Adopting the Euro: a synthetic control approach

Gabriel, Ricardo Duque and Pessoa, Ana Sofia

Bonn Graduate School of Economics and Department of Economics, University of Bonn., Bonn Graduate School of Economics and Department of Economics, University of Bonn.

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Adopting the Euro: a synthetic control approach*

Ricardo Duque Gabriel†
University of Bonn

Ana Sofia Pessoa‡
University of Bonn

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Abstract

We investigate whether joining the European Monetary Union and losing the ability to set monetary policy affected the economic growth of Eurozone countries. We use the synthetic control approach to create a counterfactual scenario for how each Eurozone country would have evolved without adopting the Euro. We let this matching algorithm determine which combination of other developed economies best resembles the pre-Euro path of twelve Eurozone economies. Our estimates suggest that there were some mild losers (France, Germany, Italy, and Portugal) and a clear winner (Ireland). Nevertheless, a gross domestic product decomposition suggests that the drivers of the economic gains and losses are heterogeneous. In particular, our results show that for the majority of Eurozone countries, Euro spurred government consumption and deterred investment and private consumption. The common currency also stimulated trade for most cases but only Germany and Ireland bear positive net trade benefits.

JEL classification: E30, E60, C32, E02, E52, E65

Keywords: Monetary union, Eurozone, Macroeconomic performance, Synthetic control method, GDP decomposition

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†Corresponding author: Bonn Graduate School of Economics and Department of Economics, University of Bonn. E-mail address: ricardo.gabriel@uni-bonn.de. Postal address: Kaiserstrasse 1, 53113 Bonn, Germany

‡Bonn Graduate School of Economics and Department of Economics, University of Bonn. E-mail address: sofia.pessoa@uni-bonn.de

"For all the seven long years since the signing of the Maastricht treaty started Europe on the road to that unified currency, critics have warned that the plan was an invitation to disaster." (Krugman, 1998)

1 Introduction

In January 1999, the exchange rates between member countries' national currencies and the euro were fixed irrevocably and the European Central Bank (ECB) officially took over the responsibility of conducting the unified monetary policy. Twenty years have passed since the Euro was launched and the member states gave up the ability to set their own monetary policy. In this work, we evaluate whether joining the Euro had any macroeconomic effect for twelve of the Eurozone countries.

To address this question, we develop a counterfactual scenario that represents how each Eurozone country would have evolved without adopting the Euro as their currency. For this analysis, we employ what is arguably the most important innovation in the policy evaluation literature in the last fifteen years - the synthetic control method (SCF) (Athey and Imbens (2017)). We let this matching algorithm determine which combination of other OECD advanced economies best resembles the pre-Euro path of each Eurozone member. We then compare the post-Euro macroeconomic performance of each economy to its synthetic doppelganger. In particular, by decomposing the countries' and the doppelgangers' gross domestic product (GDP) into their components, we identify the main drivers of the accession gains and losses.

In the context of the Eurozone, it was expected that adopting a common currency would reduce the exchange rate volatility, the transaction costs, and any price discrimination (De Grauwe (2020)). Most likely, it could spur trade and investment within the Euro area (Frankel and Rose (1998)). Notwithstanding, since its announcement, many have been calling into question the success of the Euro (Wyplosz (2006)). They believed that the Eurozone did not satisfy the requirements of an Optimum Currency Area, especially due to the lack of labor mobility (Jonung, Drea, et al. (2009)). Additionally, the Euro area countries could no longer set monetary policy independently thus becoming more exposed to external (asymmetric) shocks. Nowadays, the rising strength of nationalism movements in Europe has intensified doubts about the advantages of the Eurozone (Fligstein et al. (2012), Guiso et al. (2019)). Some of the arguments put forward are the loss of sovereignty and the suitability of the "one-size-fits-all" monetary policy. Moreover, the recent developments of the Covid-19 pandemic in Europe have highlighted the lack of solidarity, ability and, in some cases, the willingness of the Eurozone to take action during such fragile and crucial moments.

Our contribution is two-folded. First, we evaluate the macroeconomic impact of adopting the Euro measured by the real gross domestic product (GDP). Theoretical predictions about this effect are ambiguous and depend on whether the costs outweigh the benefits of joining the Eurozone.[1] Indeed, we find that there are some mild losers (France, Germany, Italy, and Portugal) and a clear winner (Ireland). Such heterogeneous findings are in line with De Grauwe (2020) and Puzzello and Gomis-Porqueras (2018).

Next, we investigate which were the channels driving the output gains and losses and if they differed from country to country. For Ireland, the private consumption and investment notably explain almost 80% of the total output gain from joining the Euro. While for France and Portugal, the private consumption and the net exports accounted for a large share of the economic loss, in the case of Germany and Italy, the private consumption and the investment explain the negative impact of the Euro. For most countries, the trade volume was significantly higher than if they had not joined the Eurozone. Nonetheless, the common currency had a positive impact on the trade balance solely for Germany and Ireland.

This paper is related to several strands of the literature. The first one is directly related to the methodology used to construct the counterfactuals. To employ the Synthetic Control Method (SCM), we follow the original work by Abadie and Gardeazabal (2003), Abadie et al. (2010) and (2015) who developed the methodology.[2] Furthermore, we follow more recent work by Campos et al. (2018) who evaluate the impact of the European Union accession, Born et al. (2019) who assess the macroeconomic impact of the election of Donald Trump as the President of the USA, and finally Breinlich et al. (2020) and Born et al. (2020) who study the costs of economic nationalism by looking at the Brexit vote impact on the transactions and GDP, respectively.

This paper also contributes to the literature that studies the macroeconomic impact of joining a currency union. Starting from the groundbreaking contribution of Mundell (1961) on the theory of optimal currency areas, many economists have been studying the key characteristics that allow a group of countries to benefit from having the same currency. McKinnon (1963) and Kenen (1969) have added seminal contributions to this theory by exploring the role of international trade and diversified output structures in determining the costs and benefits of joining a monetary union.

More recent work from Alesina and Barro (2002) explains that forgoing monetary policy, on the one hand, implies losing a stabilization device to deal with domestic shocks but, on the other hand, can boost credibility and price stability. Alesina and Barro (2002) show

[1] We refer the reader to Lane (2006) and Beetsma and Giuliodori (2010) who provide a more recent account of the real effects of the European Monetary Union by surveying the literature on its macroeconomic costs and benefits.

[2] A good overview of the literature using this methodology can be found in Abadie (2019).

that if there is a reduction in trading costs, the adoption of a common currency has a direct positive effect on trade, output, and consumption.[3]

There is also a broad literature that tests empirically these theoretical links. At about the time the euro was launched, Rose (2000) famously estimated that a currency union could boost up to three times bilateral trade. The relevance of these results to the euro case was immediately doubted since the sample used for the analysis was based on unions of small, poor, and remote countries. Micco et al. (2003) developed the first comprehensive study for the impact of the European Monetary Union (EMU) on trade, concluding that the Euro had a positive impact not only on trade between member states but also with third parties.

Some papers have also highlighted the impact of currency unions on investment. Among others, Barr, Breedon, and Miles (2003) suggest that inward investment in the countries outside the union would have been greater if they had joined the EMU. Furthermore, De Sousa and Lochard (2011) estimate that, in the Eurozone countries, investment increased with the single currency adoption.

In particular, this paper closely relates to the recent literature about the Euro adoption using the synthetic control approach (Fernández and Garcia-Perea (2015), Verstegen et al. (2017), and Gasparotti and Kullas (2019) among others). We build directly on the work of Puzzello and Gomis-Porqueras (2018) by extending their analysis from six to the twelve member states which joined the Euro before 2007. Furthermore, we use a GDP decomposition to investigate the channels that drove the economic gains and losses of the accession.

The remainder of this paper is organized as follows. Section 2 describes the construction of the doppelganger, its implementation, and the data used. Section 3 presents the results and performs robustness exercises. Section 4 explores the potential channels through which the Euro adoption affected the GDP. We briefly conclude in Section 5.

[3] Alesina, Barro, and Tenreyro (2002) and Barro and Tenreyro (2007) empirically investigate and present evidence in accordance with these theoretical predictions.

2 Constructing the doppelganger

2.1 The synthetic control method

To measure the impact of the EMU accession on the macroeconomic performance of the Eurozone countries, we construct a doppelganger for each Eurozone country based on the synthetic control methodology (SCM) developed by Abadie and Gardeazabal (2003), Abadie et al. (2010) and (2015).[4] Ideally, these doppelgangers behave just like the Eurozone economies except for the Euro adoption.

The goal is to compute the treatment effect of a policy intervention:

$$\tau_{i,t} \equiv Y_{i,t}^{I} - Y_{i,t}^{C}$$

where $Y_{i,t}^{I}$ represents the realized outcome of country i in period t and $Y_{i,t}^{C}$ stands for the non-observable outcome of country i in period t absent from the policy intervention. Abadie and Gardeazabal (2003) proposed the SCM to estimate $Y_{i,t}^{C}$ by constructing a doppelganger as a weighted average of the outcomes of non-treated units. We refer to these units as "donor countries" and to the set of these countries as "donor pool" throughout the paper. Suppose that we have $N+1$ countries and country $i=1$ is exposed to the intervention of interest. Then, an unbiased estimate of the treatment effect, which we refer to as doppelganger gap throughout this paper, is defined as:

$$\hat{\tau}_{1,t} = Y_{1,t}^{I} - \sum_{i=2}^{N+1} w_i Y_{i,t} \tag{1}$$

where w_i is the estimated weight assigned to donor country i to construct the doppelganger.

The weights are chosen to minimize the difference between each treated unit and its doppelganger's pre-intervention outcome variable and predictors. The outcome variable studied is real GDP and the set of predictors used is based on Abadie and Gardeazabal (2003) and Born et al. (2019). These predictors are the average GDP shares of private consumption, government consumption, investment, exports, imports, the employed share of the population, the labor productivity growth, the real GDP and its lags.[5]

Formally, let $\mathbf{x_1}$ denote the (37×1) vector of 30 observations for real GDP and 7 covariates' averages in each Eurozone country and $\mathbf{X_0}$ denote a (37×14) matrix with observations from the donor countries. Finally, $\mathbf{w}$ denotes a (14×1) vector of weights w_i, $i = 2, ..., 15$.

[4] A detailed exposition of the method can be found in Abadie (2019).

[5] We avoid the so-called cherry-picking problem in Ferman et al. (2020) by choosing a standard set of predictors based on previous empirical literature.

Then, the optimal weighting scheme is defined by $\mathbf{w}^*$ which minimizes the following mean squared error:

$$(\mathbf{x_1} - \mathbf{X_0 w})' \mathbf{V} (\mathbf{x_1} - \mathbf{X_0 w}) \tag{2}$$

subject to:

$$w_i \geq 0 \; for \; i = 2, ..., 15 \tag{3}$$

$$\sum_{i=2}^{15} w_i = 1 \tag{4}$$

where $\mathbf{V}$ is a (14×14) symmetric and positive semidefinite weighting matrix assigning different relevance to the characteristics in $\mathbf{x}_1$ and $\mathbf{X}_0$. Following Abadie and Gardeazabal (2003) and Abadie et al. (2010), we choose a diagonal V matrix such that the mean squared prediction error of the outcome variable (and the covariates) is minimized for the pre-treatment period.[6]

2.1.1 Implementation

The SCM offers several advantages to study the question at hand. This method is transparent regarding the construction of the counterfactual and the fit of the control unit to the treated unit. It provides the exact weight of each donor country for the construction of the doppelganger. The fit of the counterfactual can be inspected by comparing the outcome variable and other characteristics of the treated unit with the estimated data. It is also important to highlight that this method allows the design decisions, like the choice of donor pool and predictors, to be made regardless of post-treatment considerations and without knowing the implication for the results. Moreover, the SCM precludes extrapolation since the estimated weights are non-negative and sum to one.[7]

To successfully implement the SCM several contextual and data requirements should be satisfied.[8] Especially for estimating causal effects, the credibility of the results severely depends on whether these requirements are met in the empirical application at hand. Therefore, we now present these requirements and how we address them.

First, *treated units and the donor countries should be comparable.* The counterfactual

[6] Including the covariates in the optimization differs from Kaul et al. (2018) who have raised concerns about including all pre-intervention outcomes together with covariates when using the SCM. The covariates used are relevant for the computation of the doppelgangers and its choice hinged on theoretical grounds.

[7] See King and Zeng (2006) for more information about the dangers of relying on extrapolation to estimate counterfactuals

[8] See Abadie (2019) for more detail on these requirements.

should be identical to the treated unit in all dimensions except for the treatment assignment. When the treated unit is a country, an "ideal" control unit rarely exists in observed data because countries differ widely across demographic, legislative and economic characteristics (Born et al., 2020). Yet, the donor pool selection should try to accommodate this need.

Unlike Puzzello and Gomis-Porqueras (2018) and Gasparotti and Kullas (2019), we ensure that the donor countries can resemble the level of economic and social development of the treated units by using only OECD economies in our estimates. It is important to restrict the donor pool to units with outcomes that are expected to be driven by the same structural processes as the treated unit (Abadie et al., 2015). When using developing countries with structurally higher growth rates to create a doppelganger for an advanced economy with structurally more modest growth rates, results are condemned to be biased. Using a smaller donor pool that guarantees more similarities with the treated unit should be preferred, albeit the expected poorer fit (Abadie & Gardeazabal, 2003).

Secondly, since the counterfactual weights are constructed according to the pre-intervention characteristics, we have to assure that *there are no (external) differentiated shocks during the study period in the donor pool countries* (Abadie (2019)). To account for this issue, contrarily to Fernández and Garcia-Perea (2015) and Verstegen et al. (2017), we only consider observations until 2007. From 2008 onward, the Great Recession affected countries in very different ways and arguably provoked structural changes in the affected economies.

It is also important to *exclude any country that was treated from the donor pool*. In this context, this is addressed by using only donor countries that never adopted the Euro.

Furthermore, policy interventions frequently have spillover effects to non-treated units. When employing the SCM, it is important to ensure that the *counterfactuals are not affected by the treatment*. In our analysis, this is equivalent to ruling out the possibility that the Euro adoption by an individual country affected the outcome variable of the donor countries. This assumption is tested by performing in-space placebo testes in section 3.2.2.

Fourth, *the intervention has no effect on the outcome before the implementation period*. In section 3.2.1, potential anticipation effects are tested by changing the treatment date used in the analysis.

The SCM requires as well a *sizable number of pre- and post-intervention periods*. In the literature, previous SCM applications with yearly data use between 20 (Abadie & Gardeazabal, 2003) and 30 pre-treatment periods (Abadie et al., 2015). The reason is that the credibility of a synthetic control depends upon how well it tracks the treated unit's characteristics and outcomes over an extended period of time prior to the treatment. The post-treatment period should be long enough to account for delayed or dissipated effects of the intervention. These requirements are satisfied with the data used in the analysis as discussed next in section .

Finally, it is important to guarantee that there are *no extreme values in the variable of interest for the treated units*. The SCM is based on the idea that a combination of unaffected units can approximate the pre-intervention characteristics of the affected unit. However, if the treated unit exhibits “extreme” values for the outcome variable this is not possible. We address this issue by normalizing real GDP to unity in 1970.

2.2 Data and Sample

We use annual data from 1970 until 2007 from the Penn World Tables, version 9.1 (PWT 9.1 - Feenstra, Inklaar, and Timmer (2015)) and the World Bank. We focus on the real GDP as our main outcome variable and conduct our analysis on twelve Eurozone countries, namely Austria, Belgium, Finland, France, Germany, Greece, Ireland, Italy, Luxembourg, the Netherlands, Portugal, and Spain.[9]

We assume the treatment date takes place in 1999 for all countries except for Greece, which joined the Eurozone later in 2001. In our baseline estimate, we have at least 29 pre-intervention periods, from 1970 to 1998, which is sufficiently large to apply the SCM.

Doppelgangers are constructed on the basis of a donor pool of 14 countries selected as follows. First, only OECD countries are used to ensure that doppelgangers are sufficiently similar to the treated countries. Then, all countries that joined the European Union or the Eurozone during the post-treatment period are excluded. This guarantees that the donor countries are neither affected by the treatment nor suffer a differentiated external shock during the post-treatment period.

For our baseline estimates, we do not restrict the donor pool further except for countries for which the necessary data is not available. The pool is composed of Australia, Canada, Chile, Denmark, Iceland, Israel, Korea, Mexico, New Zealand, Norway, Sweden, Switzerland, the United Kingdom, and the United States.

We believe this donor pool is just narrow enough to guarantee that these donor countries are comparable to the treated units but do not compromise the application of the SCM and estimation of the counterfactuals. Possible flukes to this belief are assessed in section 3.3.1 where we perform robustness checks by excluding individual and groups of countries from the donor pool.

[9] The outcome variable is normalized to unity in 1970 in each country. Consult Table A.1 for further details on the data. Focusing on the normalized *per capita* real GDP instead does not change the results.

3 Empirical Results

This section starts by presenting the baseline results for the impact of the Euro accession. Next, taking into account the assumptions addressed in Section 2.1.1, we discuss the statistical significance and causality of these results by performing two types of placebo exercises. First, we apply in-space placebo tests in Section 3.2.2 which assign the treatment to all countries in the donor pool. Then, in Section 3.2.1, we perform in-time placebo tests in which placebo treatment dates are assigned to the treated countries.

The main findings in this section corroborate the results of Puzzello and Gomis-Porqueras (2018) and add new insights by concluding that the results for France, Germany, Ireland, Italy, and Portugal are statistically significant.

3.1 Baseline results: Assessing Euro's macroeconomic impact

It is expected that the SCM yields an imperfect pre-treatment match for some countries given that our procedure determines 14 parameters (country weights) to match 37 observations. Notwithstanding, this methodology can provide substantial improvement relative to alternative methods as differences-in-differences (Ferman and Pinto (2019)) and thus, we are confident that this data-driven approach is the best to study the problem at hands.

