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Winners and losers from the €uro

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ABSTRACT

Using the synthetic control method, this paper estimates the effect of having joined the monetary union on the income per capita of six early adopters of the euro. Our estimates suggest that while the income per capita of Belgium, France, Germany and Italy would have been higher without the euro, that of Ireland would have been considerably lower. In contrast, the Netherlands would have been as well off without the euro. We show that these estimates are not contingent on our choice of baseline control groups, growth predictors and pre-treatment period. In addition, we use the insights from the literature on the economic determinants of the costs and benefits of monetary unions to explain our estimates. We find that early euro adopters with a business cycle more synchronized to that of the union and more open to intra-union trade or migration, lost less or gained more from the euro. A key role in increasing post-euro income losses of union members has been played by the integration of capital markets.

1. Introduction

In the wake of the Great Recession of 2008 several member states of the Eurozone were confronted with sovereign debt crises. Via inter-governmental mechanisms and programs, such as the European Financial Stability Facility and the European Financial Stabilisation Mechanism, the European Commission became an important source of external financial support to member countries in crisis. These programs, however, imposed strict conditions on the borrowing countries, including the implementation of fiscal consolidation, restructuring of the financial sector and broader structural reforms. As a result, Greece, Ireland and Spain raised taxes and lowered public expenditure, given that inflation and devaluation of their currencies were not possible. Such fiscal measures generated social unrest and significant debate regarding the benefits of running greater deficits when economies are struggling, the future of the financial stabilizing role of the European Central Bank (ECB) and the perceived benefits and costs of the monetary union. This paper contributes to this debate by providing estimates of the effect of the euro on the income per capita of six early adopters of the single currency before the global financial and Eurozone crises took place. We focus on countries' income per capita because this is an informative indicator of economic performance likely to capture the net benefits of having adopted the euro. To gain further insights on these estimates, we relate them to commonly recognized economic determinants of the costs and benefits of monetary unions.

On the one hand, joining a currency union is costly. Most of the insights related to the costs of monetary unions are from the literature on optimum currency areas (OCA) initiated by Mundell (1961). The biggest cost a country bears once it

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joins a monetary union is the lost ability to use monetary policy to accommodate external shocks. If a country faces shocks similar to those of other union members, this policy loss is not too onerous. In fact, in this case, monetary policy at the union level would often be in line with the optimal one at the national level. In contrast, if a country is highly indebted and the union imposes fiscal discipline on members, the loss of monetary policy might be onerous. Another important insight from the OCA literature is that a country might face lower costs from joining a monetary union if, by doing so, it gains access to additional shock absorbers through greater mobility of production factors within the union or a system of fiscal federalism. Further, a country's labor market conditions, e.g., its flexibility and its similarity to those of other countries in the union, affect the effective costs of monetary unions.

On the other hand, joining a currency union benefits a country because currency conversion costs and exchange rate uncertainty with other union members are eliminated. Given that these cost savings increase with the degree to which a country trades with other union members, countries more open to intra-union trade benefit more from the monetary union.

Before the adoption of the euro the consensus among economists was that the costs of the single currency would likely outweigh the benefits for most of the countries involved (Eichengreen and Frieden, 1993; Feldstein, 1997). Even though the euro has been in use for more than a decade, no direct evidence has been brought in this regard. Our paper aims to shed light on the economic effects of the euro on adopters by undertaking two different but interrelated exercises.

First, we estimate who lost and who gained, in real income per capita terms, from the adoption of the euro during the pre-crises period. We use the synthetic control method introduced by Abadie and Gardeazabal (2003), henceforth AG), and further developed by Abadie et al. (2010), ADH) to obtain our estimates. This method allows us to estimate the income per capita that members of the European Economic and Monetary Union (EMU) would have experienced had they kept their independent monetary policy by exploiting data from the year they committed to the EMU. In particular, the methodology uses the data before the introduction of the euro to find, for each EMU member, a convex combination of similar countries not in the EMU (*synthetic control unit*). An algorithm that minimizes the difference in the relevant economic characteristics between the chosen EMU member and its synthetic counterpart determines the exact weights assigned to countries in the synthetic control unit. The comparison of the evolution of the income per capita of euro adopters with that of the corresponding synthetic controls after the introduction of the euro allows us to determine the winners and losers from the euro. In order to obtain accurate estimates the synthetic control method requires a reasonable number of years pre-euro. Thus, our analysis only focuses on those countries that committed to forming the EMU in the early 1970s and adopted the euro first. Namely, Belgium, France, Germany, Ireland, Italy and the Netherlands.

Our findings suggest that Belgium, France, Germany and Italy have lost from adopting the euro. More specifically, their annual income per capita would have been, on average, between 7.5 and 16.3 percent higher had they not adopted the euro. In contrast, both the Netherlands and Ireland are estimated to have benefitted from the euro adoption, with Ireland having experienced, on average, 23.4 percent higher annual income per capita than it would have had without the euro. We conduct placebo studies reassigning the euro adoption either to countries in the control groups or back to 1987 to verify the significance of our estimates. We find evidence in favor of the significance of our estimates for all countries except the Netherlands.

The second exercise of the paper consists of relating the synthetic estimates of the losses and gains from the euro to the economic determinants of the costs and benefits of monetary unions. This exercise has two advantages. First, it is a simple way to further validate the significance of our synthetic estimates by verifying their economic content. Second, it provides useful insights into the economic consequences of adopting the single currency for prospective members of the EMU.

Consistent with the predictions of the literature, we find that countries with a business cycle more correlated to that of the union and greater openness to intra-union trade or migration experienced lower costs or larger gains from the euro. Countries with more rigid labor markets and more divergent labor market institutions had larger losses from the euro. Finally, we find evidence that deeper financial market integration played a key role in increasing the post-euro income losses of EMU members. Our results are relevant for prospective members because they help both to predict the country-specific net cost of adopting the euro and to identify which economic factors should be adjusted to tilt the balance in favor of a positive outcome.

In addition to the theoretical literature on currency unions, this paper relates to a growing literature trying to quantify the net economic benefits of monetary unions. Using a stochastic dynamic general equilibrium framework, Carré and Collard (2003) find that, following a 1% permanent domestic technology (fiscal) shock, domestic households would need a 0.38% (0.14%) permanent rise in consumption to be compensated for their loss in utility as a regime of flexible exchange rates is chosen in place of a monetary union. Devereux et al. (2003), using a New Keynesian model, find that the benefit of introducing the euro for Europe and the U.S. is equivalent to, respectively, a 15% and 5% reduction in the standard deviation of monetary shocks worldwide. For countries that did not join the EMU, Ferreira-Lopes (2010) finds that consumers in Sweden and the UK are willing to give up part of their consumption in order to retain an economy where monetary policy is conducted at the national level.

Pesaran et al. (2007) estimate global macroeconomic (Global Vector Auto Regressive, GVAR) models to determine the probability that the UK or Sweden and the euro area would have experienced higher output and lower prices if the UK or Sweden adopted the euro in 1999. Their estimates suggest that all countries would probably have experienced higher GDP if the UK or Sweden adopted the euro. These gains would have been small though, except for Sweden. Pesaran et al.'s methodology requires estimating two GVAR models, an unrestricted one and another one with restrictions dictated by a specific counterfactual (e.g., the UK adopting the euro at a given exchange rate and fixing short-term interest rates to the euro area level). So when Dubois et al. (2009) use it to study the effect of the euro adoption on adopting countries' interest rates and output, they consider that national monetary policies would have followed either a German-type or a British-type one if the euro had not been adopted. Relative to this approach, our challenge is not defining and imposing a specific counterfactual but finding the linear combination of control countries that can best approximate the counterfactual income per-capita of treated units.

As mapping the estimated net benefits of monetary unions from existing studies to our results is not obvious, the paper that is most closely related to ours is the empirical study by Frankel and Rose (2002). Their work establishes that trade is the main channel through which currency unions increase income growth. More specifically, they have two main findings. First, being part of a currency union triples trade with other union members. Second, a one percent increase in a country's overall trade increases income per capita by at least one-third of a percent. Combining these key results, Frankel and Rose predict that non-EMU members (Denmark, the UK and Sweden) would experience an increase in income per capita of about 20% by joining the monetary union. In contrast to Frankel and Rose (2002), our estimated gains and losses from the euro are not out-of-sample predictions but they are obtained after having constructed appropriate counterfactuals.

The rest of the paper is organized as follows. Section 2 briefly summarizes the history of the euro. Section 3 discusses the synthetic method, our estimates of the income gains and losses from the euro and their robustness. Section 4 summarizes the insights from the literature on the economic determinants of the costs and benefits of monetary unions, which are then used to explain our synthetic income estimates. Section 5 concludes.

2. A Brief History of the Euro

In 1971 the member countries of the European Community (EC, hereafter) - France, West Germany, Italy, Belgium, Luxembourg and the Netherlands - committed to forming an economic and monetary union by adopting a resolution that broadly outlined the necessary stages to achieve it.[1] Two years later, Denmark, the UK and Ireland joined the EC. The initial process of integration was discontinuous, with the most effective steps taken toward the formation of a monetary union being: the introduction of the European Currency Unit (ECU)[2] and the Exchange Rate Mechanism (ERM) in 1979, and the adoption of the Single European Act in 1987. The ERM, by limiting fluctuations in the value of member countries' currencies, successfully increased monetary, exchange rate and price stability in member states. The Single European Act, by adding the 'single market' to the list of objectives of the community, emphasized the necessity of a single currency. Greece joined the EC in 1981. Spain and Portugal did the same in 1986. In 1988, the 'Delors Commission' was appointed to propose the necessary stages for the realization of the EMU. Three stages were proposed. The first two would lay down the institutional foundation for the adoption, in Stage Three, of a stable single currency.

During Stage One (1989–1993), the Maastricht Treaty (officially called the Treaty on European Union) was signed, entering into force on November 1, 1993. The treaty established the economic and legal conditions countries must satisfy in order to adopt the single currency. Importantly, the economic requirements specified therein include: a high degree of price stability, sustainability of the financial position of governments, the observance of the ERM bands for at least two years prior to the single currency adoption, and the convergence of long-run interest rate levels. In accordance with the treaty, Denmark and the UK were given the option of retreating from the last stage of the EMU.

In Stage Two (1994–1998), the European Monetary Institute was established to increase coordination of monetary policies across member countries, and to prepare for the introduction of the euro and the ECB. The European Monetary Institute also monitored member states' progress in fulfilling the conditions for the adoption of the single currency. In the meantime, countries adopted the Stability and Growth Pact, further enforcing the budgetary rules set by the Maastricht Treaty. Denmark and the UK exercised their right not to participate in Stage Three of the EMU in December 1992 and October 1997, respectively.[3] Despite having opted out of the monetary union, Denmark joined the ERM permanently in 1999. In 1995, Austria, Finland and Sweden joined the European Union. In May 1998 the birth of the euro was officially announced, giving life to the biggest currency union of all time. In fact, only Greece and Sweden had not met the conditions for adopting the euro, and the eleven constituent members accounted for 19.4 percent of world GDP and 18.6 percent of world trade, internal trade excluded. On June 1, 1998 the ECB formally replaced the European Monetary Institute.

In Stage Three (1999-present) exchange rates between participating member countries' currencies and the euro were fixed irrevocably, and the ECB officially took over the responsibility of conducting the unified monetary policy. The introduction of the euro was completed with the cash changeover on January 1, 2002. Greece joined the Eurozone in 2001.

[1] Resolution on the achievement by stages of economic and monetary union in the Community, 22 March 1971. Through this resolution EC members agreed, among other objectives, to increase integration of financial markets, closely coordinate monetary and credit policies, gradually shift main economic decisions from national to Community level, and to fiscal discipline for growth and stability.

[2] The value of the ECU was defined as a fixed combination of the values of the member countries' currencies. The exchange rate ECU\USD, for example, was determined as the (fixed) weighted average of the exchange rates of each of the member countries' currencies with the US dollar. The ECU mainly served as a unit of account of the EC and was used only in some international financial transactions.

[3] The debate on the participation of the UK in the EMU centered around the following issues: (1) whether the UK and the Eurozone had converged sufficiently to make a single monetary policy desirable; (2) whether the UK economy was sufficiently flexible to join a common currency; and (3) how the adoption of the euro would affect the position of the City of London as Europe's predominant financial capital, investment, employment and growth more generally.

Table 1
Key dates in the making of the Eurozone.

