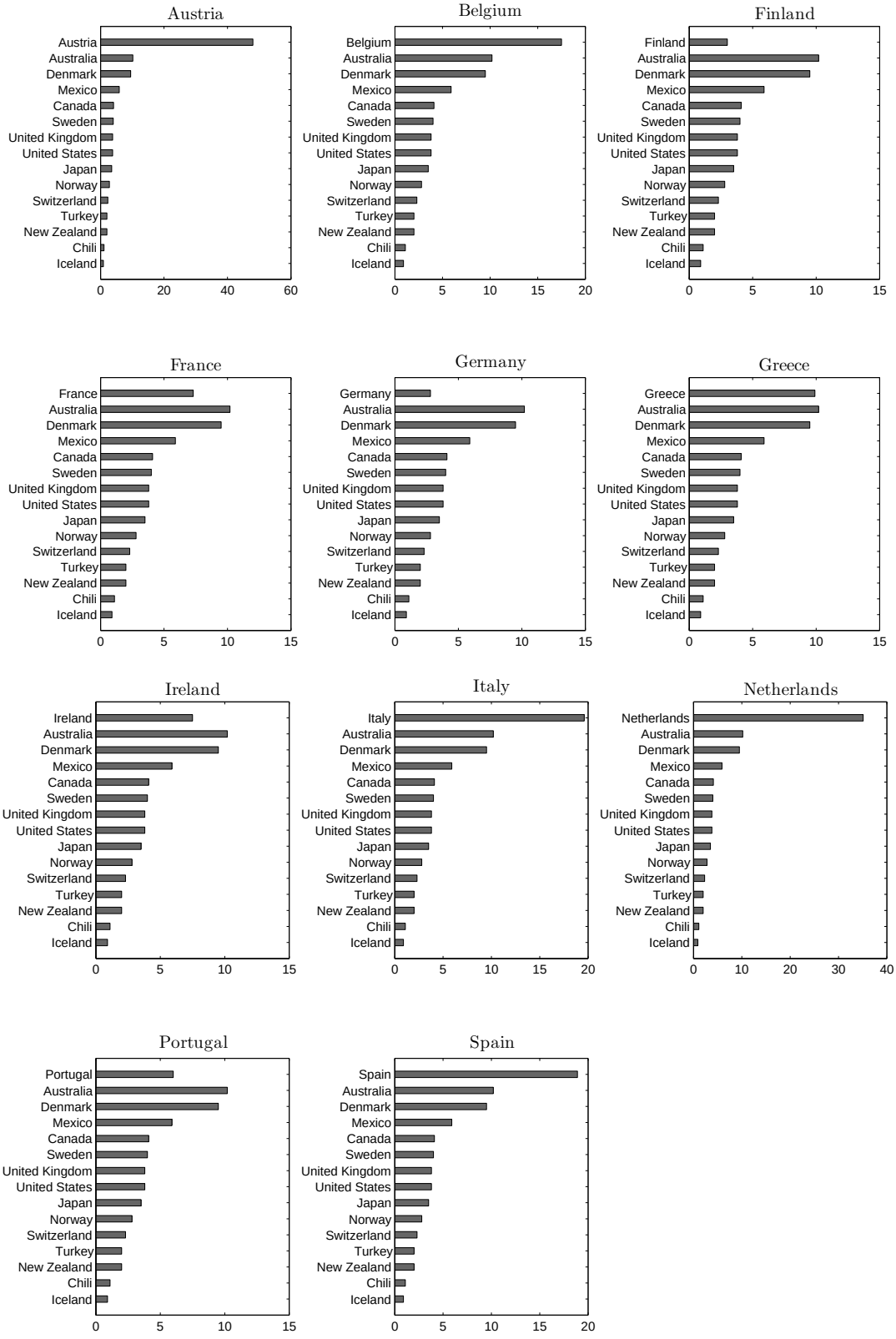
The ratio of post- to pre-EMU root mean squared prediction error (RMSPE) measures the cumulative real GDP per capita gap after 1997 relative to the this gap before 1997, which reflects the quality of the match with the synthetic control. The ratios for the EMU countries can be compared to those of the control countries, that arise from the placebo tests. If the ratio is high enough relative to the ratios of the control countries, then the estimated EMU effect is significant. This measure combines advantages of both the placebo tests and the difference-in-difference estimates. The ratio of post- to pre-EMU RMSPE corrects for the prediction error in the period before 1997, just like the DID estimates, and allows for the control countries to play a role in the significance measure, as in the placebo tests. In contrast to the placebo tests, this measure does not require a cut-off for excluding badly matched placebo counterfactuals. Figure 6 shows the ratios of post- to pre-EMU RMSPE measures for all the EMU members and the small donor pool.[11]

The significance of the estimated EMU benefit for Austria and the Netherlands is confirmed by the results in figure 6. The root mean squared prediction error after EMU introduction is

[10] Countries in the small donor pool are left out of the analysis if either the RMSPE over the period before 1997 is larger than 2000 or the average prediction error over the period 1986-1996 is larger than 5 percent.

[11] The RMSPE ratio for the control countries are the same in each of the 11 graphs.

Figure 6: Ratio of post-EMU to pre-EMU RMSPE



respectively 47 and 35 times larger than the pre-EMU RMSPE, whereas no control country has such a large ratio. The estimated EMU effect for Belgium, Italy and Spain appear quite robust as the ratio of post-EMU to pre-EMU RMSPE of these countries is at least twice as large as that of the control countries. As we would expect, the EMU effect for Ireland is far from significant when using this measure, which is related to the bad quality of the match to the synthetic control reflected by the large RMSPE in the pre-EMU period.

5.1.2 Confidence intervals

An alternative approach to assess statistical significance of the estimated EMU effect is a subsampling method based on Saia (2017). Firstly, we construct 50 counterfactual groups, consisting of 11 randomly drawn countries out the small donor pool with 14 countries. Then, we apply the synthetic control method to all these 50 counterfactuals to find a distribution of the EMU effect for each EMU member. A confidence interval based on the 10th and 90th percentile of the distribution gives us insight in the credibility of the estimated effect and can also tell us whether the effect of EMU participation is significantly different from zero. The results are reported in table 4.

Table 4: Confidence intervals by subsampling on donor pool

EMU country	Period	Average	Median	10% perc.	90% perc.
Austria	Overall	+7.18%	+8.45%	+2.61%	+8.60%
	Until 2008	+5.20%	+6.24%	+1.10%	+6.35%
	Crisis	+1.83%	+1.54%	-0.20%	+3.73%
Belgium	Overall	+4.75%	+5.66%	+0.50%	+6.46%
	Until 2008	+4.87%	+5.35%	+1.63%	+6.58%
	Crisis	-0.11%	-0.16%	-1.46%	+0.91%
Finland	Overall	+5.44%	+4.45%	+3.69%	+7.56%
	Until 2008	+6.10%	+5.45%	+4.69%	+7.71%
	Crisis	-2.51%	-2.67%	-2.87%	-2.06%
France	Overall	-0.34%	+1.14%	-3.58%	+2.58%
	Until 2008	+0.63%	+1.99%	-2.60%	+3.11%
	Crisis	-0.36%	-0.07%	-2.38%	+1.13%
Germany	Overall	+0.99%	+2.79%	-4.38%	+3.95%
	Until 2008	-0.84%	+0.71%	-5.37%	+1.66%
	Crisis	+3.02%	+2.20%	+1.13%	+7.38%
Greece	Overall	+4.05%	+4.50%	+0.37%	+6.76%
	Until 2008	+8.14%	+9.31%	+4.73%	+10.12%
	Crisis	-15.38%	-16.00%	-17.04%	-11.89%

Ireland	Overall	+29.65%	+27.65%	+27.23%	+35.46%
	Until 2008	+29.74%	+27.86%	+27.41%	+34.97%
	Crisis	-5.52%	-5.55%	-6.80%	-3.86%
Italy	Overall	-5.23%	-3.94%	-10.21%	-3.44%
	Until 2008	-0.92%	+0.27%	-5.05%	+0.56%
	Crisis	-8.78%	-7.61%	-10.91%	-7.13%
Netherlands	Overall	+5.49%	+5.44%	+1.75%	+9.01%
	Until 2008	+4.51%	+4.86%	+1.52%	+7.29%
	Crisis	-0.02%	-0.95%	-2.08%	+3.08%
Portugal	Overall	+2.40%	+3.10%	-4.89%	+7.21%
	Until 2008	+5.69%	+6.27%	-0.53%	+10.15%
	Crisis	-8.68%	-7.28%	-11.52%	-5.46%
Spain	Overall	+6.60%	+7.89%	+0.88%	+9.33%
	Until 2008	+8.52%	+9.73%	+3.64%	+10.96%
	Crisis	-7.47%	-7.21%	-7.81%	-6.38%

Table 4 shows the confidence intervals for the period from 1997 until 2014, as well as the period before the crisis and the crisis period itself. For example, we find that with 80% confidence the overall effect of EMU participation for Austria has been between 2.61% and 8.60%. For the overall period between 1997 and 2014, there are significant gains from EMU participation for Austria, Belgium, Finland, Greece and the Netherlands. If we only consider the period until 2008, also Spain has had significant benefits. As before, it appears that the loss of EMU participation for Italy is significant as with 80% confidence the loss lies between 3.44% and 10.21%.