Table A.3 displays the donor country weights that constitute each doppelganger. For instance, the synthetic Spain is composed by all countries in the donor pool yet being significantly constructed by using data from the United States (46%), Mexico (19%), Switzerland (18%), and Australia (16%). We are overall confident on the plausibility and credibility of the methodology weighting scheme.[10]

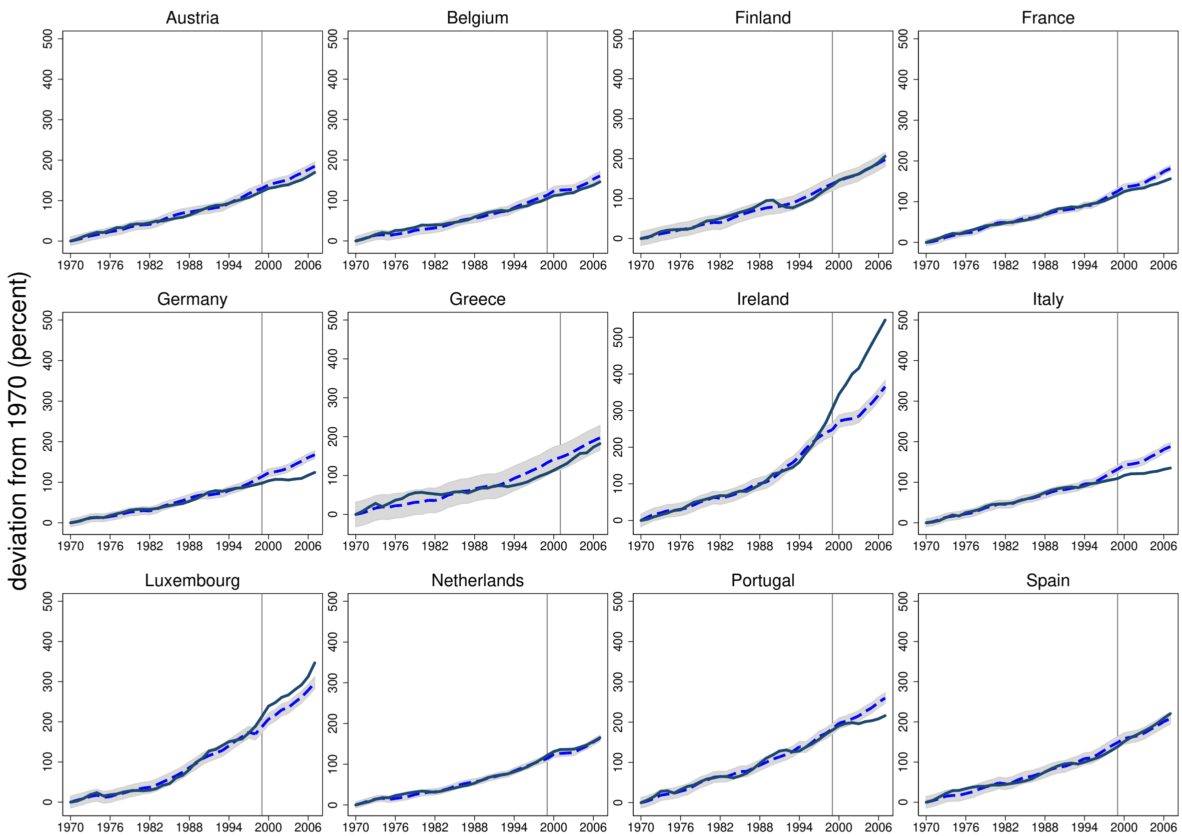
Table A.2 shows that doppelgangers are very similar to the actual countries when comparing their predictors means despite using the same specification for all countries.[11] Furthermore, in Appendix A.7, we show that the doppelgangers are successful in recovering the time path of all GDP components for most of the analyzed countries.

Figure 1 displays the real GDP for each country (full black line) and doppelganger (dashed blue line) presented as the deviation from the first year of the sample in percent. The shaded area represents two standard deviations of the pre-treatment difference between the actual and the counterfactual series. When the doppelganger series deviates from the realized path in such a way that exceeds these bounds, it indicates that such deviation is non-standard compared to the pre-Euro period.

[10] Potential concerns regarding the use of countries which belong to the Exchange Rate Mechanism (Denmark, Sweden, and the United Kingdom) are addressed in Section 3.3.1.

[11] Matching only the key variable might suffice but having further similarities in related variables is also important and ensures the robustness of the findings (Botosaru and Ferman (2019)).

Figure 1: The impact of the Eurozone accession



Notes: In each graph, the dashed line represents the normalized real GDP for the synthetic country and the continuous line represents the series for the actual country. The shaded area corresponds to two standard deviations of the difference between the treated country and the doppelganger prior to the Euro accession. The vertical line represents the treatment period - 1999 for all countries except for Greece which is 2001. For each country, the analysis starts in 1970 and ends in 2007.

A number of observations stand out. The pre-treatment paths for most countries and their doppelgangers are overlapping. Moreover, Figure 1 shows some series embarking on a different growth trajectory relative to their counterfactuals only around the Eurozone creation.

Table 1 presents the exact doppelganger gaps measured in Euro *per capita*. Ireland benefited the most from the Euro adoption. Its GDP *per capita* was 10,781 Euro higher due to the common currency adoption. However, France, Germany, Italy, and Portugal would be better off by not participating in this currency union. Yet, Germany and Italy lost the most: 5,788 and 6,089 Euro *per capita* respectively.

Table 1: Doppelganger Output Gap

	AUT	BEL	FIN	FRA	DEU	GRC	IRL	ITA	LUX	NLD	PRT	ESP
Gap (Euros *per capita*)	-1,712	-1,668	777	-2,632	-5,788	-1,098	10,781	-6,089	4,697	168	-2,558	900

Notes: This table presents the doppelganger output gap *per capita* in 2007. This measure is obtained by adjusting the real GDP gap for the population size and converting 2011 US dollars into 2011 Euro. We use the conversion rate available from the PWT 9.1 for this year (≈ 0.73).

3.2 Causality

A key assumption to study the impact of a policy intervention is that there is no reverse causality. In our context, this means that countries must not have adopted the Euro due to economic considerations. This assumption is plausible because the Eurozone accession was driven mainly by political rather than economic factors (Eichengreen and Frieden (1993), Feldstein (1997)). In fact, by not satisfying the requirements of an Optimum Currency Area, many economists believed that countries adopting the Euro would face economic losses (Jonung et al., 2009). This argument holds even for the Greek case which had decided to join the Euro before the single currency was a reality.[12]

Sections 2.1.1 and 2.2 discussed the conditions under which the SCM provides suitable estimates of causal effects and this section addresses some of these requirements. To further back the notion that the doppelganger gap is indeed caused by the Euro adoption, Sections 3.2.1 and 3.2.2 provides a number of placebo experiments and robustness checks. We can be confident that the synthetic control estimator captures the causal effect of an intervention as long as similar magnitudes are not estimated in cases where the intervention did not take place (Born et al., 2020). Finally, Section discusses the statistical significance of the results 3.2.3.

3.2.1 In-time placebo test: anticipation effects

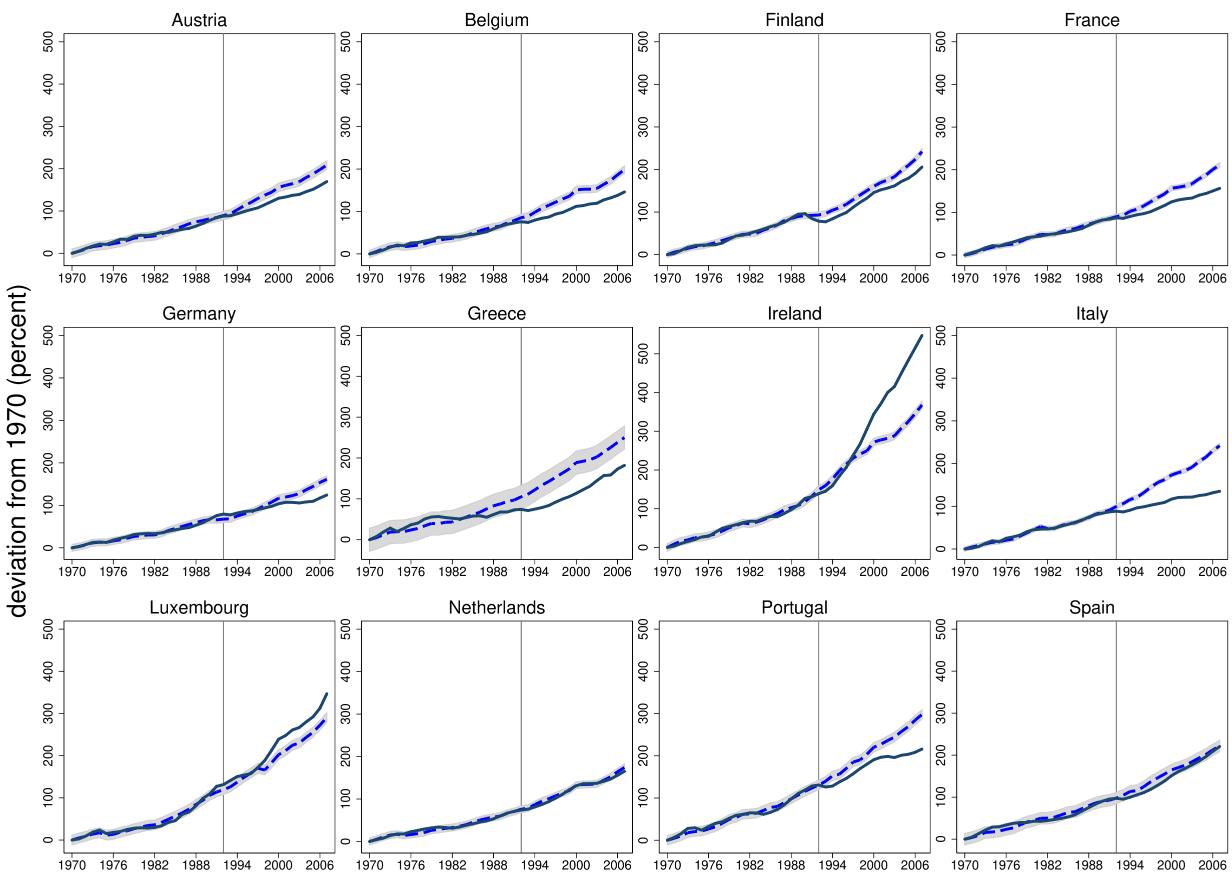
On 7 February 1992, representatives from twelve countries signed the Maastricht Treaty – Belgium, Denmark, France, Germany, Greece, Ireland, Italy, Luxembourg, Netherlands, Portugal, Spain, and the United Kingdom. Upon signing it, it was common knowledge that a monetary union, with a central banking system and a common currency, was to be created within the next years. It is, therefore, reasonable to think that countries experienced, at least partly, the Eurozone accession's impact before the Euro was launched.

[12]According to the 1998 convergence report from the European Commission, Greece did not join the single currency in 1999 because it had not fulfilled any of the four convergence criteria. Notwithstanding, the decision of joining was already made.

To check for anticipation effects of the Euro adoption, we perform in-time placebo tests by inspecting different intervention periods in our analysis. The date the Maastricht Treaty was signed is taken as the placebo treatment period. Figure 2 suggests that the main conclusions from Figure 1 remain unchanged.

We ran further time-placebo tests in which the placebo treatment date is set artificially to be every year from 1992 until 1998. For the sake of brevity, besides the Maastricht Treaty date 1992, we only report the tests for 1995 and 1998 in Figures A.1 and A.2. Reassuringly, the results remain unaltered.[13]

Figure 2: In-time placebo tests



Notes: In each graph, the blue dashed line represents the normalized real GDP for the synthetic country and the black full line represents the series for the actual country. The shaded area corresponds to two standard deviations of the difference between the treated country and the doppelganger prior to the Euro accession. The vertical line depicts the placebo treatment period - 1992 for all countries. For all countries, the analysis starts in 1970 and ends in 2007.

Figure 2 presents limited evidence in favor of the existence of anticipation effects. If

[13] The remaining figures can be provided by the authors upon request.

anything, the gap between the actual and the synthetic series becomes wider than the one analyzed in Figure 1. Notwithstanding, the direction of the effect remains unchanged. Thus, ignoring possible anticipation effects in our baseline estimates may lead to a lower bound of the Euro impact for countries like Austria, Belgium, France, and Italy.[14]

The absence of anticipation effects for the remaining countries may be due to two things. First, the key event representing a change for most European citizens was the irrevocably the exchange rate fix on 31st December 1998 and the Euro launch on the 1st of January 1999. Second, most of these countries had already experienced trade and economic gains from joining the European Union (Campos et al., 2018). Therefore, such effects lie in our pre-treatment sample and thus, are already being considered.

3.2.2 In-space placebo test

Following Abadie et al. (2010), Abadie and Cattaneo (2018), and Firpo and Possebom (2018), we employ the synthetic control methodology on the donor pool countries while exposing them to a placebo treatment in 1999. The idea is to sequentially "re-assign" the treatment to all units in the donor pool and, for each of them, estimate a fictitious doppelganger using the remaining donor countries and the originally treated unit. We repeat this process for every treated country.

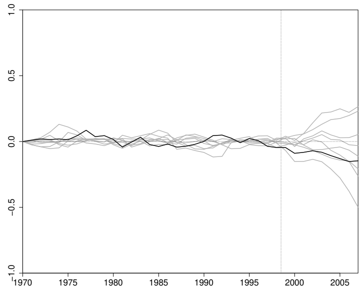
Next, we compare the post and pre-treatment behavior of these series and inspect the differences between treated and fictionally treated units. If our benchmark estimates for each Eurozone country are picking up the causal effect of the Euro accession, these should dominate any possible impact of the fictitious event in the donor countries. On the other hand, if no difference is found, then most likely the actual intervention had no effect. Applying this idea to each country in the donor pool allows us to compare the estimated effect of the Euro accession on Eurozone countries to the distribution of placebo effects obtained for the other countries (Abadie et al., 2015).

The plots from Figure 3 depict the doppelganger gaps for treated countries (black lines) and donor countries (grey lines), that is, the differences between each countries' normalized GDP and their doppelgangers' estimates. The smaller the gap for the pre-treatment period, the better the fit of the synthetic series to the outcome variable. Countries with a bad pre-intervention fit are excluded from the in-space placebo test because they are not suited to inform about the post-treatment effect.[15]

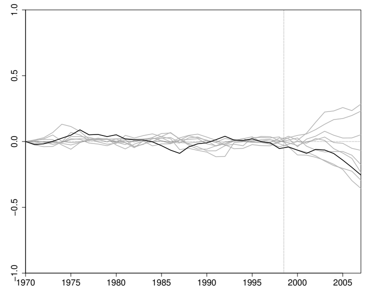
[14] The case for Greece is not worrisome given its bad pre-treatment fit and, therefore, its lack of significance.

[15] We define a good pre-intervention fit following Firpo and Possebom (2018) when the pre-intervention MSPE of a donor country is at most four times greater than the Eurozone country's pre-intervention MSPE being analyzed.

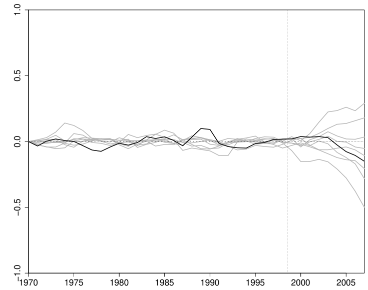
Figure 3: In-space placebo tests



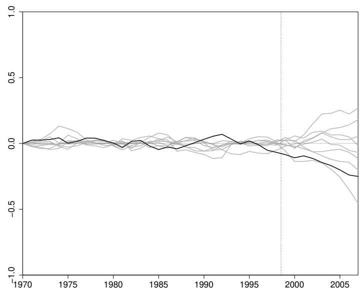
(a) Austria



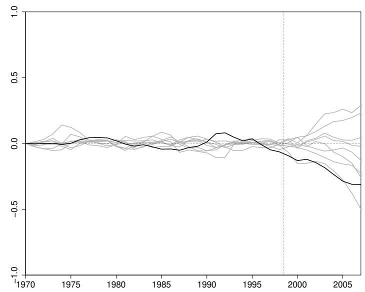
(b) Belgium



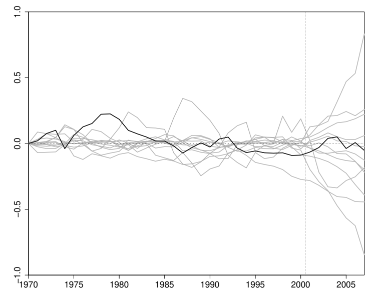
(c) Finland



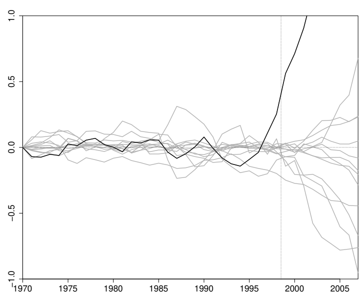
(d) France



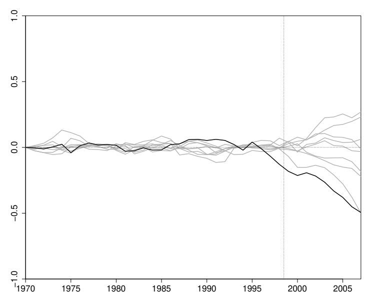
(e) Germany



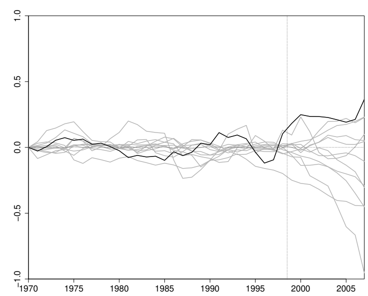
(f) Greece



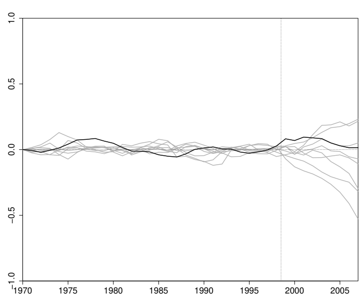
(g) Ireland



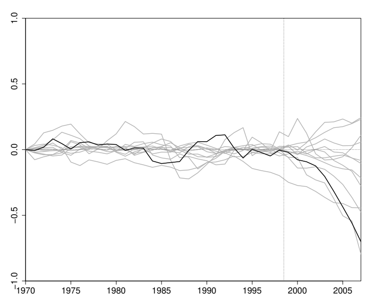
(h) Italy



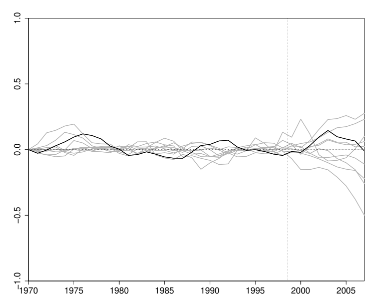
(i) Luxembourg



(j) The Netherlands



(k) Portugal



(l) Spain

Notes: The plotted lines represent the prediction error for the treated country (black) and donor countries (grey) for which we impose a fictitious Euro accession. We plot the donor countries whose pre-treatment MSPE was four times larger than the one of the treated country.

Visually, Figure 3 reinforces the findings in Figure 1. When comparing the full black lines from each Euro-adopter country to the grey lines of fictitious treated units, it is clear that, for some countries, the post-treatment gap is unusually bigger. Specifically, it suggests a positive impact of the Euro accession on Ireland and Luxembourg and a negative impact, if any, on France, Germany, Italy, and Portugal.

