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Assessing the Causal Effects of Austerity Measures on Southern European Economies During the Debt Crisis: A Synthetic Control Method Approach

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Abstract

During the European debt crisis of 2010, policymakers in southern European Union (EU) countries implemented severe austerity measures such as cuts in public spending or increase taxes to address their national debt. This study examines the causal effects of these measures on the gross domestic product (GDP) per capita of struggling southern EU countries, both in the short-term (3 years) and long-term (12 years). The study employs the Synthetic Control Method (SCM) to construct a counterfactual scenario using a group of countries that did not implement austerity measures. By analyzing the economic conditions before and after the implementation of austerity, the study finds that these measures did not achieve their intended fiscal goals. In fact, they exacerbated economic problems, having a negative causal effect on the GDP per capita of Greece, Spain, and Portugal, both in the short and long term. These findings are further supported by placebo tests. Additionally, this study addresses the challenge of accurately controlling for debt-to-GDP as a predictor of GDP per capita in the post-austerity period for Greece and Portugal, given their high debt-to-GDP ratios during this period. For Greece and Portugal, this research can therefore not conclude that the found negative effect is solely caused by austerity measures. Concluding, this study provides evidence against the effectiveness of austerity measures in improving GDP per capita during uncertain financial times. It underscores the importance of adopting fiscal strategies that balance short-and long-term economic resilience. Policymakers are encouraged to explore alternative strategies during times of crisis. Future research may consider a multiple treated unit application of SCM and include other countries as target countries that also implemented austerity.

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1 Introduction

Following the global financial crisis in 2008, the European debt crisis severely affected countries like Greece, Spain, and Portugal. To address their budget deficits and escalating debt, these countries implemented drastic austerity measures. These measures involved significant reductions in public spending and increases in taxes. The aim was to restore competitiveness with other European Union (EU) countries through fiscal consolidation. Policymakers believed that by reducing the state's debt and deficits, economic growth would be promoted by restoring investor confidence. The socioeconomic and macroeconomic impacts of these austerity measures are still highly debated, making this area of study interesting. Recent reports, such as the statement by Amnesty International (2022), which holds the Greek authority accountable for the negative impact of these measures, highlight the significant long-term effects of austerity measures on public health and economic stability.

The relevance of this research is academically significant and supports policymakers in the EU and similar economies with informed policy decisions. As these economies face the challenges of rapidly changing global financial conditions, understanding the effects of austerity measures becomes increasingly important. This study provides evidence-based insights that help in shaping responses to economic downturns, ensuring that fiscal policies not only address immediate financial crises but can also contribute to short-and long-term economic stability and resilience. The significance of this research lies in its timing and applicability. In today's interconnected global economy, the effects of austerity in one region can extend beyond its borders, influencing economic stability worldwide. By exploring the impacts of austerity, this research aims to contribute to a more comprehensive understanding of fiscal policies during financial crises, offering valuable lessons for future economic policy-making and helping to avoid the pitfalls observed during the European debt crisis.

This study seeks to uncover the varied effects of austerity measures on southern EU countries hardest hit by the debt crisis, focusing on Greece, Spain, and Portugal as target countries (Eißel, 2015). It aims to offer a clear and thorough understanding of how austerity contributes to the development of the GDP per capita of these countries. From this, the main research question is formulated: What was the causal effect of cuts in public expenditure on the economic performance of southern EU countries struggling during the debt crisis, both in the immediate aftermath and over an extended period?

This study employs a dataset that spans the economic conditions before, during, and after the implementation of austerity measures. The focus is on analyzing economic performance using GDP per capita and identifying countries that enacted spending cuts. Careful selection of predictors and weights ensures that the synthetic counterfactual accurately reflects the pre-austerity conditions. The complexity of assessing the impacts of austerity measures on EU economies is the reason behind the selection of data and methodology. The challenge in this comparative case study is that no single country perfectly mirrors the target country (Greece, Spain, or Portugal) in terms of macroeconomic indicators while not implementing austerity measures. To address this, the Synthetic Control Method (SCM) is applied. This method was first developed and applied by Abadie and Gardeazabal (2003) in their study on the causal effect of terrorism on the economy in the Basque Country. For the underlying research, the SCM will

be used to assess the causal effects of austerity measures on EU countries heavily impacted by the debt crisis. The methodology involves creating a synthetic version of each country under study, which approximates the country's economic conditions if austerity measures had not been implemented. This synthetic version serves as the counterfactual and mirrors the country that did undertake austerity measures during the pre-treatment phase. It is achieved by forming a weighted average from control countries.

As described by Abadie (2021), there are several key advantages to using synthetic control analysis for investigating the causal effects of policy interventions. Firstly, synthetic control avoids extrapolation by restricting weights to the $[0, 1]$ range, ensuring that estimated effects are based solely on observed data within the given range. Additionally, synthetic control does not use post-treatment data when determining the synthetic control in the pre-treatment period; post-treatment data is only needed for the target variable to estimate the effect. This means that the selection of countries in the synthetic control and the relevance of covariates are determined without knowledge of their impact on the research outcome. Although covariates, predictors, and macroeconomic indicators are distinct terms, they can be considered interchangeable in the context of this study due to their overlapping roles in the analysis. Lastly, synthetic control provides a clear interpretation of the results, explicitly stating the contribution of each country to the synthetic outcome. This clarity makes it easier to validate results, especially when the number of countries in the synthetic counterpart is sparse.

The causal effects of cuts in public expenditure on economic performance can be demonstrated if this study identifies a significant gap between the GDP per capita of the target countries and their synthetic counterparts in the post-austerity period. To test for the significance of the results, this research implements two placebo tests, similar to Abadie et al. (2015). An in-time placebo test performs a synthetic control analysis on the target country by backdating the treatment moment 5 years before the actual treatment to see if a visible treatment effect occurs in 2005 instead of 2010. If the synthetic control closely mimics the target country during this pre-treatment period but deviates after the actual treatment in 2010, it suggests that the observed effect is genuinely due to the specific treatment moment rather than occurring prematurely. The in-space placebo test determines whether there is an effect on GDP per capita in other countries that did not implement austerity measures. The test performs the synthetic control analysis on all countries in the donor pool, each considered separately as the target country. The difference between the pre-treatment fit and post-treatment deviation between the target country and its synthetic control is compared for all countries, determining the significance of the results. The robustness of the research is assessed through a leave-one-out analysis, where each positively weighted country in the synthetic control is iteratively eliminated from the donor pool to evaluate how robust the results are to the exclusion of any particular country.

During the European debt crisis, European leaders demanded that struggling countries, whose debt to GDP ratio was increasing, took fiscal consolidation measures before receiving additional financial support. They believed that these struggling countries could correct their economic imbalances and eventually achieve economic growth by reducing costs to improve competitiveness without devaluing their national currency (Perez and Matsaganis, 2018). Underlying research focuses on three countries that implemented austerity measures by cutting

public expenditure: Greece, Spain, and Portugal. As described by Callan et al. (2011), the austerity measures implemented by Greece, Portugal, and Spain were not identical but were driven by similar underlying reasons. Greece is considered one of the weakest links in the debt crisis. Firstly, the Greek government deficit reached 15.4% of GDP in 2009, a significant increase compared to 9.8% in 2008 (Kondilis et al., 2013). European policymakers began to suspect that the increasing deficit was not just a symptom of the crisis but might actually be causing it. The International Monetary Fund (IMF) provided assistance to Greece by agreeing to loans of €110 billion in May 2010 and an additional €130 billion in February 2012 to help reduce the government's deficit. One of the conditions of these loans was that the Greek government implemented austerity measures, including cuts in total government expenditure. Greece announced its initial set of austerity measures in March 2010, which was then followed by a tax reform in April 2010. (Callan et al., 2011). When these measures proved insufficient in May 2010, a second austerity package was introduced. Secondly, in Spain, investment in social policies increased significantly between 2000 and 2009, compared to the European Union. In this time period, Spain achieved an average annual growth rate of public expenditure of 4.7%, while the European Union's average was 2.5% during the same period (Pavolini et al., 2015). However, in 2010, pressure from financial markets and the European Commission led the Spanish government to announce the largest public spending cuts since the beginning of democracy. The impact of these austerity measures is evident in the decrease in average annual growth rate of public expenditure, which fell by 1.2% between 2009 and 2010, compared to a 0.6% decrease for the European Union in the same period. Lastly, the Portuguese economy experienced a slowdown after the financial crisis hit the United States in 2008 (Moury and Freire, 2013). According to this research, currency devaluation was not an option, so the initial approach was fiscal expansion, aligning with the EU's counter-cyclical policy at the time. However, in 2009, the European Council encouraged Portugal to quickly implement fiscal consolidation policies, which required a shift in their strategy, leading to cuts in public expenditure. By the end of September 2010, significant pay cuts for civil servants marked one of the first serious signs of austerity experienced by the Portuguese. These cuts remained in effect through 2012 (Costa, 2012). The implementation of austerity measures for these three countries can thus not be pinned to a specific point in time, as it represents ongoing policy actions during the debt crisis. For the countries considered in this research, 2010 is identified as the date of intervention. This identification follows the approach of Rachiotis et al. (2015) and Kubrin et al. (2022), marking the period when these countries began implementing austerity measures.

Research conducted by Eißel (2015) indicates that in Greece, attempts to balance the public budget through spending cuts not only failed to address fiscal challenges but also led to social and economic problems, increased inequality, and disproportionately affected the financially disadvantaged. Additionally, Guajardo et al. (2011) challenge the expansionary austerity hypothesis, which suggests that fiscal contractions can promote economic growth. Their research suggests that the initial impacts of fiscal consolidation are typically contractionary, especially in the absence of supportive monetary policy. Similarly, Batini et al. (2012) demonstrate that rapid fiscal consolidation, particularly through cuts in public spending, can indeed extend recessions and fail to achieve the expected fiscal savings. Callan et al. (2011) discusses the importance

of accurately identifying the counterfactual to assess the impacts of austerity measures. Specifically, they emphasize the need to understand what economic conditions would have been without such interventions and investigate the distributional effects of austerity measures on six EU countries during the debt crisis. A study conducted by Rickman and Wang (2018), using the SCM on the U.S. states of Kansas and Wisconsin, suggests that austerity measures frequently result in heightened economic uncertainty. This underscores the often harmful consequences of these policies.

One of the challenges in this research is determining which countries implemented austerity measures and to what extent. This research compares the changes in total government expenditures from the year before austerity, 2009, with the average change in total government expenditure over six years following the debt crisis, from 2010 to 2015. A negative comparison indicates that a country reduced its total government expenditure, thereby categorizing it as a country that implemented austerity measures. This research focuses on cuts in public spending as the indicator for austerity instead of tax increases due to the fact that the majority of austerity policies in Europe, exceeding 80%, have involved reductions in budgets rather than increases in taxes (Reeves et al., 2013). Also, an IMF working paper supports this approach, indicating that austerity measures implemented through spending cuts are generally more harmful than those implemented through tax increases (Woo et al., 2013).

One of the key drivers that explains the economic performance of a nation is the existence of the debt crisis. Research by Mencinger et al. (2014) investigates the relationship between debt-to-GDP ratios and economic growth in EU countries during the debt crisis. The study reveals a significant non-linear effect of debt-to-GDP on annual GDP per capita. For the synthetic control analysis, this is taken into account in two ways. First, the debt-to-GDP ratio is included as one of the covariates in the pre-treatment matching between the target country and its synthetic control. This ensures that countries that receive a positive weight in the synthetic control are similar to the target countries in terms of their debt-to-GDP ratio. Secondly, only countries that have experienced a debt crisis post-treatment are included in the donor pool. In this causal inference study, it is essential to control for the debt crisis to isolate the effect of the austerity measures. If an estimated effect of austerity on GDP is found post-treatment but the synthetic control is not properly adjusted for debt-to-GDP, the effect on GDP cannot be solely attributed to the austerity measures, as it may be confounded by the resolution of the debt crisis. It is important to note that it is difficult to control for the debt crisis in Greece in this research. This is because Greece has a uniquely large government deficit. This is why Spain and Portugal are also included as target countries in this research. These countries have also implemented austerity measures, and their pre- and post-treatment government deficits are more comparable to potential donor pool countries (more detail in Section 3.2). The *Fiscal Sustainability Report 2015* (2016) elaborates on public government debt being one of the indicators that define the fiscal sustainability of a country, where a debt target of 60% public debt-to-GDP is considered to be a ceiling for this indicator. This threshold aligns with the fiscal rules in the Maastricht Treaty for the European Economic and Monetary Union, which state that countries are perceived to be at higher sustainability risk when they are above this threshold and are not expected to approach it in the foreseeable future. The underlying principle is that EU countries should have

sufficient fiscal space to manage adverse macroeconomic developments throughout the economic cycle. This research defines a threshold of 60% debt-to-GDP to determine which countries are considered to be in a similar debt-crisis state as the target countries. Countries are included in the donor pool if, for the post-treatment period of 3 years, they are above the 60% debt threshold for at least 2 of those 3 years.