For the crisis period, we have calculated the confidence intervals in the same manner as before in which the synthetic control method is applied to the year 2008. Hence, we have calculated the differential impact of the crisis on EMU countries for 50 different subsamples of the donor pool. Germany has been significantly better off by being in the EMU during the crisis, whereas the loss is significant for Finland, Greece, Ireland, Italy, Portugal and Spain.

The subsampling method can also be applied to the computation of synthetic counterfactuals using different subsamples for the GDP predictors. The set of GDP predictors for the main analysis consists of 29 variables. Here we randomly draw 50 subsets with 25 out of 29 variables and estimate the synthetic counterfactual using these 50 subsets for the predictors. The confidence intervals based on this distribution of the EMU effect in table 5 give us insight in whether

the EMU effect depends heavily on the set of GDP predictors and hence it is another way of assigning credibility to the results.

Table 5: Confidence intervals by subsampling on GDP predictors

EMU country	Period	Average	Median	10% perc.	90% perc.
Austria	Overall	+7.59%	+8.39%	+5.91%	+8.90%
	1997-2007	+5.64%	+6.23%	+4.25%	+6.55%
	Crisis	+1.70%	+1.74%	+0.50%	+2.55%
Belgium	Overall	+4.10%	+5.46%	-0.83%	+5.98%
	1997-2007	+3.80%	+5.07%	-0.59%	+5.28%
	Crisis	+0.71%	+0.69%	-0.58%	+2.36%
Finland	Overall	+5.36%	+5.64%	+4.32%	+6.02%
	1997-2007	+6.02%	+6.19%	+5.28%	+6.53%
	Crisis	-2.79%	-2.87%	-2.87%	-2.67%
France	Overall	-3.55%	-3.40%	-7.67%	+0.32%
	1997-2007	-2.22%	-2.08%	-6.18%	+1.73%
	Crisis	-0.18%	+0.51%	-3.00%	+2.01%
Germany	Overall	-0.46%	-0.60%	-2.37%	+1.19%
	1997-2007	-1.94%	-2.37%	-3.64%	-0.22%
	Crisis	+2.79%	+2.33%	+1.62%	+4.49%
Greece	Overall	+2.64%	+3.89%	-0.61%	+5.45%
	1997-2007	+7.40%	+8.73%	+3.80%	+10.15%
	Crisis	-16.08%	-16.00%	-16.40%	-16.00%
Ireland	Overall	+26.20%	+25.00%	+25.00%	+27.92%
	1997-2007	+24.90%	+23.70%	+23.70%	+26.84%
	Crisis	-6.81%	-6.80%	-7.17%	-6.71%
Italy	Overall	-3.96%	-3.58%	-5.07%	-3.44%
	1997-2007	+0.10%	+0.43%	-0.96%	+0.56%
	Crisis	-9.47%	-9.62%	-11.69%	-6.85%
Netherlands	Overall	+5.06%	+5.10%	+2.25%	+8.05%
	1997-2007	+4.02%	+3.78%	+2.00%	+6.98%
	Crisis	-0.81%	-0.95%	-0.95%	-0.64%
Portugal	Overall	+2.73%	+3.09%	-3.05%	+7.21%
	1997-2007	+6.06%	+6.42%	+0.78%	+10.15%
	Crisis	-9.60%	-7.12%	-12.09%	-6.73%
Spain	Overall	+6.59%	+7.22%	+3.48%	+8.25%
	1997-2007	+8.55%	+8.77%	+5.75%	+10.26%
	Crisis	-7.86%	-7.60%	-8.35%	-7.44%

From table 5, one can observe that these confidence intervals are smaller. Hence, the EMU effect is somewhat more sensitive to changes in the composition of the donor pool than changes in the set of GDP predictors. Apart from the significant results in table 4, here we find a significant gain

of EMU participation for Spain for the whole period. On the other hand, the result for Belgium becomes insignificant. For the period between 1997 and 2007, Germany has had a significant, though small, loss of EMU participation. With the smaller confidence intervals, Austria has a significantly positive EMU effect during the crisis, whereas that for the Netherlands is also negative and significant.

5.1.3 Conclusion

These different ways for statistical inference together support the significance of the estimated EMU benefit, at least until the crisis, for Austria, Belgium, the Netherlands and Spain, whereas there is a clear loss of EMU participation for Italy. Furthermore, being an EMU member during the crisis seems to have had a significantly positive effect on Germany, whereas this effect is negative and significant for Finland, Ireland and the PIGS-countries.

In comparison to the existing papers by Gomis-Porqueras & Puzzello (2014) and Fernandez & Perea (2015), the amount of data available and the size and composition of the donor pool allows us to produce counterfactuals of decent quality which lead to different estimates for the effects of EMU participation. Our results point to a significant benefit of EMU participation for Austria, whereas Fernandez & Perea where not able to find a gain or loss. Though both papers report a loss for Belgium, our analysis shows that Belgium did not experience a substantial loss but benefited from joining the Euro area. The paper by Gomis-Porqueras & Puzzello (2014) reports a loss of EMU participation of 13.2% for the German economy, which is not even close to the effect we find. Moreover, our results do not show a significant loss for Portugal, whereas the Netherlands benefits from its EMU participation. In general, the quantitative results in this paper are very different from Gomis-Porqueras & Puzzello (2014) that report very large losses for Belgium, France, Germany and Italy between 7.7 and 17.3 percent.

5.2 Counterfactuals for the fixed effects method

The most common econometric method in the related literature to identify the effect of an event, such as the introduction of the euro, is the fixed effects panel data regression. The advantages of the synthetic control method compared to a fixed effects regression, in general, are discussed in

section 3.3. In the specific case of the introduction of the euro, we will elaborate a bit more on the advantages. The use of a fixed effects regression prevents the use of time-invariant variables, which could potentially be very important predictors of real GDP per capita. Moreover, the fixed effects regression cannot deal with missing observations for the EMU country over the whole period between 1986 and 2013. Hence, in a fixed effects regression we would lose the political, financial, unemployment and school enrollment variables.

In order to facilitate a comparison between the synthetic control method and a fixed effects regression, we construct a counterfactual real GDP per capita for the 11 individual member countries based on the fixed effects regression. The synthetic control method bases the relationship between real GDP per capita and its predictors on the period between 1986 and 1996[12] and then the counterfactual is based on the weighted combination of its matching control countries. A comparison with the fixed effects regression thus allows for two possibilities. On the one hand, one could regress real GDP per capita on its economic predictors and a dummy variable for the introduction of the EMU. The counterfactual is then based on the relationship between the predictors and real GDP per capita setting the dummy for the EMU equal to zero. We will refer to this as fixed effects method 1. On the other hand, a regression based on the period between 1986 and 1996 is run to establish a relationship between GDP and its predictors which is then extrapolated until 2013.[13] This counterfactual refers to the fixed effects method 2.

These two methods have different similarities with the synthetic control method. Method 1 takes the development of GDP of the control countries in the years after 1997 into account, which is not the case in method 2. However, the use of the dummy variable in method 1 leads to a constant coefficient for this dummy variable, meaning that the effect of the introduction of the EMU is assumed to be constant over time. This is quite a strong restriction being imposed on the results, which leads to a loss of valuable information as we have seen before that the effect of being in the EMU can vary a lot over time. Method 2 does allow the effect of having the euro to differentiate over time, but since the relationship between GDP and its predictors is based solely on the period until 1996, the counterfactual might miss out on major events affecting both EMU members and control countries.

[12]Here we make use of the results that take into account the anticipation effects of the introduction of the euro, hence the introduction is 'assumed' to take place in 1997.

[13]Note that it is not possible to extrapolate until 2014 because of missing observations.

Figure 7: Comparison synthetic control method & fixed effects regression for Greece