3.2.3 Statistical Significance

To evaluate the statistical significance of our estimates and following Abadie et al. (2010) and Abadie and Cattaneo (2018), we use a test based on the classic framework for permutation inference which builds on the computations presented in the previous section.

Given our estimates of all fictional treatment effects in the previous section, we can evaluate the statistical significance by computing a p-value associated with the treatment. First, we compute the ratio of root mean squared prediction errors (RMSPE) in the post-intervention period relative to the pre-intervention period for treated and fictitiously treated units as follows:

$$\chi \equiv \frac{RMSPE_{post}}{RMSPE_{pre}} \equiv \frac{\sqrt{\frac{1}{T-T_0+1}\sum_{t=T_0}^{T}(x_{1,t}-\mathbf{x_{0,t}}\mathbf{w})^2}}{\sqrt{\frac{1}{T_0-1}\sum_{t=1}^{T_0-1}(x_{1,t}-\mathbf{x_{0,t}}\mathbf{w})^2}} \tag{5}$$

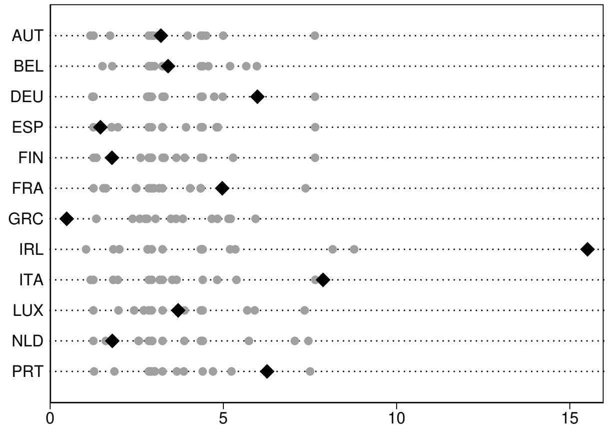
where $x_{1,t}$ denotes the GDP of the treated country at period t; $\mathbf{x_{0,t}}$ denotes a vector of observations of GDP for the donor countries in period t; $\mathbf{w}$ denotes a vector of weights for the donor countries, T denotes the total number of periods, and T_0 denotes the treatment date.

This statistic already allows a quantitative analysis of the treatment effect taking into account the quality of the match produced by the SCM. A small pre-treatment RMSPE implies a good fit of the synthetic series to the actual series and a large post-treatment RMSPE suggests, for the treated units, a large intervention impact. Therefore, obtaining a larger ratio for the treated unit than for the placebo-treated units would entail a significant treatment effect.[16]

Figure 4 depicts this relative measure for the Eurozone countries (black diamonds) and its donors (grey circles). Ireland clearly stands out as the country with the highest RMSPE ratio with a post-intervention gap about 16 times larger than its pre-intervention gap.

[16] A large post-intervention RMSPE *per se* is not indicative of a large effect of the intervention. It depends on whether the synthetic control can reproduce closely the outcome of interest prior to the intervention (Abadie, 2019).

Figure 4: Ratio between the post- and pre-treatment RMSPE



Notes: The plots show the ratio between the post- and the pre-intervention RMSPE for the treated units (in black diamonds) and all donor countries (in grey circles).

We deem the effect of the Euro adoption significant if the estimated effect for the treated units is unusually large relative to the distribution of the placebo effects. To test this in practice, we compute a p-value which compares the value of the RMSPE for the treated country to that of all other units as follows:

$$\rho_1 = \sum_{i=1}^{N+1} I(\chi_i \geq \chi_1) \ / \ (N+1) \tag{6}$$

where $I(.)$ denotes the indicator function, N the number of donor countries, χ_1 the RMSPE ratio for the treated unit and χ_i is the RMSPE ratio for country i which can be a donor or the treated country.

Table A.4 presents the RMSPE ratios, (χ), for all countries in the baseline analysis and correspondent p-values for the treated units. If one were to pick a country at random from the Irish sample, the chances of obtaining a ratio as high as the Irish would be $1/15 = 0.067$ which we consider to be statistically significant. A closer look at Table A.4 and Figure 4 shows that Ireland, Italy, Portugal, Germany, and France experienced a significant impact from adopting the Euro in terms of their real GDP.

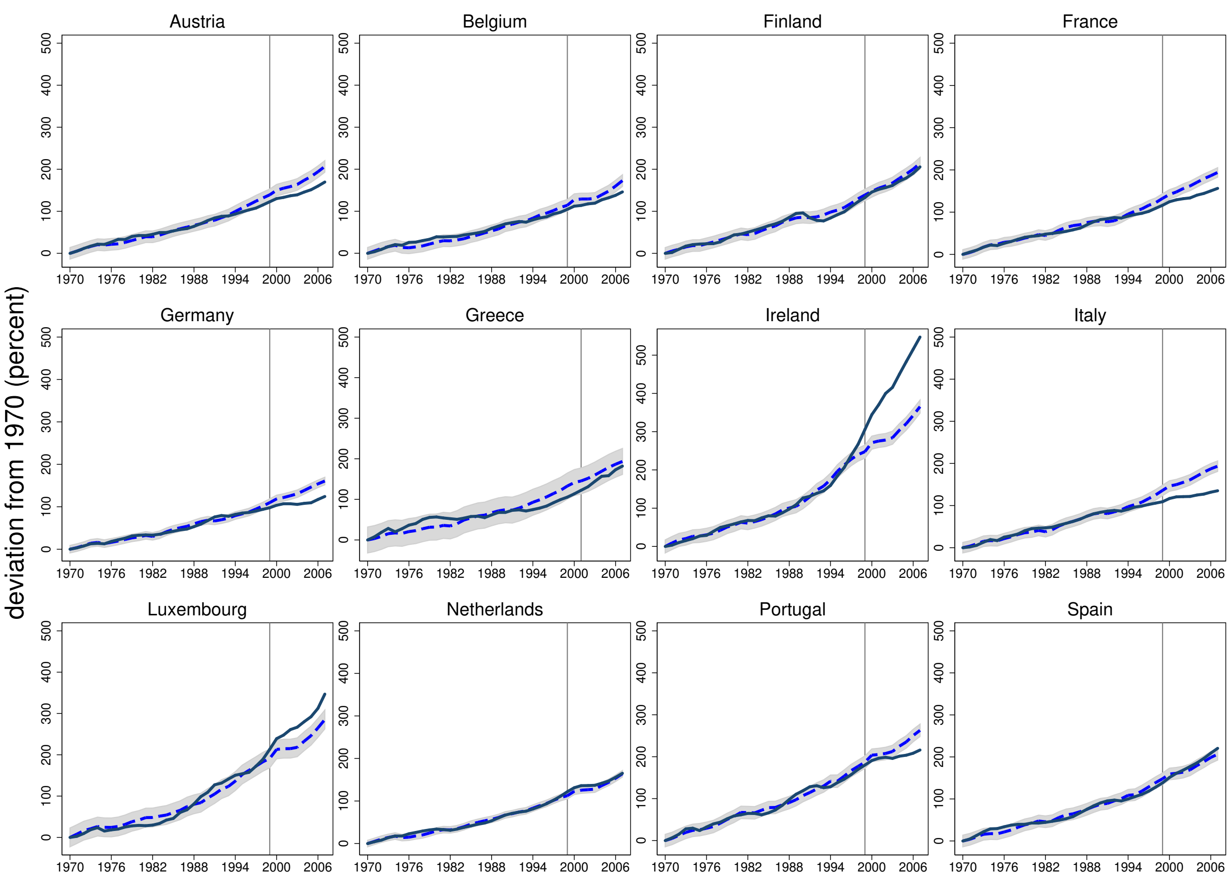
3.3 Further robustness checks

3.3.1 Changes to donor pool

This section addresses two concerns. First, some countries in the control group may have opted out of the treatment. This would suggest a reverse causality problem and raise doubts about the credibility of the results presented. As discussed at the beginning of Section 3.2, countries used in the analysis must not have opted in or out due to economic considerations.

In fact, the UK, Sweden, and Denmark belonged to the European Union at the time but did not adopt the common currency. Even though they did opt out due to political reasons, we still address this issue by excluding these countries altogether from the donor pool. We redo our analysis with this new pool and the results are presented in Figure 5. The main conclusions remain unchanged for all the Eurozone countries. With special attention for the ones whose doppelgangers' construction highly relied on this trio - Austria, Belgium, France, Germany, Italy, and Portugal.

Figure 5: Impact of the Euro accession with a change in the donor pool



Notes: In each graph, the blue dashed line represents the normalized real GDP for the synthetic country and the black full line represents the series for the actual country. The shaded area corresponds to two standard deviations of the difference between the treated country and the doppelganger prior to the Euro accession. The vertical line depicts the treatment period - 2001 for Greece and 1999 for the remaining countries. For all countries the analysis starts in 1970 and ends in 2007. Relative to the baseline analysis, the donor pool now excludes Denmark, Sweden and the United Kingdom. Table A.5 show the weights used to construct these results.

Second, there might have been spillover effects of the treatment onto the donor countries. We address this issue by iteratively re-estimating our baseline estimate for each Eurozone country excluding in each iteration one of the countries with positive weight.

We display this robustness check for countries that weighted, at least, 10% in the construction of, at least, 2 countries' counterfactuals in Appendix A.6. This exercise shows that no particular donor country is driving the main conclusions. So, it is unlikely that neither spillover effects nor one specific country in the donor pool is driving the results.

3.3.2 Changes in the sample period

The credibility of the SCM results severely depends on whether the requirements specified in Section 2.1.1 are satisfied. One of these requirements was that countries should not experience differentiated shocks during the sample period. Several analysed countries joined the European Union during the pre-treatment period may concern the most attentive reader.

For countries which joined the EU at least 10 years before the Eurozone creation, we re-do the estimates using their accession data as the start of our sample, i.e. Ireland (1973), Greece (1981), Portugal and Spain (1986). From Figure 6, it is possible to conclude that the results from the baseline analysis are robust.

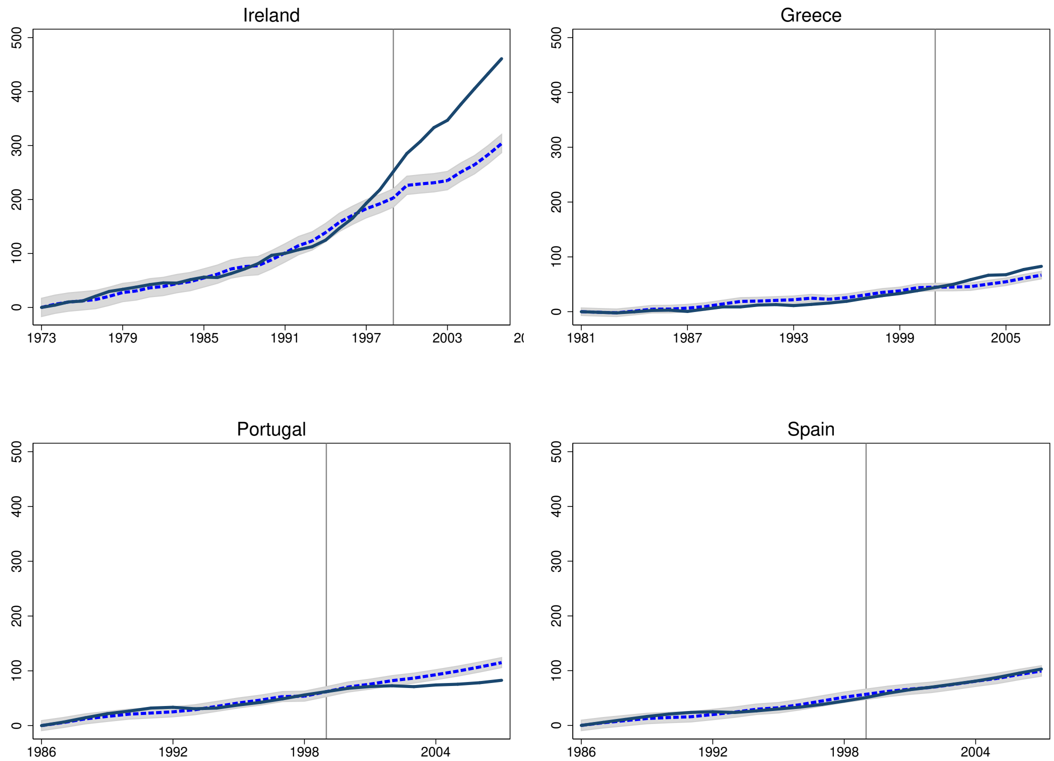
Unfortunately, it is not possible to re-estimate the results for Austria and Finland because they joined the EU in 1995. Yet, according to Campos et al. (2018), Austria and Finland were not significantly affected by the EU accession and thus we believe that this does not pose a problem to our analysis.

4 What drives the doppelganger gap?

In this section, we take one step further and investigate what drives the results presented in Figure 1 by decomposing the Euro accession response of GDP into the response of its components. First, we compute the series for each GDP component for both countries and corresponding counterfactuals. Then, we try to understand what explains the output gains and losses from the accession by accounting the role of each component for the doppelganger GDP gap.

This analysis begins by constructing the synthetic shares of GDP components using the weights estimated in Section 2 and the data from the donor countries. Similarly to the construction of the synthetic GDP series, we now compute the synthetic shares of each GDP component as a weighted average of the shares of GDP components for the donor countries. Namely, we obtain GDP shares of private consumption, investment, government consumption, exports, and imports. Then, we use each component share and the GDP

Figure 6: The impact of the Euro accession with a change in the sample period



Notes: In each graph, the blue dashed line represents the normalized real GDP for the synthetic country and the black full line represents the series for the actual country. The shaded area corresponds to two standard deviations of the difference between the treated country and the doppelganger prior to the Euro accession. The vertical line depicts the treatment period - 1999 for Ireland, Greece, and Portugal and 2001 for Greece. The analysis starts in 1973 for Ireland, 1981 for Greece, and 1986 for Portugal and Spain. For all countries, the analysis ends in 2007.

series to compute the five GDP components series for both countries and doppelgangers. In Appendix A.7, we present these series as a deviation from the 1970 value in percent.

It is important to highlight that comparing the actual and the synthetic series from Appendix A.7 also indicates whether the doppelganger can really mimic the behaviour of each country prior to the Euro accession. We must recall that the construction of the doppelganger in Section 2 does not target the time path of GDP components and thus, a good fit in this regard can not be taken for granted. Overall, the figures from Appendix A.7 reassure us of the good fit of the our estimates.

Next, we compute the contribution of each GDP component for the output gap generated by the treatment. In section 2.1, Equation 1 defines the doppelganger gap as the difference in the outcome variable (here, real GDP) between the treated and the synthetic country. The cumulative treatment effect can be estimated by computing the doppelganger gap for

$t = 2007$, the last year of our analysis.

Here, we proceed in four steps. Analogously to Equation 1, we start by computing doppelganger gaps for each GDP component. Then, we compute the relative weight of each component z on the output doppelganger gap in the following way:

$$\text{weight of } z_{c,t} = \frac{z_{c,t} - z_{c,t}^{dop}}{GDP_{c,t} - GDP_{c,t}^{dop}} \tag{7}$$

where z is either private consumption, government consumption, investment, exports, or imports, the subscript c stands for one of the twelve treated countries, and the subscript t represents the time period. Thereafter, we calculate the **percent** doppelganger gap for GDP as follows:

$$\text{percent output doppelganger gap }_{c,t} = \frac{GDP_{c,t} - GDP_{c,t}^{dop}}{GDP_{c,t}^{dop}} \tag{8}$$

Showing the treatment effect in percent terms allows a direct interpretation of how much larger/smaller the GDP is due to the Euro accession. Finally, we multiply the relative weight of each doppelganger gap $z_{c,t}$ by the percent output doppelganger gap. This allows us to understand the direct contribution of each channel to the treatment effect.

Figure 7 depicts, for each country, the percent GDP gap in 2007 and its decomposition. It clearly shows that countries experienced the Euro accession heterogeneously.[17]

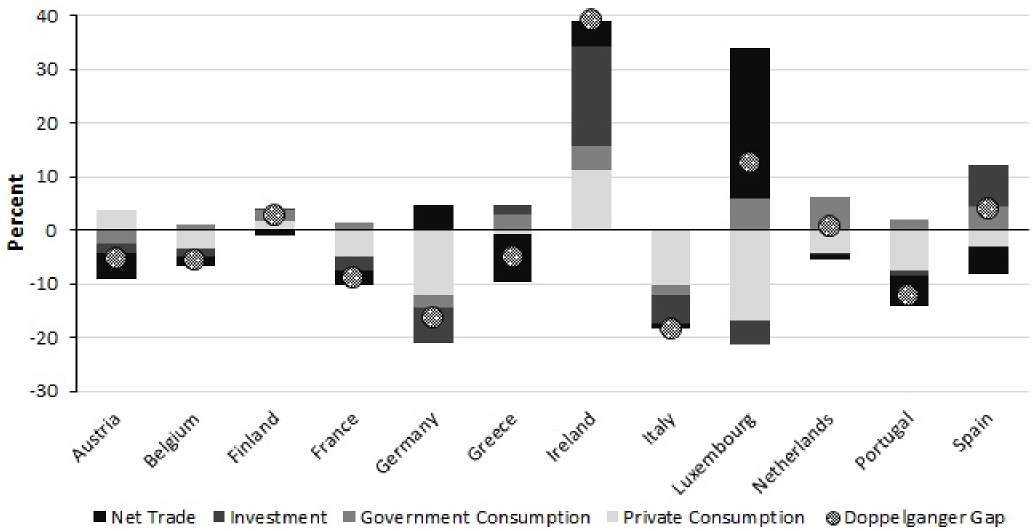
We now take a deeper look into the countries which were significantly affected as argued in Section 3.2. For Ireland, joining the Euro area boosted GDP by 39%. Even though all GDP components contribute positively to this result, the private consumption and investment together can explain almost 80% of the total output gain from the treatment.

Table A.6 also shows that the reasons behind the economic slowdown experienced by some countries at the Euro accession differ from country to country. We find that for France and Portugal, the private consumption and the net exports accounted for a large share of the GDP gap. For Germany and Italy, it is the doppelganger difference in private consumption alongside investment that better explains the negative economic impact of the Euro on GDP.

Before the Euro, the need to exchange local currencies implied extra transaction costs and exchange rate risk. The single currency was expected to boost cross-border trade and investment between the member states since doing business in the euro area would be more cost-efficient and less risky (De Grauwe (2020)). For third parties, the Euro area would be an attractive place to invest as well. Consumers would benefit from price transparency and stability. Therefore, it would be expected an increase in investment, exports, and imports

[17] See Table A.6 for the exact values depicted in Figure 7.

Figure 7: Doppelganger gaps and GDP components



Notes: The dot depicts, for each country, the percent doppelganger gap of output computed as in Equation 8. The stacked bars represent the contribution of each GDP component for these gaps. The values for GDP component sum up the percent doppelganger gap for each treated unit. The values represent the cumulative effect of the Euro accession since they are computed for 2007, the last year of the analysis.

but it is not clear in which direction the trade balance would go.