Year	Political developments
1971	France, West Germany, Italy, Belgium, Netherlands, Luxembourg (European Community, EC) commit to forming an economic and monetary union.
1973	Denmark, Ireland and the UK join the EC.
1979	Introduction of the ECU and the ERM.
1981	Greece joins the EC.
1986	Portugal and Spain join the EC.
1987	The Single European Act comes into effect.
1991	The Maastricht Treaty transforms the EC into the European Union (EU) and sets the criteria for the adoption of the common currency.
1992	Denmark opts out the European Monetary Union (EMU).
1995	Austria, Finland and Sweden join the EU.
1997	The UK opts out the EMU.
1998	The European Central Bank is created. Austria, Belgium, Finland, France, Germany, Ireland, Italy, Luxembourg, the Netherlands, Portugal and Spain fix their exchange rates with the euro.
2001	Greece joins the Eurozone.
2003	Sweden voters reject the adoption of the euro in a referendum.
2004	Cyprus, the Czech Republic, Estonia, Hungary, Latvia, Lithuania, Malta Poland, Slovakia, and Slovenia join the EU.
2007	Slovenia joins the Eurozone.
2008	Cyprus and Malta join the Eurozone.
2009	Slovakia joins the Eurozone.
2011	Estonia joins the Eurozone.
2014	Latvia joins the Eurozone.
2015	Lithuania joins the Eurozone.

Sweden never joined the ERM, intentionally not fulfilling the requirements for the euro adoption.[4] To date, the Eurozone consists of 19 countries.[5] Table 1 summarizes the key dates and political developments in the making of the Eurozone.

3. Estimating Income Gains and Losses from the Euro

3.1. On the Synthetic Control Method

In order to estimate the effect of the euro on the income per capita of candidate countries that joined the EMU, we use the synthetic control method proposed by AG (2003), and further developed in ADH (2010). The intuition behind this methodology is to measure the economic effect of an intervention or shock on a unit, which can be thought of as a region, state or country. In order to do so one first has to find a convex combination of similar but unaffected units (*synthetic control unit*) that best fits the relevant economic characteristics of the affected unit in the pre-intervention period. Then one compares the post-intervention economic evolution of the synthetic control to the one observed for the affected unit.

ADH rationalizes the synthetic control method using traditional regression frameworks. Formally, suppose that we observe J+1 units, the first unit of which experiences an intervention at time $1 < T_0 < T$. Assume that the intervention does not affect, either directly or indirectly, the remaining J units, then these can be used as a control group. Let Y_{it} indicate the observed value of the outcome of interest for the i-th unit at time $t = 1, 2, ..., T$, and Y_{it}^N be the outcome that would be observed for unit i at time t without the intervention. As a result, we have that $Y_{it}^N = Y_{it}$ for all $i \neq 1$. The estimate of interest is the intervention effect as denoted by $\alpha_{1t} = Y_{1t} - Y_{1t}^N$ at time $t = T_0 + 1, ..., T,$ during which Y_{1t}^N is not observed. Assume that Y_{it}^N is represented by the following factor model:

$$Y_{it}^N = \delta_t + \theta_t Z_i + \lambda_t \mu_i + \epsilon_{it} \tag{1}$$

where δ_t is an unknown common factor, Z_i is a (rx1) vector of observed covariates unaffected by the intervention, θ_t represents a (1xr) vector of unknown parameters, λ_t denotes an unknown common factor with factor loadings, μ_i, varying across units, and ϵ_{it} represents transitory shocks with mean zero for all i. ADH show that if one finds a vector of non-negative weights that sum to one, $W^* = (w_2^*, w_3^*, ..., w_{J+1}^*),$ such that the following conditions hold:

$$\sum_{j=2}^{J+1} w_j^* \overline{Y_j^k} = \overline{Y_1^k} \quad \text{for} \quad k = 1, ...K, \qquad \text{and} \qquad \sum_{j=2}^{J+1} w_j^* Z_j = Z_1 \tag{2}$$

[4] In 2003, the Swedish people rejected the adoption of the euro in a referendum.

[5] The countries belonging to the Eurozone are: Austria, Belgium, Cyprus, Estonia, Finland, France, Germany, Greece, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, the Netherlands, Portugal, Slovakia, Slovenia, and Spain.

where $\overline{Y_i^k}$ is any k-th linear combination of i's pre-intervention outcomes, then Y_{1t}^N can be well approximated by $\sum_{j=2}^{J+1} w_j^* Y_{jt}$ as the number of observed pre-intervention periods increases. As a consequence, an unbiased estimate of the intervention effect is given by:

$$\hat{\alpha}_{1t} = Y_{1t} - \sum_{j=2}^{J+1} w_j^* Y_{jt}. \quad (3)$$

The conditions in equation 2 can hold exactly only if $(Y_{11}, Y_{12}, ..., Y_{1T_0}, Z_1^{'})$ belongs to the convex hull of $(Y_{21}, Y_{22}, ..., Y_{2T_0}, Z_2^{'})$, ..., $(Y_{J+11}, Y_{J+12}, ..., Y_{J+1T_0}, Z_{J+1}^{'})$. This rarely occurs in practice. Thus, the synthetic control approach provides a relatively simple procedure to find W^* that approximately satisfies the conditions in equation 2.

Formally, let X_1 be a $((r+K)$x$1)$ vector that contains information on K linear combinations of pre-intervention outcomes and r outcome predictors for unit 1. Let also X_0 denote a $((r+K)$x$J)$ matrix which collects the same pre-intervention economic variables for each of the J unaffected units. Then, the synthetic approach consists of finding the vector of weights, W^*, that minimizes some distance in the pre-intervention characteristics between unit 1 and the J control units. More precisely, W^* minimizes the following metric: $\sqrt{(X_1 - X_0W)'V(X_1 - X_0W)}$, where V is some $((r+K)$x$(r+K))$ diagonal and positive semidefinite matrix. This minimization problem provides a solution for W^* that is a function of the elements of the matrix V. These elements are in turn chosen so that $W^*(V^*)$ minimizes the pre-intervention Mean Square Prediction Error (MSPE) of the outcome of interest: $\frac{1}{T_0}\sum_{t=1}^{T_0}\left(Y_{1t} - \sum_{j=2}^{J+1} w_j^* Y_{jt}\right)^2$. The elements in V are non-negative weights assigned to each of the pre-intervention characteristics in the matrices X depending on their relative importance in explaining the outcome of interest. These weights are normalized to sum to one for identification purposes. In a nutshell, the synthetic method estimates the unobserved counterfactual as a weighted average of the control units' outcomes, with weights being chosen to best match the pre-intervention characteristics of the affected unit.

Even though the synthetic control method has the flavor of comparative case studies, where researchers compare units affected by an intervention to one or more unaffected units, it addresses two of their major shortcomings. First, in comparative case studies, researchers choose their control units on the basis of relatively subjective measures of affinity with the affected unit. In contrast, the synthetic method is a data-driven method that finds suitable comparison groups and makes explicit the similarities between the affected unit and its synthetic control. Second, in comparative case studies there is uncertainty about how well the control units replicate the evolution of the outcome of interest were the affected unit not treated. Instead, inference on the fit of the synthetic control is possible through placebo experiments. A way of implementing these tests is to reassign the intervention to each of the control units and estimate the intervention effect in each case using the synthetic estimator. If the estimated intervention effect for the control units is comparable or larger than the one estimated for the unit actually exposed to it, the latter cannot be taken as significant. Alternatively, one can reassign the intervention to an earlier time period and estimate the corresponding intervention effect using the synthetic estimator. If the estimated intervention effect when the treatment date is set early is comparable or larger than the one estimated using the effective intervention date, the latter cannot be taken as significant. The inference from these tests is always exact and it becomes more informative as the number of control units or time periods increases.

An important advantage of the synthetic control estimator over usual difference-in-difference (fixed-effects) models is that it allows the effect of the unobserved individual heterogeneity to be time varying.[6] However, the identification of the synthetic estimator rests on the assumption that a unit does not select into the treatment based on current or future values of the outcome of interest.

The synthetic control method has been used in a number of recent papers. AG pioneered it by quantifying the Basque country's income losses from the terroristic activity of the 1970s. ADH apply this method to measure the effect of the passage of Proposition 99 on per capita cigarette consumption in California. Multi-country studies exploiting the synthetic control approach include those of Billmeier and Nannicini (2013) and Cavallo et al. (2013), who analyze the effects on economic growth of openness to international markets and large natural disasters, respectively. Campos et al. (2015) examine the effects of entry into the EC[7] on non-founding members' income per capita and labor productivity. Unlike them, our focus is on the effects of the euro adoption. To avoid that our estimates are affected by the entry into the EC, our sample starts only once EC members committed to the monetary union.[8] This frees the sample from potential structural shocks, which would invalidate our estimates. We control for heterogeneous effects of membership to the EC/EMU by ensuring long pre-treatment periods. Most closely related to our study, the synthetic control method has been used by Manasse et al. (2013) to

[6] An advantage of the synthetic estimator over regression estimators is that it does not allow for extrapolation (ADH, 2015), which can lead to large biases in the context of treatment models (King and Zeng, 2006). Also, as implied by the model in (1), the covariates and unobserved heterogeneity do not need to be independent of the error term.

[7] We use EC instead of EU in this discussion because the countries in our sample were members of what then was called the EC when they committed to the EMU.

[8] For Ireland, 1973 coincides with the year when it became member of the EC.

Table 2
Sample period and baseline control group by EMU member.

EMU member	Sample period	Baseline control group
Belgium	1971–2007	Australia, Bahrain, Barbados, Canada, Norway, New Zealand, Singapore, USA
France	1971–2007	Australia, Bahrain, Barbados, Canada, Norway, New Zealand, Singapore, USA
Germany	1971-2007	Australia, Bahrain, Barbados, Canada, Norway, New Zealand, Singapore, USA
Ireland	1973-2007	Gabon, New Zealand, Singapore, Trinidad and Tobago
Italy	1971-2007	Australia, Barbados, Canada, Norway, New Zealand, Singapore, Trinidad and Tobago, USA
Netherlands	1971-2007	Australia, Bahrain, Barbados, Canada, Norway, New Zealand, Singapore, Switzerland, USA

examine the effect of euro adoption on five indicators of the Italian economy, including per-capita GDP,[9] and Saia (2017) to determine the effect of non-adoption of the euro on the European bilateral trade flows of the UK.[10]

3.2. Sample and Data

3.2.1. Treated and Control Group Countries

We conduct our analysis on six EMU members: Belgium, France, Germany, Italy, the Netherlands and Ireland. From our main analysis we exclude: Greece because economic considerations might have played a key role in the decision to adopt the euro, especially once it was officially announced in 1998; Portugal and Spain due to the pre-intervention period between the acquisition of EMU membership (1986) and the treatment date (1995) being too short to accurately estimate the income effects of the euro.[11] Further, we do not consider Austria and Finland as they joined the EMU in 1995, making it impossible for us to disentangle the benefits of integration from those due to the euro adoption. Finally we do not consider Luxembourg because we failed to find an appropriate set of control countries. Indeed, Luxembourg was one of the richest countries in the world during our sample period.

For each EMU member we choose the *baseline* control group to include countries with similar levels of income per capita during the pre-treatment period. We do so to avoid interpolation biases, which might arise when regions in the control group are very different in their economic characteristics (ADH, 2010). This also allows us to limit the size of the control group and avoid overfitting (ADH, 2015). More precisely, among all possible control units, countries that make it to an EMU member's baseline control group are only those whose income per capita during the pre-treatment period diverges from that of the EMU member by, on average, no more than 40%. We further limit our baseline control group to countries that have never diverged more than 50% in a given year, except in at most 7 instances.[12] We choose to restrict the baseline control group based on income per capita as this summarizes the effects of its determinants.

Looking at Table 2, Belgium, France and Germany share the same control group, which differs from that of the Netherlands because it excludes Switzerland. Ireland and Italy's control groups share some of the countries with the other EMU member control groups but include lower income countries such as Gabon and Trinidad and Tobago. Note that none of the control groups includes the UK, Denmark and Sweden, which are EU members not in the Eurozone. This is because these countries' decision not to adopt the euro was mostly driven by economic considerations. Simply put, including them in our control groups would violate the assumption of random assignment, which is one of the key identifying assumptions of the synthetic methodology.[13]

In Section 3.4.1 we consider two additional control groups common to all EMU members. The first consists of *industrial countries* as classified by the IMF in 1998, for which all data on baseline predictors are available and that did not suffer large shocks during our sample period. This control group consists of 7 countries: Australia, Canada, New Zealand, Norway, Singapore, Switzerland and the USA. The second one consists of *all* countries with available data and no profound structural

[9] Specifically, Manasse et al. (2013) consider the effect of the euro on Italy's bilateral trade, inflation, government bond yields, labor productivity and real per capita GDP.

[10] El-Shagi et al. (2016) study the effect of the euro adoption on real effective exchange rates to determine misalignments at the start of the global financial crisis.

[11] However, for these countries we report our estimates in the Online Appendix (Tables OA1–OA3), where we stress they must be interpreted with caution.

[12] Seven years corresponds to about one-fourth of the sample period. Lifting this restriction does not change our results. For detailed results contact the authors.

[13] Japan would be in the control group of all EMU members but we excluded it for two reasons. First and foremost, an extensive literature documents that the economic downturn of the 1990s and the subsequent output stagnation were due to changes in the operating procedures for monetary policies (Canova and Menz, 2010; Inoue and Okimoto, 2008; Krugman, 1998). Inoue and Okimoto (2008) find evidence of a structural break in 1996 due to changes in the conduct of Japanese monetary policy. Second, the Kobe earthquake in 1995 caused a persistent and widening drop in the GDP of the Hyogo Prefecture (Du Pont and Noy, 2015), which accounted for 3.8%-4.1% of Japan's total GDP between 1995 and 2006.