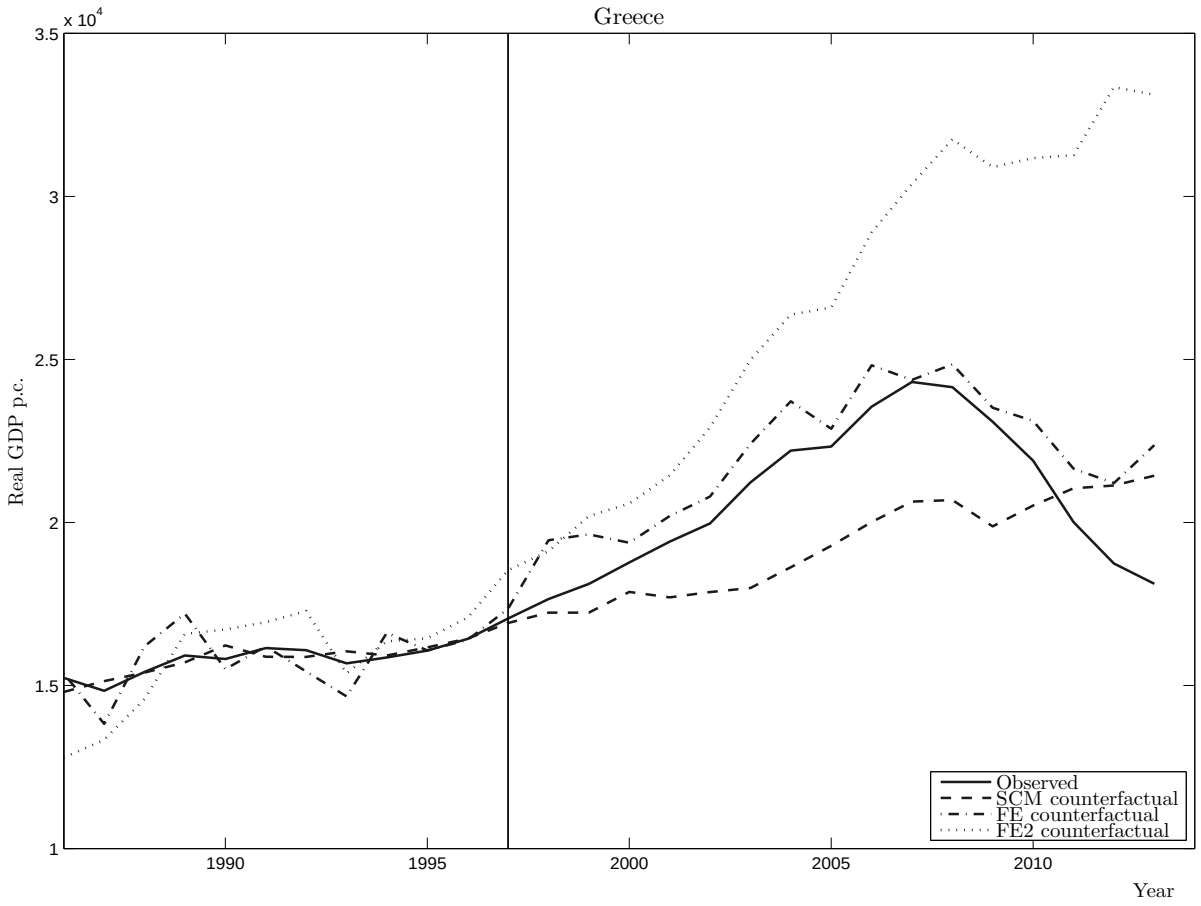


Figure 7 shows the comparison of the observed GDP series of Greece with the counterfactuals produced by the synthetic control method and the fixed effects regressions. The graphs for the other 10 EMU members in our study are shown in figure A.1. The graph shows clearly that the counterfactuals based on the different methods can be very far apart. The counterfactual for the synthetic control method is as we have seen in figure 3. The fit in the period before 1997 is fairly good, and then there is a large benefit from being in the EMU until the crisis, when this effect reverses. The counterfactual of the fixed effects method 1 does capture the rise and fall of real GDP per capita in the period after 1997, which is an implication of the method used. The regression is based on the whole period between 1986 and 2013, and only a constant effect of participation in the EMU is subtracted, which is the negative coefficient of the dummy variable for being in the EMU. However, the fact that this method captures the rise and fall of GDP well is not a signal that the method is reliable. For reliability of the different methods, we resort to table 6, which shows the root mean squared prediction error of the three methods in the period before 1997 for the 11 individual countries. A smaller prediction error in the period before the introduction of the euro indicates that the method does well in predicting real GDP per capita in this period, and hence the method is more likely to produce a reliable counterfactual for the period after the introduction of the EMU. The prediction error for most countries in the synthetic control method is much smaller than the RMSPE with fixed effects method 1.

Table 6: Root mean squared prediction error: SCM vs FE

	Synthetic	Fixed effects regression	
	control method	Method 1	Method 2
Austria	76	918	432
Belgium	118	692	380
Finland	627	1454	793
France	125	904	630
Germany	452	458	535
Greece	261	702	1093
Ireland	1744	1066	414
Italy	114	1225	465
Netherlands	115	1905	658
Portugal	232	1610	962
Spain	133	2099	392
average	363	1185	614

The counterfactual for fixed effects method 2 as shown in figure 7 shows that the fit in the period before 1997 is not great and, more importantly, that the counterfactual for Greece is on a very steep path up to a point where it is twice as high as actual GDP per capita in 2013. The unrealistic implication of this would be that the estimated loss of being in the EMU would be around 50% of its GDP per capita. Because the relationship between GDP and its predictors is only based on the period before 1997, there is a chance that in the 20 years after this time the world looks differently than this relationship depicts. Hence, this method allows the counterfactual to deviate far away from realistic numbers as it does not take into account events that would change economic growth either in the EMU countries or in the donor countries such as an economic crisis. Based on the prediction error, we see that the synthetic control method outperforms method 2 as well.

Figure A.1 as well as table 6 show that the synthetic control method produces a better fit of the counterfactual to the observed GDP series before 1997 and a more reliable counterfactual afterwards. This is not only the case for Greece, but holds for all EMU members except for Ireland. Since Ireland has experienced a particular pattern of GDP growth that started off earlier than 1997, both method 1 and method 2 are better able to capture this in the counterfactual. For all other countries, the results provide evidence that the synthetic control method does a better job in constructing reliable counterfactuals for participation in the EMU than fixed effects methods would do.

6 Conclusion

In this paper, the synthetic control method is used to estimate the effect of having the euro and participating in the Economic and Monetary Union for 11 individual countries in the Euro area. This method resulted in synthetic counterfactual GDP paths for the member countries, that reflect real GDP per capita if the country had not joined the EMU. An important aspect to highlight is that the counterfactual reflects the case in which a country decided not to introduce the euro, not the case in which the EMU and the euro would not have existed.

Austria, Belgium, the Netherlands and Spain have benefited from joining the EMU, and this benefit is substantial and significant according to several robustness measures. Italy would have been clearly better off if it had decided not to join the euro, an effect that is reinforced by the economic crisis in 2008. Most other countries have also profited from EMU participation, although this effect is not significant over the whole period. There is evidence of anticipation effects, as in most countries participation in the EMU was anticipated two years before the official introduction in 1999. Moreover, the main drivers of the benefits and losses of having the euro are identified as trade openness, openness to migration, fiscal stance as well as rigidity of labor markets and competitiveness.

It is interesting to observe the effect of EMU participation over time, and to split the period from 1997 until 2014 in the years before the financial crisis and the recession period. Until the crisis started in 2008, all countries except for Italy gained from being in the EMU. However, many members have lost from having the euro during the crisis, implying that they would have been better off if they had not been in a monetary union during the 2008 recession. This negative impact of being in the EMU during the crisis is substantial and even significant for Greece, Italy and Spain.

These results point to an important advantage of the synthetic control method compared to a fixed effects panel data regression, namely that the EMU effect is allowed to vary over time. We have made an explicit comparison between the counterfactuals of these two methods, showing that the counterfactual of the synthetic control method fits the actual series before the intervention much better, for all countries except for Ireland. Hence, the synthetic control method proves to be a useful method in analyzing the effect of such big policy events on economic

outcomes.

There are several directions in which future research could extend this work. As more data on the years after introduction of the euro becomes available for the late adopters of the euro, the effect of EMU participation for these countries could be estimated in the near future. Extending the analysis to Cyprus, Estonia, Latvia, Lithuania, Malta, Slovenia and Slovakia might lead to interesting insights in whether these, mostly eastern European, countries benefit or lose from joining the monetary union. The advantages of this method could also be utilized for outcome variables different than GDP, for example for unemployment figures or inflation series. One might be curious to find out whether joining the EMU has been positive or detrimental for the unemployment rate. Finally, repeating the analysis in a couple of years could add value to the interpretation of the results. When data observations on the years after the crisis become available, the benefits or losses of EMU participation could be compared for the pre-crisis and crisis period as well as the post-crisis period.

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Appendix 1: Data collection

For the analysis of the effects of EMU participation on real GDP per capita, data is collected for EMU members and potential control countries from various databases. Here we will first discuss the countries for which data is collected and later we will discuss the variables used as economic predictors for real GDP per capita.

The EMU members considered in the analysis are the early adopters of the euro, which are Austria, Belgium, Finland, France, Germany, Greece, Ireland, Italy, the Netherlands, Portugal and Spain. The late adopters of the euro, i.e. Cyprus, Estonia, Latvia, Lithuania, Malta, Slovenia, Slovakia, are not considered, as well as Luxembourg.

Countries in the large pool of donor countries are: Argentina, Australia, the Bahamas, Bangladesh, Burundi, Canada, Chile, Colombia, Costa Rica, Denmark, Ecuador, El Salvador, Fiji, Guatemala, Guyana, Honduras, Iceland, Indonesia, Israel, Japan, Mexico, Morocco, New Zealand, Nigeria, Norway, Panama, Paraguay, Philippines, Sri Lanka, Sweden, Switzerland, Thailand, Trinidad and Tobago, Tunisia, Turkey, United Kingdom, United States, Venezuela and Zimbabwe.

The small pool of countries is limited to Australia, Canada, Chile, Denmark, Iceland, Japan, Mexico, New Zealand, Norway, Sweden, Switzerland, Turkey, United Kingdom and United States.

The synthetic control method makes use of predictors for real GDP per capita to find a counterfactual that matches closely these characteristics. The variable of interest in this study is real GDP per capita, the variables following in the list are considered as predictors of this variable. Below we will explain the variables and disclose the source of the data used.

- **Real GDP per capita**: Gross domestic product divided by midyear population. Data are in constant 2005 U.S. dollars. The source of the data is the World Bank Database, and data is available for 215 countries from 1960 until 2015 (with some missing observations).
- **Growth rate of real GDP**: Gross domestic product in constant 2005 U.S. dollars. The source of the data is the World Bank Database.
- **Total population (in logs)**: Midyear estimates of all residents within a country. The

source of the data is the World Bank Database.