Table A.7 indeed reveals that, with the exception of France and Italy, all countries had a higher trade volume than if they had not adopted the common currency. This result is in accordance with Baldwin et al. (2008) and Schmitz and Von Hagen (2011) who argue that the Euro has significantly promoted trade in the Eurozone countries. Yet, net exports changed differently across countries. Only Germany and Ireland experienced significant net trade benefits from the Euro accession. We corroborate the negative impact on net exports in most cases as documented in Hope (2016).

Moreover, even though the common currency was expected to attract foreign investment for the whole Euro area, Ireland stands out from the remaining member countries. Investment in Ireland increased significantly because of the Euro adoption. Therefore, country-specific characteristics have significantly shaped the impact across member states.

5 Conclusion

In this paper we study the impact of the EMU accession on the macroeconomic performance of the first twelve member states. We use the synthetic control method to construct a counterfactual of these countries' GDP. This method allows building a doppelganger which should represent the economic activity of these countries in the absence of the Euro adoption.

Our findings suggest that there are mild losers (France, Germany, Italy, and Portugal) and a clear winner (Ireland). Notwithstanding, the drivers of such estimates are heterogeneous as our GDP decomposition analysis indicates. Our results show that for the majority of Eurozone countries, Euro spurred government consumption and deterred investment and private consumption. The common currency also stimulated trade for most cases but only Germany and Ireland bear positive net trade benefits.

These evidence points out to the importance of analyzing in detail the heterogeneous responses of GDP components and their implications. For example, given the different responses of investment and government consumption across member states, it is natural to ask if the effectiveness of national fiscal policies has changed. This could be especially interesting given that, with the common currency adoption, countries forgo important policy instruments.

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A Appendix

A.1 Variables description and source

Table A.1: Variables Description

Variable code	Description	Source
rgdpna	Real gross domestic product at constant 2011 national prices in million 2011 US dollars normalized to unity in 1970.	PWT 9.1
emp	Total employment - number of persons engaged in millions.	PWT 9.1
csh_prod	Labor productivity growth computed by taking the log-difference between real gdp and total employment	PWT 9.1
pop	Total population in millions.	PWT 9.1
csh_emp	Employment share - ratio between total employment and total population	PWT 9.1
csh_c	Private consumption expenditure (% of GDP) obtained by subtracting general government final consumption expenditure to the series of final consumption expenditure	World Bank
csh_g	General government final consumption expenditure (% of GDP)	World Bank
csh_i	Gross fixed capital formation (% of GDP)	World Bank
csh_x	Exports of goods and services (% of GDP)	World Bank
csh_m	Imports of goods and services (% of GDP)	World Bank

Notes: All variables collected directly from the Penn World Table are from version 9.1 (PWT 9.1) (Feenstra et al., 2015). All level variables are in real terms and at annual frequency spanning the year 1970 until 2007. GDP components were collected from the World Bank database in shares of GDP. The data were collected on the 30-10-2019.

A.2 Comparison Tables

Table A.2: Predictors' means (in %) for each country during pre-treatment period

Variable Names	Country	Doppelganger
Austria		
Share of Priv. Consumption	56.27	51.57
Share of Gov. Consumption	17.91	20.58
Share of Investment	26.53	26.27
Share of Imports	32.57	32.35
Share of Exports	31.85	33.93
Employment Share	45.16	48.33
Labor productivity growth	2.47	2.07
Belgium		
Share of Priv. Consumption	54.14	54.15
Share of Gov. Consumption	21.41	20.59
Share of Investment	22.87	24.74
Share of Imports	53.80	36.03
Share of Exports	55.39	36.55
Employment Share	38.01	49.41
Labor productivity growth	2.33	1.57
Finland		
Share of Priv. Consumption	52.51	52.30
Share of Gov. Consumption	19.38	19.96
Share of Investment	26.66	26.54
Share of Imports	26.57	26.66
Share of Exports	28.02	27.86
Employment Share	47.26	47.22
Labor productivity growth	3.08	1.87
France		
Share of Priv. Consumption	55.16	56.10
Share of Gov. Consumption	21.24	19.47
Share of Investment	23.11	23.42
Share of Imports	20.54	21.50
Share of Exports	21.03	22.51
Employment Share	40.49	43.80
Labor productivity growth	2.20	1.23
Germany		
Share of Priv. Consumption	57.15	57.29
Share of Gov. Consumption	19.68	18.18
Share of Investment	24.50	24.30
Share of Imports	21.40	21.25
Share of Exports	20.06	21.48
Employment Share	48.36	48.23

Continued on next page...

... table A.2 continued

Variable Names	Country	Doppelganger
Labor productivity growth	2.41	1.48
Greece		
Share of Priv. Consumption	63.06	60.84
Share of Gov. Consumption	16.75	17.21
Share of Investment	26.46	22.76
Share of Imports	21.77	17.88
Share of Exports	15.50	17.07
Employment Share	38.77	45.51
Labor productivity growth	1.69	1.21
Ireland		
Share of Priv. Consumption	61.17	55.50
Share of Gov. Consumption	18.72	24.34
Share of Investment	21.65	24.24
Share of Imports	52.85	34.67
Share of Exports	51.30	30.59
Employment Share	35.36	39.90
Labor productivity growth	3.43	2.14
Italy		
Share of Priv. Consumption	59.00	58.72
Share of Gov. Consumption	17.55	17.63
Share of Investment	22.87	23.15
Share of Imports	19.28	19.37
Share of Exports	19.86	19.86
Employment Share	38.25	44.11
Labor productivity growth	2.48	1.24
Luxembourg		
Share of Priv. Consumption	48.16	58.05
Share of Gov. Consumption	15.33	10.82
Share of Investment	22.57	29.26
Share of Imports	81.83	39.32
Share of Exports	95.78	41.20
Employment Share	46.63	51.00
Labor productivity growth	1.81	1.54
The Netherlands		
Share of Priv. Consumption	50.90	54.78
Share of Gov. Consumption	21.94	18.40
Share of Investment	22.62	26.16
Share of Imports	47.47	37.62
Share of Exports	52.01	38.27
Employment Share	43.78	49.70

Continued on next page...

... table A.2 continued

Variable Names	**Country**	**Doppelganger**
Labor productivity growth	1.56	1.48
Portugal		
Share of Priv. Consumption	66.93	65.45
Share of Gov. Consumption	14.03	13.91
Share of Investment	26.93	21.36
Share of Imports	31.16	21.84
Share of Exports	23.27	21.12
Employment Share	41.81	38.57
Labor productivity growth	2.02	1.29
Spain		
Share of Priv. Consumption	63.12	61.46
Share of Gov. Consumption	14.51	14.58
Share of Investment	23.78	23.82
Share of Imports	18.55	17.34
Share of Exports	17.13	17.47
Employment Share	35.38	43.58
Labor productivity growth	2.56	1.10

Notes: Predictors' means for each country during the pre-treatment period. All numbers are in percent. Variables definitions can be find in Table A.1.

A.3 Weights Table

Table A.3: Composition of each doppelganger: country weights (in %)

Donor countries	Austria	Belgium	Finland	France	Germany	Greece	Ireland	Italy	Luxembourg	Netherlands	Portugal	Spain
Australia	< 0.1	< 0.1	26.6	< 0.1	0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	15.6
Canada	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1
Chile	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	22.0	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1
Denmark	< 0.1	46.5	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	26.4	< 0.1	< 0.1
Iceland	< 0.1	< 0.1	< 0.1	< 0.1	0.2	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1
Israel	< 0.1	13.2	< 0.1	< 0.1	0.9	3.1	50.1	< 0.1	< 0.1	13.5	< 0.1	2.0
Korea	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	14.0	< 0.1	4.0	< 0.1
Mexico	< 0.1	< 0.1	< 0.1	29.2	< 0.1	< 0.1	< 0.1	22.4	< 0.1	< 0.1	43.0	18.5
New Zealand	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	42.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1
Norway	48.2	7.2	33.9	< 0.1	< 0.1	< 0.1	27.9	< 0.1	0.2	13.0	< 0.1	< 0.1
Sweden	33.9	< 0.1	29.0	57.8	31.8	< 0.1	< 0.1	34.9	< 0.1	< 0.1	< 0.1	< 0.1
Switzerland	7.2	33.1	4.2	< 0.1	17.4	< 0.1	< 0.1	5.6	85.8	47.1	5.1	17.6
United Kingdom	10.7	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	4.0	< 0.1	< 0.1	47.9	< 0.1
United States	< 0.1	< 0.1	6.2	13.0	49.6	54.8	< 0.1	33.1	< 0.1	< 0.1	< 0.1	46.2

Notes: This table summarizes the weights in percent attributed to each donor country to construct the synthetic treated units. These weights are used in the baseline analysis.

A.4 RMSPE

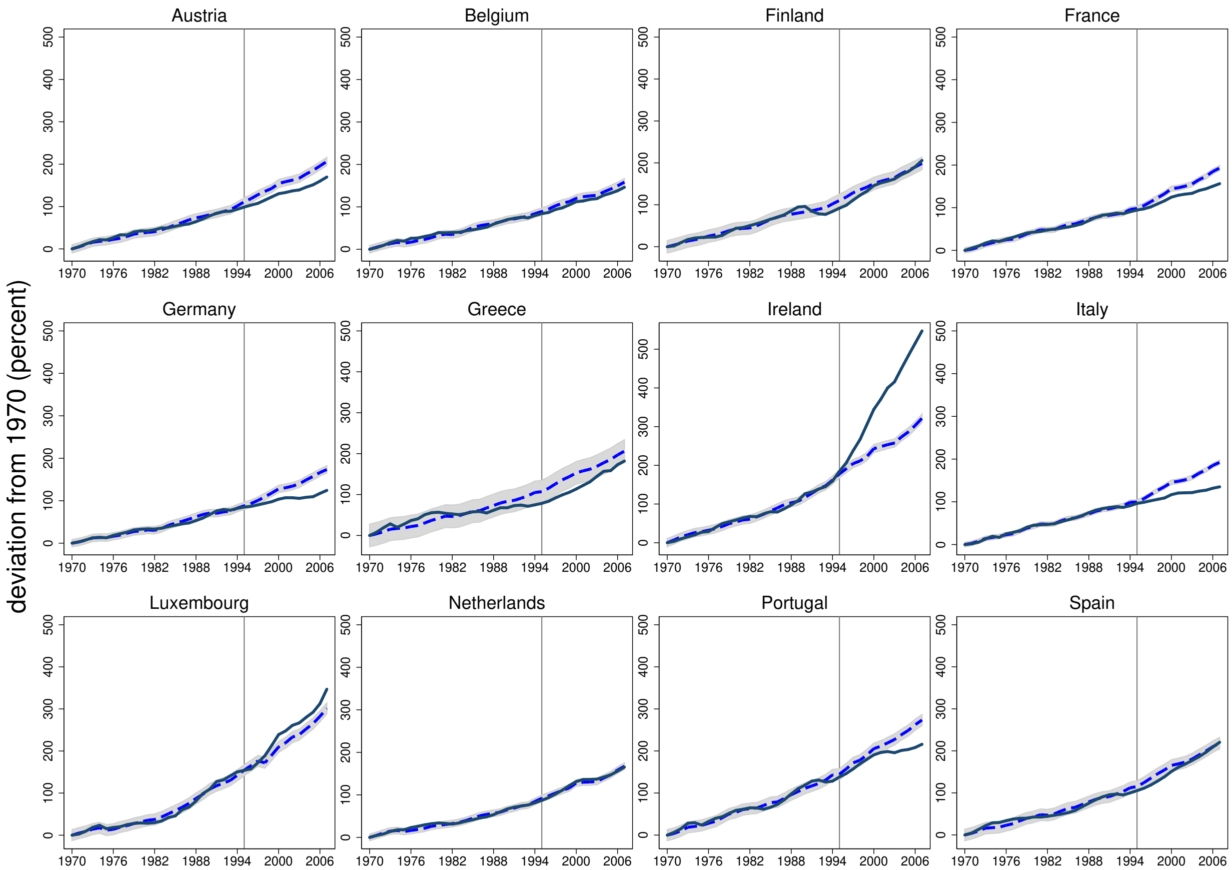
Table A.4: Relative root mean squared prediction error of the pre- and post- treatment doppelganger gaps.

	AUS	***CAN***	***CHL***	***DNK***	***ISL***	***ISR***	***KOR***	***MEX***	***NZL***	***NOR***	***SWE***	***CHE***	***GBR***	***USA***	***Treated***	***P-Value (ρ)***
AUT	2.98	5.00	2.85	4.50	1.73	1.25	2.93	4.35	3.10	7.64	4.41	3.24	1.16	3.97	3.20	0.533
BEL	2.86	4.57	2.85	5.97	3.01	1.79	2.93	4.35	3.28	5.66	4.41	3.24	1.51	5.19	3.40	0.467
FIN	2.61	5.28	2.85	4.42	2.89	1.25	2.93	4.35	3.30	7.65	3.64	3.24	1.33	3.88	1.78	0.867
FRA	2.99	2.49	2.85	4.34	1.61	1.25	2.93	4.35	3.14	7.37	2.47	3.24	1.54	4.04	4.97	**0.133**
DEU	2.80	4.74	2.85	4.98	2.88	1.25	2.93	4.35	3.30	7.65	4.40	3.24	1.22	2.86	5.98	**0.133**
GRC	2.81	3.83	2.59	4.83	3.49	2.38	2.74	5.15	3.63	5.93	4.66	3.04	1.33	5.21	0.48	1.000
IRL	2.81	5.34	1.04	4.37	2.00	8.16	2.93	4.35	2.81	8.77	4.40	3.24	1.82	5.19	15.51	**0.067**
ITA	1.95	3.65	2.85	4.82	1.82	1.25	2.93	3.52	3.16	7.65	4.40	3.24	1.17	5.38	7.88	**0.067**
LUX	2.70	5.69	2.85	5.90	1.97	1.25	2.93	4.35	2.71	7.35	4.40	3.24	2.43	3.88	3.69	0.467
NLD	2.95	5.74	2.85	7.06	2.56	1.25	2.93	4.35	2.55	7.45	4.41	3.24	1.61	3.87	1.79	0.867
PRT	3.02	5.23	2.85	4.70	3.01	1.27	2.93	3.66	2.88	7.50	4.40	3.24	1.85	3.86	6.26	**0.133**
ESP	1.95	4.84	2.85	4.81	1.77	1.25	2.93	4.35	3.24	7.65	4.40	3.24	1.77	3.92	1.45	0.933

Notes: The column *Treated* displays the RMSPE ratio for each country, χ in equation 5. The column *P-Value* tell us the chances of obtaining a ratio as high as the treated country if one were to pick a country at random from the sample including also the treated country, ρ in equation 6. Given the small number of donor countries, we consider the results significant if there at most 2 countries with a higher RMSPE ratio. For example, for Ireland there is only 1 out of 15 countries with an RMSPE ratio of at least 15.51 yielding a p-value of 0.067.

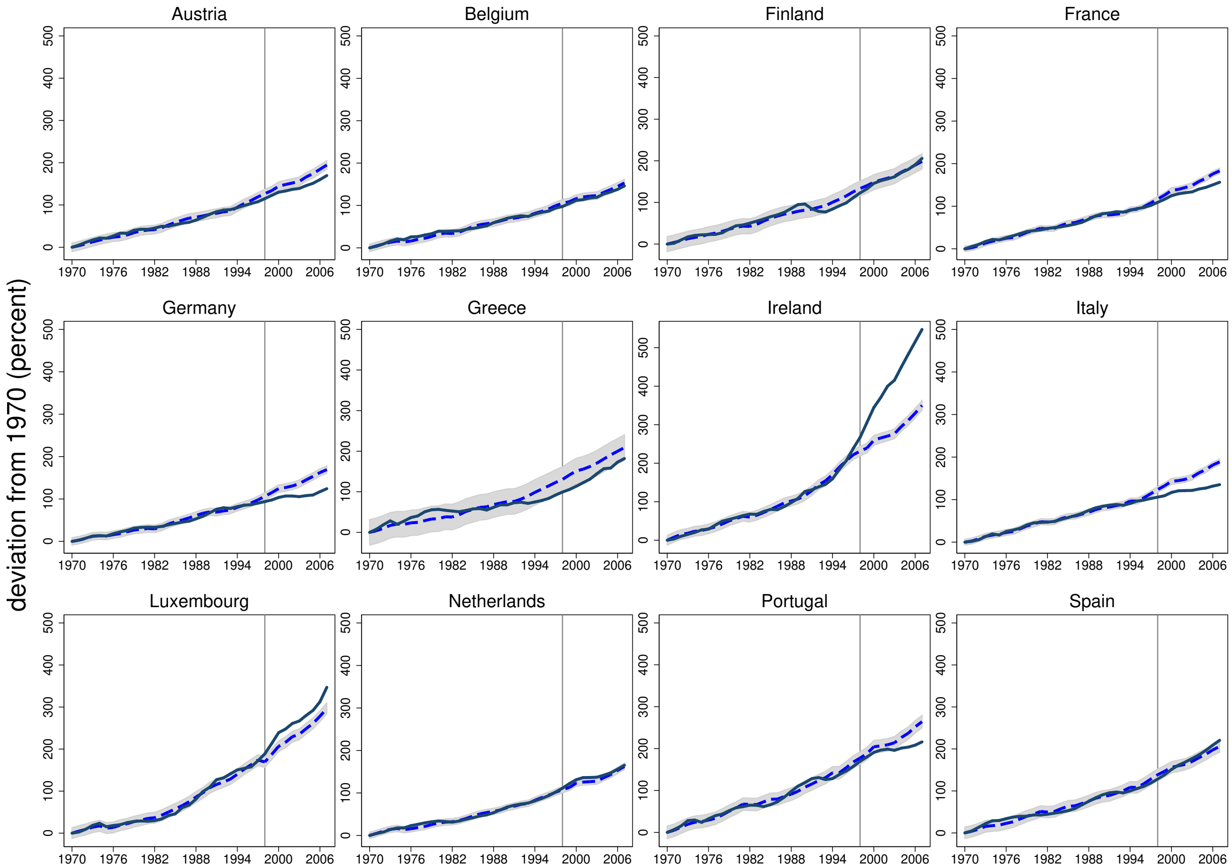
A.5 In-time placebo test

Figure A.1: In-time placebo test - 1995



Notes: In each graph, the blue dashed line represents the normalized real GDP for the synthetic country and the black full line represents the series for the actual country. The shaded area corresponds to two standard deviations of the difference between the treated country and the doppelganger prior to the Euro accession. The vertical line depicts the placebo treatment period - 1995 for all countries. For all countries the analysis starts in 1970 and ends in 2007.