This research will initially employ a donor pool consisting only of Organisation for Economic Co-operation and Development (OECD) countries. This choice is made because OECD countries are developed countries which have a strong tendency to co-move over time across countries. Additionally, a second, larger donor pool is considered, which includes all countries in the world that meet the donor pool requirements. The inclusion of this second donor pool aims to strike a balance between having more countries in the dataset, and maintaining interpretability in the countries under consideration.

Kubrin et al. (2022) employed the SCM to investigate how governmental spending cuts during economic downturns could worsen health effects by reducing the buffering social support. Their study particularly highlights the increase in suicide rates in Greece, a country where such rates were historically low. Their research established a causal relationship between the austerity measures imposed by the IMF in 2010 and the subsequent rise in suicide rates among both genders in Greece. However, their study does not assess whether these austerity measures had the expected effect of improving the GDP per capita of Greece in comparison to alternative approaches. Underlying research addresses this gap in the literature by combining a causal investigation with an analysis of economic performance, providing a comprehensive understanding of the impact of austerity policies.

The main findings of this research, which is based on a synthetic control analysis of the economic performance of Greece, Spain, and Portugal, indicate a significant negative causal effect between the austerity measures implemented during the debt crisis and the trend in GDP per capita. This negative effect is observed in both the short and long term, and it becomes even more pronounced over time for Greece and Spain. These findings are further supported by placebo studies. It is important to note that the synthetic control used for Greece and Portugal is not able to properly account for the impact of the debt crisis, which is a strong predictor for GDP per capita in the post-treatment period. In general, these results support the growing criticism of austerity measures, particularly the impact of public expenditure cuts on economic performance. They also offer valuable insights for policymakers on how to address financial instability during times of economic instability. Following this introduction, Chapter 2 will delve into the methodology, followed by the data section in Chapter 3, the analysis results in Chapter 4, and the conclusion in Chapter 5.

2 Methodology

2.1 The Synthetic Control Method

A convincing model to detect the effects of austerity measures on the GDP per capita of struggling countries during the European debt crisis, is the synthetic control method. The rationale behind this method is that comparing a single target country with multiple reference countries offers a more comprehensive analysis, as it is challenging to find a single untreated country that closely matches the relevant characteristics of the target country. For this method, based on Abadie et al. (2010), $i = 1, ..., C+1$ countries are considered, for which the first country is assumed to be the target country. The countries are observed at time t that runs from $1, ..., T$, where T^* is defined as the treatment moment, thus the moment austerity measures are taken, where $1 \leq T^* < T$.

$Y_{i,t}^{\mathrm{NT}}$ is defined as the observed target variable of country i at time t in the case there is no treatment, and $Y_{i,t}^{\mathrm{T}}$ as the target variable of country i at time t in the case there is a treatment. The donor pool which is considered to be the reference pool should only contain countries that are not affected by the treatment, so it excludes countries that did incorporate austerity measures. Also, the assumption of no interference between countries is made, and thus the economic performance of countries that did not take austerity measures is not affected by the fact that the target country did take austerity measures (Rosenbaum, 2007). Further, this study follows the assumption in Abadie et al. (2010) that $Y_{i,t}^{\mathrm{NT}}$ is generated from a factor structure

$$Y_{i,t}^{\mathrm{NT}} = \beta_t + \boldsymbol{\theta}_t \boldsymbol{Z}_i + \boldsymbol{\lambda}_t \boldsymbol{\mu}_i + \varepsilon_{i,t}, \tag{1}$$

where β_t is an unknown common factor, $\boldsymbol{\theta}_t$ is a $1 \times M$ vector of unknown parameters associated with $\boldsymbol{Z}_i$, a $M \times 1$ vector of observed covariates which are not effected by the treatment, $\boldsymbol{\lambda}_t$ is a $1 \times F$ vector of unobserved common factors with $\boldsymbol{\mu}_t$ a $F \times 1$ vector of unknown factor loadings. The error terms $\varepsilon_{i,t}$ are considered to be the transitory shocks of country i at time t.

The observed outcome for country i at time t is defined as

$$Y_{i,t} = \begin{cases} Y_{i,t}^{\mathrm{T}} & \text{if } i = 1 \text{ and } t > T^*, \\ Y_{i,t}^{\mathrm{NT}} & \text{otherwise,} \end{cases} \tag{2}$$

where

$$Y_{i,t}^{\mathrm{T}} = Y_{i,t}^{\mathrm{NT}} + \alpha_{i,t}, \tag{3}$$

with $\alpha_{i,t}$ the treatment effect of country i at time t.

The estimate of the synthetic control of the treated country is defined as the linear combination of the weighted observed countries in donor pool:

$$\widehat{Y}_{1,t}^{\mathrm{NT}} = \sum_{i=2}^{C+1} w_i Y_{i,t}, \tag{4}$$

where it's assumed that only the first country takes austerity measures, $\boldsymbol{W} = (w_2, ..., w_{C+1})^{\mathrm{T}}$, all $w_i \geq 0$, and

$$\sum_{i=2}^{C+1} w_i = 1. \tag{5}$$

The estimated treatment effect at time t, which is the causal effect of interest in this research, is defined as

$$\widehat{\alpha}_{1,t} = Y_{1,t}^{\mathrm{T}} - \widehat{Y}_{1,t}^{\mathrm{NT}} = Y_{1,t} - \sum_{i=2}^{C+1} w_i Y_{i,t}, \text{ where } t = T^* + 1, ..., T. \tag{6}$$

To construct the synthetic counterfactual, the difference between the target country and the synthetic counterpart should be minimized. To optimize the similarity to the target country, a set of M pre-treatment covariates for the target country are chosen and stored in the $(T^* + M) \times 1$ matrix $\boldsymbol{X}_1$, based on empirical evidence. Then, let $\boldsymbol{X}_0$ be a $(T^* + M) \times C$ vector, which contains the same set of pre-treatment covariates for all the control countries. The objective is to minimize the pre-treatment difference between the predictors of the target country and the control countries as

$$\min_{\boldsymbol{W}} (\boldsymbol{X}_1 - \boldsymbol{X}_0 \boldsymbol{W}). \tag{7}$$

However, for a correct matching of the covariates, their different scales have to be taken into account. In this minimization problem, all covariates get the same weight assigned. Consequently, the difference is disproportionately influenced by the scale of the units in which the covariates are measured, rather than their relative importance. To overcome this issue, a $(T^* + M) \times (T^* + M)$ diagonal matrix $\boldsymbol{V}$ is defined, where its diagonal elements indicate the relative significance of the predictors.

Following notation from Abadie et al. (2010), subject to all $w_i \geq 0$ and equation (5), the goal is to minimize $\boldsymbol{W}$ in

$$\|\boldsymbol{X}_1 - \boldsymbol{X}_0 \boldsymbol{W}\|_{\boldsymbol{v}} = \sqrt{(\boldsymbol{X}_1 - \boldsymbol{X}_0 \boldsymbol{W})^{\mathrm{T}} \boldsymbol{V} (\boldsymbol{X}_1 - \boldsymbol{X}_0 \boldsymbol{W})}. \tag{8}$$

This research follows Abadie and Gardeazabal (2003), using a data-driven approach to select $\boldsymbol{V}$ from the set of positive definite diagonal matrices, aiming to reduce the average squared prediction error for the outcome variable before treatment.

The solution of equation (8), $\boldsymbol{W}^*(\boldsymbol{V})$, is a matrix of weights that reflect the relative importance of the variables in $\boldsymbol{X}_0$ and $\boldsymbol{X}_1$. The matrix $\boldsymbol{V}$ is chosen in order to ensure that the pre-treatment GDP of the target country is most accurately represented by the synthetic control weights defined by $\boldsymbol{W}^*(\boldsymbol{V})$. Let $\boldsymbol{H}_1$ be a $(T^* \times 1)$ vector that includes the actual GDP per capita values for the target country during the pre-treatment period. Let $\boldsymbol{H}_0$ be a $(T^* \times C)$ matrix that includes GDP per capita values for the C control countries. The optimal matrix $\boldsymbol{V}^*$ is determined by choosing $\boldsymbol{V}$ such that $\boldsymbol{W}^*(\boldsymbol{V})$ minimizes

$$(\boldsymbol{H}_1 - \boldsymbol{H}_0 \boldsymbol{W}^*(\boldsymbol{V}))' (\boldsymbol{H}_1 - \boldsymbol{H}_0 \boldsymbol{W}^*(\boldsymbol{V})). \tag{9}$$

In essence, the pre-treatment period acts as a validation since the optimal $\boldsymbol{V}$ is obtained simultaneously with minimizing the difference between the target variable of the target country and the control countries in the pre-treatment period.

2.2 Test for Inference

To evaluate the synthetic control method's effectiveness in modeling the evolution of a counterfactual, two placebo tests following the approach of Abadie and Gardeazabal (2003) are conducted.

2.2.1 In-time Placebo

The first method for conducting a placebo test is to perform a synthetic control analysis on the target country for a period several years before the actual treatment moment. In this approach, the synthetic control is matched to the target country up until this new, earlier treatment period. Then, a visible treatment effect between this new treatment moment and the actual treatment moment is examined. If the synthetic control closely mimics the target country during this period, it suggests that the observed effect is genuinely due to the specific treatment moment and does not occur prematurely. Conversely, if the target country and the synthetic control start to deviate significantly after a new treatment moment but not after the actual treatment moment, it suggests that the deviation is due to a causal effect, but this effect is not attributable to the defined treatment moment itself; instead, it is likely caused by one of the covariates. This research uses the average values of macroeconomic indicators over the period from 1990-2010 to fit the synthetic control with the target country. For the in-time placebo test, the same analysis is conducted, but the treatment moment is backdated to 2005. This means that for this analysis, the pre-treatment fit for the macroeconomic indicators is based on their average values for the 1990-2005 period. Since no macroeconomic data is used between 2005-2010, the fit between the target variable and the synthetic counterpart for this period should still be good, and the deviation is expected to start only in 2010.

2.2.2 In-space Placebo

In an alternative process, the synthetic control method is applied to countries that did not take austerity measures post-debt crisis, now considering those that did as part of the donor pool. If the placebo tests yield treatment effects similar to those anticipated for the target countries, this research can conclude that the analysis does not yield substantial evidence of the impact of austerity measures on GDP per capita. Alternatively, if the estimated effect for all countries not enacting austerity measures is smaller than that of the anticipated target countries enacting austerity measures, then this research can conclude that the analysis provides significant evidence of a causal relationship between austerity and economic performance.

The Root Mean Squared Percentage Error (RMSPE) indicates the size of the difference between the target variable and the synthetic control. For the in-space placebo test, the pre-treatment fit and post-treatment differences are analyzed by comparing the target country's fit and effect to those of the control countries. In this setup, each control country is treated as the target, with the remaining countries serving as controls.

Abadie (2021), elaborate on a test statistic proposed by Abadie et al. (2010) to validate the results obtained with the synthetic control analysis. The pre-RMSPE and post-RMSPE of country j, with $j = 1, ..., C + 1$, are defined as follows:

$$\text{Pre-RMSPE}_j = \left(\frac{1}{T^*} \sum_{t=1}^{T^*} \left(Y_{j,t} - \sum_{i \neq j}^{C+1} w_i Y_{i,t} \right)^2 \right)^{1/2} \tag{10}$$

$$\text{Post-RMSPE}_j = \left(\frac{1}{T - T^*} \sum_{t=T^*+1}^{T} \left(Y_{j,t} - \sum_{i \neq j}^{C+1} w_i Y_{i,t} \right)^2 \right)^{1/2}. \tag{11}$$

If there is a treatment effect, a large difference between the post-period and pre-period RMSPE is expected. A good pre-treatment fit results in a low pre-RMSPE, while a substantial divergence between the target variable and synthetic control variable post-treatment indicates an effect. To validate the results of the synthetic control, the target country should have the highest post-period RMSPE to pre-period RMSPE ratio compared to the control countries. This suggests that the observed effect is specific to the target country, implying a causal relationship, as this country implemented austerity measures while the control countries did not. The Post-RMSPE$_j$ to Pre-RMSPE$_j$ ratio for country j is

$$R_j = \frac{\text{Post-RMSPE}_j}{\text{Pre-RMSPE}_j}. \tag{12}$$

In essence, the in-space placebo reveals whether there is an effect visible in other countries that did not implement austerity measures. It is important to note that both the pre-treatment fit and the post-treatment effect are key indicators when comparing the effect on the target country with the effect on the countries in the donor pool. For example, consider the case where one of the donor countries is considered the target country and there is a post-treatment deviation between this donor country and its synthetic control. Before making conclusions, the pre-treatment fit between this donor country and its synthetic control should still be considered. If there is a poor pre-treatment fit between the donor country and its synthetic control, the visible post-treatment effect is not valid. Therefore, it is essential to consider both the pre-treatment fit and the post-treatment difference to determine if there is an effect visible in other countries that did not implement austerity measures.