Table 3
Predictors: Data sources and baseline periods of averaging by EMU member.

Predictor	Source	Belgium	France	Germany	Ireland	Italy	Netherlands
Real GDP per capita	PWT 7.1	1971–1975 1976–1985 1986–1994	1971–1980 1981–1994	1971–1980 1981–1994	1973–1980 1981–1994	1971–1980 1981–1994	1971–1980 1981–1994
Inflation rate, GDP deflator	WDI	1991–1994	1991–1994	1991–1994	1986–1994	1986–1990	1991–1994
Industry share of value added	WDI	1986–1994	1971–1980	1986–1994	1986–1994	1981–1994	1976–1994
Investment to GDP	WDI	1981–1994	1986–1994	1986-1990	1976–1985	1986–1990	1971–1994
Secondary education	Barro-Lee	1991–1994	1971–1994	1991–1994	1973–1980	1981–1994	1991–1994
Trade openness	WDI and CEPII	1986–1991	1979–1994	1986–1994	1986–1990	1986–1994	1986– 1994

Note. Investment to GDP is: Gross capital formation as a percentage of GDP. Secondary Education is the percentage of total population aged 25+ that has attained secondary schooling (Barro and Lee, 2013). Trade Openness is: Total trade in goods and services as a percentage of GDP. WDI stands for World Development Indicators. CEPII stands for for Centre d'Études Prospectives et d'Informations Internationales.

shocks during the sample period.[14] It includes: Australia, Benin, Bahrain, Barbados, Botswana, Canada, Costa Rica, Gabon, Korea, Sri Lanka, Morocco, Mauritius, Malaysia, Norway, New Zealand, Singapore, South Africa, Switzerland, Tonga, Trinidad and Tobago, USA.

Table A1 in Appendix A. reports sample averages for all treated countries and control groups during the pre-treatment period. By construction, the baseline control group matches the average income per capita of the treated country more closely than the common control groups. It also does the same on most of the remaining predictors' averages. Together with our concerns of interpolation biases and overfitting, this explains why the baseline control group is our preferred.

3.2.2. Sample Period

We use annual country-level data from the year a country joined the EMU up to 2007 to exclude the global financial and Eurozone crises. We do not consider the post-crises period for two reasons. First, the global financial crisis might have caused structural changes in the economies most affected by it. This implies that the economic evolution of a synthetic control unit might no longer represent that of the corresponding EMU member. In addition, the effects of the global financial crisis were compounded by the Eurozone crisis, implying that treated and control countries in our sample were exposed to different types of shocks after 2007.

Even though the creation of the euro was officially announced in 1998, most EMU countries took actions to meet the Maastricht requirements before that. To account for anticipation effects we consider 1995 as the treatment date. Thus, for all the EMU members in our sample we have a pre-intervention period of 26 years, except for Ireland whose pre-intervention period is 23 years long. A pre-intervention period of more than 20 years is standard in the literature. It is long enough so that matching on pre-intervention outcomes allows heterogeneous responses to unobserved factors, including EC/EMU membership, to be controlled for. Since our study ends in 2007, post-intervention periods are more than a decade long.

In Section 3.4.2 we show how robust our estimates are to changing the sample starting date to 1981, and the treatment date to 1994 or 1996, and 1998.

3.2.3. Data

Our outcome of interest, Y_{jt}, is real GDP per capita. The real GDP per capita data we use are from the Penn World Tables version 7.1 (PWT 7.1), they are PPP-adjusted and measured in 2005 international dollars. As in ADH (2015), the pre-euro characteristics in X_{it} include the following predictors of economic growth: per capita real GDP, inflation rate, industry share of value added, investment share of GDP, secondary education and trade openness. Table 3 reports the data source for each predictor and, for each EMU member, the pre-intervention periods over which predictors are averaged in the baseline to minimize RMSPEs and the likelihood of interpolation biases.

In Section 3.4.2 we check how robust our estimates are when we consider predictors' averages over the full pre-treatment period. We also consider a specification that adds countries' financial and migration openness, unemployment rate, volatility of inflation and government debt as predictors. We use the Chinn-Ito index to measure a country's degree of financial openness (Chinn and Ito, 2006).[15] Data on migration openness (International migrants stock, % of population) and unemployment are from the World Development Indicators (WDI). Data on inflation and debt to GDP are taken from the International Financial Statistics (IFS). We use monthly data on inflation to construct annual measures of volatility. For Australia and New Zealand the volatility of inflation is calculated using quarterly data due to data availability.

3.3. Baseline Results

The first column of Panel A in Tables 4–9 show the baseline results for each EMU member, respectively. The first row in this column lists the countries that contribute with a positive weight to the synthetic control unit of the corresponding

[14] To identify this control group we started from the set of countries we have good data on baseline predictors. We then dropped all countries that experienced wars, changes in political regimes, transition, and repeated deep economic crises as identified in the dataset assembled by Reinhart and Rogoff (2009).

[15] This index is now available for 182 countries between 1970 and 2015. It can be downloaded at: http://web.pdx.edu/~ito/Chinn-Ito_website.htm

Table 4
Results for Belgium.

Panel A. Results for Belgium: Different control groups				
	Baseline (1)	Baseline w/o USA (2)	Industrial countries (3)	All (4)
Control countries with positive weights	Bahrain (0.079) Barbados (0.172) Canada (0.167) Singapore (0.389) USA (0.192)	Bahrain (0.091) Barbados (0.191) Canada (0.223) Norway (0.118) Singapore (0.376)	Canada (0.326) New Zealand (0.199) Singapore (0.322) Switzerland (0.153)	Barbados (0.158) Botswana (0.016) Costa Rica (0.004) Mauritius (0.007) Singapore (0.277) Trinidad and Tobago (0.098) USA (0.440)
RMSPE	481.11	485.6	591.06	549.0
Difference in Real GDP per capita pre-intervention:				
$ (μ)	23.359	26.418	−14.161	0.710
% of EMU member's RGDP p.c. (μ)	0.093	0.066	−0.097	−0.060
Difference in Real GDP per capita post-intervention:				
$ (μ)	−2424.17	−2435.67	−1714.39	−2222.51
% of EMU member's RGDP p.c.(μ)	−7.498	−7.536	−5.261	−6.8357
$P(\frac{R^c_{post}}{R^c_{pre}}) \geq P(\frac{R^{BEL}_{post}}{R^{BEL}_{pre}})$	1/9	1/8	2/8	2/22

Panel B. Other results for Belgium					
	Average pre-1995 (1)	Add predictors (2)	$T_0 = 1996$ (3)	$T_0 = 1998$ (4)	Start 1981 (5)
Control countries with positive weights	Bahrain (0.098) Canada (0.239) New Zealand (0.130) Singapore (0.296) USA (0.238)	Bahrain (0.086) Barbados (0.177) Canada (0.161) Singapore (0.386) USA (0.189)	Bahrain (0.077) Barbados (0.156) Canada (0.179) New Zealand (0.03) Singapore (0.369) USA (0.189)	Bahrain (0.075) Barbados (0.091) Canada (0.466) New Zealand (0.037) Singapore (0.303) USA (0.028)	Barbados (0.319) New Zealand (0.038) Singapore (0.416) USA (0.227)
RMSPE	532.31	475.44	509.47	569.78	538.11
Difference in Real GDP per capita pre-intervention:					
$ (μ)	−23.811	17.284	−8.285	−10.968	9.426
% of EMU member's RGDP p.c.(μ)	−0.141	0.021	−0.049	−0.098	0.039
Difference in Real GDP per capita post-intervention:					
$ (μ)	−2087.90	−2277.64	−2326.04	−1616.33	−2483.00
% of EMU member's RGDP p.c. (μ)	−6.437	−7.038	−7.142	−4.817	−7.701
$P(\frac{R^c_{post}}{R^c_{pre}}) \geq P(\frac{R^{BEL}_{post}}{R^{BEL}_{pre}})$	1/9	1/9	1/9	1/9	1/9

Note. RMSPE stands for Root Mean Square Prediction Error, c refers to any country in the relevant control group, and *BEL* stands for Belgium. μ indicates the mean over a period. Control groups in Panel A are detailed below. The control group in Panel B is the Baseline. The specification "Add Predictors" adds to the Baseline predictors: Financial and migration openness, unemployment rate, volatility of inflation and government debt (% of GDP). T_0 is the treatment date.
Baseline: Australia, Bahrain, Barbados, Canada, Norway, New Zealand, Singapore and USA.
Baseline w/o USA: Australia, Bahrain, Barbados, Canada, Norway, New Zealand and Singapore.
Industrial countries: Australia, Canada, New Zealand, Norway, Singapore, Switzerland and USA.
All: Australia, Benin, Bahrain, Barbados, Botswana, Canada, Costa Rica, Gabon, Korea, Sri Lanka, Morocco, Mauritius, Malaysia, Norway, New Zealand, Singapore, South Africa, Switzerland, Tonga, Trinidad and Tobago, and USA.

EMU member. Each synthetic unit we obtain is a convex combination of four to six countries. Bahrain, Gabon, and Trinidad and Tobago take on positive weights whenever they belong to an EMU member control group.[16] In contrast, Australia consistently takes on a zero weight. Table A2 compares the pre-treatment characteristics of each member with those of its synthetic control. In general, the synthetic control unit matches the characteristics of the corresponding treated country quite closely and better than the simple average in the control group.

[16] Our results are robust to the omission of any of these countries from the relevant control group. These results are available upon request.

Table 5
Results for France.

Panel A. Results for France: Different control groups					
	Baseline (1)	Baseline w/o USA (2)	Baseline w/o Norway (3)	Industrial countries (4)	All
Control countries with positive weights	Bahrain (0.08) Barbados (0.152) New Zealand (0.190) Norway (0.182) Singapore (0.289) USA (0.107)	Bahrain (0.045) Barbados (0.161) Canada (0.344) New Zealand (0.083) Norway (0.086) Singapore (0.281)	Canada (0.541) Bahrain (0.063) Barbados (0.097) New Zealand (0.028) Singapore (0.271)	Canada (0.320) New Zealand (0.352) Norway (0.143) Singapore (0.146) Switzerland (0.04)	Benin (0.174) Norway (0.307) Switzerland (0.107) Trinidad and Tobago (0.083) USA (0.328)
RMSPE	586.90	484.86	446.69	598.76	490.45
Difference in Real GDP per capita pre-intervention:					
\$ (μ)	29.450	1.282	−2.803	−22.710	9.237
% of EMU member's	0.094	−0.159	−0.031	−0.186	−0.001
Difference in real GDP per capita post-intervention:					
\$ (μ)	−4388.27	−3861.58	−3428.29	−3338.66	−2852.35
% of EMU member's RGDP p.c. (μ)	−14.717	−12.899	−11.408	−11.144	−9.549
$P(\frac{R^c_{post}}{R^c_{pre}}) \geq P(\frac{R^{FRA}_{post}}{R^{FRA}_{pre}})$	1/9	1/8	1/8	1/8	1/22
Panel B. Other results for France					
	Average pre-1995 (1)	Add redictors (2)	$T_0 = 1994$ (3)	$T_0 = 1998$ (4)	Start 1981 (5)
Control countries with positive weights	Bahrain (0.046) Barbados (0.155) New Zealand (0.293) Norway (0.285) Singapore (0.222)	Bahrain (0.084) Barbados (0.161) New Zealand (0.180) Norway (0.174) Singapore (0.286) USA (0.115)	Bahrain (0.087) Barbados (0.184) New Zealand (0.087) Norway (0.238) Singapore (0.367) USA (0.036)	Canada (0.190) New Zealand (0.409) Norway (0.095) Singapore (0.117) USA (0.189)	Barbados (0.284) New Zealand (0.269) Norway (0.166) Singapore (0.185) USA (0.096)
RMSPE	613.19	535.91	387.72	704.69	552.93
Difference in Real GDP per capita pre-intervention:					
\$ (μ)	−42.314	−35.456	138.050	−11.220	18.816
% of EMU member's	−0.295	−0.239	0.746	−0.739	−0.654
Difference in Real GDP per capita post-intervention:					
\$ (μ)	−4283.53	−4306.17	−5339.49	−3434.64	−3158.14
% of EMU member's RGDP p.c. (μ)	−14.376	−14.442	−18.018	−11.220	−10.584
$P(\frac{R^c_{post}}{R^c_{pre}}) \geq P(\frac{R^{FRA}_{post}}{R^{FRA}_{pre}})$	1/9	1/9	1/9	1/9	1/9

Note. RMSPE stands for Root Mean Square Prediction Error, *c* refers to any country in the relevant control group, and *FRA* stands for France. μ indicates the mean over a period. Control groups in Panel A are detailed below. The control group in Panel B is the Baseline. The specification "Add Predictors" adds to the Baseline predictors: Financial and migration openness, unemployment rate, volatility of inflation and government debt (% of GDP). T_0 is the treatment date.
Baseline: Australia, Bahrain, Barbados, Canada, Norway, New Zealand, Singapore and USA.
Baseline w/o USA: Australia, Bahrain, Barbados, Canada, Norway, New Zealand and Singapore.
Industrial Countries: Australia, Canada, New Zealand, Norway, Singapore, Switzerland and USA.
All: Australia, Benin, Bahrain, Barbados, Botswana, Canada, Costa Rica, Gabon, Korea, Sri Lanka, Morocco, Mauritius, Malaysia, Norway, New Zealand, Singapore, South Africa, Switzerland, Tonga, Trinidad and Tobago, and USA.