- **Birth rate**: Crude birth rate per 1000 people. The source of the data is the World Bank Database.
- **Death rate**: Crude death rate per 1000 people. The source of the data is the World Bank Database.
- **Net exports (as % of GDP)**: The value of exports of goods and services minus the value of imports of goods and services as a percentage of nominal GDP. Both series for exports and imports are available in the World Bank Database.
- **Sum of exports and imports (as % of GDP)**: Sum of exports of goods and services and imports of goods and services as a percentage of GDP. Both series for exports and imports are available in the World Bank Database.
- **Gross fixed capital formation (as % of GDP)**: Gross fixed capital formation includes land improvements; plant, machinery, and equipment purchases; the construction of roads, railways, and the like, including schools, offices, hospitals, private residential dwellings, and commercial and industrial buildings; and net acquisitions of valuables, measured as a percentage of GDP. The source of the data is the World Bank Database.
- **GDP deflator**: Inflation as measured by the annual growth rate of the GDP deflator, measured as the ratio of GDP in current local currency to GDP in constant local currency. The source of the data is the World Bank Database.
- **Labor force participation (as % of working-age population)**: The proportion of the population aged 15 and older that supplies labor for the production of goods and services. The source of the data is the World Bank Database.
- **Female labor force participation (as % of female working-age population)**: Labor force participation of females as a percentage of the female population of the age of 15 and above. The source of the data is the World Bank Database.
- **Life expectancy**: Life expectancy at birth measured as the number of years a newborn would live if the patterns of mortality do not change throughout its life. The source of the data is the World Bank Database.

- **Patent applications (per capita)**: Worldwide patent applications filed through the Patent Cooperation Treaty procedure or with a national patent office. These include patents filed by residents as well as nonresidents. The total number of patent applications is divided by midyear population. The source of the data is the World Bank Database.
- **Primary school enrollment (in percentages)**: Ratio of total enrollment in primary education to the population of the age group that officially corresponds to primary education. The source of the data is the World Bank Database.
- **Secondary school enrollment (in percentages)**: Ratio of total enrollment in secondary education to the population of the age group that officially corresponds to secondary education. The source of the data is the World Bank Database.
- **Tertiary school enrollment (in percentages)**: Ratio of total enrollment in tertiary education to the population of the age group that officially corresponds to tertiary education. The source of the data is the World Bank Database.
- **Unemployment (as % of the labor force)**: Share of the labor force that is without work but available for and seeking employment. The source of the data is the World Bank Database.
- **Youth unemployment (as % of youth labor force)**: Share of the labor force aged between 15 and 24 without work but available for and seeking employment. The source of the data is the World Bank Database.
- **Urban population (as % of total population)**: Share of the population living in urban areas as defined by national statistical offices. The source of the data is the World Bank Database.
- **Public debt (as % of GDP)**: Gross government debt measured as percentage of GDP. The source of the data is the Historical Public Debt Database (Abbas et al. (2011)).
- **Net migration (as % of the population)**: Net total migrants measured as percentage of the population, which is the total number of immigrants less the the annual number of emigrants, including both citizens and noncitizens. The source of the data is the World Bank Database.

- **International migrant stock (as % of the population)**: The number of people born in a country other than that in which they live, including refugees, measured as a percentage of the population. The source of the data is the World Bank Database.
- **Liquid liabilities (as % of GDP)**: Liquid liabilities as a percentage of GDP. The source of the data is the Global Financial Development Database constructed by the World Bank.
- **Private credit (as % of GDP)**: Domestic private credit by deposit money banks and other financial sector to the real sector as percentage of local currency GDP. The source of the data is the Global Financial Development Database constructed by the World Bank.
- **Deposit money banks' assets (as % of GDP)**: Assets of deposit money banks as a percentage of GDP. The source of the data is the Global Financial Development Database constructed by the World Bank.
- **Credit to government (as % of GDP)**: Credit to government and state owned enterprises as a percentage of GDP. The source of the data is the Global Financial Development Database constructed by the World Bank.
- **Voice and accountability**: This measure reflects perceptions of the extent to which a country's citizens are able to participate in selecting their government, as well as freedom of expression, freedom of association, and a free media. The estimate ranges from approximately -2.5 (weak) to 2.5 (strong) governance performance. The source of the data is the Worldwide Governance Indicators Dataset by Kaufmann et al. (2010).
- **Political stability**: The variable for political stability and absence of violence or terrorism measures perceptions of the likelihood of political instability and/or politically-motivated violence, including terrorism. The estimate ranges from approximately -2.5 (weak) to 2.5 (strong) governance performance. The source of the data is the Worldwide Governance Indicators Dataset by Kaufmann et al. (2010).
- **Government effectiveness**: This measure reflects perceptions of the quality of public services, the quality of the civil service and the degree of its independence from political pressures, the quality of policy formulation and implementation, and the credibility of the government's commitment to such policies. The estimate ranges from approximately -2.5

(weak) to 2.5 (strong) governance performance. The source of the data is the Worldwide Governance Indicators Dataset by Kaufmann et al. (2010).

- **Regulatory quality**: This measure reflects perceptions of the ability of the government to formulate and implement sound policies and regulations that permit and promote private sector development. The estimate ranges from approximately -2.5 (weak) to 2.5 (strong) governance performance. The source of the data is the Worldwide Governance Indicators Dataset by Kaufmann et al. (2010).

- **Rule of law**: This measure reflects perceptions of the extent to which agents have confidence in and abide by the rules of society, and in particular the quality of contract enforcement, property rights, the police, and the courts, as well as the likelihood of crime and violence. The estimate ranges from approximately -2.5 (weak) to 2.5 (strong) governance performance. The source of the data is the Worldwide Governance Indicators Dataset by Kaufmann et al. (2010).

- **Control of corruption**: This measure reflects perceptions of the extent to which public power is exercised for private gain, including both petty and grand forms of corruption, as well as "capture" of the state by elites and private interests. The estimate ranges from approximately -2.5 (weak) to 2.5 (strong) governance performance. The source of the data is the Worldwide Governance Indicators Dataset by Kaufmann et al. (2010).

The set of variables for the synthetic control method using the small pool of countries includes 37 predictors. Firstly, the averages of real GDP per capita and the growth rate of real GDP of three separate subperiods are used in the analysis. Next to these 6 predictors, the set includes: birth rate, death rate, life expectancy, log population, urban population, labor force participation, female labor force participation, public debt, net exports, fixed capital formation, GDP deflator, patents per capita, primary school enrollment, secondary school enrollment, tertiary school enrollment, unemployment, youth unemployment, private credit, credit to government, deposit banks' assets, liquid liabilities, emigration of tertiary educated, international migrant stock, net migration, sum of exports and imports, voice and accountability, political stability, government effectiveness, regulatory quality, rule of law, control of corruption. When the synthetic control method is applied to the year 1997, the variables 'government effectiveness' and 'control of

corruption' are left out because of data availability.

The set of predictors is smaller for the large pool, as the data is not available for all of the control countries. Here, the variables public debt, patents per capita, credit to government, government effectiveness and control of corruption are not part of the analysis.

Appendix 2: Tables and graphs

Table A.1: Synthetic weights of large donor pool countries

	Austria	Belgium	Finland	France	Germany	Greece
Argentina	0	0	0	0	0.034	0.015
Australia	0	0	0	0	0	0
Bahamas	0	0	0.374	0	0	0
Bangladesh	0	0	0	0	0	0
Burundi	0	0	0	0	0	0
Canada	0	0	0	0	0	0
Chile	0.3	0.124	0	0	0	0
Colombia	0	0	0	0	0	0
Costa Rica	0	0	0	0	0	0
Denmark	0	0	0	0	0.192	0.069
Ecuador	0	0	0	0	0	0
El Salvador	0	0	0	0	0	0
Fiji	0	0.011	0	0	0.008	0.011
Guatemala	0	0	0	0	0	0
Guyana	0	0	0	0	0	0
Honduras	0	0	0	0	0	0
Iceland	0	0	0.087	0	0	0
Indonesia	0	0	0	0	0	0
Israel	0	0.064	0	0	0	0
Japan	0.336	0.311	0	0.299	0.607	0
Mexico	0	0	0	0	0	0
Morocco	0	0.012	0	0.056	0	0.163
New Zealand	0	0	0	0	0	0
Nigeria	0	0	0	0	0.051	0
Norway	0.196	0.069	0	0.023	0	0
Panama	0	0	0	0	0.042	0
Paraguay	0	0	0	0	0	0
Philippines	0	0	0	0	0	0
Sri Lanka	0	0	0	0	0	0
Sweden	0	0	0.109	0	0	0.076
Switzerland	0.168	0.144	0	0.153	0.053	0.15
Thailand	0	0	0	0	0	0
Trinidad and Tobago	0	0	0	0	0.013	0.079
Tunisia	0	0.052	0	0.17	0	0.378
Turkey	0	0	0	0	0	0
United Kingdom	0	0.01	0.43	0	0	0
United States	0	0.203	0	0.299	0	0.059
Venezuela	0	0	0	0	0	0
Zimbabwe	0	0	0	0	0	0