Based on Abadie (2021), a p-value for the distribution of R_j is defined as

$$p = \frac{1}{C+1} \sum_{j=1}^{C+1} \mathbb{I}_{+\{R_j - R_1\}}, \tag{13}$$

with R_1 the ratio for the actual target country and

$$\mathbb{I}_{+\{R_j - R_1\}} = \begin{cases} 1 & \text{if } R_j - R_1 \geq 0 \\ 0 & \text{otherwise.} \end{cases} \tag{14}$$

The p-value then indicates the probability that when considering all countries as potential target countries, an equal or larger post/pre-RMSPE ratio then the actual target country is found.

2.3 Leave-One-Out Robustness

Besides validating the results using in-space and in-time placebo tests, this research also employs a robustness test to analyze whether the results are sensitive to the countries included in the synthetic control. Similar to Abadie et al. (2015), a leave-one-out analysis is conducted. For each target country, after identifying which countries in the donor pool contribute to the synthetic control with a positive weight, the synthetic control analysis is iteratively redone, excluding each of these positively weighted countries from the donor pool one at a time. By excluding one of the positively weighted countries from the donor pool, new weights will be assigned to the remaining countries, which creates the leave-one-out synthetic control. There are two aspects to investigate for the leave-one-out synthetic control. First, the pre-treatment trajectory of the GDP per capita of the leave-one-out is compared with that of the original synthetic control. It then becomes clear if the pre-treatment fit is robust to the exclusion of any particular country. Secondly, it is important to analyze if the estimated effect after the treatment changes in magnitude or perhaps even in sign for the leave-one-out synthetic control with respect to the original synthetic control. It then becomes clear if the post-treatment estimated effect is robust to the exclusion of any particular country.

3 Data

This section describes the data used in the research. First, the macroeconomic indicators that predict GDP per capita and their sources are detailed, referred to as the main data set. Next, the data on debt-to-GDP, which is part of the main data set, is used to define the debt crisis threshold. Then, another data set containing the central government total expenditure of 196 countries is analyzed to determine which countries implemented austerity measures and should thus be excluded from the donor pool. Finally, the construction of the donor pool as well as the descriptive statistics for the main data set are discussed.

3.1 GDP per capita and Macroeconomic indicators

The initial main dataset contains the target variable GDP per capita and macroeconomic predictors for the target variable for 215 countries spanning from 1960 to 2022. The data on GDP per capita, inflation, trade, and industry share of value added are obtained from the World Bank's Databank, specifically the World Development Indicators (World Bank, 2024). The data on debt-to-GDP is obtained from the Global Debt Database (International Monetary Fund, 2023a) and the data on schooling from Barro and Lee (2013).

The primary variable of interest is GDP per capita, which serves as a measure of the economic performance of the countries under investigation. Furthermore, this research carefully selects macroeconomic indicators that predict GDP per capita. These indicators are chosen to ensure that the synthetic counterfactual accurately reproduces the values of these predictors in the period prior to the implementation of austerity measures. A set of predictors is formulated based on a literature review on identifying macroeconomic characteristics that influence GDP per capita (Abadie et al., 2015 and Barro, 1996). The macroeconomic indicators in the dataset, employed for the pre-treatment fit, are described in Table 1. The dataset is initially sorted by

country and then by year, allowing for a direct comparison of macroeconomic indicators between different countries within the same time period. To ensure accurate comparisons between countries, the variables in the dataset either do not scale with size (e.g., inflation) or have been adjusted to account for size differences (e.g., debt-to-GDP ratio).

Variable	**Short Name**	**Description**
GDP per capita	GDP	Real GDP per capita at purchasing power parity (PPP) in current $. It is corrected for differences in price levels between different countries to enable a fair comparison of economic performance.
Debt-to-GDP	DEBT	Central Government Debt as a percentage of GDP. This provides insight into a country's fiscal health and its ability to manage debt relative to the size of its economy.
Industry share of value added	IND_VAL	Annual percentage of GDP, including construction. This provides insight into the level of industrialization and economic structure of a specific country.
Inflation rate	INFL	Annual percentage based on consumer prices. This gives insight into changes in the cost of goods and services and their impact on a country's purchasing power, thus indicating economic stability.
Trade	TRADE	Trade measures the total sum of imports and exports as a percentage of GDP. This provides insight into the extent of a country's involvement in economic activity with other countries.
School enrollment	SCHOOL	Secondary school enrollment as a percentage of the population aged between 15 and 64 reported in five-year increments. This gives an indication of the education level of a country, which affects its economic performance.

Table 1: Variables and descriptions

3.2 The Debt Crisis

After the global financial crisis of 2008-09 hit, multiple European countries were affected, leading to the euro area sovereign debt crisis of 2010-12. The English economist Keynes advocated for a counter-cyclical role for the government, suggesting minimal interference during economic booms and advocating for public spending to stimulate the economy during downturns. During this second crisis, however, the financial flexibility to implement counter-cyclical policies was significantly constrained, leaving struggling countries to resort to austerity measures (Hobelsberger et al., 2022). Figure 1 illustrates the trajectory of central government debt for the countries under investigation for this research: Greece, Portugal, and Spain, to highlight the severity of the debt these nations incurred during the debt crisis and uses the data on debt-to-GDP from

International Monetary Fund (2023a).

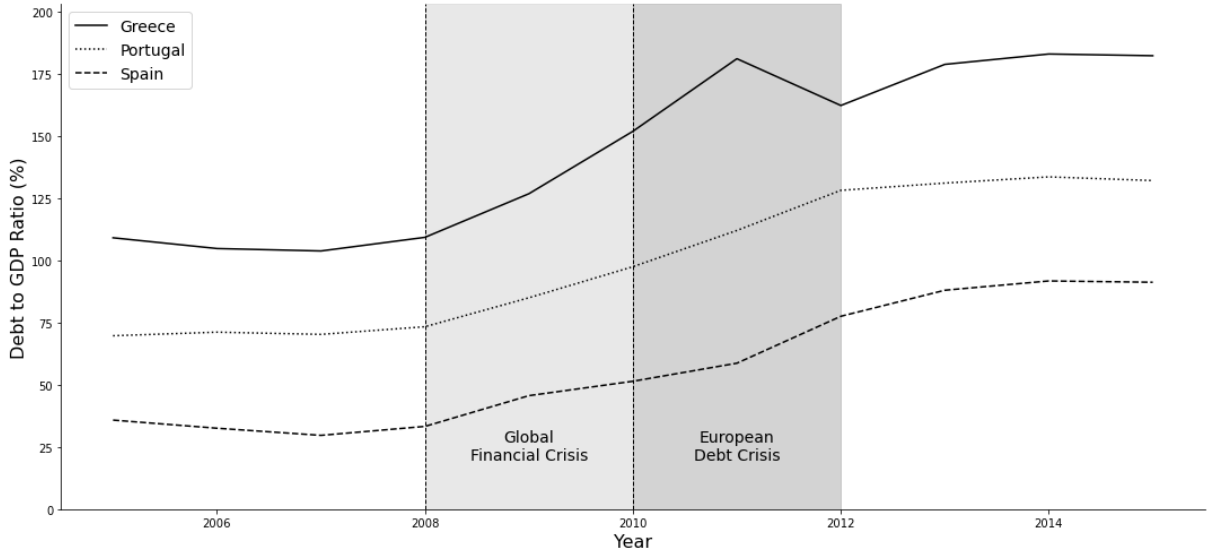

Figure 1: Central government debt-to-GDP ratio of Greece, Portugal and Spain (Hobelsberger et al., 2022 and International Monetary Fund, 2023a)

For the synthetic control analysis, it is important to control for the debt crisis in order to accurately isolate the effect of austerity on economic performance. In addition to controlling for debt as a pre-treatment covariate, it is also necessary to control for the debt crisis post-treatment. The *Fiscal Sustainability Report 2015* (2016) highlights public government debt as a key indicator of fiscal sustainability, with a 60% public debt-to-GDP ratio considered as the maximum threshold. This threshold, which is consistent with the Maastricht Treaty fiscal rules, indicates a higher risk of sustainability for countries that exceed it. It is used to determine which countries are suitable to be included in the donor pool. When examining the early post-austerity years, Figure 2 displays the countries that exceed the 60% debt-to-GDP threshold for at least 2 out of the 3 years (2011, 2012, and 2013) and are therefore considered part of the donor pool.

3.3 Austerity Measures

For the synthetic control analysis, it is essential that countries in the donor pool did not implement as severe austerity measures. To determine which countries did not undertake austerity measures as severe as those in the investigated target countries and are thus suitable for the donor pool, the central government total expenditure as a national amount between 2008 and 2015 for 196 countries is examined, retrieved from International Monetary Fund (2023b). This indicator identifies which countries reduced their spending during and after the debt crisis and should thus be excluded from the donor pool.

The percentage change of total expenditure of the central government as an absolute amount is examined rather than a percentage of GDP. This is because when the expenditure as a percentage of GDP is compared, the fluctuation in GDP affects this trajectory, when in fact the interest is the absolute change of expenditure over the years based on government policy. This approach thus works with a scaled version and can still define a clear threshold. To assess whether a country is considered to have undergone austerity measures in the aftermath of the

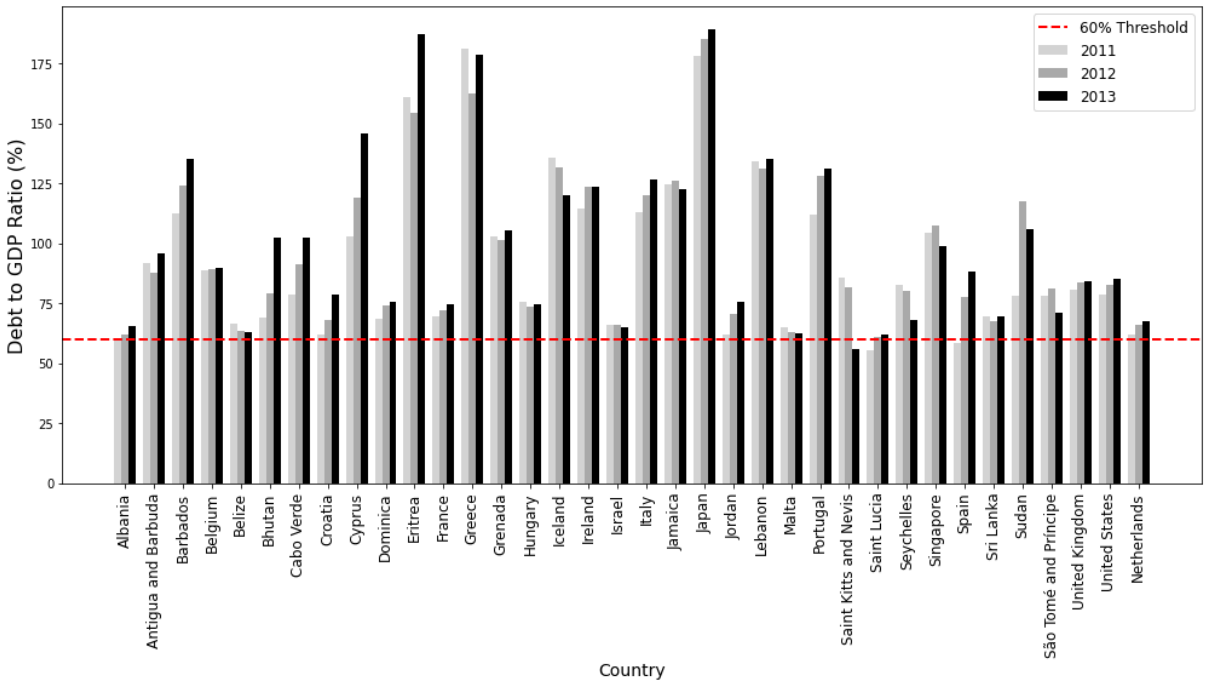

Figure 2: Central government debt-to-GDP for 2011, 2012 and 2013 (International Monetary Fund, 2023a)

debt crisis, the percentage change in expenditure in 2009, the year before the austerity measures were undertaken, is compared with the average percentage change in expenditure over the six years after the debt crisis, from 2010-2015. This comparison suits the purpose of the research, as the trend of public spending in the aftermath of the debt crisis is of interest, and not individual spending years. This overcomes the issue that countries that did undergo austerity measures in the years 2010-2015 but not in each year individually are still excluded from the donor pool. If the percentage change in total government expenditure in 2009 is lower than the average from 2010-2015, these countries are excluded from the donor pool. This indicates that these countries increased their public spending in 2009 but, on average, made cuts in their public spending from 2010-2015.