Fig. 1 shows the trends in real GDP per capita of each EMU member and its synthetic counterpart from the beginning of the sample period until 2007. The real GDP per capita of each EMU member follows very closely the real GDP per capita of its synthetic counterpart until 1995. This is further confirmed by the values of the root MSPE (RMSPE) and pre-euro gaps in income per-capita, which are reported in the second and third row of Panel A in Tables 4–9, respectively. In the baseline, the average gap in per capita incomes during the pre-euro period amounted to less than one percent of the relevant EMU member per capita income for all the EMU members but Ireland. Even though its synthetic counterpart does not track Ireland's real GDP per capita as closely as that of the other EMU members, the pre-treatment percentage gap is estimated to be less than 1.3 percent, on average.

As shown in Fig. 1, the trends in the real per capita GDPs of each EMU member and its synthetic counterpart diverge after 1995. The fourth row of Panel A in Tables 4–9 summarize the average gaps in income per-capita of each EMU member

Table 6
Results for Germany

Panel A. Results for Germany: Different control groups				
	Baseline (1)	Baseline w/o USA (2)	Industrial countries (3)	All (4)
Control countries with positive weights	Bahrain (0.070) Canada (0.291) New Zealand (0.123) Singapore (0.253) USA (0.263)	Bahrain (0.054) Canada (0.572) New Zealand (0.089) Norway (0.059) Singapore (0.225)	Australia (0.152) Canada (0.558) New Zealand (0.096) Singapore (0.182) USA (0.012)	Botswana (0.133) Gabon (0.045) Norway (0.195) Trinidad and Tobago (0.08) USA (0.547)
RMSPE	315.71	362.33	394.96	323.16
Difference in Real GDP per capita pre-intervention:				
\$ (μ)	−41.847	30.635	−18.704	−14.241
% of EMU member's	−0.206	0.1578	−0.087	−0.095
Difference in Real GDP per capita post-intervention:				
\$ (μ)	−3217.58	−2756.35	−2805.54	−2404.48
% of EMU member's RGDP p.c. (μ)	−10.203	−8.695	−8.852	−7.606
$P(\frac{R^c_{post}}{R^c_{pre}}) \geq P(\frac{R^{DEU}_{post}}{R^{DEU}_{pre}})$	1/9	1/8	1/8	1/22

Panel B. Other results for Germany					
	Average pre-1995 (1)	Add predictors (2)	$T_0 = 1996$ (3)	$T_0 = 1998$ (4)	Start 1981 (5)
Control countries with positive weights	Bahrain (0.089) Canada (0.476) Singapore (0.250) USA (0.185)	Australia (0.214) Bahrain (0.070) Canada (0.410) Singapore (0.250) USA (0.058)	Bahrain (0.056) Canada (0.333) New Zealand (0.139) Singapore (0.231) USA (0.241)	Bahrain (0.042) Canada (0.601) New Zealand (0.105) Singapore (0.207) USA (0.045)	Australia (0.308) Bahrain (0.052) New Zealand (0.111) Singapore (0.220) USA (0.309)
RMSPE	456.62	270.79	331.01	395.79	419.77
Difference in Real GDP per capita pre-intervention:					
\$ (μ)	−255.28	−26.186	91.718	−11.356	−226.44
% of EMU member's	−1.274	−0.1206	0.2301	−0.061	−0.934
Difference in Real GDP per capita post-intervention:					
\$ (μ)	−3668.89	−3187.87	−3251.51	−2872.29	−4175.76
% of EMU member's RGDP p.c. (μ)	−11.688	−11.041	−10.288	−8.991	−13.314
$P(\frac{R^c_{post}}{R^c_{pre}}) \geq P(\frac{R^{DEU}_{post}}{R^{DEU}_{pre}})$	1/9	1/9	1/9	1/9	1/9

Note. RMSPE stands for Root Mean Square Prediction Error, c refers to any country in the relevant control group, and *DEU* stands for Germany. μ indicates the mean over a period. Control groups in Panel A are detailed below. The control group in Panel B is the Baseline. The specification "Add Predictors" adds to the Baseline predictors: Financial and migration openness, unemployment rate, volatility of inflation and government debt (% of GDP). T_0 is the treatment date.
Baseline: Australia, Bahrain, Barbados, Canada, Norway, New Zealand, Singapore and USA.
Baseline w/o USA: Australia, Bahrain, Barbados, Canada, Norway, New Zealand and Singapore.
Industrial Countries: Australia, Canada, New Zealand, Norway, Singapore, Switzerland and USA.
All: Australia, Benin, Bahrain, Barbados, Botswana, Canada, Costa Rica, Gabon, Korea, Sri Lanka, Morocco, Mauritius, Malaysia, Norway, New Zealand, Singapore, South Africa, Switzerland, Tonga, Trinidad and Tobago, and USA.

and its synthetic control during the post-intervention period. Belgium, France, Germany and Italy are estimated to have lost from adopting the euro. More specifically, according to our baseline estimates, their income per capita would have been, on average, between 7.5 and 16.3 percentage points higher had they not adopted the euro.[17] In contrast, both the Netherlands and Ireland are estimated to have gained from adopting the euro, with Ireland having experienced 23.4 percent higher real income per capita, on average, than it would have had without the euro.

Recall that the RMSPE provides a measure of the gap in the outcome variable of interest between each EMU member and its synthetic counterpart. So, a helpful measure to gauge the size of the income gap post-intervention relative to the

[17] Manasse et al. (2013) find that both Italy and Germany have lost from the euro but only a little. The difference in findings is probably due to the choice of the control group. In Manasse et al. (2013) the synthetic control unit of Italy includes Sweden, the UK and Turkey, that of Germany includes Switzerland, Denmark and Japan. Except for Switzerland, our control groups do not include any of these countries for reasons explained in subsection 3.2.1 and note 13.

Table 7
Results for Ireland

Panel A. Results for Ireland: Different control groups			
	Baseline (1)	Industial countries (2)	All (3)
Control countries with positive weights	Gabon (0.301) New Zealand (0.061) Singapore (0.475) Trinidad and Tobago (0.162)	New Zealand (0.576) Singapore (0.424)	Benin (0.128) Barhain (0.072) Botwana (0.144) Morocco (0.140) Singapore (0.141)) USA (0.375)
RMSPE	941.91	3194.96	590.03
Difference in Real GDP per capita pre-intervention:			
\$ (μ)	−169.37	−2983.72	0.293
% of EMU member's	−1.282	−19.382	−0.181
Difference in Real GDP per capita post-intervention:			
\$ (μ)	8472.20	3740.28	10281.54
% of EMU member's RGDP p.c. (μ)	23.406	9.174	28.677
$P(\frac{R^c_{post}}{R^c_{pre}}) \geq P(\frac{R^{IRL}_{post}}{R^{IRL}_{pre}})$	1/5	6/8	1/22

Panel B. Other results for Ireland					
	Average pre-1995 (1)	Add predictors (2)	$T_0 = 1994$ (3)	$T_0 = 1998$ (4)	Start 1981 (5)
Control countries with positive weights	Gabon (0.157) New Zealand (0.209) Singapore (0.365) Trinidad and Tobago (0.269)	Gabon (0.302) New Zealand (0.062) Singapore (0.474) Trinidad and Tobago (0.162)	Gabon (0.298) New Zealand (0.065) Singapore (0.479) Trinidad and Tobago (0.158)	Gabon (0.299) New Zealand (0.067) Singapore (0.474) Trinidad and Tobago (0.160)	Gabon (0.388) New Zealand (0.401) Singapore (0.211)
RMSPE	1252.53	942.00	956.46	926.63	1014.92
Difference in Real GDP per capita pre-intervention:					
\$ (μ)	−686.12	−182.71	−205.07	1.599	33.024
% of EMU member's	−5.153	−1.375	−1.542	−0.631	−1.430
Difference in Real GDP per capita post-intervention:					
\$ (μ)	8672.19	8474.15	7686.43	10472.77	11830.02
% of EMU member's RGDP p.c. (μ)	24.314	23.410	21.102	28.357	38.331
$P(\frac{R^c_{post}}{R^c_{pre}}) \geq P(\frac{R^{IRL}_{post}}{R^{IRL}_{pre}})$	1/5	1/5	1/5	1/5	1/5

Note. RMSPE stands for Root Mean Square Prediction Error, *c* refers to any country in the relevant control group, and *IRL* stands for Ireland. μ indicates the mean over a period. Control groups in Panel A are detailed below. The control group in Panel B is the Baseline. The specification "Add Predictors" adds to the Baseline predictors: Financial and migration openness, unemployment rate and government debt (% of GDP). T_0 is the treatment date.
Baseline: Gabon, New Zealand, Singapore, and Trinidad and Tobago.
Industrial Countries: Australia, Canada, New Zealand, Norway, Singapore, Switzerland and USA.
All: Australia, Benin, Bahrain, Barbados, Botswana, Canada, Costa Rica, Gabon, Korea, Sri Lanka, Morocco, Mauritius, Malaysia, Norway, New Zealand, Singapore, South Africa, Switzerland, Tonga, Trinidad and Tobago, and USA.

estimated gap pre-intervention is the ratio of post- to pre-intervention RMSPEs. The first column of Table 10 reports the ratio corresponding to each of the EMU members' estimates. With the exception of the Netherlands, the post-1995 RMSPE is at least 5.53 times the pre-1995 RMSPE. The Netherlands has a low post- to pre-intervention RMPSE ratio, mostly driven by the small estimated income gains post-1995.

In order to determine the significance of our baseline estimates, in the first set of placebo tests we reassign the euro adoption date to a year other than 1995. To conduct these tests we re-estimate each model for the case when adoption of the euro is reassigned to 1987. We use the same control groups and lag the predictors to minimize economic differences with the relevant EMU country during the pre-treatment period. Fig. 2 shows the trends in real GDP per capita of each EMU member and its synthetic counterpart from the beginning of the sample period until 1995, when the treatment year is moved to 1987. For all countries except the Netherlands, the estimated income gaps post-1987 do not appear large relative to the income gaps pre-1987. More importantly, glancing over Figs. 1 and 2 the estimated intervention effect when the treatment date is set to 1987 appears much smaller than the one estimated using the effective intervention date. To verify

Table 8
Results for Italy

Panel A. Results for Italy: Different control groups					
	Baseline (1)	Baseline w/o USA (2)	Industrial countries (3)	All (4)	
Control countries with positive weights	Canada (0.334) New Zealand (0.151) Singapore (0.383) Trinidad and Tobago (0.055) USA (0.077)	Canada (0.376) New Zealand (0.208) Norway (0.022) Singapore (0.374) Trinidad and Tobago (0.020)	Canada (0.031) New Zealand (0.443) Norway (0.213) Singapore (0.313)	Gabon(0.001) Korea (0.194) Morocco (0.121) Norway (0.211) USA (0.473)	
RMSPE	564.43	555.42	724.29	559.24	
Difference in Real GDP per capita pre-intervention:					
\$ (μ)	−15.985	−9.857	−87.764	−4.178	
% of EMU member's	−0.127	−0.122	−0.659	−0.094	
Difference in Real GDP per capita post-intervention:					
\$ (μ)	−4733.99	−4589.18	−4403.10	−3825.50	
% of EMU member's RGDP p.c. (μ)	−16.301	−15.808	−15.181	−13.227	
$P(\frac{R^c_{post}}{R^c_{pre}}) \geq P(\frac{R^{ITA}_{post}}{R^{ITA}_{pre}})$	1/9	1/8	1/8	1/22	
Panel B. Other results for Italy					
	Average re-1995 (1)	Add predictors (2)	$T_0 = 1996$ (3)	$T_0 = 1998$ (4)	Start 1981 (5)
Control countries with positive weights	New Zealand (0.227) Singapore (0.372) Trinidad and Tobago (0.084) USA (0.317)	Canada (0.428) New Zealand (0.165) Singapore (0.377) Trinidad and Tobago (0.029)	Canada (0.345) New Zealand (0.187) Singapore (0.361) Trinidad and Tobago (0.052) USA (0.055)	Canada (0.345) New Zealand (0.187) Singapore (0.361) Trinidad and Tobago (0.052) USA (0.55)	Australia (0.398) New Zealand (0.320) Singapore (0.214) USA (0.068)
RMSPE	652.33	542.13	635.76	635.75	700.59
Difference in Real GDP per capita pre-intervention:					
\$ (μ)	−36.197	−20.208	−25.859	−202.33	−34.173
% of EMU member's	−0.306	−0.168	−0.223	−0.874	−0.257
Difference in Real GDP per capita post-intervention:					
\$ (μ)	−4949.66	−4527.76	−4521.94	−4944.67	−4051.62
% of EMU member's RGDP p.c. (μ)	−17.069	−15.584	−15.498	−16.795	−13.966
$P(\frac{R^c_{post}}{R^c_{pre}}) \geq P(\frac{R^{ITA}_{post}}{R^{ITA}_{pre}})$	1/9	1/9	1/9	1/9	1/9