	Ireland	Italy	Netherlands	Portugal	Spain
Argentina	0	0	0	0	0
Australia	0	0	0.303	0	0
Bahamas	0	0	0	0	0
Bangladesh	0	0	0	0	0
Burundi	0	0	0	0	0
Canada	0	0	0	0	0
Chile	0	0	0	0.629	0.292
Colombia	0	0	0	0	0
Costa Rica	0	0.024	0	0	0
Denmark	0	0.11	0	0	0
Ecuador	0	0	0	0	0
El Salvador	0	0	0	0	0
Fiji	0	0.058	0.008	0	0
Guatemala	0	0	0	0	0
Guyana	0	0	0	0	0
Honduras	0	0	0	0	0
Iceland	0	0	0	0	0
Indonesia	0	0	0	0	0
Israel	0.681	0	0	0	0
Japan	0	0.333	0.345	0.314	0.28
Mexico	0	0	0	0	0
Morocco	0	0.021	0.075	0	0
New Zealand	0	0	0	0	0
Nigeria	0	0.025	0	0	0
Norway	0.319	0	0.247	0	0
Panama	0	0	0	0	0
Paraguay	0	0	0	0	0
Philippines	0	0	0	0	0
Sri Lanka	0	0	0	0	0
Sweden	0	0	0	0	0
Switzerland	0	0.083	0.021	0	0
Thailand	0	0	0	0	0
Trinidad and Tobago	0	0.1	0	0	0
Tunisia	0	0	0	0	0.145
Turkey	0	0	0	0	0
United Kingdom	0	0.246	0.001	0.057	0.145
United States	0	0	0	0	0.138
Venezuela	0	0	0	0	0
Zimbabwe	0	0	0	0	0

Table A.2: Synthetic weights of small donor pool countries: intervention year 1997

	Austria	Belgium	Finland	France	Germany	Greece
Australia	0	0.048	0	0.002	0	0
Canada	0	0.028	0	0.118	0	0
Chile	0.015	0.208	0	0	0	0
Denmark	0.327	0.185	0	0	0.067	0.005
Iceland	0	0	0	0	0	0
Japan	0.517	0.405	0	0.389	0.355	0
Mexico	0.049	0	0	0.192	0.218	0
New Zealand	0	0	0	0	0	0.064
Norway	0	0	0	0	0.165	0
Sweden	0	0	0.828	0	0	0
Switzerland	0	0.125	0	0.103	0.118	0.223
Turkey	0.092	0	0.172	0	0.077	0.708
United Kingdom	0	0	0	0	0	0
United States	0	0	0	0.196	0	0

	Ireland	Italy	Netherlands[14]	Portugal	Spain
Australia	0	0	0	0	0
Canada	0	0.245	0.008	0	0
Chile	0.547	0.189	0.094	0.398	0.222
Denmark	0	0.087	0.366	0	0
Iceland	0	0	0	0	0
Japan	0	0.407	0.52	0.36	0.369
Mexico	0	0	0	0	0
New Zealand	0	0	0.013	0	0
Norway	0.453	0	0	0	0
Sweden	0	0	0	0	0
Switzerland	0	0.06	0	0	0.06
Turkey	0	0.011	0	0.241	0.266
United Kingdom	0	0	0	0	0.082
United States	0	0	0	0	0

[14]The variable RuleOfLaw is deleted to make the synthetic control method find a match.

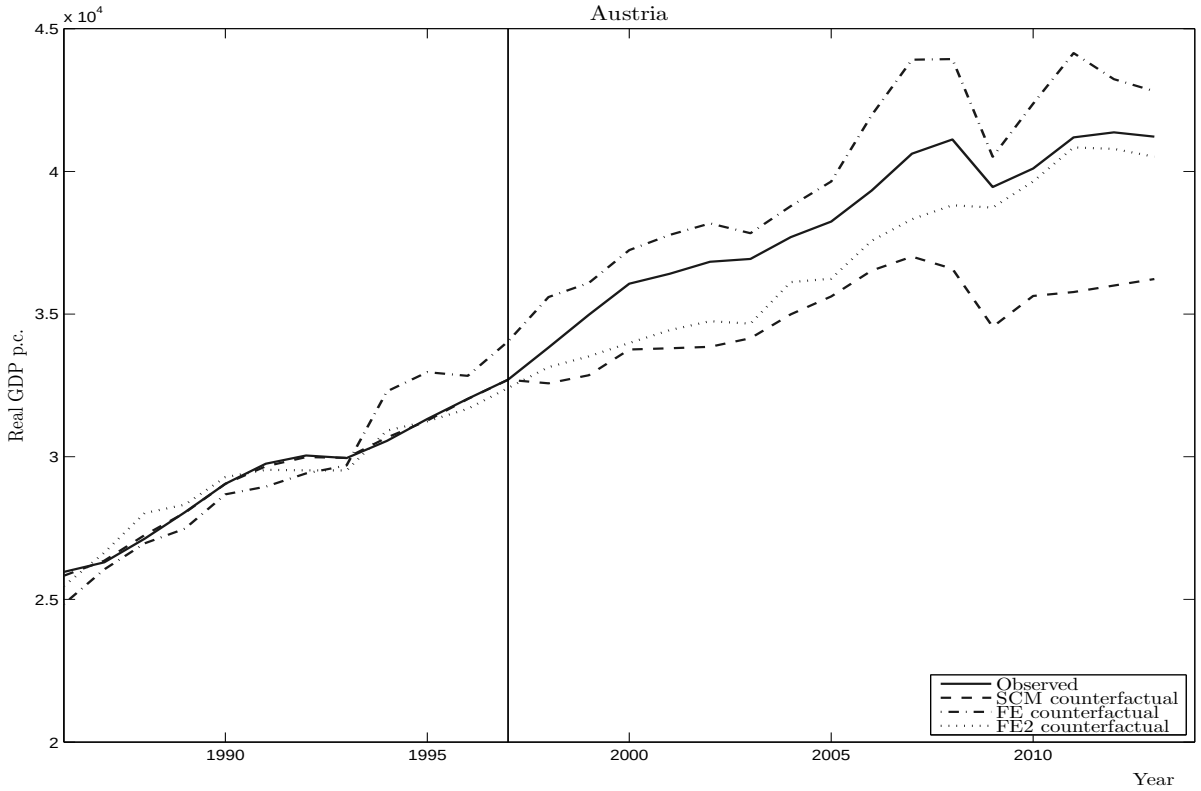
Table A.3: In-sample forecasts: average forecast error over 1993-1996

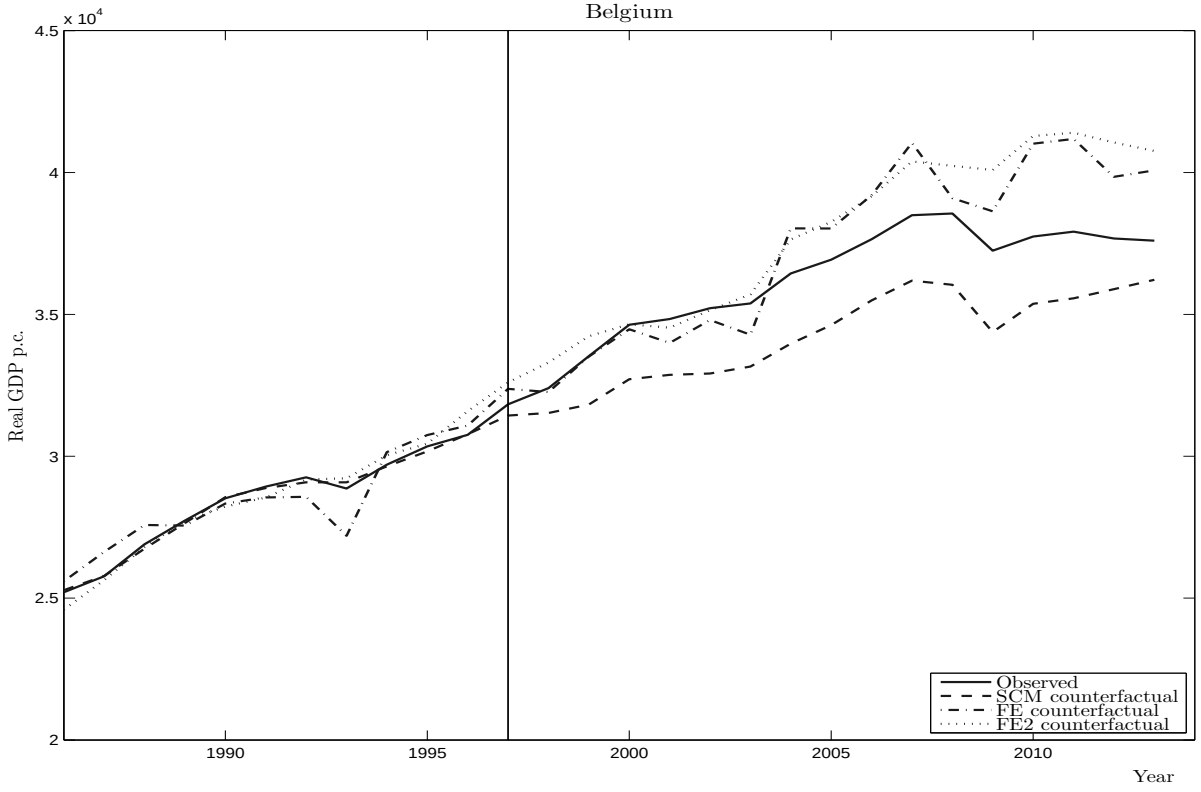
EMU country	average error
Austria	+1.50%
Belgium	-0.70%
Finland	-4.54%
France	-2.16%
Germany	-1.21%
Greece	-5.45%
Ireland	+16.52%
Italy	-2.75%
Netherlands	+0.60%
Portugal	-2.24%
Spain	-2.11%