Table 2 shows the trajectory of the total government expenditure of the target countries from 2009-2015 and the comparison of 2009 to the average from 2010-2015. As expected, Greece, Spain, and Portugal are countries that underwent austerity following this assessment. Figure 3 displays the percentage change in public spending from 2009 to the average from 2010-2015 that have shown a negative difference. This is the which is the case for 13 out of the 196 countries, which gives an indication of the uniqueness of the spending cuts during the debt crisis as well as the potential for the donor pool.

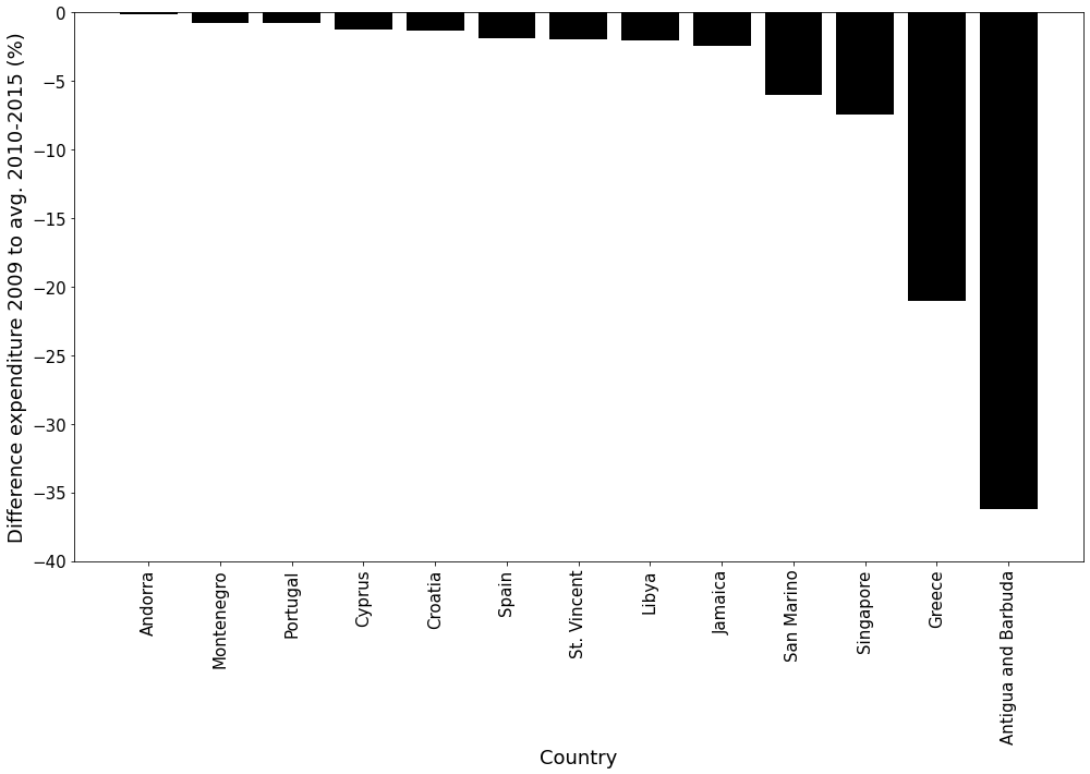

Figure 3: Percentage of difference in public expenditure between 2009 and the average of 2010-2015 for 196 countries
Note: Only the countries which made cuts in public expenditure are displayed.

Country	2009	2010	2011	2012	2013	2014	2015	2009 to avg. 2010-2015 (%)
Greece	128.469	118.690	112.064	102.005	94.368	90.678	90.933	-21.03
Spain	494.355	493.815	490.976	510.092	473.465	468.113	474.881	-1.85
Portugal	88.099	93.216	88.088	82.278	85.112	89.448	86.523	-0.74

Table 2: Total government expenditure 2009-2015 for the target countries

3.4 Constructing the donor pool

After determining which countries should be excluded from the potential donor pool due to implementing austerity measures and including countries affected by the debt crisis, the final donor pool is established. From the initial dataset of 215 countries, all countries that have implemented austerity measures, as shown in Figure 3, are first removed, with the exception of Greece, Spain, and Portugal, which are the target countries. The revised dataset then consists of 206 countries. Next, only those countries that are considered to be in the debt crisis after implementing austerity measures, as depicted in Figure 2, are included. The revised dataset then comprises 28 countries.

It may seem that the synthetic fit will be negatively affected by the significant reduction in the donor pool due to the debt restriction. However, as mentioned by Abadie (2021), the risk of overfitting actually increases when there are too many countries included in the donor pool.

With a fixed T^*, having a larger number of donor units C makes it easier to fit pre-treatment outcomes, even when there are substantial differences in the covariates between the treated unit and the synthetic control. Based on this reasoning, the bias bound for the synthetic control estimator is positively dependent on C, which implies that having a large number of countries in the donor pool may increase the bias of the synthetic control estimator.

The reliability of a synthetic control significantly relies on its capacity to accurately follow the trend of the pre-treatment period of the target country. For this reason, extensive data on both the target country and the donor countries for a long pre-treatment period is essential. Complete data for the target variable is essential for the synthetic control analysis to be effective. The dataset starts in 1990 to ensure a sufficient pre-treatment period and to avoid excluding many countries from the donor pool due to missing GDP per capita values from 1980-1990. Countries with missing GDP per capita information from 1990 onward are excluded from the dataset. The pre-treatment period spans from 1990 to 2010 to maximize accuracy and obtain a fit that closely mirrors the historical economic paths of the target countries, which gives us a pre-treatment period of 20 years. The post-treatment period, from 2010 to 2022, is used to assess the causal effect and examine both the immediate and long-term effects of austerity measures on the economic performance of these countries.

For this analysis, the synthetic control is derived using the average values of the covariates during the pre-treatment period. Consequently, it is not problematic if some covariates have missing values for certain years within this period. However, if a donor country lacks data for the entire prediction period for a covariate, the synthetic control analysis cannot minimize the distance between the covariate average of the donor and target country. Appendix B indicates which countries are dropped from the dataset due to insufficient data availability. After the data cleaning, the main dataset now contains 21 countries. To finalize the donor pools, the three target countries are eliminated. From this, the research defines two donor pools: a world donor pool consisting of 18 countries and an OECD donor pool consisting of 11 countries, as displayed in Table 3. As mentioned, for the synthetic control analysis, the OECD donor pool balances the trade-off between having fewer donor countries in the dataset to reproduce the target country and gaining in interpretability, considering that OECD countries strongly co-move over time across countries.

Table 4 displays the descriptive statistics of the target variable for the target countries. The full time period covers 33 years from 1990 to 2022. The descriptive statistics of the proposed economic growth predictors for the world donor pool and OECD donor pools are displayed in Tables 5 and 6, respectively. The values of predictors for GDP per capita for the target country and the potential donor countries are incorporated in $\boldsymbol{X}_1$ and $\boldsymbol{X}_0$, respectively, following the methodology.

The prediction period runs from 1990 to 2010, and this research follows Abadie et al. (2015) by averaging the covariates over this period to obtain the synthetic control. For the entire pre-treatment period from 1990 to 2010, the synthetic control aims to minimize the difference between the averages of the covariates that predict GDP per capita between the donor countries and the target country. Another approach is to use individual time-specific values of the covariates to generate the synthetic control, which increases the number of covariates included in the

OECD Donor Pool	World Donor Pool
Belgium	Belgium
France	France
Hungary	Hungary
Iceland	Iceland
Ireland	Ireland
Israel	Israel
Italy	Italy
Japan	Japan
Netherlands	Netherlands
United Kingdom	United Kingdom
United States	United States
	Albania
	Barbados
	Belize
	Jordan
	Malta
	Sri Lanka
	Sudan

Table 3: OECD donor pool and world donor pool

Country	Count	Mean	Std. Deviation	Min	Max
Greece	33	32959.70	4412.79	26924.40	41920.10
Portugal	33	34630.20	3692.79	27161.20	41240.40
Spain	33	40052.70	4783.48	31353.70	46424.30

Table 4: Descriptive statistics of GDP per capita of the target countries

analysis. For example, Abadie et al. (2010) used three time-specific values of cigarette sales per capita before the passage of Proposition 99 to predict post-treatment cigarette sales per capita, specifically the values from 1988, 1980, and 1975, instead of an average for the cigarette sales per capita for the pre-treatment period. As described in Abadie (2021), a potential advantage of averaging pre-treatment covariates, rather than using time-specific values of the covariates from 1990 to 2010, is that it can result in greater sparsity of the synthetic control outcome. This is because the number of countries with positive weights in the synthetic control is controlled by the number of pre-treatment covariates included in the analysis. Therefore, using averages rather than time-specific values reduces the number of countries in the synthetic control, making the results more interpretable.

4 Results

This section elaborates on the main findings obtained in this research. The synthetic control analysis uses the OECD donor pool as the basis due to the gains in interpretability of the results, given that OECD countries tend to co-move strongly over time. First, an overview of the short-term (3 years) and long-term (12 years) estimated causal effects of the austerity measures in 2010

Variables	Mean	Std. Deviation	Min	Max
GDP ($)	34839.50	19545.70	2547.53	122596.00
DEPT (%)	83.38	44.10	22.85	495.20
IND_VAL (%)	22.20	5.54	4.87	50.78
INFL (%)	6.70	21.68	-7.11	359.09
TRADE (%)	86.78	58.68	2.70	333.00
SCHOOL (%)	55.10	17.38	9.68	92.58

Table 5: Descriptive statistics of variables for world donor pool

Variables	Mean	Std. Deviation	Min	Max
GDP ($)	45510.90	13249.30	18242.00	122596.00
DEPT (%)	82.86	38.26	26.11	226.12
IND_VAL (%)	22.74	4.60	13.35	41.49
INFL (%)	3.35	4.32	-4.45	34.82
TRADE (%)	79.34	47.96	15.72	252.50
SCHOOL (%)	52.83	12.06	24.72	84.09

Table 6: Descriptive statistics of variables for OECD donor pool

on GDP per capita for the three target countries—Greece, Spain, and Portugal—is presented. Then, a detailed examination of the results for each of the three countries will provide insight into the quality of the pre-treatment fit, the countries included in the synthetic control, the handling of the debt crisis, and the in-time and in-space placebo tests. For Greece, this description will be more detailed, whereas for Spain and Portugal, the focus will be on reporting the results to avoid too much repetition. Following this, an analysis of the effects of expanding the donor pool from the OECD to the entire world will be given. This section concludes with a leave-one-out robustness test for all three countries.

4.1 Main Results

Table 7 presents the key findings from the synthetic control analysis investigating the causal impact of austerity measures on three countries during the debt crisis. The table displays the GDP per capita for Greece, Spain, and Portugal, as well as their respective synthetic counterparts, at two time points: three years (2013) and twelve years (2022) after the implementation of austerity measures in 2010. All results are significant at a 10% significance level. The largest estimated effect is observed for Greece, with a short-term causal effect of -25.66%, and a more severe long-term impact of -30.38% on GDP per capita. However, because the synthetic control analysis for Greece fails to control for the debt crisis post-treatment, it is important to make a limitation note for these results. This is further discussed in Section 4.2. For Spain, the size of the impact increases from -9.22% over three years to -15.93% over twelve years, with details described in Section 4.3. In the case of Portugal, the estimated effect of austerity is quite similar for both time points, -14.00% after three years and -13.47% after twelve years. The same concerns regarding validity as for Greece apply to Portugal and are discussed in Section 4.4.