Note. RMSPE stands for Root Mean Square Prediction Error, *c* refers to any country in the relevant control group, and *ITA* stands for Italy. μ indicates the mean over a period. Control groups in Panel A are detailed below. The control group in Panel B is the Baseline. The specification "Add Predictors" adds to the Baseline predictors: Financial and migration openness, unemployment rate, volatility of inflation and government debt (% of GDP). T_0 is the treatment date.
Baseline: Australia, Barbados, Canada, Norway, New Zealand, Singapore, Trinidad and Tobago, and USA.
Baseline w/o USA: Australia, Barbados, Canada, Norway, New Zealand, Singapore, and Trinidad and Tobago.
Industrial Countries: Australia, Canada, New Zealand, Norway, Singapore, Switzerland and USA.
All: Australia, Benin, Bahrain, Barbados, Botswana, Canada, Costa Rica, Gabon, Korea, Sri Lanka, Morocco, Mauritius, Malaysia, Norway, New Zealand, Singapore, South Africa, Switzerland, Tonga, Trinidad and Tobago, and USA.

that this is the case, Table 10 reports, for each EMU member, the ratio of post- to pre-treatment RMSPE when the intervention is assigned to 1987 next to the same ratio when the intervention year is 1995. With the exception of the Netherlands, all other EMU members have a much lower ratio of RMPSE when the treatment is assigned to 1987 instead of 1995. Put another way, for these countries, our 1987 placebo euro adoption does not have a sizeable effect. This provides evidence in favor of the fact that our estimates in Fig. 1 do pick up the effect of the euro adoption on the income per capita of Belgium, France, Germany, Ireland and Italy.[18] In contrast, the results for the Netherlands imply that the estimated gains from the euro adoption in Fig. 1 might not be significant.

[18] We obtain similar conclusions if we move the euro adoption year to 1985 and 1989, except for Italy in 1985. Results are available upon request.

Table 9
Results for the Netherlands

Panel A. Results for the Netherlands: Different control groups

	Baseline (1)	Baseline w/o USA (2)	Baseline w/o CHE (3)	Industrial countries (4)	All (5)
Control countries with positive weights	Bahrain (0.130) Barbados (0.189) New Zealand (0.018) Singapore (0.160) USA (0.503)	Bahrain (0.177) Barbados (0.301) Norway (0.357) Singapore (0.165)	Bahrain (0.169) Barbados (0.157) Singapore (0.159) USA (0.515)	Canada (0.279) New Zealand (0.201) Singapore (0.183) Switzerland (0.337)	Bahrain (0.146) Barbados (0.140) Costa Rica (0.023) Singapore (0.141) Switzerland (0.011) USA (0.539)
RMSPE	545.26	638.03	537.96	769.11	520.84
Difference in Real GDP per capita pre-intervention:					
\$ (μ)	−10.293	−4.645	−89.254	−8.242	−17.037
% of EMU member's	−0.098	−0.154	−0.447	−0.085	−0.202
Difference in Real GDP per capita post-intervention:					
\$ (μ)	434.70	80.340	487.45	1334.42	1119.15
% of EMU member's RGDP p.c. (μ)	1.287	0.245	1.438	3.888	3.265
$P(\frac{R^c_{post}}{R^c_{pre}}) \geq P(\frac{R^{NLD}_{post}}{R^{NLD}_{pre}})$	7/10	6/9	7/9	4/8	16/22

Panel B. Other Results for the Netherlands

	Average pre-1995 (1)	Add predictors (2)	$T_0 = 1996$ (3)	$T_0 = 1998$ (4)	Start 1981 (5)
Control countries with positive weights	Bahrain (0.161) Barbados (0.137) Singapore (0.216) Switzerland (0.108) USA (0.378)	Bahrain (0.154) Barbados (0.140) New Zealand (0.026) Singapore (0.159) Switzerland (0.006) USA (0.515)	Bahrain (0.128) Barbados (0.221) New Zealand (0.002) Singapore (0.168) USA (0.480)	Bahrain (0.128) Barbados (0.221) New Zealand (0.002) Singapore (0.168) USA (0.480)	Australia (0.139) Barbados (0.316) Singapore (0.298) Switzerland (0.247)
RMSPE	524.65	523.08	549.94	549.94	363.89
Difference in Real GDP per capita pre-intervention:					
\$ (μ)	−94.99	−5.237	48.033	71.103	−27.679
% of EMU member's	−0.473	−0.066	0.111	0.189	−0.095
Difference in Real GDP per capita post-intervention:					
\$ (μ)	584.35	411.02	622.86	675.53	−338.14
% of EMU member's RGDP p.c. (μ)	1.713	1.219	1.817	1.947	−0.922
$P(\frac{R^c_{post}}{R^c_{pre}}) \geq P(\frac{R^{NLD}_{post}}{R^{NLD}_{pre}})$	5/10	6/10	6/10	5/10	5/10

Note. RMSPE stands for Root Mean Square Prediction Error, c refers to any country in the relevant control group, and *NLD* stands for the Netherlands. μ indicates the mean over a period. Control groups in Panel A are detailed below. The control group in Panel B is the Baseline. The specification "Add Predictors" adds to the Baseline predictors: Migration openness, unemployment rate, volatility of inflation and government debt (% of GDP). T_0 is the treatment date.
Baseline: Australia, Bahrain, Barbados, Canada, Norway, New Zealand, Singapore, Switzerland and USA.
Baseline w/o USA: Australia, Bahrain, Barbados, Canada, Norway, New Zealand, Singapore, Switzerland.
Baseline w/o CHE: Australia, Bahrain, Barbados, Canada, Norway, New Zealand, Singapore and USA.
Industrial Countries: Australia, Canada, New Zealand, Norway, Singapore, Switzerland and USA.
All: Australia, Bahrain, Barbados, Canada, Gabon, Norway, New Zealand, Singapore, Switzerland, Trinidad and Tobago, and USA.

Table 10
Ratio of post- to pre-intervention RMSPEs

	Intervention Year	
	1995	1987
Belgium	5.531	1.533
France	7.878	4.285
Germany	11.601	4.685
Ireland	10.083	1.348
Italy	9.449	4.700
Netherlands	1.450	4.252

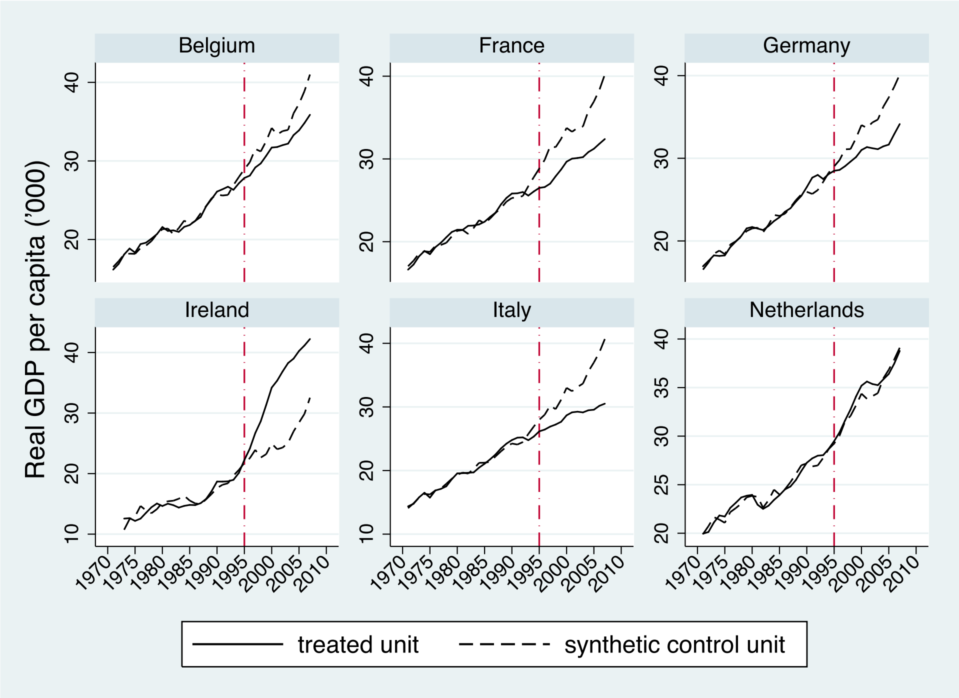

Fig. 1. Real GDP per capita: Treated vs. synthetic control unit. **Note.** The vertical line corresponds to 1995, our baseline treatment year.

In addition, we conduct placebo tests that consist of reassigning the euro adoption to any of the countries in the baseline control group of the relevant EMU member and applying the synthetic control method to obtain intervention effects for countries that did not adopt the euro. If the estimated effect of the euro for a EMU member is greater than any of the synthetic estimated effects for its control countries, we take the estimated EMU member loss or gain as significant.

To compare estimated intervention effects across units, Fig. 3 reports the ratios of the post- to pre-euro RMSPEs for each EMU member and the corresponding control countries. The advantage of using this ratio is that it can also be calculated for countries with pre-1995 GDP per capita values that are not tracked well by their synthetic counterpart. Belgium's post-euro RMSPE is 5.53 times larger than its pre-euro RMSPE. This ratio is higher than any of the post- to pre-euro RMSPEs ratios obtained for Belgium's control countries. In other words, if one were to pick a country at random from Belgium's sample, the probability of observing a ratio as high as the one of Belgium would be 1/9, i.e., 0.11. These probabilities in the baseline are reported in the last row of Panel A in Tables 4–9. All the remaining EMU members except the Netherlands, turn out to have post- to pre-euro RMSPE ratios that are far higher than the ones found for their control countries. This supports the significance of our estimates of the euro effect on the income per capita of Belgium, France, Germany, Ireland and Italy.

The placebo in-space results for the Netherlands, instead, imply that if one were to pick a country at random from its sample, the probability of observing a ratio as high as the one of the Netherlands would be 7/10, or 0.7. The estimated gains from the euro for the Netherlands cannot be taken as significant.

3.4. Robustness

Tables 4–9 report the results of a number of robustness exercises we conduct for Belgium, France, Germany, Ireland, Italy and the Netherlands, respectively. Panel A in each of these Tables shows, in addition to the baseline results, our estimates for alternative control groups. Panel B shows the sensitivity of our baseline estimates to changes in the specification and pre-treatment period.

3.4.1. Alternative Control Groups

For all EMU members, except Ireland,[19] we re-estimate the income effects of the euro when the control group excludes the USA. This robustness check is important to undertake for two reasons. First, one might worry that the U.S. economy was substantially affected by the creation of the Eurozone and that considering it as a control country violates the assumption of no structural breaks in control countries underlying the synthetic control method. The induced change in the composition of other countries' total reserves might have affected the dollar and economic activity in the USA. Second, the USA takes

[19] The USA is not in the baseline control group of Ireland.

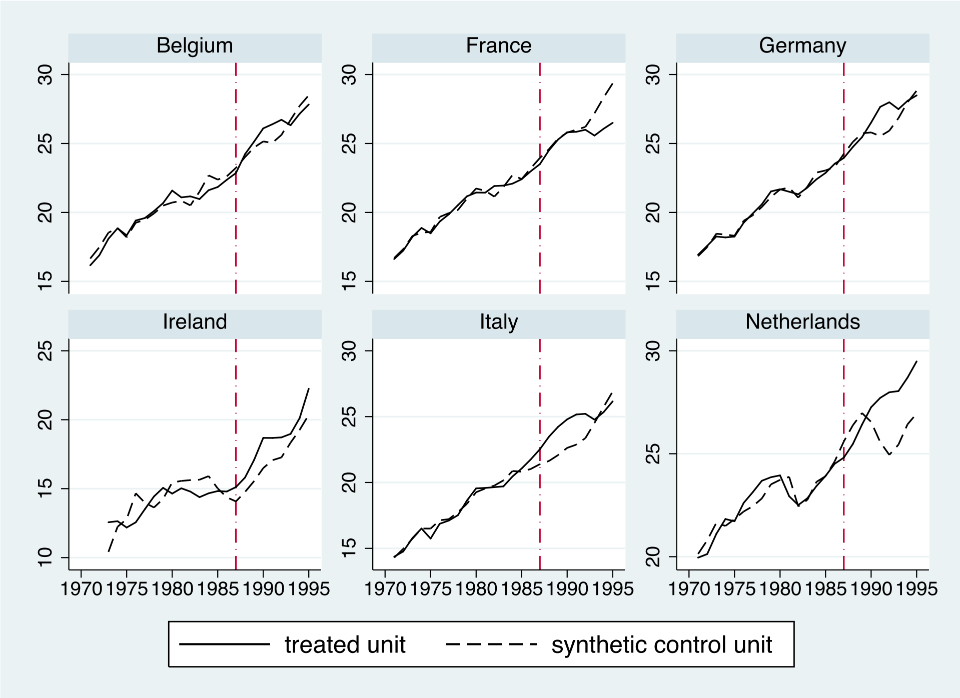

Fig. 2. Results of placebo in time tests. **Note.** The vertical line corresponds to 1987, which is the year we reassign the treatment to.

on positive weights in all synthetic control units it can potentially contribute to. Column (2) in Panel A of Tables 4–6 and 8–9 report our estimates without the USA in the baseline control group. The baseline results are robust and, for some EMU members, the RMSPE improves.