Figure A.2: In-time placebo test - 1998

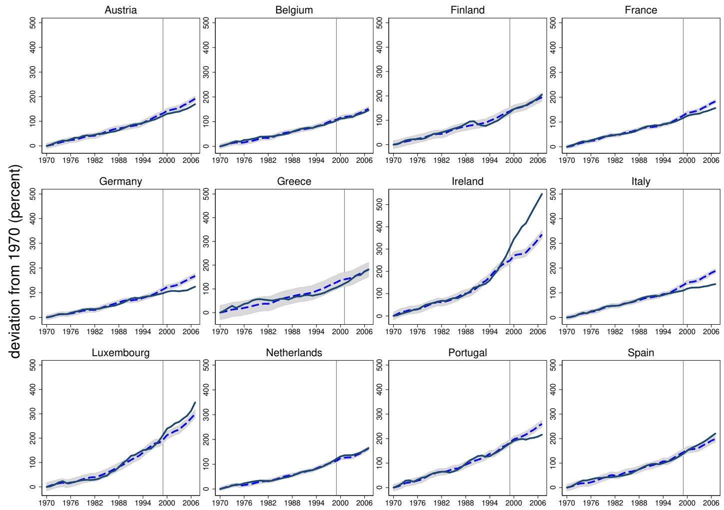


Notes: In each graph, the blue dashed line represents the normalized real GDP for the synthetic country and the black full line represents the series for the actual country. The shaded area corresponds to two standard deviations of the difference between the treated country and the doppelganger prior to the Euro accession. The vertical line depicts the placebo treatment period - 1998 for all countries. For all countries the analysis starts in 1970 and ends in 2007.

A.6 Changing donor pool

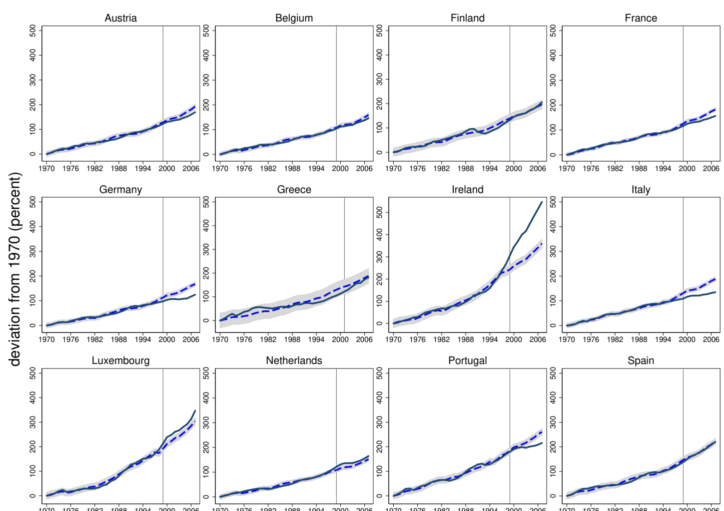
In each of the following set of graphs, the blue dashed line represents the normalized real GDP for the synthetic country and the black full line represents the series for the actual country. The vertical line depicts the treatment period. For all countries the analysis starts in 1970 and ends in 2007. We iteratively exclude different countries from the donor pool as argued in Section 3.3.1.

Figure A.3: SCM without Australia



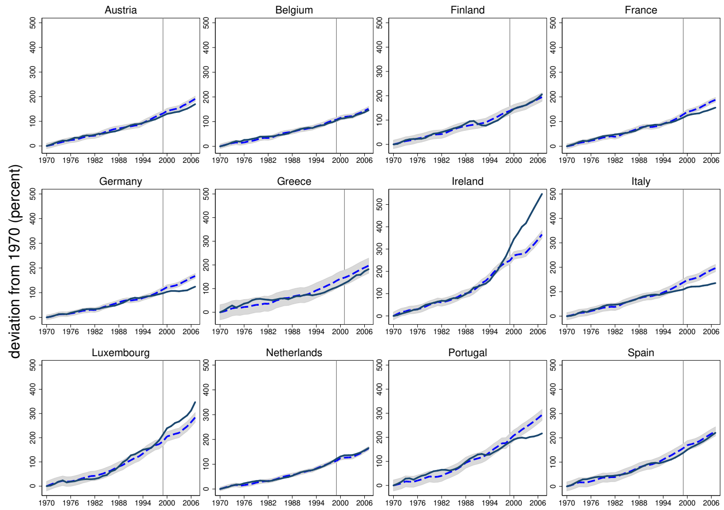
Notes: In each graph, the blue dashed line represents the normalized real GDP for the synthetic country and the black full line represents the series for the actual country. The shaded area corresponds to two standard deviations of the difference between the treated country and the doppelganger prior to the Euro accession. The vertical line depicts the placebo treatment period - 2001 for Greece and 1999 for all other countries. For all countries the analysis starts in 1970 and ends in 2007. Australia is excluded from the donor pool.

Figure A.4: SCM without Israel



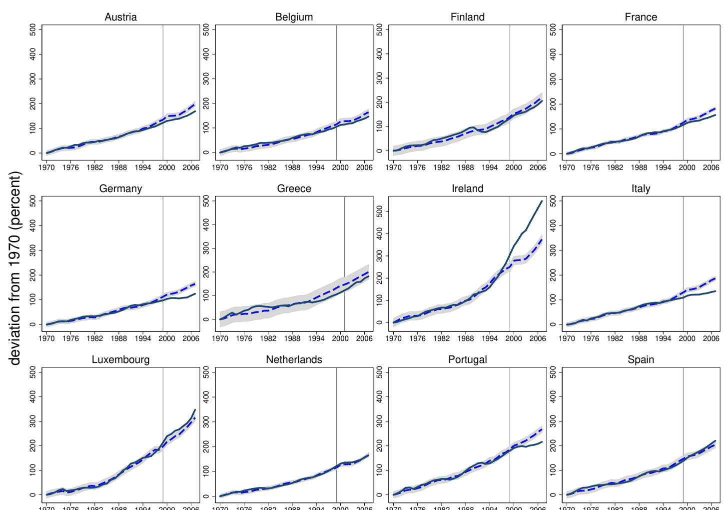
Notes: In each graph, the blue dashed line represents the normalized real GDP for the synthetic country and the black full line represents the series for the actual country. The shaded area corresponds to two standard deviations of the difference between the treated country and the doppelganger prior to the Euro accession. The vertical line depicts the placebo treatment period - 2001 for Greece and 1999 for all other countries. For all countries the analysis starts in 1970 and ends in 2007. Israel is excluded from the donor pool.

Figure A.5: SCM without Mexico



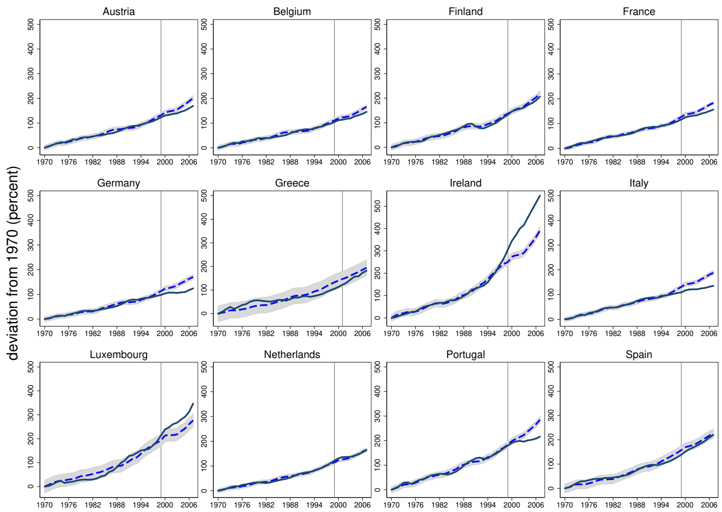
Notes: In each graph, the blue dashed line represents the normalized real GDP for the synthetic country and the black full line represents the series for the actual country. The shaded area corresponds to two standard deviations of the difference between the treated country and the doppelganger prior to the Euro accession. The vertical line depicts the placebo treatment period - 2001 for Greece and 1999 for all other countries. For all countries the analysis starts in 1970 and ends in 2007. Mexico is excluded from the donor pool.

Figure A.6: SCM without Norway



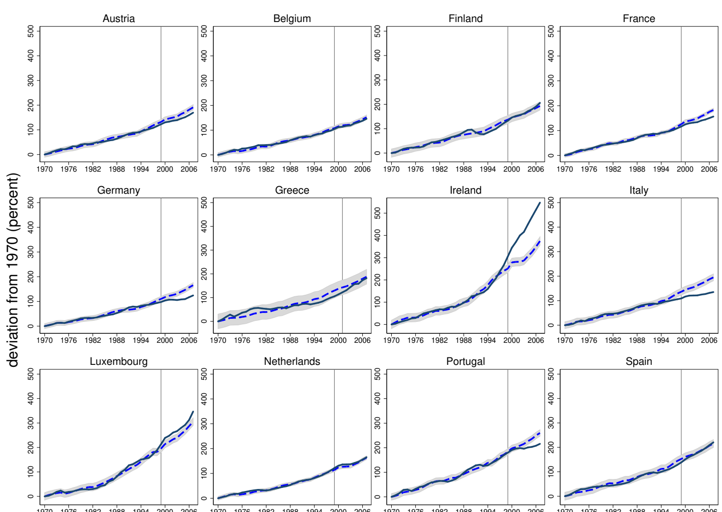
Notes: In each graph, the blue dashed line represents the normalized real GDP for the synthetic country and the black full line represents the series for the actual country. The shaded area corresponds to two standard deviations of the difference between the treated country and the doppelganger prior to the Euro accession. The vertical line depicts the placebo treatment period - 2001 for Greece and 1999 for all other countries. For all countries the analysis starts in 1970 and ends in 2007. Norway is excluded from the donor pool.

Figure A.7: SCM without Switzerland



Notes: In each graph, the blue dashed line represents the normalized real GDP for the synthetic country and the black full line represents the series for the actual country. The shaded area corresponds to two standard deviations of the difference between the treated country and the doppelganger prior to the Euro accession. The vertical line depicts the placebo treatment period - 2001 for Greece and 1999 for all other countries. For all countries the analysis starts in 1970 and ends in 2007. Switzerland is excluded from the donor pool.

Figure A.8: SCM without the United States



Notes: In each graph, the blue dashed line represents the normalized real GDP for the synthetic country and the black full line represents the series for the actual country. The shaded area corresponds to two standard deviations of the difference between the treated country and the doppelganger prior to the Euro accession. The vertical line depicts the placebo treatment period - 2001 for Greece and 1999 for all other countries. For all countries the analysis starts in 1970 and ends in 2007. The United States is excluded from the donor pool.

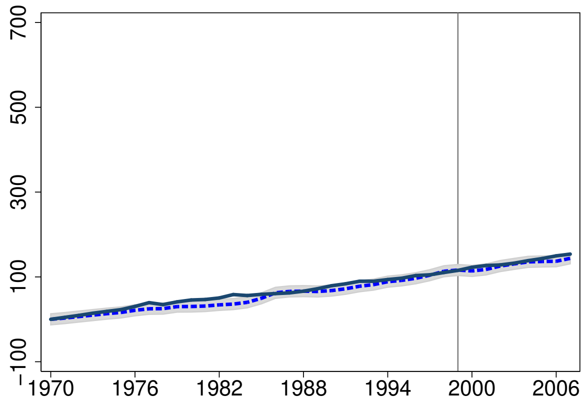
Table A.5: Composition of each doppelganger: country weights (in %)

Donor countries	Austria	Belgium	Finland	France	Germany	Greece	Ireland	Italy	Luxembourg	Netherlands	Portugal	Spain
Australia	18.1	< 0.1	39.6	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	0.1
Canada	< 0.1	< 0.1	22.6	52.0	18.3	< 0.1	< 0.1	32.4	< 0.1	< 0.1	< 0.1	< 0.1
Chile	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	22.0	< 0.1	5.2	< 0.1	< 0.1	< 0.1
Iceland	< 0.1	< 0.1	17.2	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1
Israel	16.4	24.6	< 0.1	< 0.1	< 0.1	< 0.1	50.1	< 0.1	52.3	12.0	15.1	4.0
Korea	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	1.9	< 0.1
Mexico	1.8	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	39.8	17.5
New Zealand	18.6	< 0.1	< 0.1	32.9	10.4	30.8	< 0.1	4.1	< 0.1	< 0.1	< 0.1	< 0.1
Norway	13.3	< 0.1	< 0.1	15.1	< 0.1	< 0.1	27.9	< 0.1	< 0.1	22.6	< 0.1	< 0.1
Switzerland	31.8	75.4	20.6	< 0.1	35.6	2.6	< 0.1	12.2	42.5	65.4	26.7	21.3
United States	< 0.1	< 0.1	< 0.1	< 0.1	35.7	66.6	< 0.1	51.3	< 0.1	< 0.1	16.6	57.1

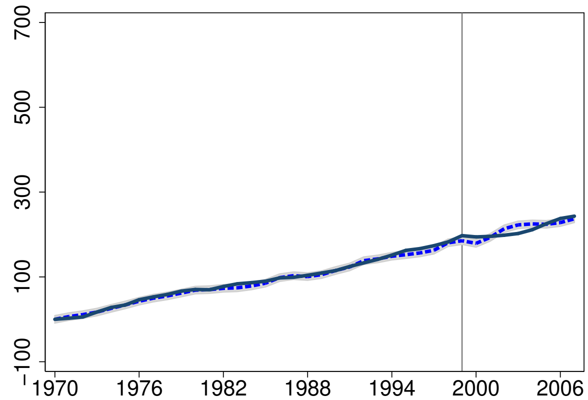
Notes: This table summarizes the weights in percent attributed to each donor country to construct the synthetic treated units. Relative to the baseline analysis, the donor pool now excludes Denmark, Sweden and the United Kingdom.

A.7 Components analysis

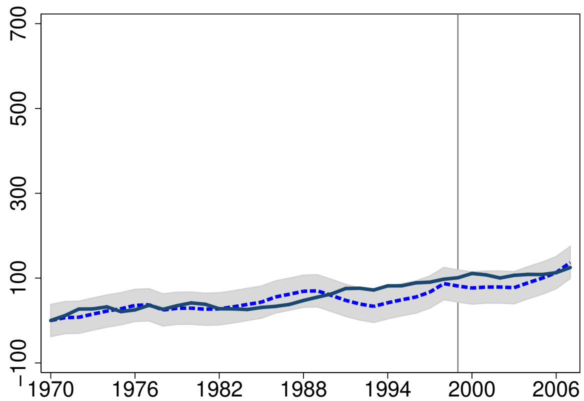
Figure A.9: Components of Austria's GDP



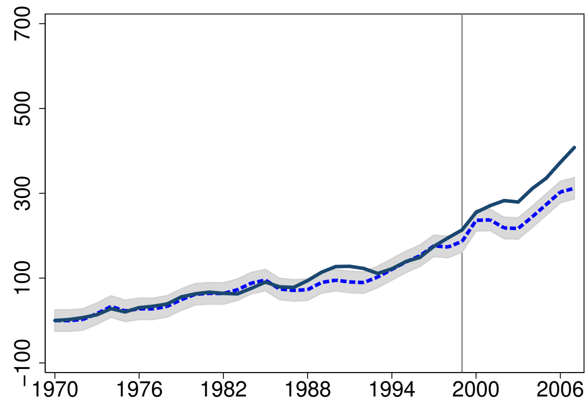
(a) Private Consumption



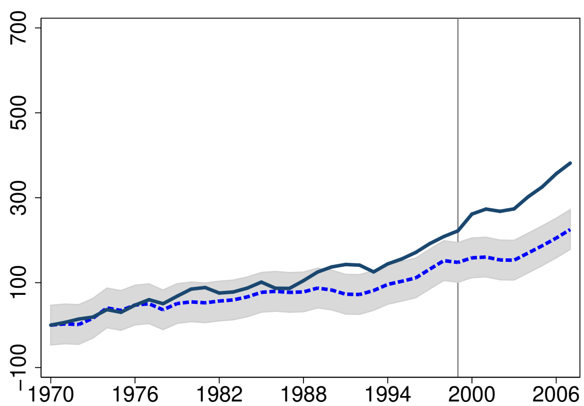
(b) Government Consumption



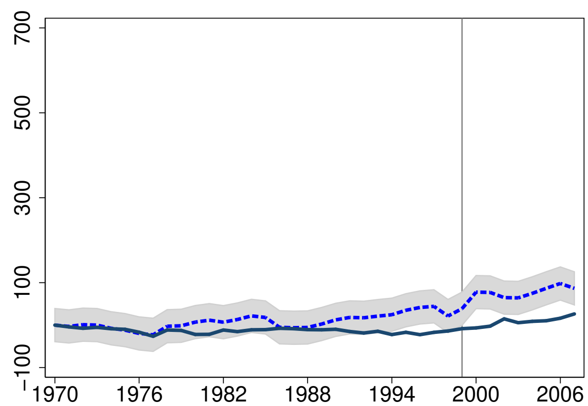
(c) Investment



(d) Exports



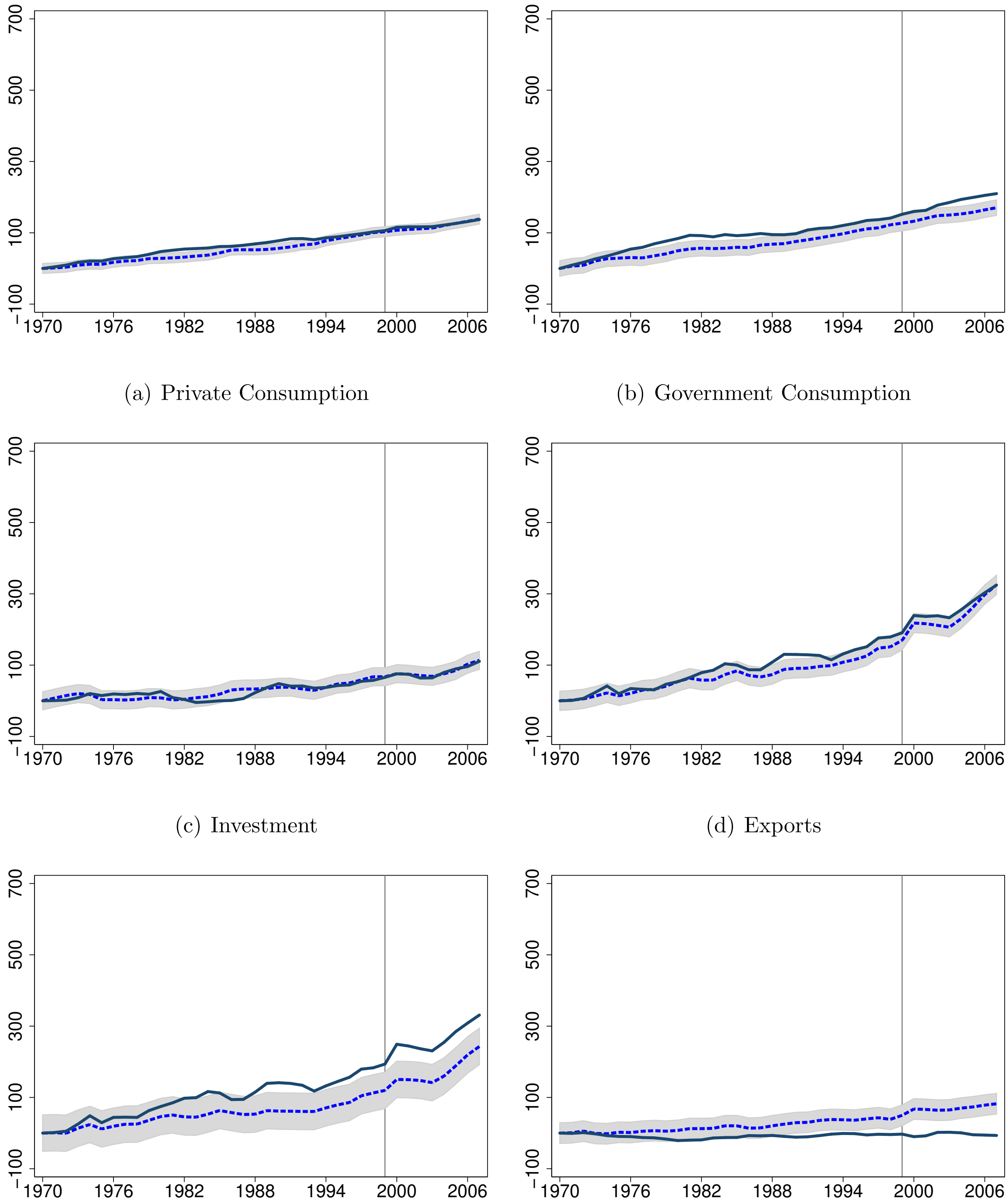
(e) Imports



(f) Net Exports

Notes: The plots depict, for each GDP component, the deviation in percent from the value of 1970. The blue dashed lines represents the synthetic Austria computed in section 2. The full black lines stand for the actual Austrian series. The shaded area corresponds to two standard deviations of the difference between the treated country and the doppelganger prior to the Euro accession.