Country	Year	GDP per capita ($)	Synt. GDP per capita ($)	Estimated Effect ($)	Estimated Effect (%)	p-value
Greece	2013	30990.18	41687.24	-10697.06	-25.66	0.0833
	2022	35328.79	50742.82	-15414.03	-30.38	0.0833
Spain	2013	40277.56	44366.52	-4088.96	-9.22	0.0833
	2022	45787.70	54466.45	-8678.75	-15.93	0.0833
Portugal	2013	34639.63	40278.22	-5638.59	-14.00	0.0833
	2022	41240.39	47657.87	-6417.48	-13.47	0.0833

Table 7: Estimated effect of austerity measures on GDP per capita for Greece, Spain, and Portugal

4.2 Greece

In Greece, the implementation of austerity measures aimed at balancing the public budget through spending cuts did not achieve its intended fiscal goals. Research conducted by Eißel (2015) demonstrates that these measures exacerbated economic problems, increased inequality, and disproportionately affected the financially disadvantaged population. Greece is the most prominent example of a country that suffered during the debt crisis and resorted to austerity measures to improve their government deficit. Below, the detailed results of the synthetic control analysis for Greece based on the OECD donor pool are described.

Table 8 provides a detailed comparison of various economic indicators between Greece and its synthetic counterpart during the pre-treatment period, from 1990-2010. Additionally, the sample mean of the OECD donor pool is displayed for comparison. The table displays that the average GDP per capita of Greece and synthetic Greece are similar for the pre-treatment period from 1990 to 2010 ($33355.37 vs $33534.38). Moreover, the macroeconomic predictors INFL and SCHOOL show a good match between Greece and Synthetic Greece for the pre-treatment period (INFL: 7.02% vs. 6.97% and SCHOOL: 47.92% vs. 47.86%, respectively). Overall, it becomes evident that Synthetic Greece provides a better comparison to Greece than taking a sample mean of the OECD donor pool. It's important to note that DEPT is especially poorly matched between Greece and Synthetic Greece, which will be discussed further in the end of this section.

Table 9 presents the weights of the countries that contribute to the synthetic control for Greece. The countries with the highest weights are Hungary (0.151), Israel (0.695), and the United States (0.149), which suggests that their economic characteristics prior to the implementation of austerity measures closely resemble those of Greece.

Figure 4 visually represents the GDP per capita trends of Greece and synthetic Greece during the pre- and post-treatment periods. The figure displays that the GDP per capita of synthetic Greece closely follows the GDP per capita trajectory of Greece before the implementation of austerity measures. This reflects the accuracy of the synthetic control in the pre-treatment period. After 2010, when the austerity measures where implemented in Greece, the GDP per capita trajectory for synthetic Greece starts to deviate from Greece. It is important to note that the pre-treatment fit for Greece is not perfect. This is caused by the fact that the pre-treatment GDP per capita, which serves as a covariate, is averaged over the full prediction period. Thus, an overestimation in the first part of the prediction period is compensated by an underestimation

Variable	Greece	Synthetic Greece	OECD Sample
GDP	33355.37	33534.38	44077.91
DEPT	102.08	79.55	70.94
INFL	7.02	6.97	3.93
TRADE	46.51	66.23	75.89
IND_VAL	18.36	22.65	24.33
SCHOOL	47.92	47.86	55.21

Table 8: Averages of pre-treatment macroeconomic predictors for Greece, synthetic Greece and the OECD donor pool
Note: GDP per capita, Debt-to-GDP, Inflation, Trade, and Industry share are averaged for the 1990-2010 period. School enrollment is averaged over the 5 year increments between 1990 and 2010.

Country	Weight
Belgium	0.000
France	0.002
Hungary	0.151
Iceland	0.000
Ireland	0.000
Israel	0.695
Italy	0.001
Japan	0.001
Netherlands	0.000
United Kingdom	0.001
United States	0.149

Table 9: Weights synthetic Greece, based on the OECD donor pool

in the second part. This is a downside of taking averages of pre-treatment covariates rather than time-specific values of the predictors as separate covariates.

The effect of the austerity measures has been a subject of debate for multiple years. This research focuses on the short-term (3 years) and long-term (12 years) causal effects of austerity on GDP per capita. Based on the post-treatment deviation between Greece and synthetic Greece, the findings indicate that in the short term (2010-2013), GDP was reduced by 25.66% (p-value = 0.08). In the long term (2010-2022), GDP per capita was reduced by 30.38% (p-value = 0.08). The justification of the p-values is described below.

To validate the results and test for significance, an in-space placebo test is conducted. The in-space placebo test determines whether there is an effect on GDP per capita in other countries that did not implement austerity measures. Figure 5 presents the results of the in-space placebo test, displaying the Post/Pre-RMSPE ratio for each country during the time period 2010-2022. Appendix C.1 provides the specific Pre-RMSPE outcomes as well as the short-and long term Post-RMSPE outcomes. Among all countries operating as target countries, Greece has the highest ratio of 5.90, indicating that the post-treatment effect in Greece is the largest when also considering the pre-treatment fit. This research finds that the probability of another country having a Post/Pre-RMSPE ratio equal to or greater than that of Greece in both the short and long term is 0.08. Following the statistical test described in Section 2.2.2, this probability represents the lowest significance level achievable when considering the 11 countries in the OECD

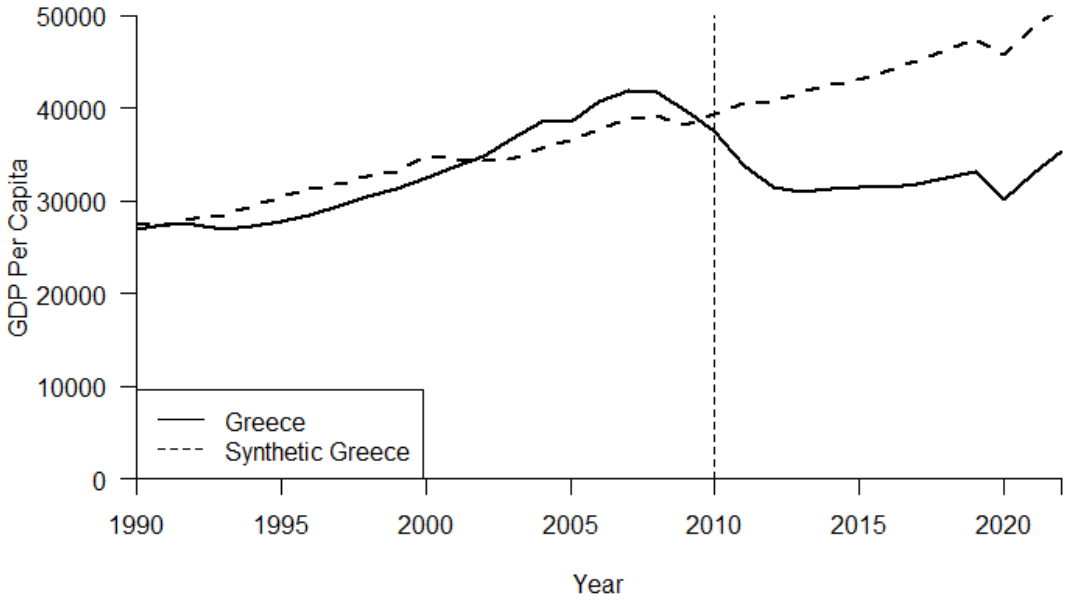

Figure 4: GDP per capita trend of Greece and Synthetic Greece

donor pool.

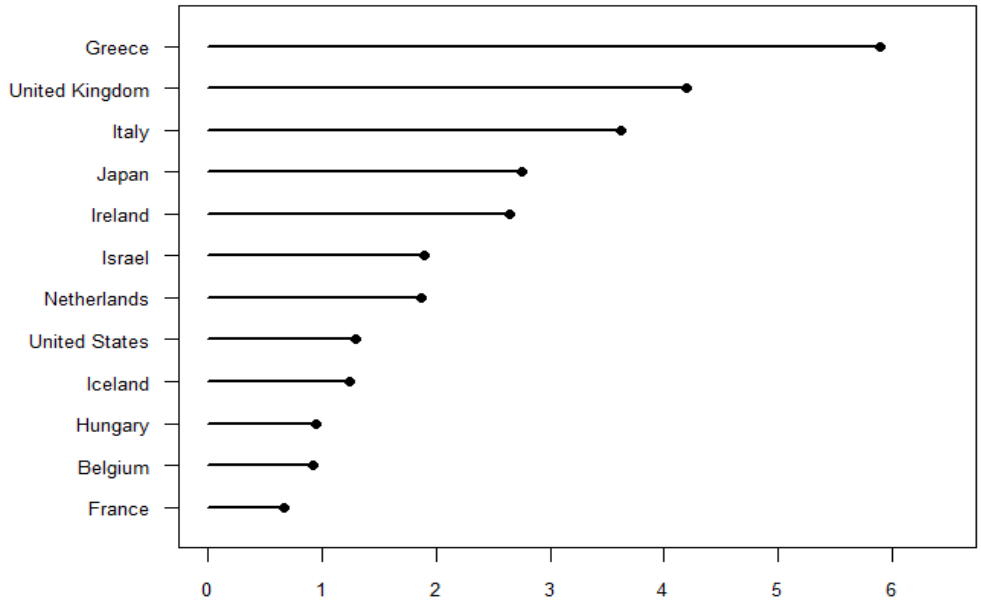

Figure 5: In-space placebo test Greece: Post-RMSPE / Pre-RMSPE

Another metric to validate the results is obtained by analyzing whether the research successfully assigned the causal effect to the austerity measures implemented in 2010. An in-time placebo test was performed to achieve this. The idea behind the in-time placebo test is that between the backdated treatment time and the actual treatment, there remains a close match

between Greece and synthetic Greece. From the actual treatment moment moving forward, Greece and synthetic Greece should only then begin to deviate, and not from the backdated treatment moment. The synthetic control is obtained by minimizing the average difference between the target variable and the covariates for the period between 1990 and 2005, instead of minimizing the difference between the original prediction period of 1990 to 2010. Figure 6 displays the synthetic control results when the prediction period is backdated from 1990-2010 to 1990-2005. The trajectory of GDP per capita for 1990 to 2010 of the synthetic Greece in Figure 6 looks similar to the trajectory of GDP per capita for 1990 to 2010 of the synthetic Greece in Figure 4. This indicates that even though the prediction time is backdated from 2010 to 2005, the average pre-treatment fit for the synthetic Greece is still quite similar to the original synthetic control analysis using the full prediction period. This result is also supported by the weights of the countries from the backdated synthetic Greece, which are quite similar to those of the original synthetic Greece (Appendix C contains the details of the weights of the countries for the in-space placebo tests). As can be seen in Figure 6, there is no worse fit between 2005 and 2010 than in the few years before the backdated treatment. In 2010, the same deviation is visible as seen in Figure 4, reinforcing that an effect that causes the GDP per capita of Greece and synthetic Greece to deviate becomes visible in 2010 (and not in 2005). It is important to note that there was no actual treatment in 2005; this placebo test is constructed to determine whether the potential austerity effect can actually be placed at the specific time in 2010.