Norway belongs only to the synthetic control unit of France. As the euro share of invoicing in Norway's imports increased slightly more than proportionally after the introduction of the euro, Norway's trade balance exposure to changes in the exchange rate increased too, making Norway more likely to import inflation in the case of a krone devaluation. To ensure this has no bearing on our estimates for France, column (3) in Panel A of Table 5 reports our estimates when Norway is removed from the control group of France. The estimated losses from the euro reduce, on average, and, according to our placebo tests, should be taken as significant.[20]

Switzerland belongs to the synthetic control unit of the Netherlands. One might argue that we should not consider Switzerland as a control country because the Swiss National Bank changed the way it conducted monetary policy once the euro was introduced. Column (3) of Panel A in Table 9 shows that our baseline results for the Netherlands are robust to the exclusion of Switzerland as a control country. The RMPSE improves and our estimated income gains for the Netherlands stay statistically insignificant.

The remaining alternative control groups we consider are common among EMU members. The first consists of countries considered industrial following the IMF classification in 1998, for which all data on baseline predictors are available and that did not suffer large shocks during our sample period. The corresponding estimates are reported in Panel A of Tables 4–9 under the heading *Industrial Countries*. The fit of the synthetic control unit worsens for all EMU members, especially for Ireland. Indeed, Ireland was much poorer than most industrial countries in the pre-euro period. Overall, our baseline estimates are robust to this control group except for Ireland and, marginally, for Belgium.

The second common control group consists of 21 countries with available data on baseline predictors and no profound structural shocks during the sample period. Our estimates using this control group are reported in Panel A of Tables 4–9 under the heading *All*. The RMPSE improves for most treated units, estimates of losses become smaller and those of gains larger. Importantly, all our estimates are now significant at least at 9%, with the exception, as before, of the Netherlands.[21]

3.4.2. Other Robustness Checks

Turning now to Panel B of Tables 4–9. Column (1) shows our baseline results are robust when growth predictors are averaged over the full pre-intervention period. Column (2) shows that adding financial and migration openness, unemployment

[20] We get similar results when we drop both Norway and the USA from the control group of France. Results are available upon request.

[21] Results are robust to the exclusion of Korea and Malaysia, which might have been affected by the Asian Financial Crisis.

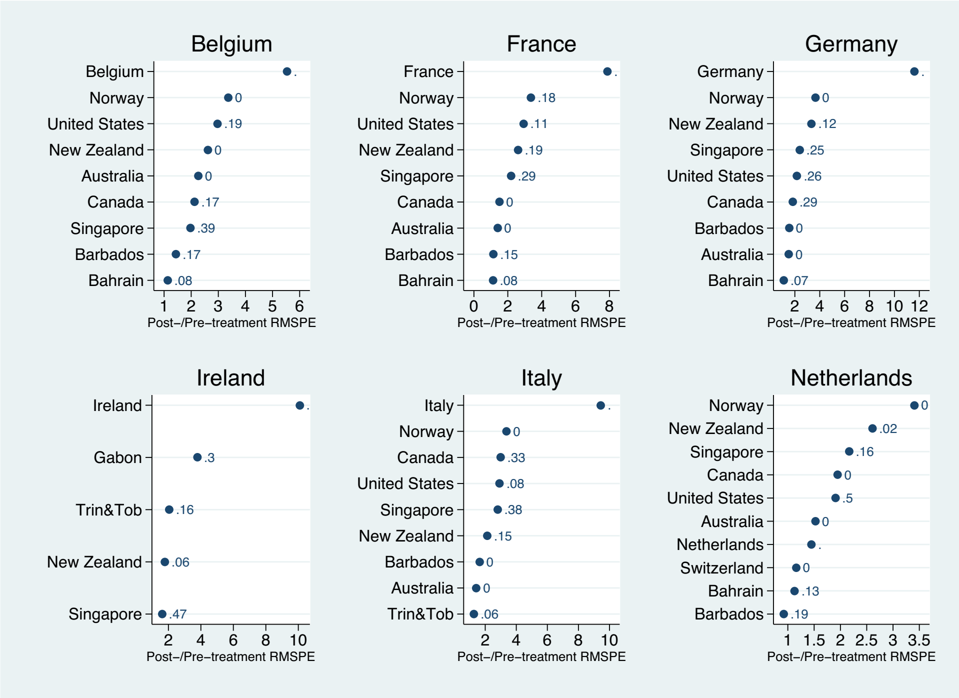

Fig. 3. Results of placebo in space tests.

rate, volatility of inflation and government debt (% of GDP) as growth predictors does not affect our results, even though at times this changes slightly the countries in the synthetic control unit.[22,23]

Columns (3) and (4) present the results we obtain when we move the treatment date to 1994 or 1996, and 1998, which is the year in which the euro was officially announced. Specifically, for each EMU member we move the treatment date to the first year after the first general election around the time the Maastricht Treaty became effective (November 1993), because one might worry that only new governments were willing to adopt the necessary policies to meet the Maastricht Treaty requirements. Italy, Germany and the Netherlands held general elections in 1994, and Belgium in 1995, so we verify our baseline estimates for these countries are robust to moving the treatment date to 1996. For France and Ireland we move the treatment to 1994 as elections were held in both countries in 1992, so anticipation effects might have taken place earlier than 1995.[24] Our results are robust to the choice of the treatment dates.

Finally, column (5) reports our estimates when we restrict the pre-treatment period to start in 1981, which gives us only 15 years for matching pre-intervention characteristics. We believe this might be too short to ensure that matching on pre-intervention outcomes allows heterogeneous responses to unobserved factors to be controlled for. Reassuringly, synthetic control units are not too different from the baseline and our baseline results are robust.[25]

Glancing over rows 4 and 5 of Panels A and B in Tables 4–9, respectively, the magnitude of our estimates varies. Nonetheless, our baseline estimates are quite robust, which suggests that even if they are not of the exact magnitude, they are capturing the income gains and losses from the euro experienced by the EMU members in our sample. Section 4 explores the economic content of our baseline estimates, providing further evidence in this respect.

3.5. Discussion

A key assumption on which the identification of the synthetic estimator rests is that endogeneity is not due to reverse causation. In the context of our application, this is equivalent to ruling out the possibility that countries adopted the euro because they expected it would spur their future economic growth. If synthetic estimates of the intervention effect were

[22] For Ireland and the Netherlands, the specification “Add Predictors” does not include, respectively, volatility of inflation and financial openness. In the case of Ireland that is because of data availability. For the Netherlands, it is because there is no data on the financial openness of Switzerland and we wanted to keep the control group as in the baseline. Dropping Switzerland and adding financial openness as a predictor does not change our estimates for the Netherlands.

[23] Our results are robust when we add to the predictors in “Add Predictors”: The volatility of the real exchange rate, government deficit or wage bargaining coordination. These results are available upon request and are not reported here as specifications vary a lot across EMU members.

[24] We obtain similar results when the treatment date is set to 1993.

[25] In the Online Appendix we perform an additional robustness check. Specifically, Table OA4 shows the robustness of our baseline estimates to fixing the weights of the V matrix to be the same for all treated countries and the control countries in placebo tests. Table OA5 reports the exact V weights we use in this exercise.

affected by endogeneity, our estimated gaps in the cases when the treated unit does better than the synthetic unit would be upward biased, while all the remaining estimated gaps would be downward biased. Having said that, we are not overly concerned that endogeneity is an issue as the literature suggests that euro adopters gave up their national currencies mainly for political reasons. In fact, economic accounts of the costs and benefits of adopting the euro in the 1990s agree that the EMU was not an OCA, it would lead to economic losses for all countries involved and was to be understood mainly as a political phenomenon (Eichengreen and Frieden, 1993; Feldstein, 1997).[26] In other words, even though economic considerations were part of the political discussions at the national level, they were not the main reasons behind the decision to adopt the euro for early adopters.

Alternative explanations for the creation of the EMU come from the political science literature that studies the process of European integration (Sadeh and Verdun, 2009; Spolaore, 2013).[27] The most prominent theory, functionalism, sees the EMU as the result of the process of integration and one of the steps toward deeper political integration. As European countries integrated their goods and capital markets, stable exchange rates at the cost of monetary autonomy became essential. In particular, the functionalist framework considers the process of integration as a sequence of agreements, where each integration phase opens the doors to the next one with the costs of exit increasing exponentially after each step is taken. This functionalist view was especially influential among supranational politicians that contributed to the makings of the EMU. It is not surprising that functionalist arguments appeared in official documents emphasizing the need for a single currency.

Another important assumption of the synthetic method is that the intervention implemented in the treated unit does not affect directly or indirectly the outcomes of the control units. In our context, this is equivalent to ruling out the possibility that a EMU member's decision to adopt the euro affected the income per capita of units in the control group.[28] Changes in trade patterns with non-EMU members brought about by the euro might be of concern in this respect. In fact, changes in bilateral trade are reflected in changes in a country's trade, which can ultimately affect growth. The existing literature estimates that the euro increased bilateral trade between EMU members and non-EMU members by between 0% and 9%, on average.[29] Combining the average estimate of 4.5% with the average share of the baseline control units' trade with an EMU member included in our sample, 3.07%, we find that the euro increased trade of a control unit by 0.14%, on average.[30] Going a step further and taking this estimate together with Frankel and Rose (2002) estimate that a one percent increase in trade increases a country's income per capita growth by one third of a percent, we calculate the euro effect on a baseline control unit's growth to be approximately 0.05%. This effect is not sizeable, and disappears if one considers that more recent studies find no significant effect of the euro on trade with either other EMU members or non-EMU members (Mancini-Griffoli and Pauwels, 2006; Silva and Tenreyro, 2010).[31]

4. Explaining the Aggregate Effects of the Euro

In this section we exploit the insights in the literature on currency unions to evaluate how our synthetic estimates of the gains and losses from the euro relate to the economic determinants of the costs and benefits of monetary unions. This type of exercise allows us to further verify the economic content and significance of our synthetic estimates.

4.1. Costs and Benefits of Monetary Unions

In a series of seminal papers by Kenen (1969), McKinnon (1963), Mundell (1961) and Ingram (1973), these authors investigate the key characteristics that define an OCA. An important insight of this early literature is that when a country gives up its currency and joins a monetary union, it is essentially abandoning its autonomous monetary policy. As a result, this country imposes a cost on itself in its ability to respond to external shocks. The more likely a country is to be hit by asymmetric shocks, the less likely it is that it will benefit from having a common currency.[32] For instance, countries with less diversified output structures experience more asymmetric shocks, thus they are less suited to be part of a monetary union Kenen (1969).

[26] We refer the reader to Lane (2006) who provides a more recent account of the real effects of the EMU.

[27] Sadeh and Verdun (2009) provide a review of the literature on the explanations behind the creation of the EMU. Spolaore (2013) provides a political guide on European integration for economists.

[28] This is distinct to ruling out the possibility that the creation of the Eurozone affected control units. As shown in Section 3.4.1, our estimates are robust to the exclusion of control units that might have been substantially affected by the creation of the Eurozone during the sample period.

[29] We refer the reader to Micco et al. (2003) and Flam and Nordström (2006) for more on these estimates.

[30] Incidentally, 4.5% is the estimated effect Micco et al. (2003) obtain from a dynamic panel model.

[31] One might be concerned about the euro effect on foreign direct investments (FDI) with non-EMU members. However, Carkovic and Levine (2005) find no effect of FDI on a country's growth. This implies that even if bilateral FDI between treated and control units were affected by the euro, that would not have affected the income growth of the control units. In sum, we believe each country's adoption of the euro has not substantially affected the income growth of the control units.

[32] Alesina and Barro (2002) formalize the importance of asymmetric shocks and price rigidities and show the adoption of another country's currency trades off the benefits of commitment to price stability against the loss of an independent stabilization policy. This trade-off depends on co-movements in disturbances, on distance, trading costs, and on institutional arrangements. In the same spirit, Galí and Monacelli (2008) show that, in the presence of country-specific shocks and nominal rigidities, the policy mix that is optimal from the viewpoint of the union as a whole requires that inflation be stabilized at the union level by the common central bank, whereas fiscal policy has a country-specific stabilization role.