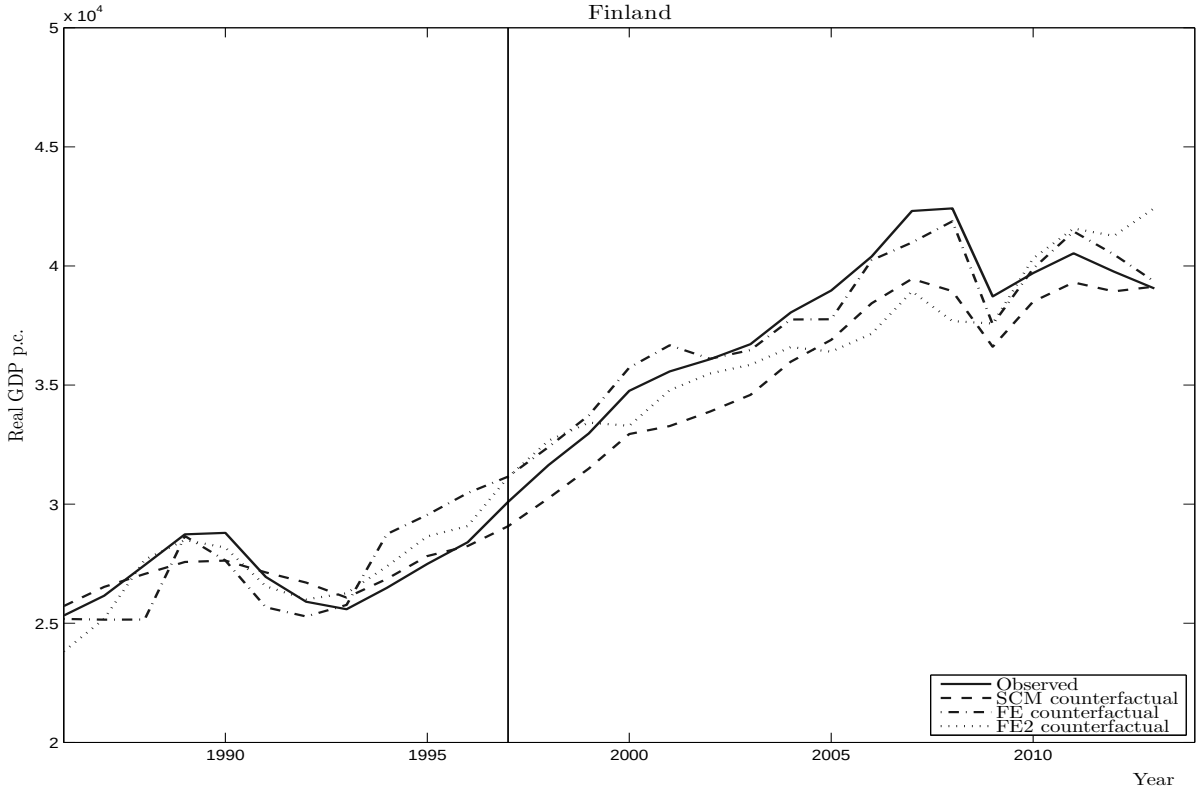
Table A.4: Estimated EMU effect (in %) for non-EU donor pool

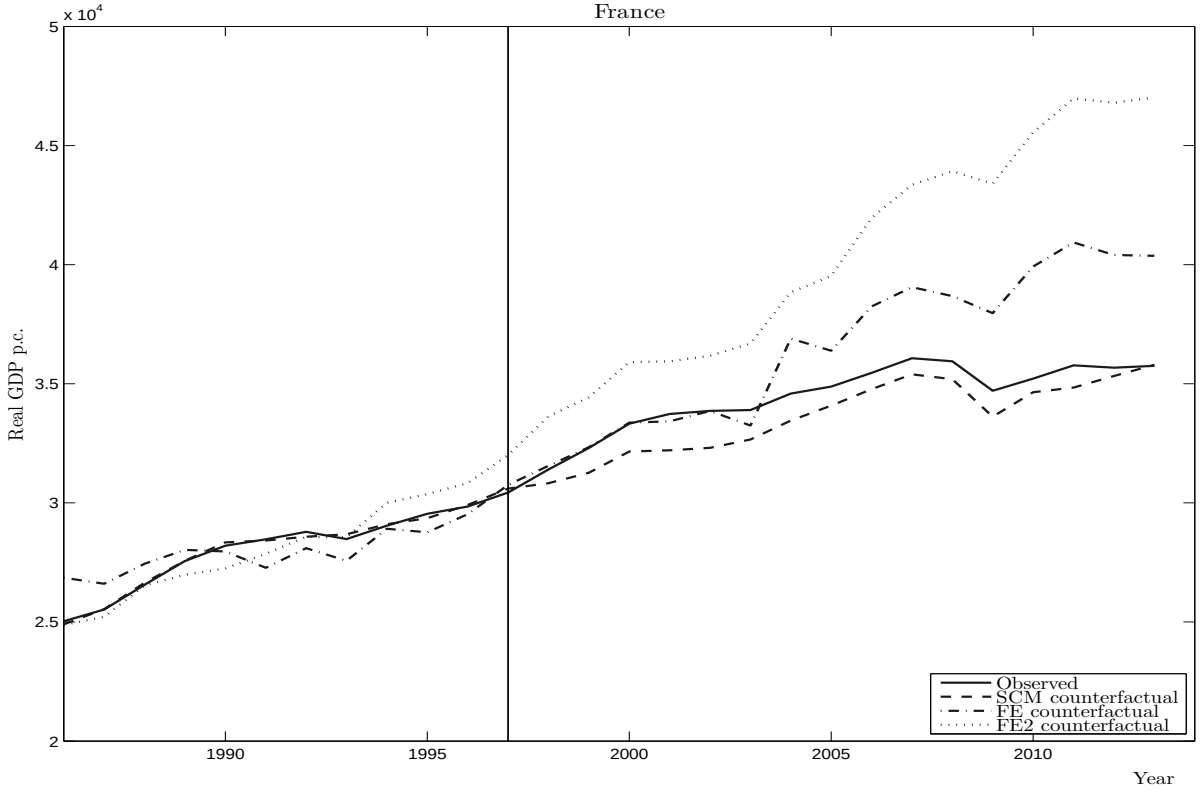
EMU country	All years	1997-2007	Crisis
Austria	+5.3%	+6.2%	-0.3%
Belgium	+6.2%	+6.0%	-1.9%
Finland	+8.9%	+9.4%	-0.8%
France	+1.0%	+2.2%	-2.0%
Germany	+1.1%	-0.0%	+2.8%
Greece	+5.8%	+10.4%	-11.0%
Ireland	+29.0%	+29.4%	-6.8%
Italy	-4.2%	+0.1%	-10.9%
Netherlands	+3.0%	+2.7%	-0.2%
Portugal	+4.8%	+8.9%	-7.2%
Spain	+8.9%	+10.9%	-7.0%

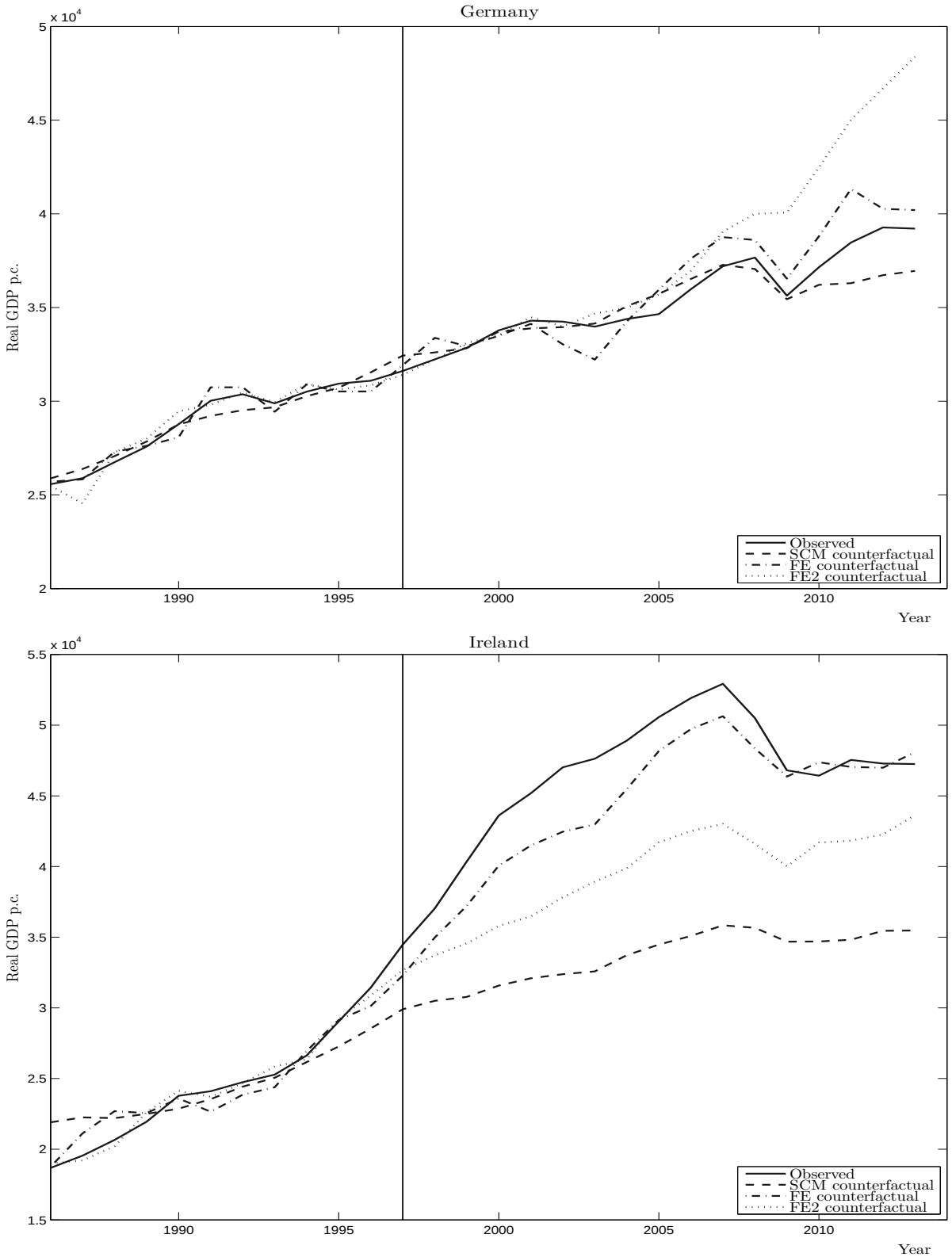
Figure A.1: Comparison synthetic control method & fixed effects regression