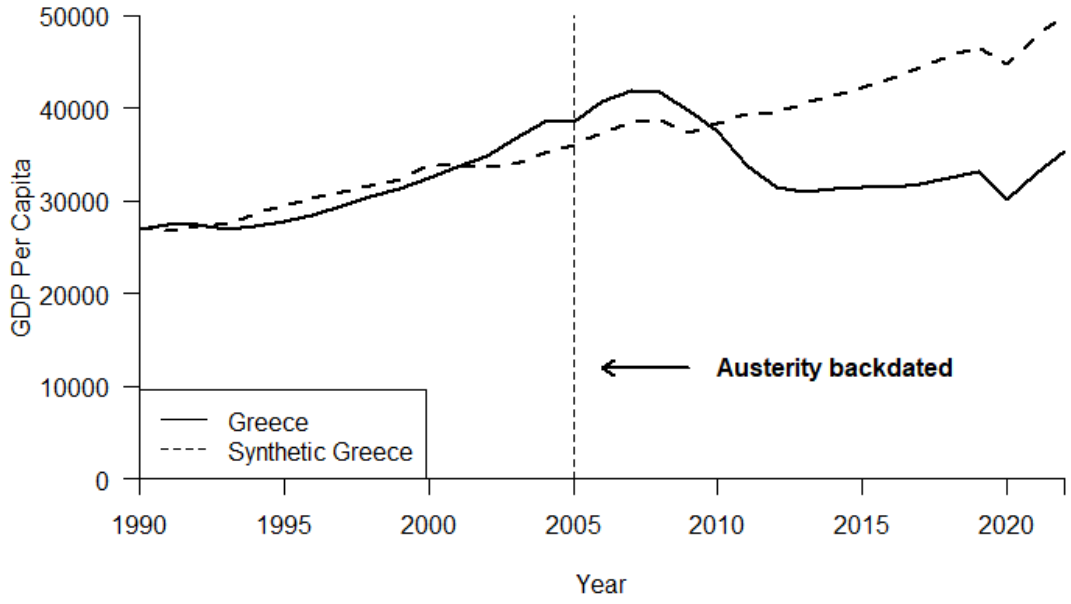

Figure 6: In-time placebo test for Greece with austerity backdated to 2005

As mentioned, the existence of the debt crisis is a strong predictor for GDP per capita. The synthetic control analysis aims to control for debt in two ways: by including debt-to-GDP as one of the covariates and by only including countries in the donor pool that have also endured the debt crisis. Since a significant effect on GDP per capita is obtained after the austerity measures, it is essential to investigate if the analysis was able to control for the debt crisis properly. Figure

7 displays the pre- and post-treatment trajectory of the debt-to-GDP of Greece and that of synthetic Greece. Just as with the GDP per capita trajectory of synthetic Greece, a linear combination of the debt-to-GDP time series for the countries in the donor pool that have a positive weight in the synthetic Greece is taken. It is important to note that the goal of the synthetic control is not to exactly match the trajectory of the debt-to-GDP ratio for Greece and synthetic Greece. Therefore, it is not expected that their trajectories will be perfectly aligned. However, controlling for this variable is crucial as it is a strong predictor of GDP per capita.

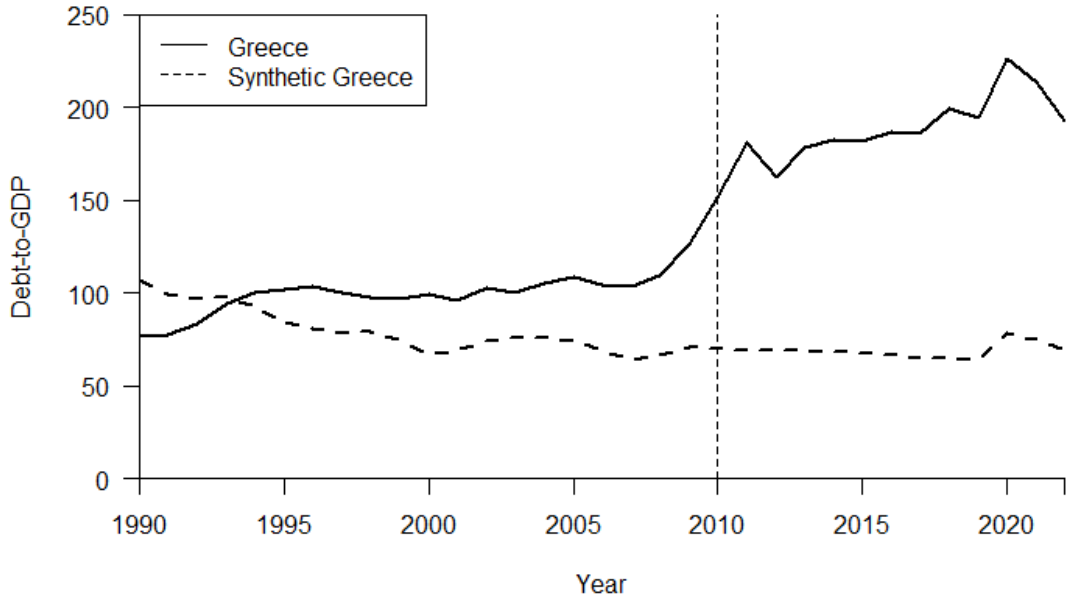

Figure 7: Debt-to-GDP of Greece and Synthetic Greece

It becomes clear that, post-treatment, the difference between the debt-to-GDP of Greece and the synthetic Greece is substantial. This is not surprising since the debt-to-GDP values for Greece were among the largest in the OECD donor pool, and even in the world, during the debt crisis. This makes it nearly impossible to mimic this macroeconomic indicator with a linear combination of countries in the donor pool. Besides the treatment effect under investigation, being in the debt crisis post-treatment has an effect on GDP per capita. Figure 7 displays that the synthetic Greece does not significantly control for the debt-to-GDP post-treatment. Therefore, it cannot be stated that the causal effect found can be solely attributed to taking the austerity measures, because the effect of debt-to-GDP on GDP per capita cannot be isolated. A potential solution for this is to only include countries in the donor pool that have an equal or higher debt-to-GDP trajectory as Greece for the post-treatment period. As displayed in Figure 2, besides Japan and Eritrea, there are are only a few countries that meet these criteria, which leaves the synthetic control with a very limited donor pool. Section 4.5 describes if it is possible to better control debt by extending the donor pool from OECD to the world.

4.3 Spain

More promising results can be found for Spain, whose pre- and post-treatment debt-to-GDP is not of the order of that of Greece. In 2010, Spain was pressured by the financial markets and the European Commission to announce their largest public spending cuts since the beginning of their democracy.

Table 10 provides a detailed comparison of various economic indicators between Spain and its synthetic counterpart during the pre-treatment period, from 1990-2010. The table displays that the average GDP per capita of Spain and synthetic Spain are similar for the pre-treatment period from 1990 to 2010 ($38269.63 vs $38301.92). Considering the other macroeconomic indicators, it becomes clear that overall, synthetic Spain provides a better comparison to Spain than taking a sample mean of the OECD donor pool. It's important to note that the average pre-treatment debt-to-GDP of synthetic Spain actually overstates the debt-to-GDP of Spain, contrary to what became clear for synthetic Greece.

Table 11 presents the weights of the countries that contribute to the synthetic control for Greece. The countries with the highest weights are Hungary (0.207), Ireland (0.073), Israel (0.037), Japan (0.211), and the United Kingdom (0.468), which suggests that their economic characteristics prior to the implementation of austerity measures closely resemble those of Spain.

Variable	Spain	Synthetic Spain	OECD Sample
GDP	38269.63	38301.92	44077.91
DEPT	42.92	61.01	70.94
INFL	3.51	4.67	3.93
TRADE	49.57	65.22	75.89
IND_VAL	27.07	25.75	24.33
SCHOOL	48.77	56.30	55.21

Table 10: Averages of pre-treatment macroeconomic predictors for Spain, synthetic Spain and the OECD donor pool
Note: GDP per capita, Debt-to-GDP, Inflation, Trade, and Industry share are averaged for the 1990-2010 period. School enrollment is averaged over the 5 year increments between 1990 and 2010.

Country	Weight
Belgium	0.000
France	0.000
Hungary	0.207
Iceland	0.002
Ireland	0.073
Israel	0.037
Italy	0.000
Japan	0.211
Netherlands	0.000
United Kingdom	0.468
United States	0.000

Table 11: Weights for synthetic Spain, based on the OECD donor pool

Figure 8 visually represents the GDP per capita trends of Spain and synthetic Spain during

the pre- and post-treatment periods. The figure displays that the GDP per capita of synthetic Spain closely follows the GDP per capita trajectory of Spain before the implementation of austerity measures. This reflects the accuracy of the synthetic control in the pre-treatment period. After 2010, when the austerity measures were implemented in Spain, the GDP per capita trajectory for synthetic Spain starts to deviate from Spain.

Based on the post-treatment deviation between Spain and synthetic Spain, the findings indicate that in the short term (2010-2013), GDP was reduced by 9.22% (p-value = 0.08). In the long term (2010-2022), GDP per capita was reduced by 15.93% (p-value = 0.08).

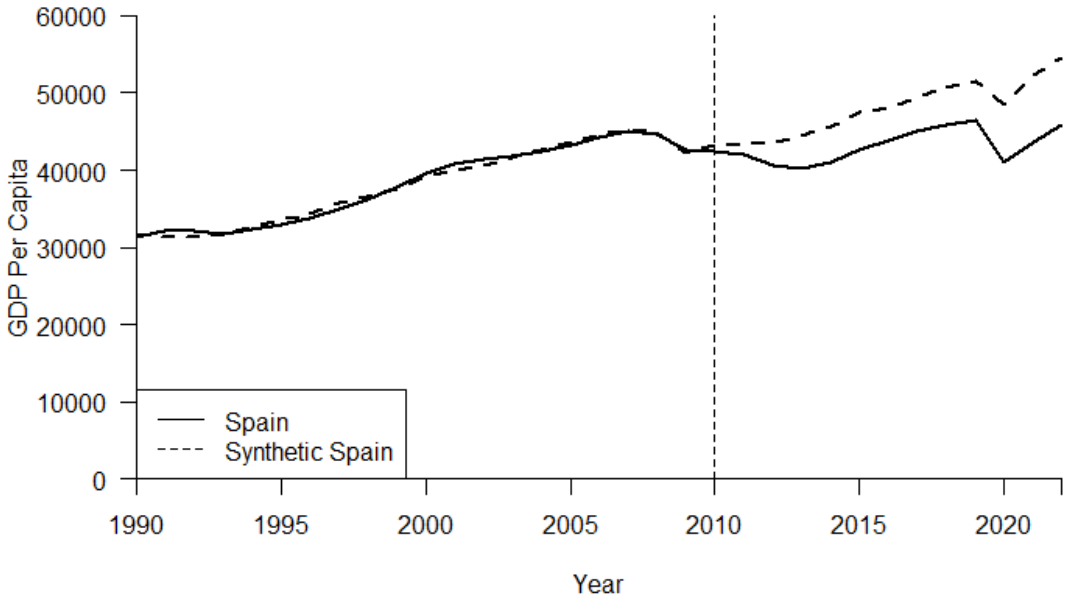

Figure 8: GDP per capita trend of Spain and Synthetic Spain

Figure 9 presents the results of the in-space placebo test, displaying the Post/Pre-RMSPE ratio for each country during the time period 2010-2022. Appendix C.2 provides the specific Pre-RMSPE outcomes as well as the short- and long-term Post-RMSPE outcomes. Among all countries operating as target countries, Spain has the highest ratio of 10.21, indicating that the post-treatment effect in Spain is the largest when also considering the pre-treatment fit. This research finds that the probability of another country having a Post/Pre-RMSPE ratio equal to or greater than that of Spain in both the short and long term is 0.08.

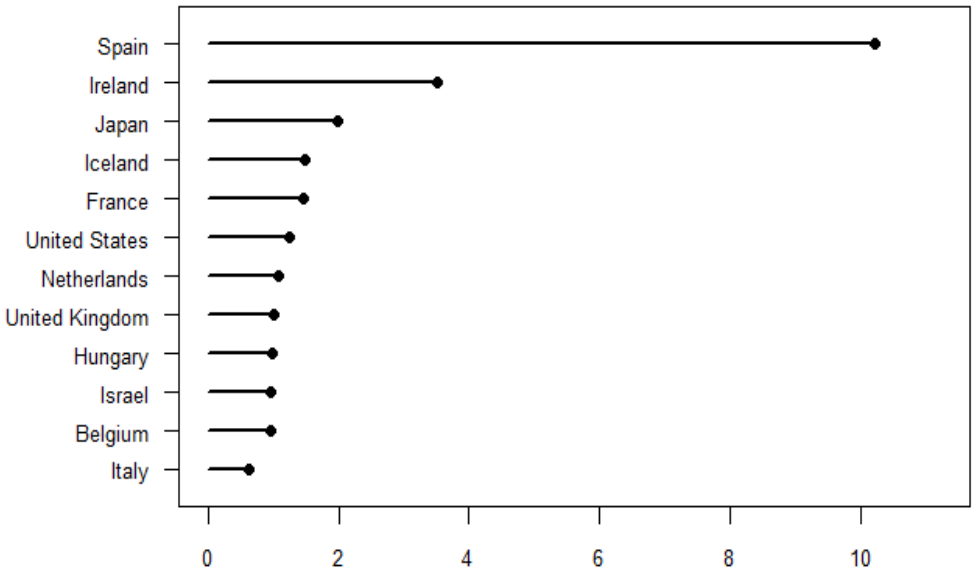

Figure 9: In-space placebo test Spain: Post-RMSPE / Pre-RMSPE

Figure 10 displays the synthetic control results when the prediction period is backdated from 1990-2010 to 1990-2005. The trajectory of GDP per capita for 1990 to 2010 of the synthetic Spain in Figure 10 looks similar to the trajectory of GDP per capita for 1990 to 2010 of the synthetic Spain in Figure 8. This indicates that even though the prediction time is backdated from 2010 to 2005, the average pre-treatment fit for the synthetic Spain is still quite similar to the original synthetic control analysis using the full prediction period. As can be seen in Figure 10, there is no worse fit between 2005 and 2010 than in the few years before the backdated treatment. In 2010, the same deviation is visible as seen in Figure 8, reinforcing that an effect that causes the GDP per capita of Spain and synthetic Spain to deviate becomes visible in 2010 (and not in 2005).