Other than the nature of shocks, Mundell (1961) emphasizes the importance of labor mobility. He argues that in order to better absorb external shocks, there should be a high degree of labor mobility among the countries in a monetary union. Allowing this factor of production to be mobile across countries helps, through migration, to manage external shocks that put pressure in local labor markets. A related mechanism is that induced by wage flexibility. If workers in the country hit by negative shocks are willing to accept lower wages, then making it cheaper for firms to hire workers can weaken the adverse effects of unemployment. Wage flexibility then lowers both the incentives of workers to emigrate and the need for exchange rate adjustments in the face of shocks.

In the same spirit as labor mobility, Ingram (1973) argues that financial integration could reduce the need for exchange rate adjustments as it may cushion temporary adverse disturbances through capital inflows/outflows. In particular, through borrowing from surplus areas or decumulating net foreign assets in depressed ones, countries in the monetary union with integrated financial markets can have better risk sharing arrangements. This multi-country insurance scheme allows the smoothing of both temporary and permanent shocks.[33] Thus, having free capital mobility reduces the need to alter real factor prices and the nominal exchange rate between countries in response to external shocks. However, for union members highly integrated in the world capital market, greater financial integration within the union might be costly if it entails shifting investment away from more productive non member countries.

Apart from factor inputs, McKinnon (1963) emphasizes the role of international trade in determining the costs of joining a monetary union. He argues that the higher the degree of openness, the more changes in international prices of tradable goods transmit to the aggregate price level. As a result, the systematic use of monetary policy, by changing the currency value, reflects in greater price variability in more open economies. As price variability implies costs, giving up independent monetary policy is less costly for more open economies.

Further, labor market institutions play a key role in determining a country's response to shocks common to union members. For instance, a supply shock might have very different effects on domestic wages and prices depending on the response of labor unions to it. Wages and prices might change dramatically in economies with an intermediate level of labor union centralization, but not much in countries with extremely centralized or decentralized labor unions (Bruno and Sachs, 1985; Calmfors and Driffill, 1988). This implies, that a country might find it costly to join a monetary union where other members have very different labor institutions. In fact, the different response in wages and prices in the face of a common shock might be difficult to correct once the exchange rate is fixed.

Finally, the literature on OCA stresses the interaction of monetary and fiscal policies. In particular, Fleming (1971) notes that when inflation rates between countries are low and similar, terms of trade will tend also to remain fairly stable. This synchronicity of inflation rates among trading countries then reduces the need for nominal exchange rate adjustments to respond to external shocks. (Sargent and Wallace, 1981) show that the government's budget constraint forces a deep interconnection between monetary and fiscal policies in any country. If the fiscal authority is dominant, it sets its budgets leading to monetization of debt, as the public cannot meet the supply of government bonds. The central bank's ability to control inflation is reduced relative to the case in which monetary policy dominates fiscal policy, or the monetary authority is independent. In these instances, the only way a country can finance debt is through changes in spending or taxes. When countries become part of a monetary union, the extent to which they can monetize debt depends on the common central bank. The union monetary policy cannot be disconnected from national fiscal policies. As shown by Chari and Kehoe (2007), in this setting, national fiscal authorities might have an incentive to generate excessive debt, imposing inflation on other union members if the union central bank inflates away nominal debt. This free-riding problem implies the necessity of fiscal discipline at the national level in monetary unions. However, if the monetary authority can commit to maintaining low inflation rates, debt constraints can hurt countries as their only tool to deal with external shocks, fiscal policy, is restricted. This loss is larger for countries with large governments where the constraints are binding and affect the functioning of automatic stabilisers.

The criteria for an OCA are likely to be endogenous. For instance, the introduction of a common currency spurs trade among union members. If trade within the union is mostly intra-industry, integration in the goods market increases the similarities in union members' production structures and their exposure to similar shocks, de facto bringing the currency union closer to being optimal (Alesina et al., 2003; Barro and Tenreyro, 2007; Frankel and Rose, 1998).[34]

Focusing on the benefits of monetary unions, these include the reduction of both transaction costs and the uncertainty related to exchange rate fluctuations. By joining a currency union, a country abates the costs of converting domestic money in other members' currencies, and it increases price transparency and competition within the union. The reduction in exchange rate uncertainty increases the welfare of risk-averse consumers and firms. More importantly, fixing the exchange rate with main economic partners brings to zero the probability of large movements in the exchange rate, which typically create large adjustment costs as firms close down and factors of production must be reallocated.[35] All these benefits tend to be larger for economies that are more open to other countries of the union. The elimination of transaction costs is greater

[33] This is the case as long as output is imperfectly correlated with these shocks.

[34] This view is supported by the European Commission in the context of the EMU. Krugman (1993), instead, argues that increased trade within a monetary union might lead to increased concentration of production at the country level. This, by increasing differences in union members' production structures, increases the incidence of asymmetric shocks within the union.

[35] In the context of the EU, Germany faced large adjustment costs following the depreciations of the Italian lira and Spanish peseta in the 1990s.

the more countries trade with other union members. Similarly, the elimination of exchange rate uncertainty benefits firms and consumers more the more business they conduct within the union.

Finally, in the context of monetary unions that impose fiscal constraints on members (like the EMU), induced changes in the conduct of fiscal policy might increase countries' macroeconomic stability and translate in higher growth (Fatás and Mihov, 2010).

4.2. Empirical Approach

In order to understand the aggregate effects of the euro we use the insights from the literature reviewed in Section 4.1 and estimate the following model:

$$\frac{Y_{1t} - \sum_{j=2}^{J+1} w_j^* Y_{jt}}{Y_{1t}} = \beta_0 + \beta_1 X_{1t}^{emu} + \beta_2 I_{1t}^{emu} + \beta_3 SEP_{1t} + \beta_4 |\Delta LI_{1t}^{emu}| + \beta_5 d_{1t} + \gamma_t + \epsilon_{1t} \quad (4)$$

where the dependent variable is the synthetic estimate of the income per capita gap for treated country 1 as a percentage of its income per capita observed at time $t = 1995, \ldots, 2007$. This variable takes on positive values for EMU members that are estimated to have gained from the euro and negative values for countries that have lost from the euro. The variable X_{1t}^{emu} measures the extent of business cycle synchronization, trade openness or labor mobility of country 1 with the founding eleven EMU members at time t.[36] I_{1t}^{emu} captures country 1's capital integration in the union and it measures the share of 1's international portfolio allocated to the founding EMU members in t. SEP_{1t} is country 1's strictness of employment protection as a proxy for wage flexibility in t. $|\Delta LI_{1t}^{emu}|$ captures differences in labor market institutions, and it is calculated as the absolute difference in wage bargaining coordination between country 1 and the founding EMU members at time t. We control for d_{1t}, country 1's debt to GDP ratio at time t, to explore the role of national fiscal policy in determining the economic effect of the euro. γ_t is a year fixed effect and controls for shocks common to our six EMU members in a given year. ϵ_{1t} is an error term with standard properties.

According to the insights in the literature on the costs and benefits of currency unions, we expect the estimate of β_1 to be positive. Greater synchronization of a country's business cycle with that of other union members reduces the cost of giving up independent monetary policy. Greater openness to migration within the union increases access to partners' labor markets and reduces the losses associated with a fixed exchange rate. Greater trade openness toward other union partners increases the benefits and lowers the costs of the adoption of a unique currency. When we estimate the model in equation 4, we include one of these factors at the time. We do so as these covariates are not independent of each other or they are highly correlated with each other. For instance, trade and migration openness are very highly correlated, which makes identification an issue in our context. Trade has been shown to increase partners' business cycle correlation, therefore, if we put both variables in the same specification, the interpretation of results is compromised.[37]

The estimated coefficient of β_2 could be positive or negative depending on whether union members, on average, gained or lost in income per capita terms after the introduction of the euro due to intra-union capital integration. A negative estimate of β_2 would suggest that by investing more in the union, EMU members have diverted their savings away from more profitable destinations.

We use the strictness of employment protection to capture the extent of a country's labor market rigidity. Less rigid labor markets allow a country to cope better with external shocks and to lose less from joining a monetary union. Thus, the expected sign of β_3 is negative. We take the absolute difference in wage bargaining coordination of a member relative to other EMU members to account for differences in labor market institutions. Because countries might find it costly to join a monetary union where other members have very different labor institutions, we expect the estimate for β_4 to be negative. Finally, a negative estimate for β_5 would imply that higher debts increase losses from the euro. This would be consistent with the idea that if the central bank is independent, restricting fiscal policy is costly, especially for members with large debts. An alternative explanation could be that countries reducing the size of their government due to the union rules might also be reducing the use of discretionary fiscal policy, thus experiencing higher macroeconomic stability and economic performance.

We consider alternative specifications of equation 4 that include country fixed effects, thus allowing us to control for country specific heterogeneity.

4.3. Data

The data we use in this section are at the country level and span the period 1995–2007. We take our synthetic estimates of percentage income per capita gaps for our six EMU members to construct the dependent variable in equation 4. This implies that the total number of observations available for our analysis is 78 (6 countries by 13 years).

[36] Crespo-Cuaresma and Fernández-Amador (2013) empirically assess the patterns of cyclical convergence in the EMU between 1960 and 2008. They also evaluate the cost of each member in terms of business cycle synchronization.

[37] Angrist and Pischke (2009) show how controlling for occupation when estimating the effect of education on earnings is problematic for the interpretation of the results. They label this the *bad control* problem.

In order to calculate the business cycle correlation of each of our six EMU members with the union, we follow Morgan et al. (2004) and use annual data on the real GDP for all the founding EMU countries from the OECD database. First, for each of our six EMU members and corresponding groups of other founding members of the EMU we obtain the growth rate deviation from its average growth rate and the union growth rate by keeping the estimated residuals from the following regression model: $Real\ GDPgrowth_{it} = \alpha_i + \theta_t + \epsilon_{it}$, where α_i and θ_t are country/group and time fixed effects, respectively. Second, we calculate the co-movement of business cycles between each of the treated EMU members, country 1, and the other founding union members, $EMU11\backslash1$, as follows: $Synchronization^{emu}_{1t} = -\left|\epsilon_{1t} - \epsilon_{(EMU11\backslash1)t}\right|$.

A country's openness to intra-EMU trade is constructed using data from the OECD Bilateral Trade Database and GDP values from the World Development Indicators (WDI). We use logs to reduce the variation due to extreme values.[38]

Our measure of a country's labor mobility in the union is based on its openness to immigrants from the founding 11 EMU countries, i.e., the share of immigrants from EMU members in total population. To calculate this measure for Germany, Italy, Belgium and the Netherlands we use the Ortega-Peri dataset (2013).[39] For Ireland and France, we use immigration data from the Central Statistics Office StatBank and the INED, respectively.[40] Population data are from the WDI. We focus on immigration openness because of data availability. However, using data on 15 OECD countries from the Ortega-Peri dataset we find that countries open to immigration from OECD countries tend to be open to emigration to the same set of countries.[41] This gives us confidence that our measure of openness to immigration captures the extent of a country's integration in the union labor market.

Data on the proportion of a country's international portfolio holdings allocated to founding EMU partners are from the IMF's Coordinated Portfolio Investment Survey (CPIS).[42] Data on the strictness of employment protection are from the OECD. Information on wage bargaining coordination for all EMU members are taken from the database on Institutional Characteristics of Trade Unions, Wage Setting, State Intervention and Social Pacts (ICTWSS; Visser, 2013). Finally, debt to GDP data is from the IFS.

4.4. Results

Table 11 summarizes the estimates for different specifications of the model in equation 4. We report standardized beta coefficients so we can directly compare the effects of our covariates on the synthetic income per capita gap. Standard errors clustered by country cell are in parentheses.[43,44]

The specification in column (1) considers the business cycle synchronization effect on our six EMU members' income gains or losses from the euro. The same specification omits the debt to GDP variable as fiscal policy affects a country's exposure to idiosyncratic shocks and its business synchronization with the union. Our results are consistent with the theory and imply that a one standard deviation increase in the business cycle synchronization decreases the costs or increases the gains from the euro by 0.17 of a standard deviation. All the remaining estimated coefficients are negative. We find that increasing shares of a country's international portfolio invested in the union decrease gains from adopting the euro. This finding is consistent with countries losing by diverting their investment toward less profitable union members. Finally, greater rigidity in labor markets or difference in labor institutions implies greater losses from the euro.

In column (2) we replace the synchronization variable with the intra-EMU trade openness measure. We further control for government debt (% of GDP). The results are again consistent with the theory: increases in trade openness toward members of the union reduce the costs of giving up monetary policy or increase the benefits from the adoption of the single currency. The estimated effect on the trade variable is likely capturing more than just the effect of intra-EMU trade openness as more open countries have a more synchronized business cycle relative to the union and are also more open to migration with other union partners. The negative estimate on the debt to GDP measure suggests that higher debts increased losses from the euro, either because the loss in flexibility of fiscal policy was more costly for highly indebted union members or because the debt reduction achieved by most union members during this period made them use fiscal policy in a less discretionary fashion, thus improving their economic performance. All the remaining coefficients are significant and take the same signs as in column (1).

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[38] Belgium has much higher intra-union trade openness than the other EMU members we consider.