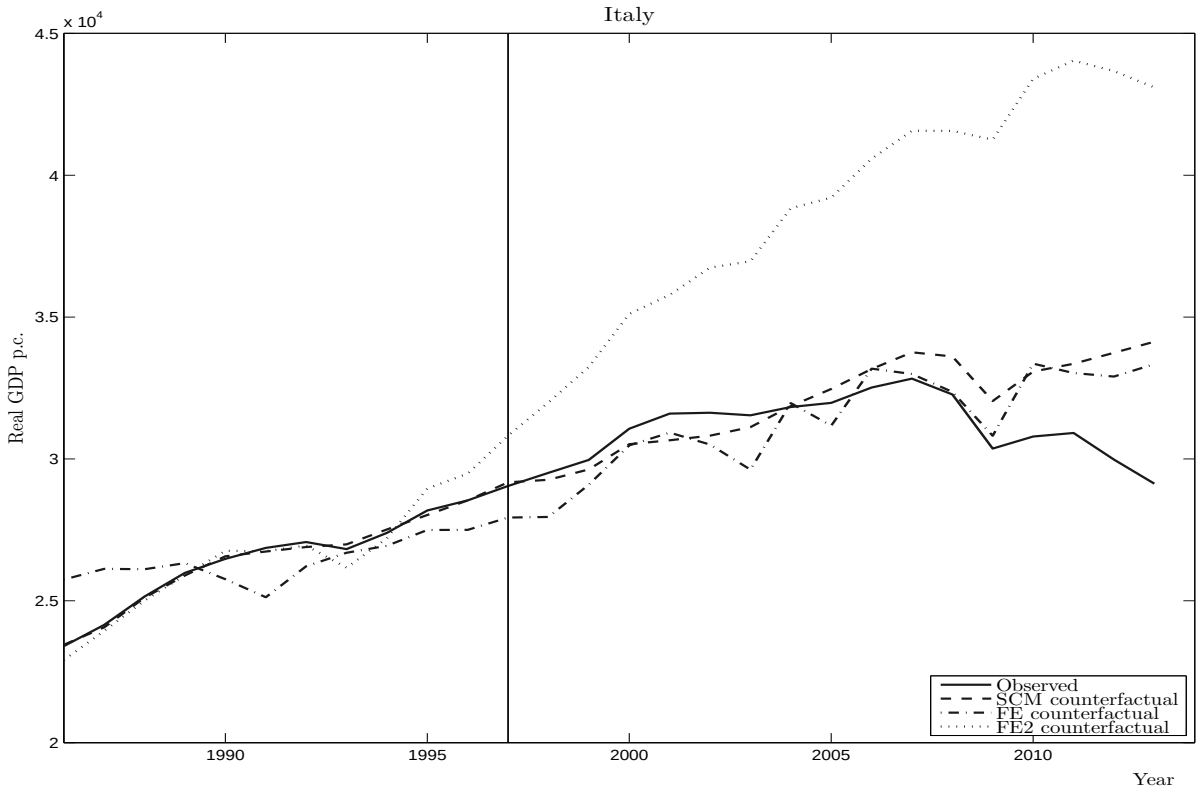


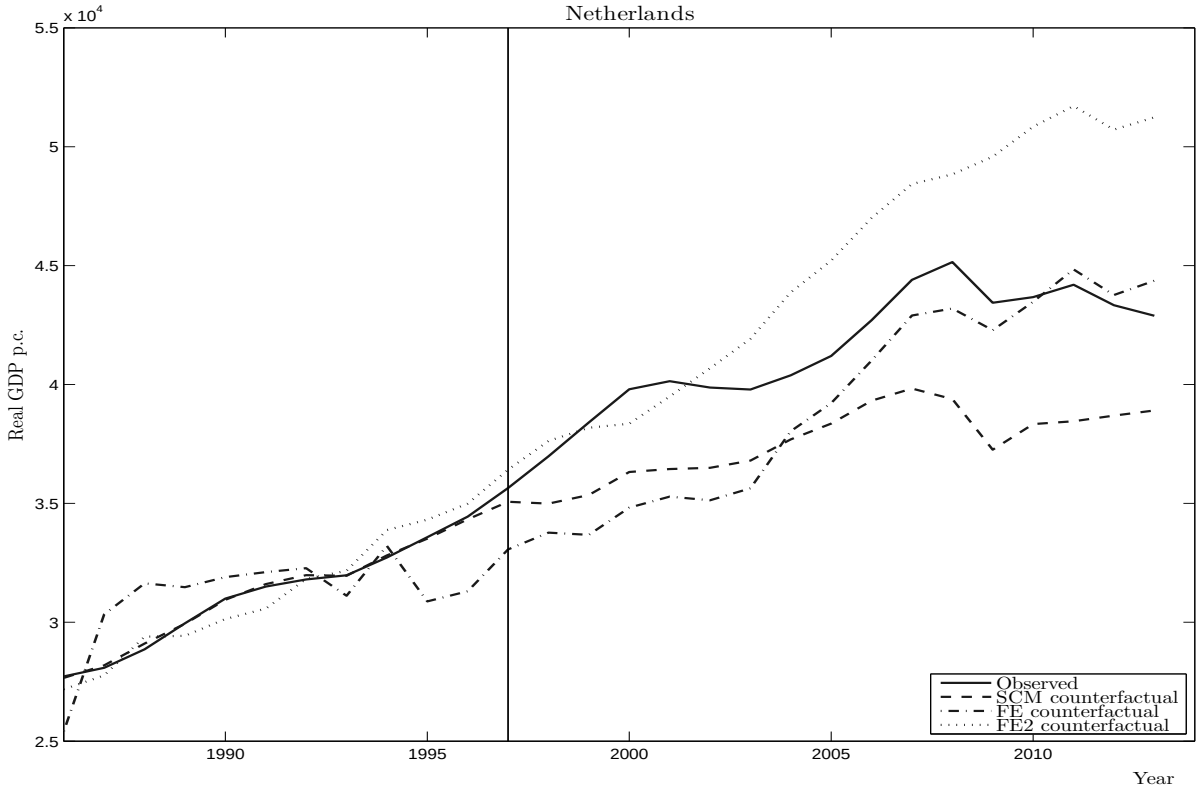


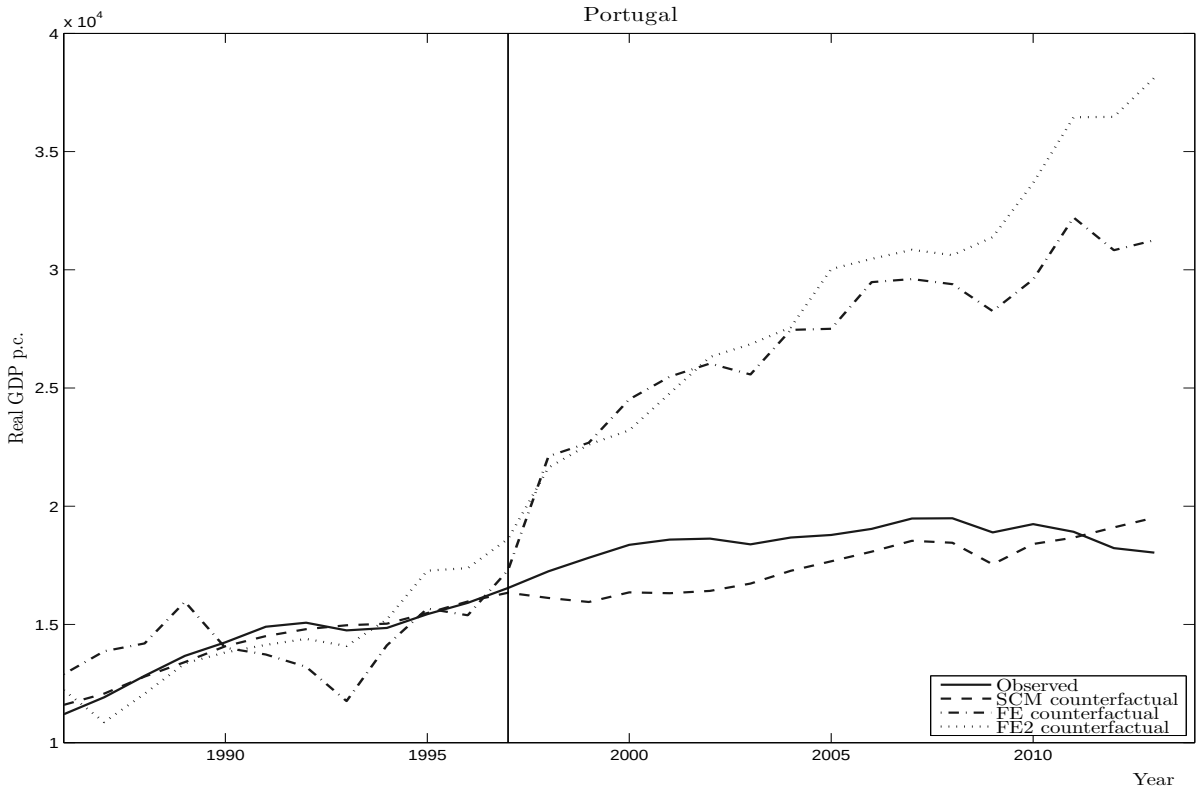

Finland
x 10^4
5
4.5
4
3.5
3
2.5
2
Real GDP p.c.
1990
1995
2000
2005
2010
Year
Observed
SCM counterfactual
FE counterfactual
FE2 counterfactual

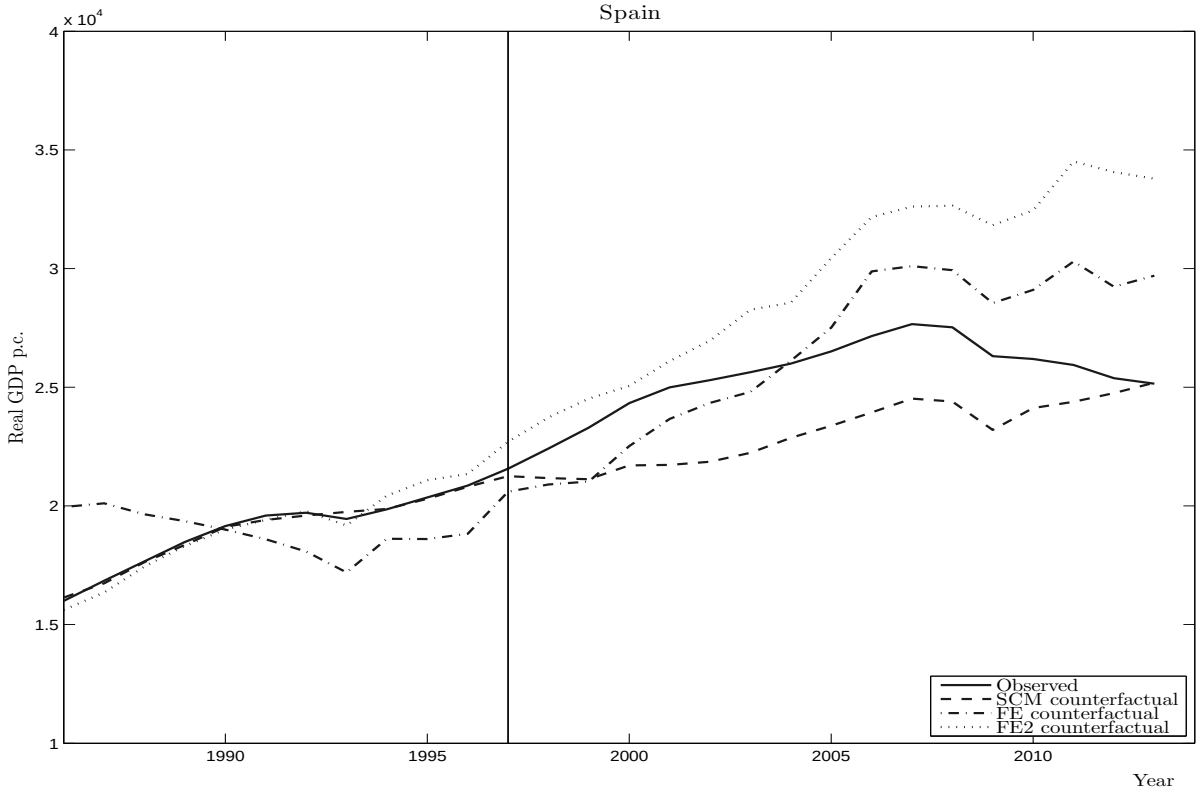

France
x 10^4
5
4.5
4
3.5
3
2.5
2
Real GDP p.c.
1990
1995
2000
2005
2010
Year
Observed
SCM counterfactual
FE counterfactual
FE2 counterfactual


Germany
x 10^4
5
4.5
4
3.5
3
2.5
2
Real GDP p.c.
1990
1995
2000
2005
2010
Year
Observed
SCM counterfactual
FE counterfactual
FE2 counterfactual
Ireland
x 10^4
5.5
5
4.5
4
3.5
3
2.5
2
1.5
Real GDP p.c.
1990
1995
2000
2005
2010
Year
Observed
SCM counterfactual
FE counterfactual
FE2 counterfactual


Italy
x 10^4
4.5
4
3.5
3
2.5
2
Real GDP p.c.
1990
1995
2000
2005
2010
Year
Observed
SCM counterfactual
FE counterfactual
FE2 counterfactual


Netherlands
x 10^4
5.5
5
4.5
4
3.5
3
2.5
Real GDP p.c.
1990
1995
2000
2005
2010
Year
Observed
SCM counterfactual
FE counterfactual
FE2 counterfactual


Portugal
x 10^4
4
3.5
3
2.5
2
1.5
1
Real GDP p.c.
1990
1995
2000
2005
2010
Year
Observed
SCM counterfactual
FE counterfactual
FE2 counterfactual


Spain
x 10^4
4
3.5
3
2.5
2
1.5
1
Real GDP p.c.
1990
1995
2000
2005
2010
Year
Observed
SCM counterfactual
FE counterfactual
FE2 counterfactual

Appendix 3: Difference-in-differences and placebo results

Table A.5: Difference-in-difference estimates of EMU effect

	Complete period		Period before crisis	
	DID estimate	Standard error	DID estimate	Standard error
Austria	3330.127***	1150.356	2338.432*	1194.934
Belgium	1954.835*	1013.445	1845.980*	1096.013
Finland	1631.393	1525.125	1942.336	1556.190
France	750.784	897.846	931.467	973.455
Germany	423.768	1122.210	-313.874	1070.357
Greece	1193.108	890.011	2121.508**	850.686
Ireland	12973.10***	1948.834	12869.04***	2346.762
Italy	-1193.243	833.5524	73.721	899.878
Netherlands	3844.590***	1186.272	3002.626**	1282.831
Portugal	862.918	649.293	1426.180*	721.474
Spain	2163.361**	829.776	2619.676***	933.509