Figure 11 displays the pre- and post-treatment trajectory of the debt-to-GDP of Spain and that of synthetic Spain. It becomes clear that, post-treatment, the debt-to-GDP of synthetic Spain is higher than the debt-to-GDP of Spain. This means that the linear combination of the countries that contribute to the synthetic control for Spain has a higher debt-to-GDP ratio. Thus, and this is an important notion, the effect of debt-to-GDP on GDP per capita is at least not stronger for synthetic Spain than for Spain, considering the negative effect of debt-to-GDP on GDP per capita. The synthetic control of Spain thus seems to control for the debt-to-GDP post-treatment. It is important to note that the goal of the synthetic control is not to exactly match the trajectory of the debt-to-GDP ratio for Spain and synthetic Spain. Therefore, it is not expected that their trajectories will be perfectly aligned. However, controlling for this variable is crucial as it is a strong predictor of GDP per capita. Based on the evidence provided, including post-austerity data, placebo testing, and controlling for the debt crisis, this research confidently concludes that austerity measures have a negative causal effect on Spain's GDP per capita.

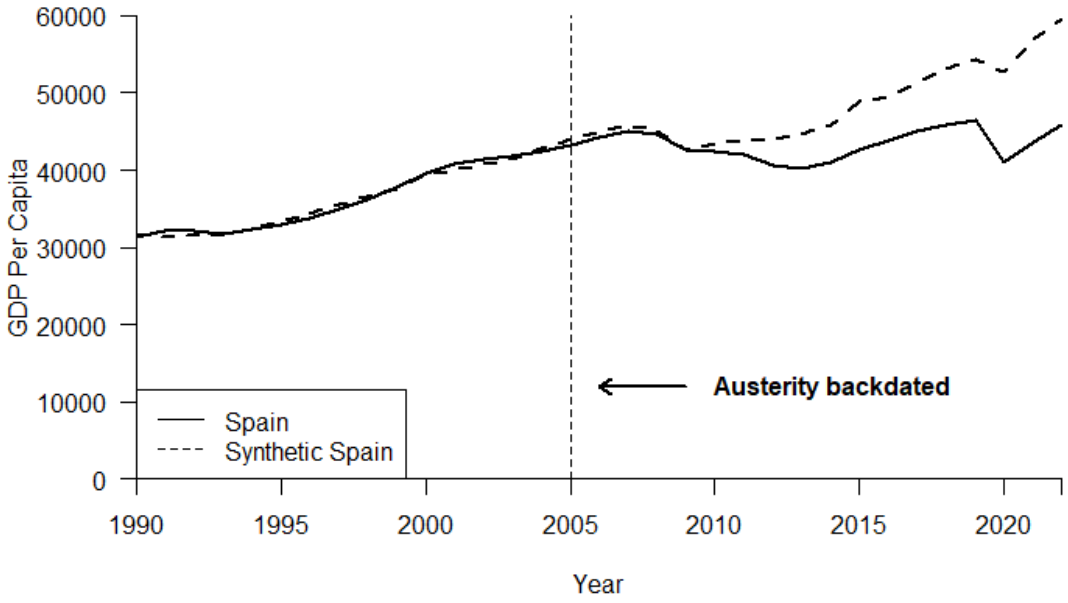

Figure 10: In-time Placebo test for Spain with austerity backdated to 2005

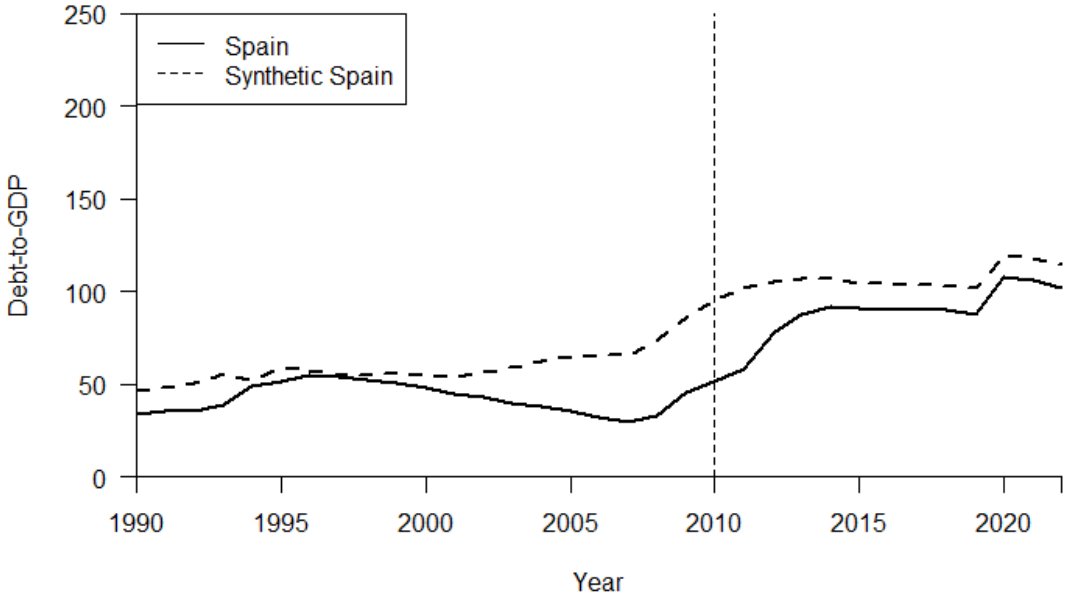

Figure 11: Debt-to-GDP of Spain and Synthetic Spain

4.4 Portugal

After the financial crisis hit the United States, Portugal's initial approach was fiscal expansion, which aligned with the EU's counter-cyclical policy at the time. However, in 2009, the European Council urged Portugal to engage in fiscal consolidation, which led to cuts in public expenditure.

Table 12 provides a detailed comparison of various economic indicators between Portugal and its synthetic counterpart during the pre-treatment period, from 1990-2010. The table displays that the average GDP per capita of Portugal and synthetic Portugal are similar for the pre-treatment period from 1990 to 2010 ($33095.88 vs $33198.48). Considering the other macroeconomic indicators, it becomes clear that overall, synthetic Portugal provides a better comparison to Portugal than taking a sample mean of the OECD donor pool. It's important to note that the average pre-treatment debt-to-GDP of synthetic Portugal actually overstates the debt-to-GDP of Portugal, contrary to what became clear for synthetic Greece.

Table 13 presents the weights of the countries that contribute to the synthetic control for Greece. The countries with the highest weights are Hungary (0.139), Israel (0.565), Japan (0.157), and the United Kingdom (0.137), which suggests that their economic characteristics prior to the implementation of austerity measures closely resemble those of Portugal.

Variable	Portugal	Synthetic Portugal	OECD Sample
GDP	33095.88	33198.48	44077.91
DEBT	62.67	80.23	70.94
INFLATION	4.25	6.00	3.93
TRADE	63.08	63.26	75.89
IND_VAL	22.94	24.22	24.33
SCHOOL	33.55	50.09	55.21

Table 12: Averages of pre-treatment macroeconomic predictors for Portugal, synthetic Portugal and the OECD donor pool
Note: GDP per capita, Debt-to-GDP, Inflation, Trade, and Industry share are averaged for the 1990-2010 period. School enrollment is averaged over the 5 year increments between 1990 and 2010.

Country	Weight
Belgium	0.000
France	0.000
Hungary	0.139
Iceland	0.000
Ireland	0.001
Israel	0.565
Italy	0.000
Japan	0.157
Netherlands	0.000
United Kingdom	0.137
United States	0.000

Table 13: Weights for synthetic Portugal, based on OECD donor pool

Figure 12 visually represents the GDP per capita trends of Portugal and synthetic Portugal during the pre- and post-treatment periods. The figure displays that the GDP per capita of

synthetic Portugal closely follows the GDP per capita trajectory of Portugal before the implementation of austerity measures. This reflects the accuracy of the synthetic control in the pre-treatment period. After 2010, when the austerity measures were implemented in Portugal, the GDP per capita trajectory for synthetic Portugal starts to deviate from Portugal.

Based on the post-treatment deviation between Portugal and synthetic Portugal, the findings indicate that in the short term (2010-2013), GDP was reduced by 14.00% (p-value = 0.08). In the long term (2010-2022), GDP per capita was reduced by 13.47% (p-value = 0.08). In contrast to Greece and Spain, for Portugal, the results don't indicate an increasingly negative effect of austerity on GDP per capita over time.

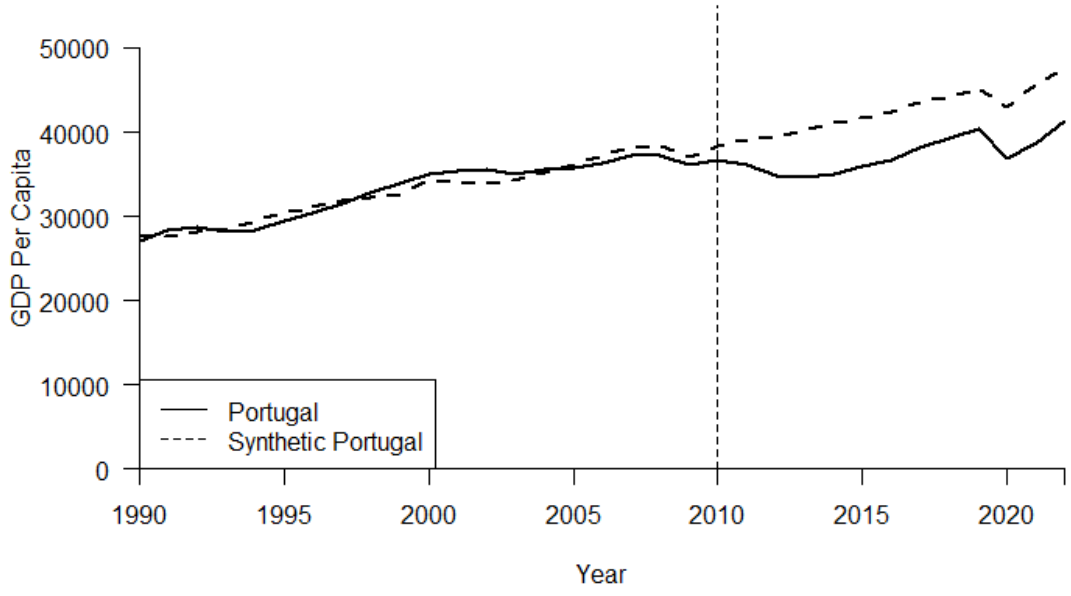

Figure 12: GDP per capita trend of Portugal and Synthetic Portugal

Figure 13 presents the results of the in-space placebo test, displaying the Post/Pre-RMSPE ratio for each country during the time period 2010-2022. Appendix C.3 provides the specific Pre-RMSPE outcomes as well as the short and long term Post-RMSPE outcomes. Among all countries operating as target country, Portugal has the highest ratio of 5.91, indicating that the post-treatment effect in Portugal is the largest when also considering the pre-treatment fit. This research finds that the probability of another country having a Post/Pre-RMSPE ratio equal to or greater than that of Portugal in both the short and long term is 0.08.