Figure A.10: Components of Belgium's GDP



(a) Private Consumption

(b) Government Consumption

(c) Investment

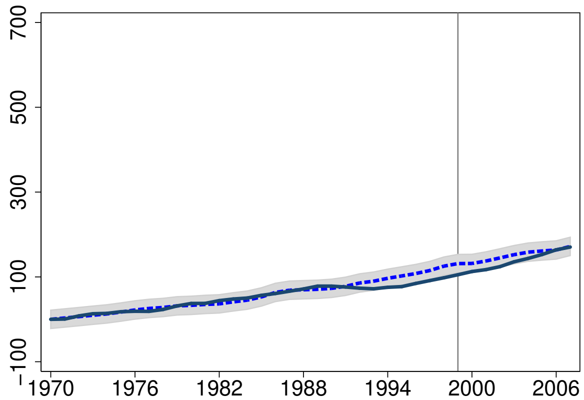
(d) Exports

(e) Imports

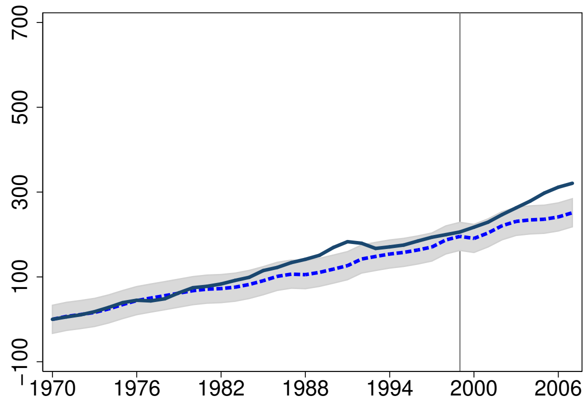
(f) Net Exports

Notes: The plots depict, for each GDP component, the deviation in percent from the value of 1970. The blue dashed lines represents the synthetic Austria computed in section 2. The full black lines stand for the actual Belgian series. The shaded area corresponds to two standard deviations of the difference between the treated country and the doppelganger prior to the Euro accession.

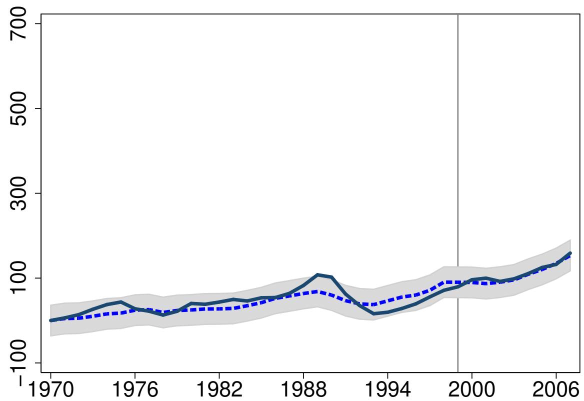
Figure A.11: Components of Finland's GDP



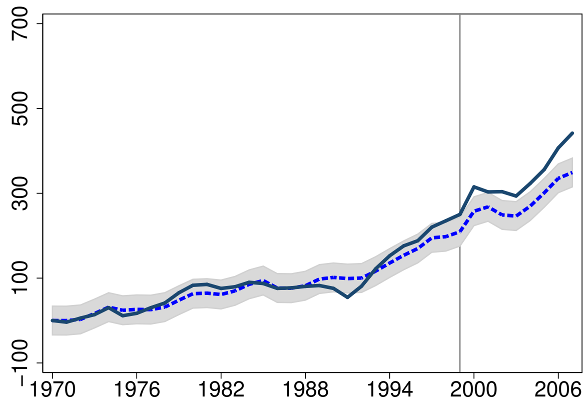
(a) Private Consumption



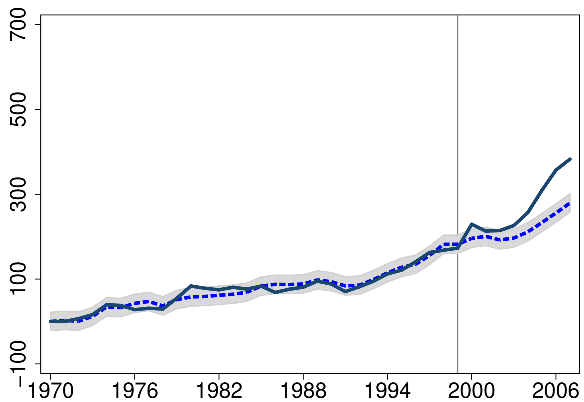
(b) Government Consumption



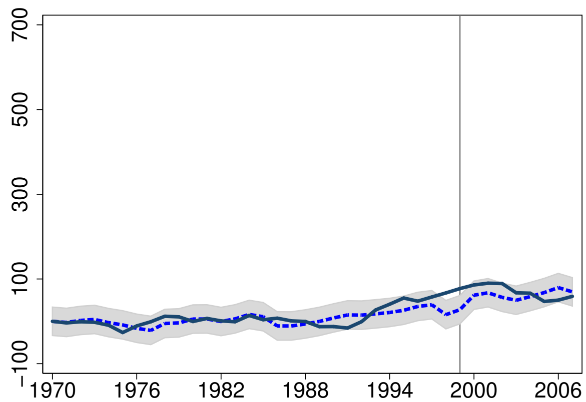
(c) Investment



(d) Exports



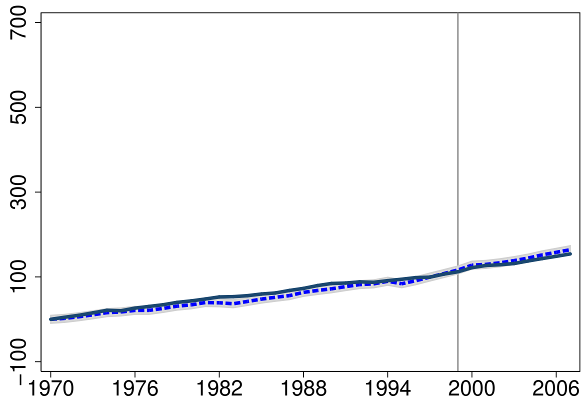
(e) Imports



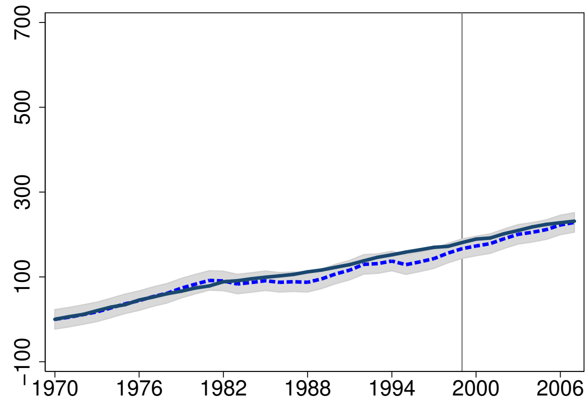
(f) Net Exports

Notes: The plots depict, for each GDP component, the deviation in percent from the value of 1970. The blue dashed lines represents the synthetic Belgium computed in section 2. The full black lines stand for the actual Finnish series. The shaded area corresponds to two standard deviations of the difference between the treated country and the doppelganger prior to the Euro accession.

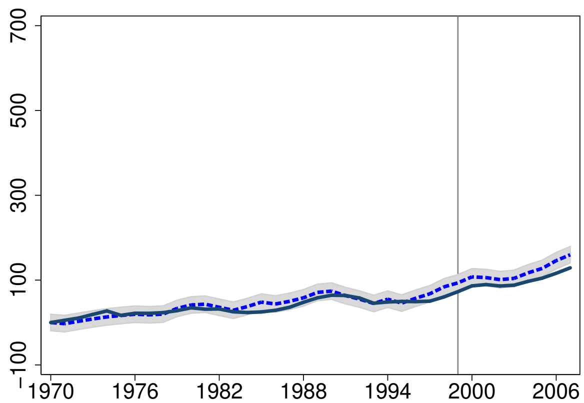
Figure A.12: Components of France's GDP



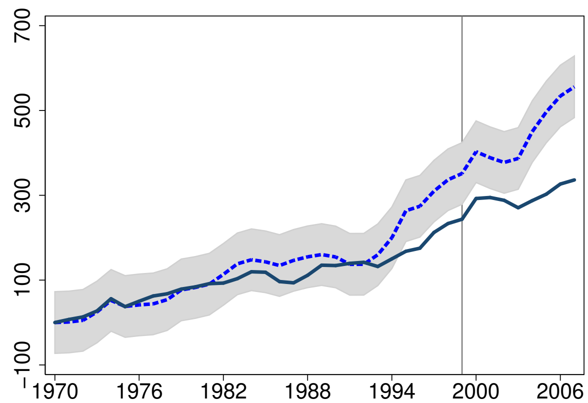
(a) Private Consumption



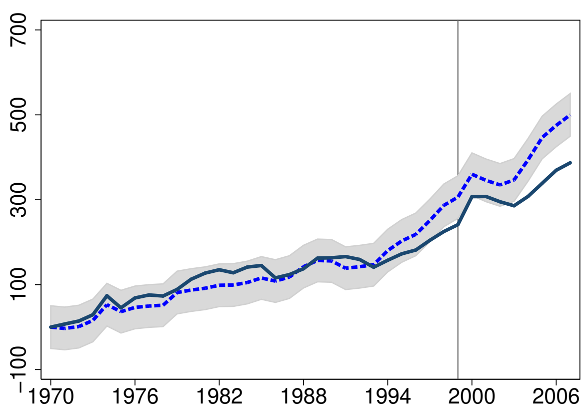
(b) Government Consumption



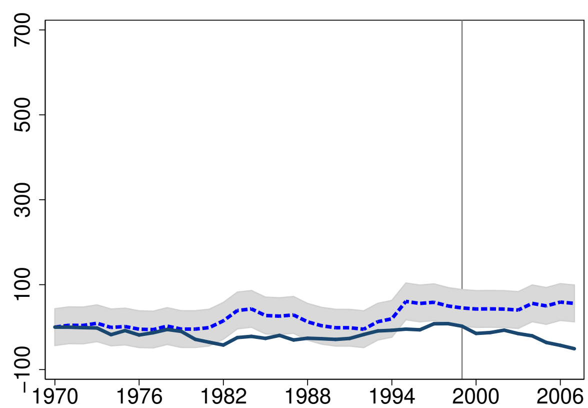
(c) Investment



(d) Exports



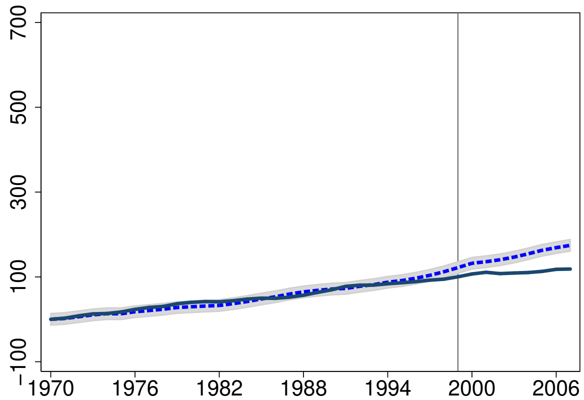
(e) Imports



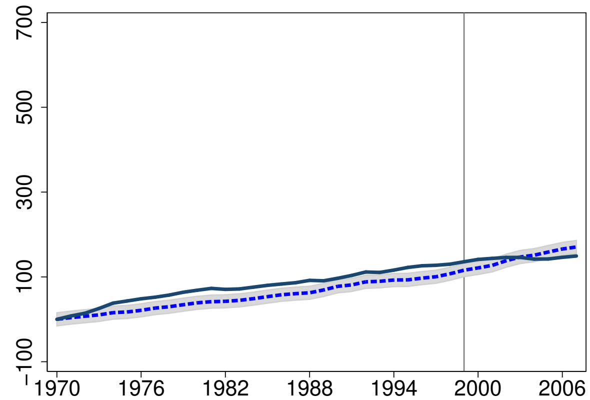
(f) Net Exports

Notes: The plots depict, for each GDP component, the deviation in percent from the value of 1970. The blue dashed lines represents the synthetic France computed in section 2. The full black lines stand for the actual French series. The shaded area corresponds to two standard deviations of the difference between the treated country and the doppelganger prior to the Euro accession.

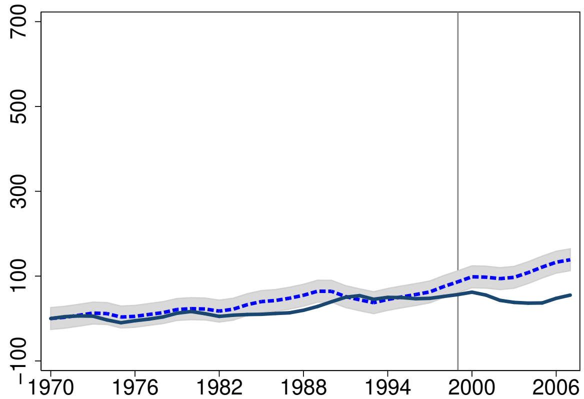
Figure A.13: Components of Germany's GDP



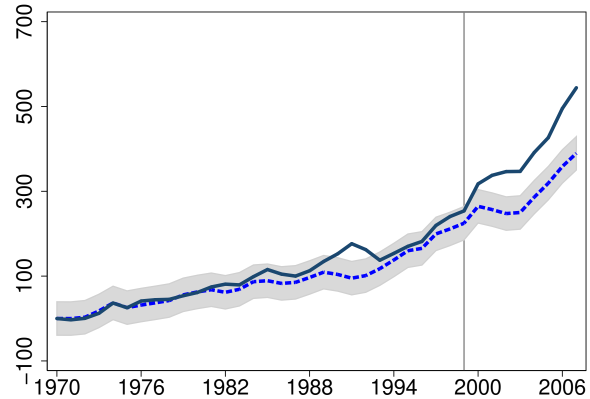
(a) Private Consumption



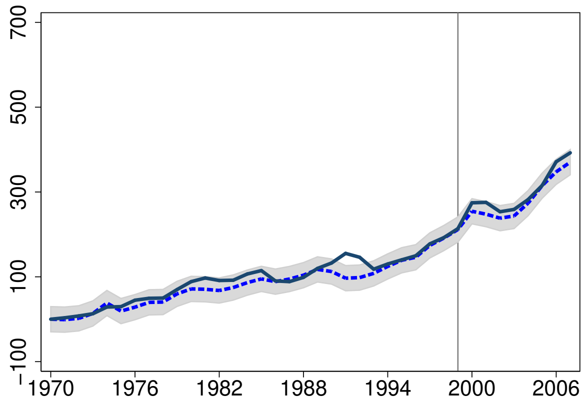
(b) Government Consumption



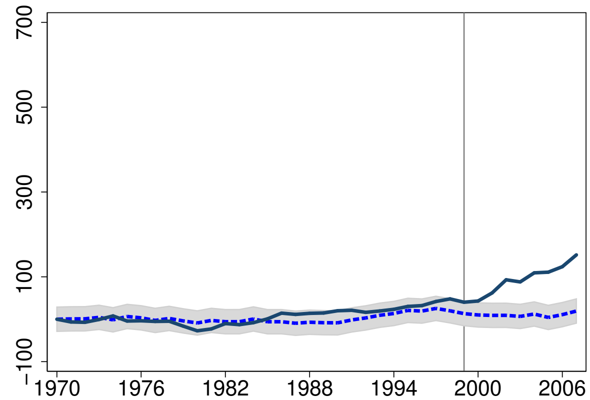
(c) Investment



(d) Exports



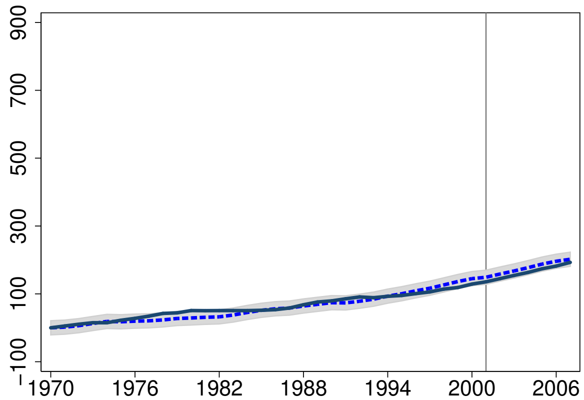
(e) Imports



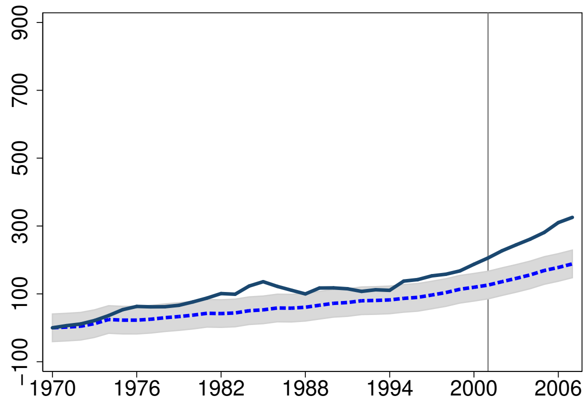
(f) Net Exports

Notes: The plots depict, for each GDP component, the deviation in percent from the value of 1970. The blue dashed lines represents the synthetic Germany computed in section 2. The full black lines stand for the actual German series. The shaded area corresponds to two standard deviations of the difference between the treated country and the doppelganger prior to the Euro accession.