[39] The data for Italy are only available up to the year 2000. We extrapolate the series to 2007 applying the average growth rate of immigration from EMU members to Italy during 1995–2000.

[40] The Irish data are available at the EU13 level (with the exclusion of Ireland and the UK). To obtain immigration flows from the founding members we first calculate the average proportion of immigrants from Denmark, Greece and Sweden that entered Italy, Germany, Belgium and the Netherlands by year from the Ortega-Peri dataset. We, then, use these averages to deflate the Irish data. We apply a similar methodology to the French data as it is available at the EU14 level.

[41] The correlation between immigration and emigration population shares is 0.75 in the data.

[42] Data are available for 1997, 2001–2007. We interpolate the data between 1997 and 2001. To extend the series back to 1995 we use the observed country-specific average growth rates in portfolio shares.

[43] Given the small number of clusters, the p-values in Table 11 are based upon the t_{G-1} distribution, where G is the number of countries in the sample. The significance of all the estimates in Table 11 strengthens if Efron (HC3) robust standard errors are considered to correct for the heterosckedasticity potentially arising because we do not observe the true income effects of the euro. Typically, when the dependent variable is a regression estimate, the corresponding standard errors from the first stage are used as weights to improve the estimator efficiency in the second stage. This approach is unfortunately unavailable to us because the synthetic method does not provide us with standard errors for our estimates.

[44] Table OA6 in the Online Appendix shows the correlation matrix of the covariates in equation 4.

Table 11
Explaining the aggregate effects of the Euro

	(1)	(2)	(3)	(4)	(5)	(6)
Business cycle synchronization with EMU 11	0.1741**			0.2811***		
	(0.6317)			(0.6769)		
Openness to trade with EMU 11 (logs)		0.3488***			−0.7741	
		(0.0100)			(0.1254)	
Immigration from EMU 11, % of population			0.6490***			0.3522**
			(10.7703)			(24.0327)
Share of int'l portfolio invested in EMU 11, I_{1t}	−0.5225***	−0.4345***	−0.8240***	−0.5070**	−0.4162***	−0.4788***
	(0.0009)	(0.0005)	(0.0012)	(0.0017)	(0.0009)	(0.0008)
Strictness of employment protection, SEP_{1t}	−0.6945***	−0.4245***		−0.2056	0.7474	
	(0.0385)	(0.0030)		(0.0666)	(0.2167)	
Absolute difference in wage bargaining coordination, $\lvert \Delta LI_{1t}^{emu} \rvert$	−0.3590**	−0.2927***		−0.0139	−0.0764	
	(0.0441)	(0.0237)		(0.0278)	(0.0205)	
Government debt to GDP, d_{1t}		−0.3273***	−0.1239		−0.5807*	−0.2387
		(0.0004)	(0.0006)		(0.0016)	(0.0018)
Year fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
Country fixed effects	No	No	No	Yes	Yes	Yes
R^2	0.8250	0.9321	0.9209	0.9568	0.9704	0.9640
N	78	78	78	78	78	78

Note. The dependent variable is the synthetic estimate of the income per capita gap for the treated country as a percentage of its observed income per capita, $\frac{Y_{1t} - \sum_{j=2}^{J+1} w_j^* Y_{jt}}{Y_{1t}}$. Standardized beta coefficients are reported, with standard errors in parentheses clustered by country cell. ***, **, * indicate significance at the 1, 5 and 10 percent level, respectively.

Column (3) focuses on the effect of labor mobility, captured by immigration openness toward union members, on the gains from the euro. Because this measure is highly correlated with the characteristics of the labor market in the host country, the specification we estimate does not include labor market related variables. A one standard deviation increase in immigration openness increases the gains from joining the union by some 0.65 of a standard deviation. As in the case of trade openness, this effect should be interpreted as the result of more than a country's integration in the union labor market. All the remaining effects are negative and consistent with the specifications estimated in columns (1) and (2).

Interestingly, glancing over the first three columns of Table 11 it appears that the most influential factor is the integration of capital markets. In fact, a one standard deviation increase in the share of a country's international portfolio invested in the union decreases the gains from adopting the euro by between 0.44 and 0.82 of a standard deviation. This finding is likely to be driven by Belgium, France and Germany, all of which did not gain from the euro. Recent evidence shows that these countries shifted their investments from countries outside the union to Greece, Ireland, Italy, Portugal and Spain (Hale and Obstfeld, 2014). Importantly they did so more than other important financial centers not in the union.[45] Our results imply that the effect of this shift contributed negatively to their economic performance.

In columns (4)-(6) we re-estimate the specifications in columns (1)-(3) adding country fixed effects. Not surprisingly the significance of our estimates disappears for all the variables whose within country values do not vary very much over the sample period, that is for intra-EMU trade openness and labor market related variables. The fact that the estimated effect of debt to GDP becomes less significant is somewhat surprising as all EMU members experienced large drops in their government debt (% of GDP) during the sample period. Exceptions were France and Germany with fairly stable debts. This result suggests that growth benefits generated by the lower use of national discretionary fiscal policy are not the driving force behind the effect of debt on the net benefits of the euro adoption found in columns (2) and (3). Indeed, Ireland experienced a large drop in its government debt during the sample period, but according to Fatás and Mihov (2010) its use of discretionary fiscal policy increased. Similarly, for France and Germany, fairly stable debts co-existed with large drops in the use of discretionary fiscal policy (Fatás and Mihov, 2010).

The results in Table 11 are essentially unchanged if one replaces the synthetic estimates of the income gains for the Netherlands with zeros or drops the Netherlands altogether.[46] We take this as further evidence of the statistical non-significance of the estimated gains from the euro for the Netherlands.

In sum, the results in this section show that our estimated income effects of the euro for adopters capture commonly recognized determinants of the economic costs and benefits of monetary union, giving us more confidence in their economic content and significance.

[45] Hale and Obstfeld (2014) consider the following financial centers: Canada, Denmark, Japan, Sweden, Switzerland, UK and USA. Note that three of these countries are control countries in our synthetic simulations. Further, Hale and Obstfeld provide many reasons behind the shift of capital flows of core EMU member.

[46] Results are available from the authors upon request.

5. Conclusions

The euro was introduced more than a decade ago, but so far no direct evidence exists on whether the adopters have economically benefitted or lost from it. Our results shed light on the economic effects of the euro on adopters by performing two interrelated exercises.

First, using the synthetic control method we estimate the income per capita EMU members would have experienced had they kept their independent monetary policies. This allows us to identify winners and losers from the euro. Our estimates suggest that the income per capita of Belgium, France, Germany and Italy would have been higher without the euro, while that of Ireland would have been considerably lower. The Netherlands has been as well off with the euro as it would have been without it. These estimates are robust to the choice of the control group, growth predictors and pre-treatment period.

Second, we relate the synthetic estimates of the income effects of the euro to the economic determinants of the costs and benefits of monetary unions. This second exercise is particularly interesting because, in addition to a simple way of verifying the economic content of our synthetic estimates, it provides useful insights for prospective members of the EMU. Consistent with the theory of currency unions, we find that early euro adopters with a business cycle more synchronized to that of the union, and more open to intra-union trade and migration experienced lower losses or greater benefits from the euro. Our evidence also suggests that a key role in increasing post-euro income losses of union members has been played by the integration of capital markets. These results are of relevance for prospective members of the EMU as they suggest intra-union trade and migration openness as well as targeted investments are key to increasing the chances of winning from adopting the euro.

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Appendix A. Comparisons of predictors' means

Table A1 provides a comparison of the means of the predictors for each EMU member, its corresponding baseline control group and the two common control groups ("Industrial countries" and "All") from the start of the sample to 1995. By construction, the baseline control group matches the average income per capita of the treated country more closely than both common control groups. It also does the same on most of the remaining predictors' averages.

Table A2 provides a comparison of the means of the predictors for each EMU member, corresponding synthetic control unit and control group in the baseline. The results show that the synthetic control unit matches the characteristics of the

Table A1
Economic growth predictor means before the Euro: Treated vs. control groups

Predictor	Belgium		France		Germany		Common Control Groups	
	Observed	Baseline Control Group	Observed	Baseline Control Group	Observed	Baseline Control Group	Industrial Countries	All
RGDP p.c.	22060.27	23311.97	22146.01	23311.97	22638.94	23311.97	24388.3	13625.77
Inflation rate	4.70	5.84	6.30	5.84	3.58	5.84	5.62	8.88
Investment to GDP (%)	21.39	24.71	20.74	24.71	22.94	24.71	25.49	25.00
Industry Share of VA	34.05	32.48	29.88	32.48	39.62	32.48	33.09	33.48
Secondary Education	39.15	43.82	27.68	43.82	24.78	43.82	45.72	33.04
Trade Openness	118.06	104.26	41.97	104.26	44.33	104.26	88.98	87.75
Predictor	**Ireland**		**Italy**		**Netherlands**		**Common Control Groups**	
	Observed	Baseline Control Group	Observed	Baseline Control Group	Observed	Baseline Control Group	Industrial Countries	All
RGDP p.c.	15718.13	15867.5	20428.37	22169.71	24319.82	24198.44	24388.3	13625.77
Inflation rate	8.73	9.09	10.64	6.92	3.64	5.65	5.62	8.88
Investment to GDP (%)	20.91	28.44	23.10	24.15	22.20	24.83	25.49	25.00
Industry share of VA	34.86	40.10	35.16	32.11	32.04	32.47	33.09	33.48
Secondary Education	40.76	25.10	34.10	43.94	59.04	44.32	45.72	33.04
Trade Openness	106.67	140.61	40.55	94.24	103.28	100.09	88.98	87.75

Note. RGDP p.c. stands for Real GDP per capita. VA stands for value added.

Table A2
Economic growth predictor means before the Euro in the baseline

Predictor	Belgium			France		
	Observed	Synthetic unit	Control group	Observed	Synthetic unit	Control group
RGDP p.c. (I)	17668.0	17646.3	20088.7	19178.1	19181.3	21094.36
RGDP p.c. (II)	20805.2	20781.6	22473.4	23955.1	23902.3	24547.0
RGDP p.c. (III)	25254.0	25230.1	25491.5			
Inflation rate	3.1	2.1	1.5	1.9	1.8	1.5
Investment to GDP (%)	19.5	26.3	24.0	19.4	23.4	22.1
Industry share of VA	30.2	30.1	30.7	33.2	33.1	32.6
Secondary Education	46.5	46.4	48.7	26.9	36.1	43.5
Trade Openness	126.0	172.2	105.3	44.1	158.3	110.3
Predictor	**Germany**			**Ireland**		
	Observed	Synthetic unit	Control group	Observed	Synthetic unit	Control group
RGDP p.c. (I)	19216.8	19234.7	21052.0	13449.8	13435.0	14787.8
RGDP p.c. (II)	24665.6	24419.5	24345.4	16547.8	16822.5	16243.4
Inflation rate	3.7	2.1	1.5	3.1	4.2	4.9
Investment to GDP (%)	21.7	23.4	23.6	24.4	35.9	31.7
Industry VA (%)	36.5	31.2	30.7	34.8	38.2	37.6
Secondary Ed	41.1	44.1	44.6	35.5	16.7	24.0
Trade Openness	47.3	123.41	112.4	107.8	199.4	135.7
Predictor	**Italy**			**The Netherlands**		
	Observed	Synthetic unit	Control group	Observed	Synthetic unit	Control group
RGDP p.c. (I)	16683.9	16723.1	19580.8	22197.8	22014.08	22104.0
RGDP p.c. (II)	22693.7	22693.1	23652.4	25466.7	25615.6	25370.6
Inflation rate	9.0	4.3	5.0	2.3	1.9	1.7
Investment to GDP (%)	21.8	23.9	22.6	22.3	22.9	25.0
Industry share of VA	33.1	33.1	32.1	31.2	31.1	32.8
Secondary Education	40.0	40.04	45.2	63.6	47.1	48.6
Trade Openness	38.0	157.6	92.0	106.2	106.1	101.3

Note. RGDP p.c. stands for Real GDP per capita. VA stands for value added.

corresponding treated country quite closely and, most often, better than the simple average of the control group. A recurrent exception is trade openness. This happens when Singapore, an important shipping and processing center with very high trade to GDP ratios, takes on a positive weight in the synthetic control of EMU members with smaller openness. This is not cause for concern because according to the estimated weights in the V matrices, trade openness plays a very minor role in predicting income per capita. For all treated countries except the Netherlands, trade openness takes on a V weight much smaller than 0.0001. Importantly, the synthetic control units match very closely pre-treatment averages of real GDP per capita. In the baseline, these predictors' V weights sum almost to 1 for all EMU members except the Netherlands. For the Netherlands, predictors with the highest predictive importance in the baseline are the industry share of value added and trade openness. The V weights corresponding to these predictors are 0.666 and 0.328, respectively. Both predictors are very closely matched by the synthetic control unit of the Netherlands.

Supplementary material

Supplementary material associated with this article can be found, in the online version, at doi:10.1016/j.euroecorev.2018.06.011.

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