The results in table A.5 confirm that the benefits from EMU participation are significantly different from zero for Austria, Belgium, Ireland, the Netherlands and Spain. If we look at the sub-period from the introduction of the EMU until the start of the crisis in 2008, we find that there are more countries for which the positive EMU effect is significant. Greece and Portugal experience a large benefit from EMU participation before the crisis, which decreases during the crisis leading to a lower differences-in-difference estimate for the whole period.

Table A.6: DID estimates of crisis effect on EMU countries

	DID estimate	Standard error
Austria	859.715	1274.265
Belgium	592.681	1164.780
Finland	-1081.831	2006.849
France	277.462	978.407
Germany	1827.362*	984.683
Greece	-2926.24**	1419.851
Ireland	-3182.42	2999.109
Italy	-2271.86***	824.9841
Netherlands	-415.027	1332.512
Portugal	-714.526	524.664
Spain	-1940.723*	1075.558

Table A.6 reports the DID estimates of the gains and losses that EMU members experience relative to countries outside the EMU during the crisis. Many countries have been suffering during the crisis as a result of their participation in the EMU, and for Greece, Italy and Spain this loss has actually been significant. Germany is one of the few countries that would have been worse off if it would have not been in the EMU during the crisis, and it is the only country for which this positive effect is significant.

The graph displays the estimated EMU effect for the EMU members and the estimated placebo effect for 10 countries in the donor pool. For some of the EMU members, this figure strengthens the confidence in the estimated effect of EMU participation. For Austria and the Netherlands, we see that the EMU effect is clearly above all the placebo effects, which are subject to larger deviations before 1997 as well. The estimated EMU effect for Ireland is clearly significant, however, there are doubts about whether the effect is truly due to EMU participation, as we have noted before. It is harder to acknowledge a significant effect for Belgium and Finland, whereas there is no significant effect for France, Germany and Italy, because the estimated EMU effect is similar in size as the placebo effects. For some countries, we only observe a significant effect in the period just after the introduction of the euro, and the significance decreases as the crisis starts to affect these economies. This is the case for Greece, Portugal and Spain.

Figure A.2: EMU effect vs placebo effects