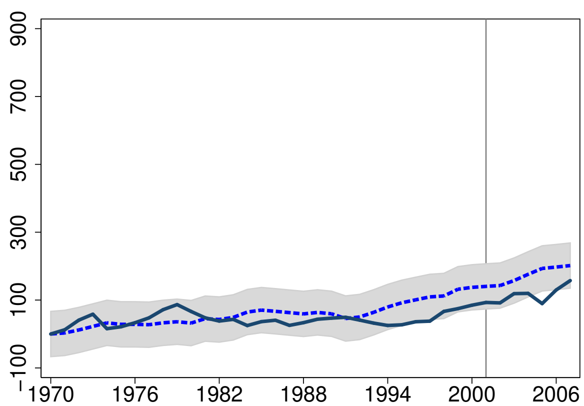
Figure A.14: Components of Greece's GDP



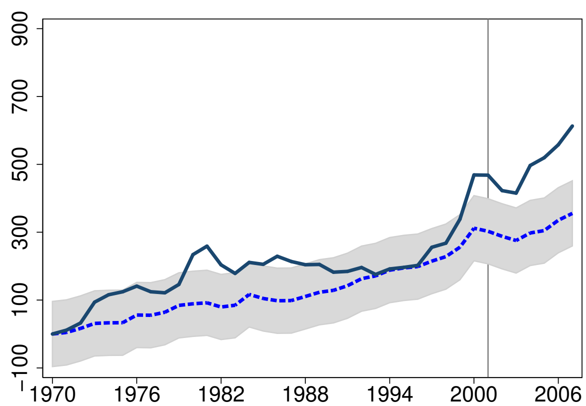
(a) Private Consumption



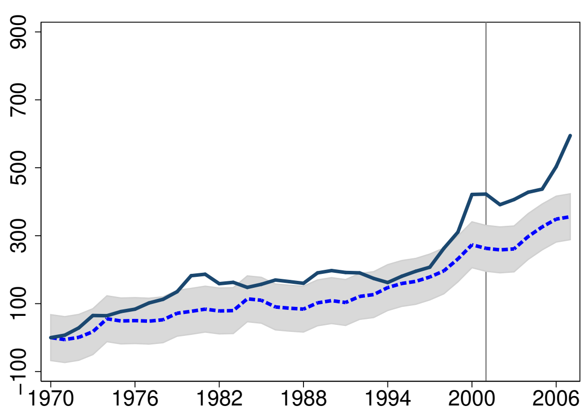
(b) Government Consumption



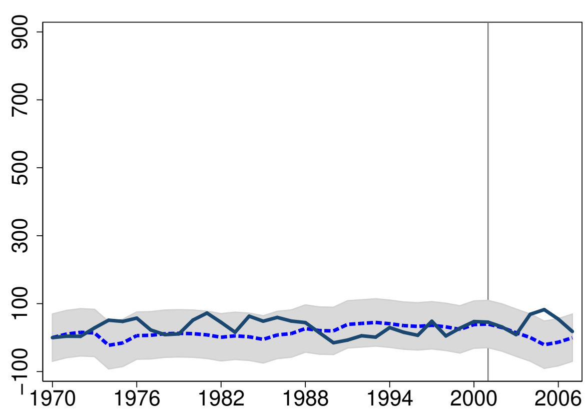
(c) Investment



(d) Exports



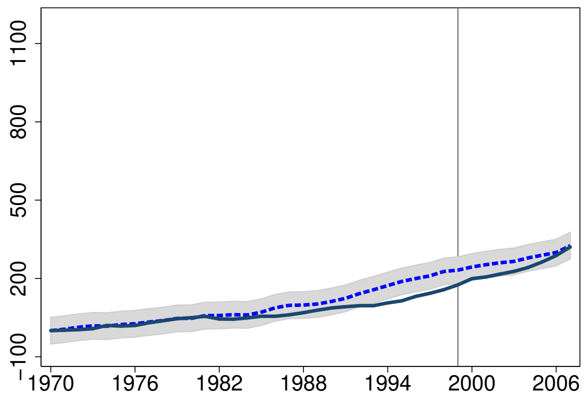
(e) Imports



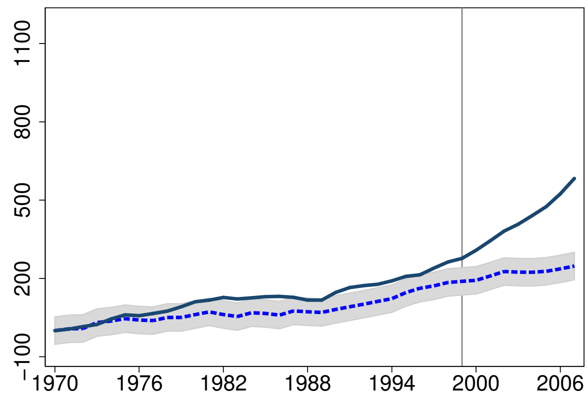
(f) Net Exports

Notes: The plots depict, for each GDP component, the deviation in percent from the value of 1970. The blue dashed lines represents the synthetic Greece computed in section 2. The full black lines stand for the actual Greek series. The shaded area corresponds to two standard deviations of the difference between the treated country and the doppelganger prior to the Euro accession.

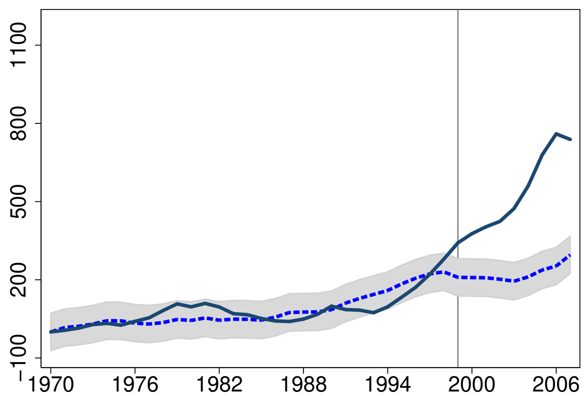
Figure A.15: Components of Ireland's GDP



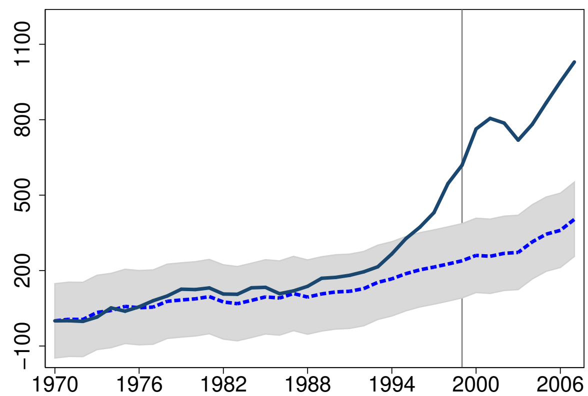
(a) Private Consumption



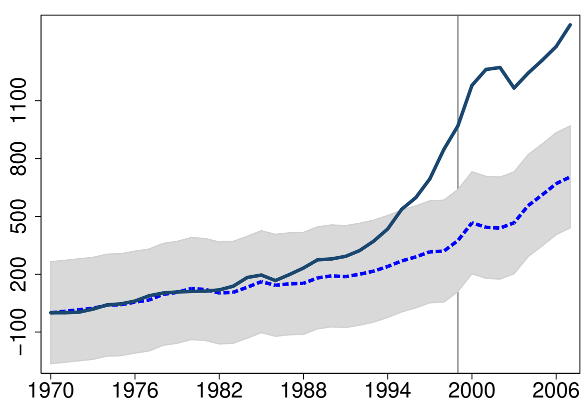
(b) Government Consumption



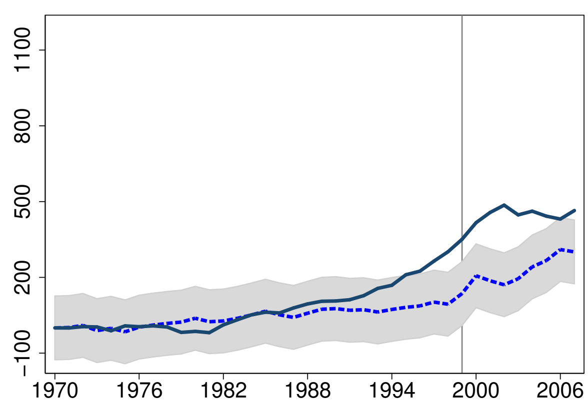
(c) Investment



(d) Exports



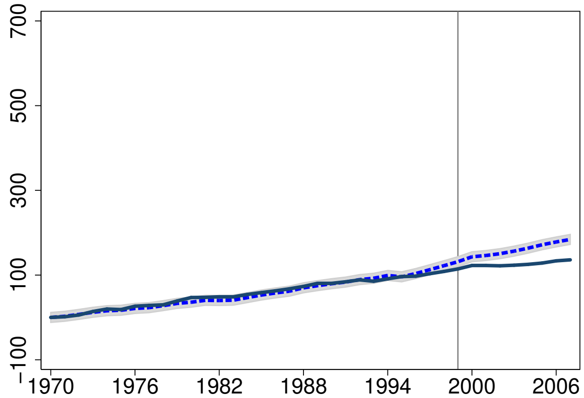
(e) Imports



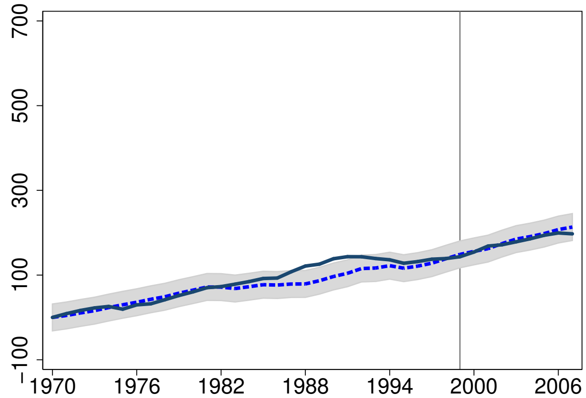
(f) Net Exports

Notes: The plots depict, for each GDP component, the deviation in percent from the value of 1970. The blue dashed lines represents the synthetic Ireland computed in section 2. The full black lines stand for the actual Irish series. The shaded area corresponds to two standard deviations of the difference between the treated country and the doppelganger prior to the Euro accession.

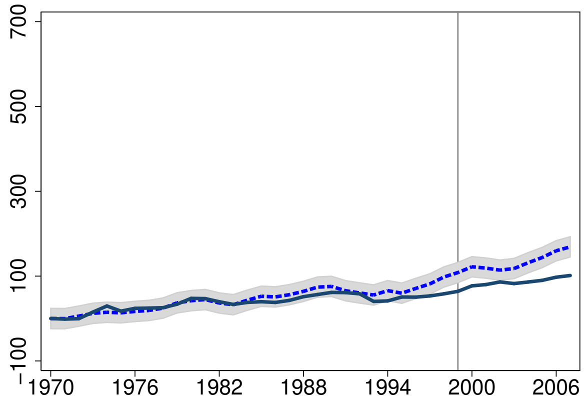
Figure A.16: Components of Italy's GDP



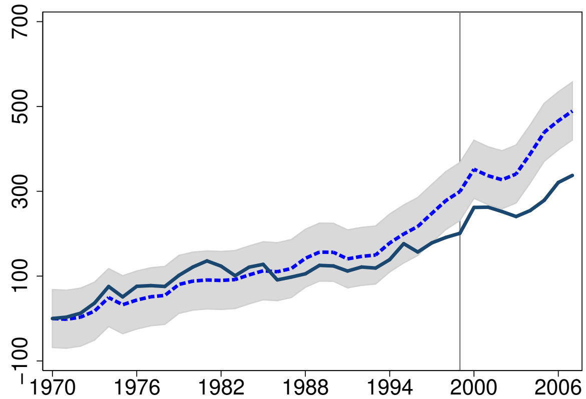
(a) Private Consumption



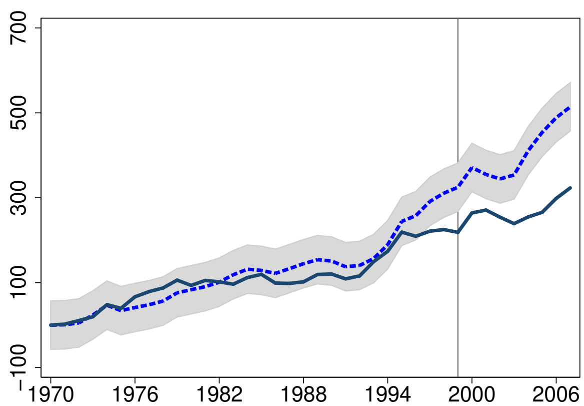
(b) Government Consumption



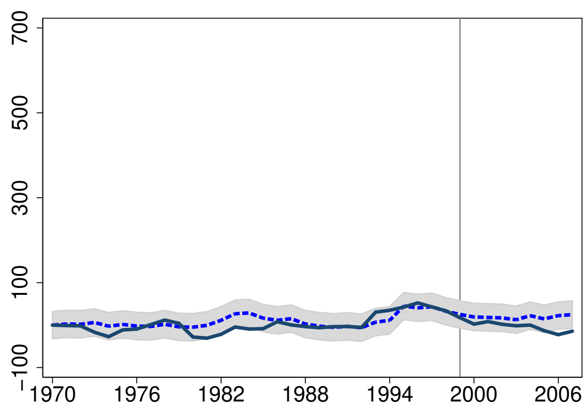
(c) Investment



(d) Exports



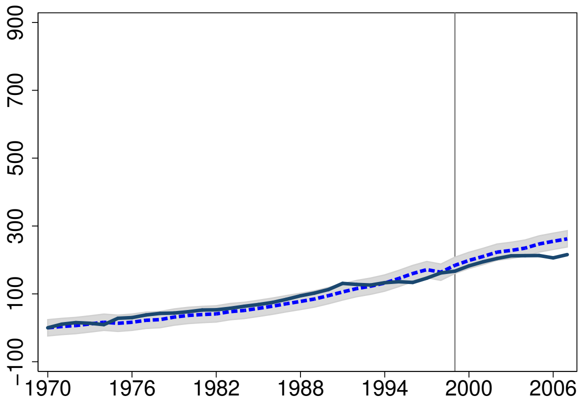
(e) Imports



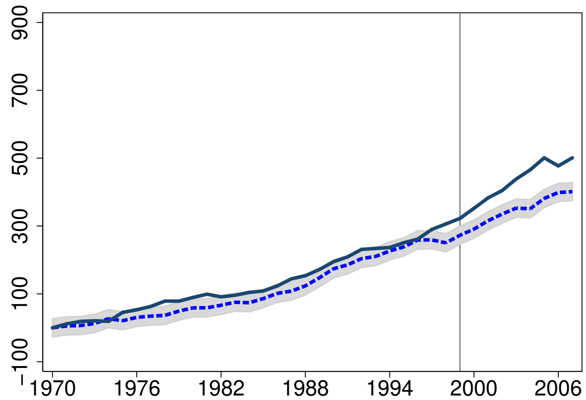
(f) Net Exports

Notes: The plots depict, for each GDP component, the deviation in percent from the value of 1970. The blue dashed lines represents the synthetic Italy computed in section 2. The full black lines stand for the actual Italian series. The shaded area corresponds to two standard deviations of the difference between the treated country and the doppelganger prior to the Euro accession.

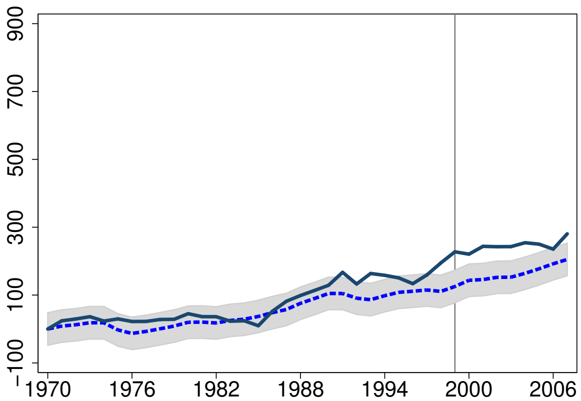
Figure A.17: Components of Luxembourg's GDP



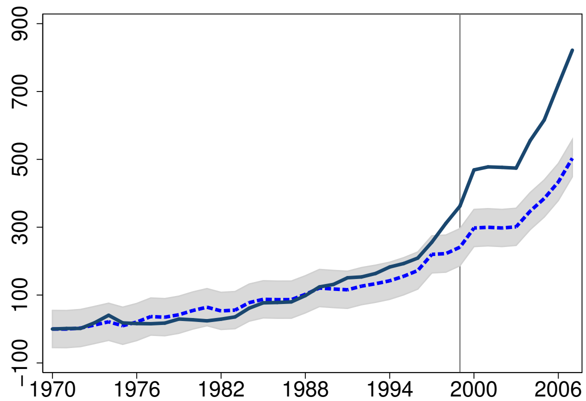
(a) Private Consumption



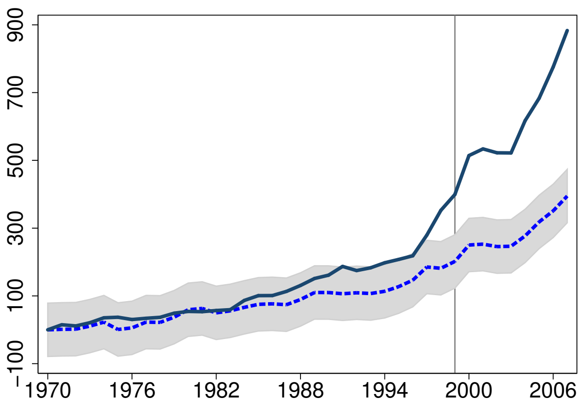
(b) Government Consumption



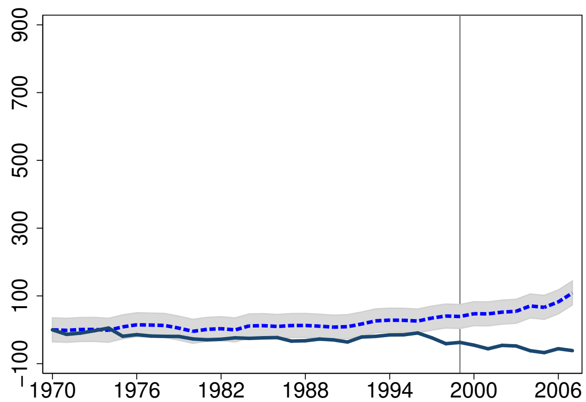
(c) Investment



(d) Exports



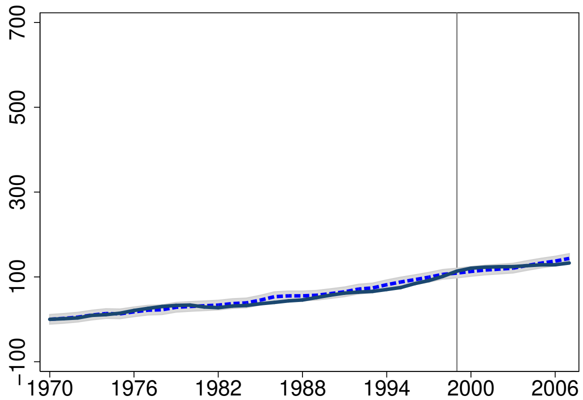
(e) Imports



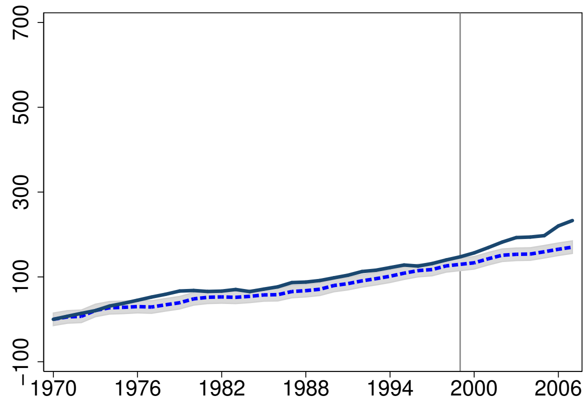
(f) Net Exports

Notes: The plots depict, for each GDP component, the deviation in percent from the value of 1970. The blue dashed lines represents the synthetic Luxembourg computed in section 2. The full black lines stand for the actual Luxembourg's series. The shaded area corresponds to two standard deviations of the difference between the treated country and the doppelganger prior to the Euro accession.

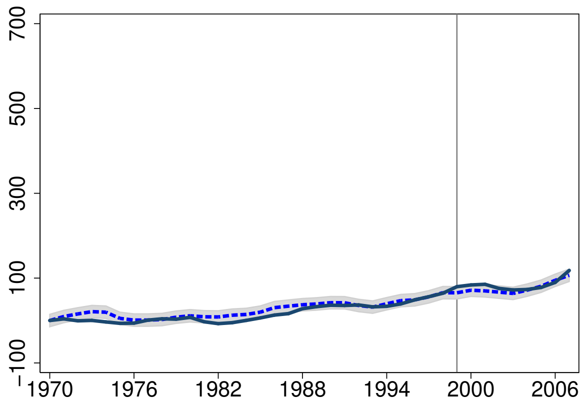
Figure A.18: Components of The Netherlands's GDP



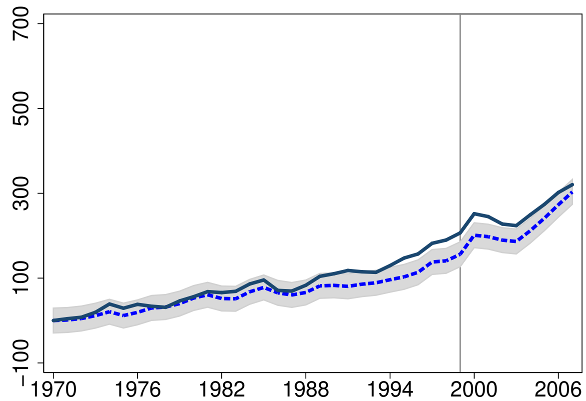
(a) Private Consumption



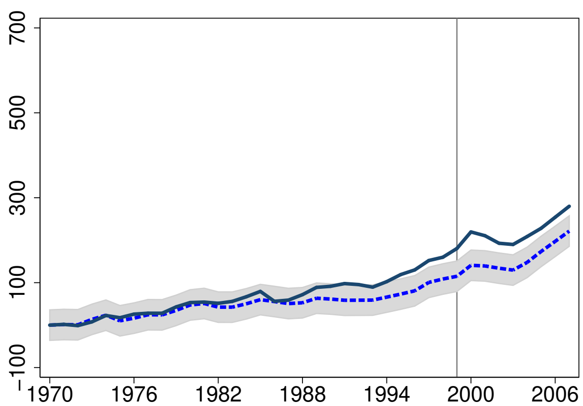
(b) Government Consumption



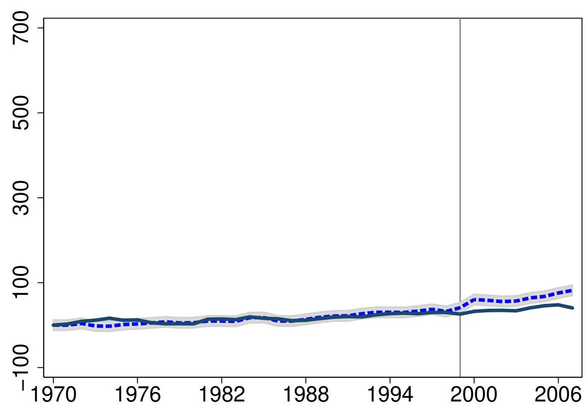
(c) Investment



(d) Exports



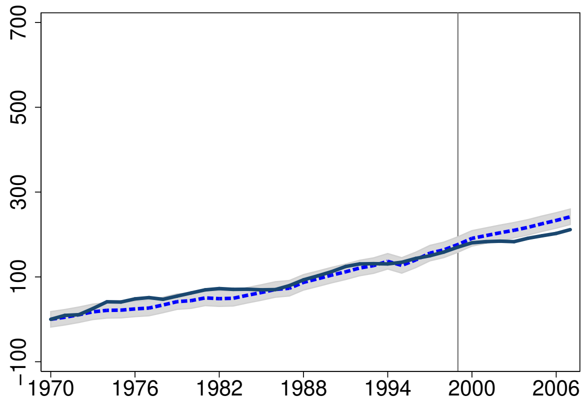
(e) Imports



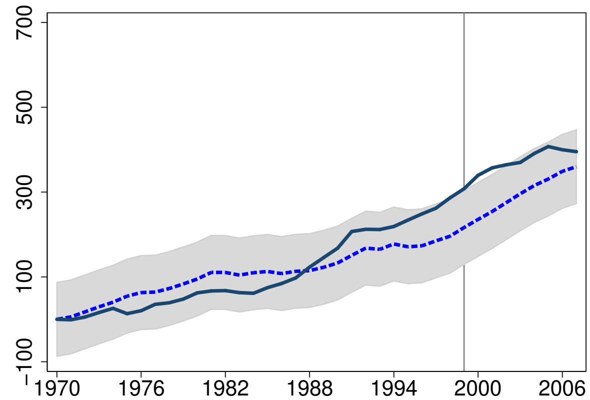
(f) Net Exports

Notes: The plots depict, for each GDP component, the deviation in percent from the value of 1970. The blue dashed lines represents the synthetic Netherlands computed in section 2. The full black lines stand for the actual Dutch series. The shaded area corresponds to two standard deviations of the difference between the treated country and the doppelganger prior to the Euro accession.

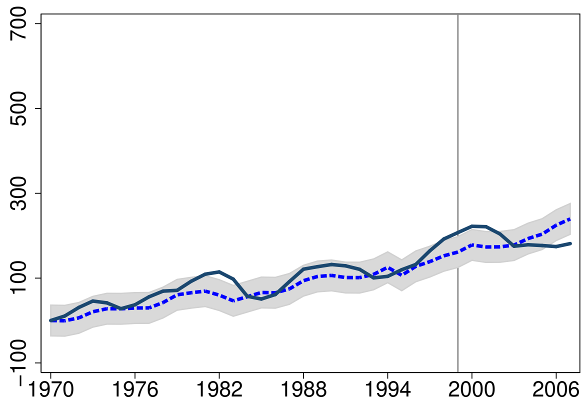
Figure A.19: Components of Portugal's GDP



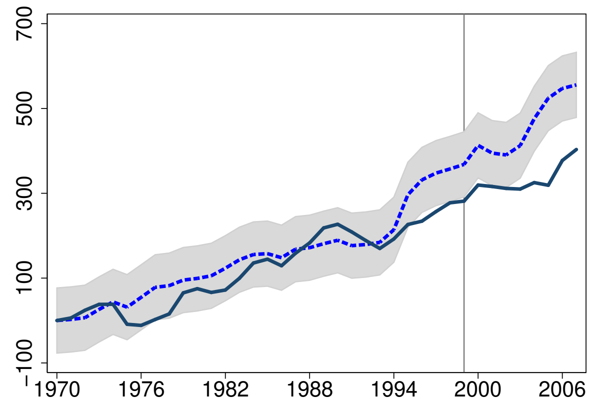
(a) Private Consumption



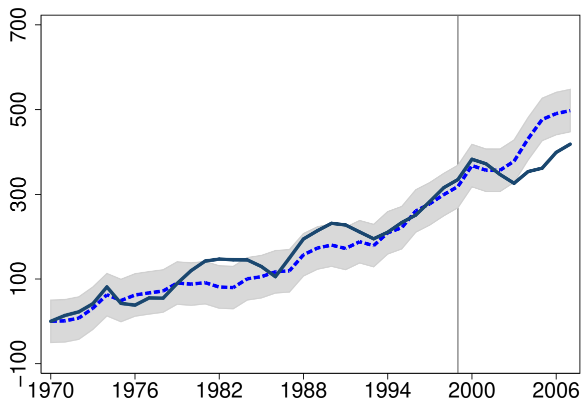
(b) Government Consumption



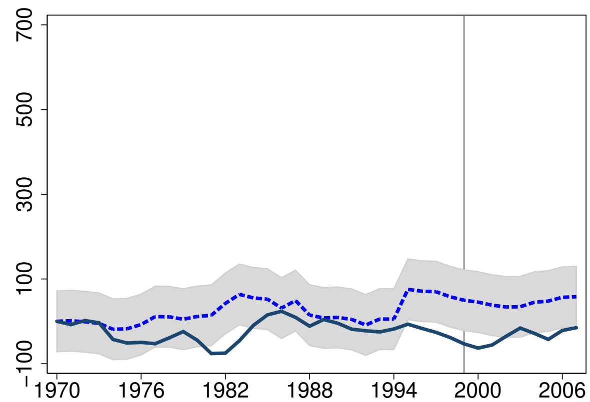
(c) Investment



(d) Exports



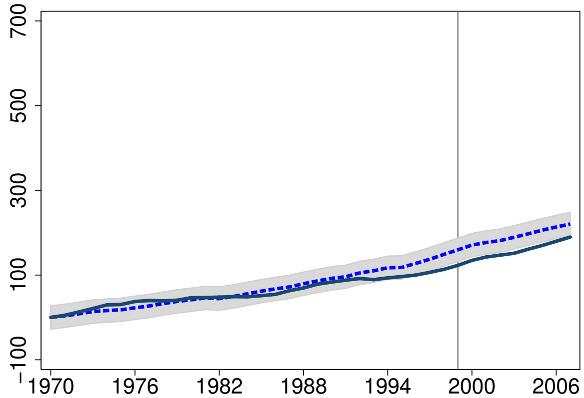
(e) Imports



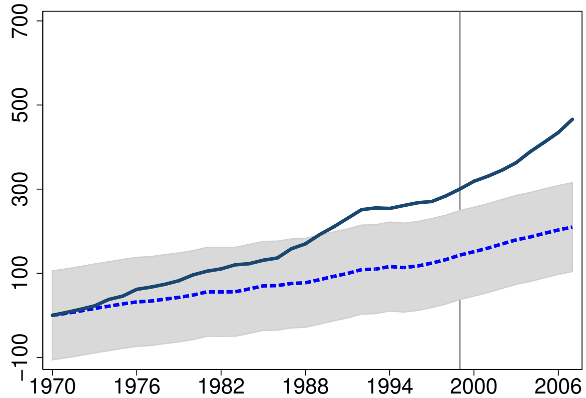
(f) Net Exports

Notes: The plots depict, for each GDP component, the deviation in percent from the value of 1970. The blue dashed lines represents the synthetic Portugal computed in section 2. The full black lines stand for the actual Portuguese series. The shaded area corresponds to two standard deviations of the difference between the treated country and the doppelganger prior to the Euro accession.

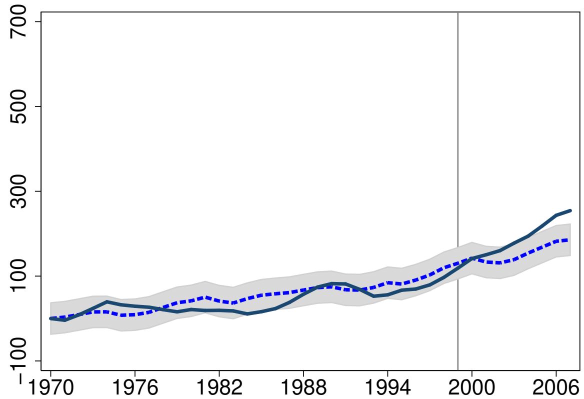
Figure A.20: Components of Spain's GDP



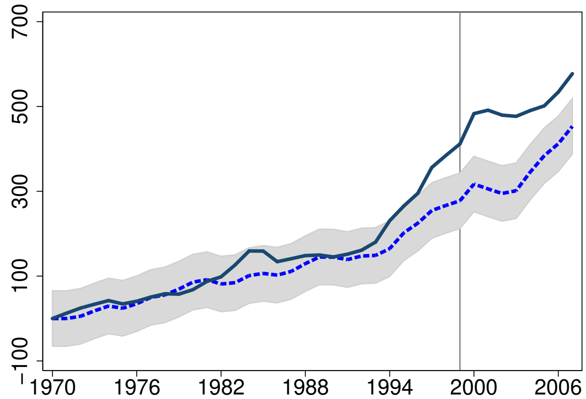
(a) Private Consumption



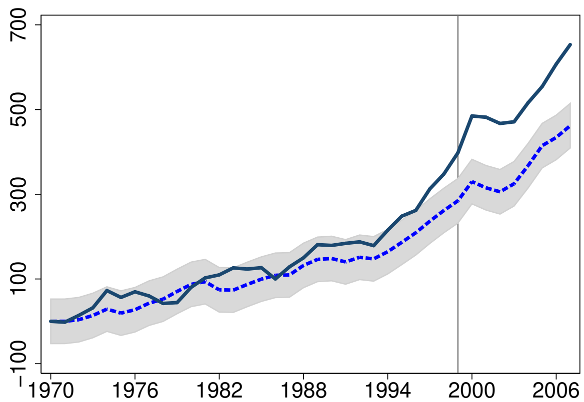
(b) Government Consumption



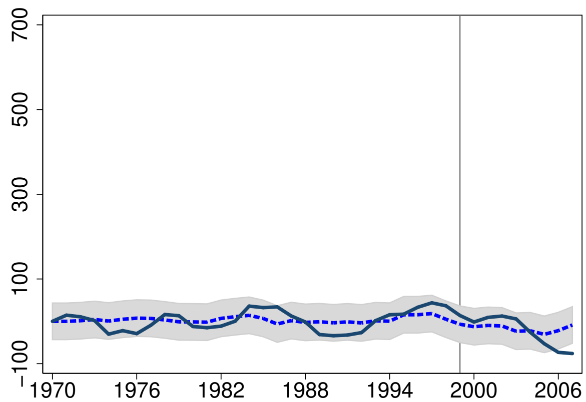
(c) Investment



(d) Exports



(e) Imports



(f) Net Exports

Notes: The plots depict, for each GDP component, the deviation in percent from the value of 1970. The blue dashed lines represents the synthetic Spain computed in section 2. The full black lines stand for the actual Spanish series. The shaded area corresponds to two standard deviations of the difference between the treated country and the doppelganger prior to the Euro accession.

A.8 What explains the doppelganger gap?

Table A.6: What explains the cumulative doppelganger gap?

	Private Consumption (%)	**Government Consumption** (%)	**Investment** (%)	**Net Exports** (%)	**Doppelganger Gap** (%)	Euro *per capita*
Austria	3.77	-2.48	-1.73	-4.96	-5.40	-1,712
Belgium	-3.35	1.08	-1.39	-2.02	-5.68	-1,668
Finland	1.69	1.93	0.06	-0.97	2.72	777
France	-5.02	1.31	-2.40	-2.86	-8.97	-2,632
Germany	-12.18	-2.34	-6.43	4.70	-16.25	-5,788
Greece	-0.83	2.83	1.87	-8.94	-5.07	-1,098
Ireland	11.36	4.31	18.51	4.90	39.09	10,781
Italy	-10.31	-1.79	-5.33	-0.93	-18.36	-6,089
Luxembourg	-16.84	5.92	-4.37	27.86	12.57	4,697
Netherlands	-4.28	6.05	-0.27	-0.98	0.52	168
Portugal	-7.46	2.07	-0.92	-5.86	-12.17	-2,558
Spain	-2.99	4.35	7.65	-5.11	3.90	900

Notes: This table summarizes the cumulative doppelganger gaps for each Euro member country and presents the channels driving the impact of the accession by decomposing GDP into its components. The doppelganger gap represents the percentage GDP gain or loss in 2007 from adopting the common currency, i.e. for country c we define $\textit{percent doppelganger gap}_{2007,c} = (GDP_{2007,c} - GDP^{dop}_{2007,c})/GDP^{dop}_{2007,c}$. Then, the table shows the contribution of each GDP component for the GDP gain or loss. Values are constructed in a way to sum up to the doppelganger gap. The decomposition of net exports into exports and imports is presented in Table A.7.

Table A.7: Net exports decomposition

	Net Exports	Exports	Imports
Austria	-4.96	5.56	10.52
Belgium	-2.02	21.17	23.19
Finland	-0.97	7.91	8.88
France	-2.86	-11.70	-8.84
Germany	4.70	4.50	-0.20
Greece	-8.94	1.62	10.56
Ireland	4.90	69.94	65.04
Italy	-0.93	-8.74	-7.81
Luxembourg	27.86	147.85	119.99
Netherlands	-0.98	15.38	16.35
Portugal	-5.86	-1.37	4.49
Spain	-5.11	1.84	6.95

Notes: This table presents the summary of the net exports decomposition into exports and imports for each treated country. It tells how much the net exports contributed to the doppelganger output gap in percent.