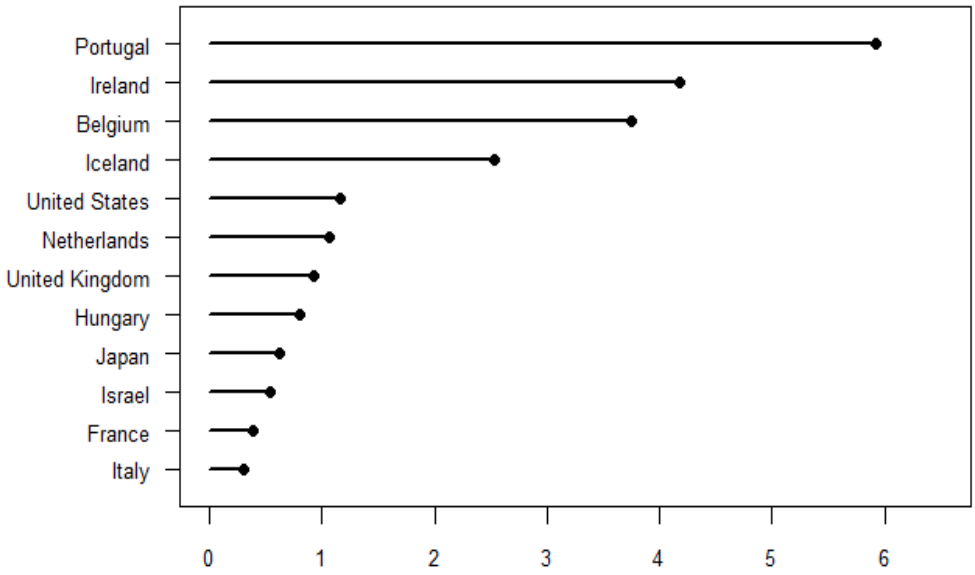

Figure 13: In-space placebo test Portugal: Post-RMSPE / Pre-RMSPE

Figure 14 displays the synthetic control results when the prediction period is backdated from 1990-2010 to 1990-2005. The trajectory of GDP per capita for 1990 to 2010 of the synthetic Portugal looks similar to the trajectory of GDP per capita for 1990 to 2010 of the synthetic Portugal in Figure 12. This indicates that even though the prediction time is backdated from 2010 to 2005, the average pre-treatment fit for the synthetic Portugal is still quite similar to the original synthetic control analysis using the full prediction period. As can be seen in Figure 14, there is a slightly worse fit between 2005 and 2010 than in the few years before the backdated treatment. It could be argued that the deviation between Portugal and synthetic Portugal now starts in 2005 and not in 2010. However, from the figure, it also becomes clear that from 2010 moving forward, the magnitude of this deviation becomes more visible, just as seen in Figure 12. This again reinforces that an effect that causes the GDP per capita of Portugal and synthetic Portugal to deviate becomes more visible in 2010 than in 2005.

Figure 15 displays the pre- and post-treatment trajectory of the debt-to-GDP of Portugal and that of synthetic Portugal. It becomes clear that, post-treatment, the debt-to-GDP of Portugal is higher than the debt-to-GDP of synthetic Portugal. This means that the linear combination of the countries that contribute to the synthetic control for Portugal has a lower debt-to-GDP ratio. Similar to the results of Greece, it becomes clear that also synthetic Portugal is not able to significantly control for the debt-to-GDP post-treatment. Therefore, it cannot be stated that the causal effect found can be solely attributed to taking the austerity measures because the effect of debt-to-GDP on GDP per capita cannot be isolated.

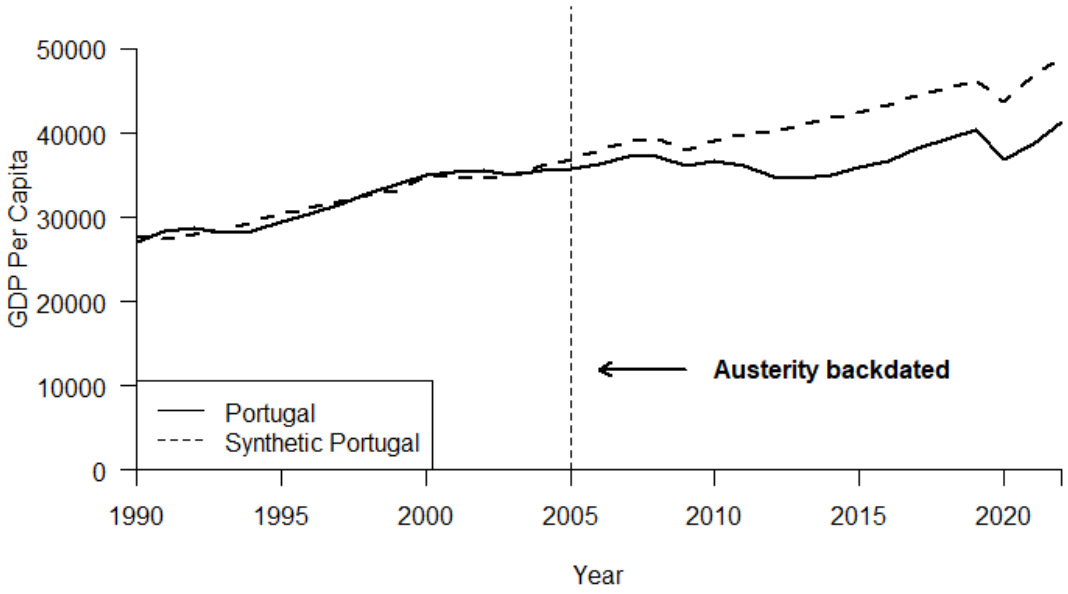

Figure 14: In-time Placebo test for Portugal with austerity backdated to 2005

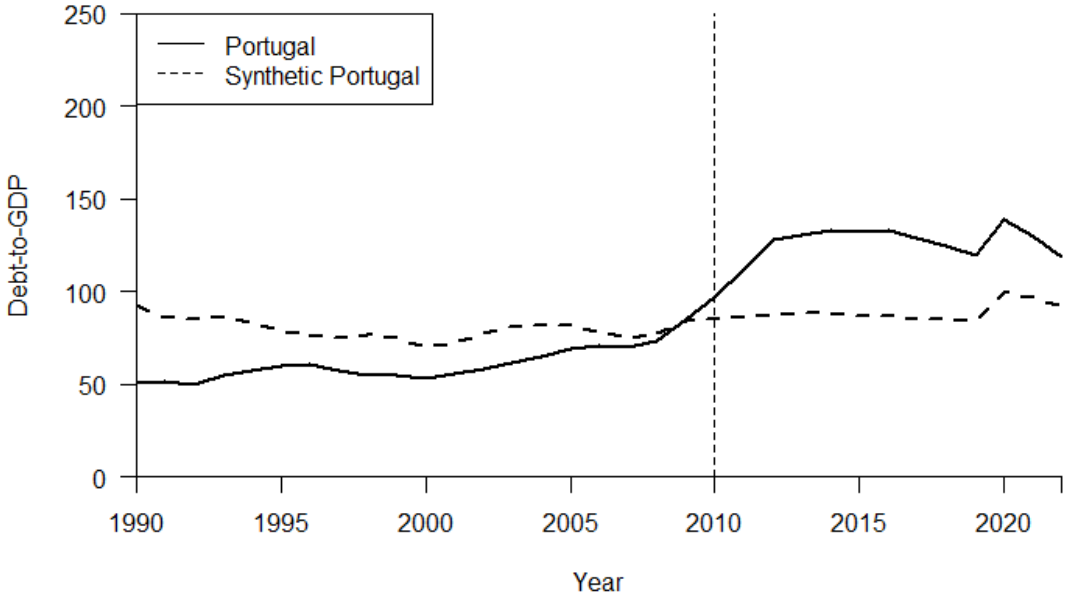

Figure 15: Debt-to-GDP of Portugal and Synthetic Portugal

4.5 From OECD to World Donor Pool?

As described in Section 4.2 and 4.4, based on the OECD donor pool, the analysis on Greece and Portugal hasn't been able to control for the debt crisis post-treatment. The main reason to increase the donor pool from the more interpretable OECD countries is to investigate if for Greece and Portugal, the debt crisis is better controlled for. For the sake of completeness, the synthetic control analysis of Spain, when considering the world donor pool, is included in Appendix D.1. Also, the undiscussed details for the synthetic control analysis of Portugal, when considering the world donor pool, can be found in Appendix D.2. Another argument to consider the world donor pool instead of the OECD donor pool follows from the assumption of no interference, which is made in Section 2.1. In this research, it is thus assumed that the austerity measures taken in Greece, Spain, and Portugal do not affect the GDP per capita of the countries in the donor pool. This is a strong assumption, and the potential existence of this so-called spillover effect is something that should be taken into account. One solution is to include countries that are less affected by policy interventions in the target countries. By expanding the donor pool from OECD countries to a broader range of the world, the synthetic control is also allowed to be formed by a set of countries for which the potential spillover effect is limited. However, including non-OECD countries as potential donor countries may undermine the interpretability of the synthetic control, as non-OECD countries do not strongly co-move over time.

4.5.1 World Donor Pool: Greece

When considering the world donor pool for the synthetic control, different weights and countries are included compared to the OECD donor pool. In Table 14 it can be found that, besides the OECD country Iceland ($w = 0.593$), the non-OECD countries Barbados ($w = 0.228$), Belize ($w = 0.097$), and Sudan ($w = 0.083$) are also included in the synthetic control. Figure 15 displays the pre-treatment averages of the covariates for synthetic Greece and Greece and the sample mean of the world donor Pool. Figure 16 displays an even closer pre-treatment fit between synthetic Greece and actual Greece than with the OECD donor pool (see Figure 4). Post-treatment, a clear gap is visible between Greece and synthetic Greece, corresponding to an estimated effect of austerity on GDP per capita of -21.80% ($p = 0.05$) for the short term (2010-2013), and a similar estimated effect of -20.21% ($p = 0.05$) for the long term (2010-2022). The significance of these results is supported by the in-space placebo test in Figure 17, where the Post/Pre-RMSPE ratios are visualized. Greece has the highest ratio, indicating that the probability of finding an equal or greater ratio than Greece is 0.05, the lowest significance level achievable when considering the 18 countries in the world donor pool.

The question then remains if the synthetic control is better able to control for the debt crisis when considering countries outside of the OECD donor pool. Figure 18, displays that the dept-to-GDP trajectory of the synthetic Greece is closer to that of Greece then if the OECD donor pool is considered (see Figure 7). However, as expected, due to the extreme debt-to-GDP ratio of Greece in the post-treatment period, the synthetic control with the non-OECD countries included is still not able to control for the high debt-to-GDP value of Greece.

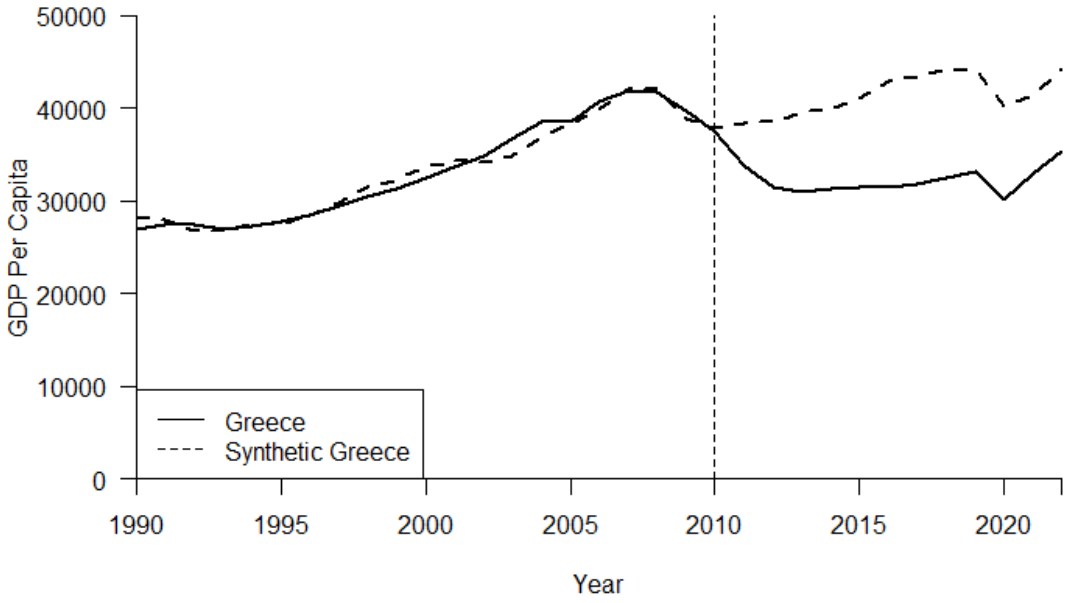

Figure 16: GDP per capita trend of Greece and Synthetic Greece considering the world donor pool

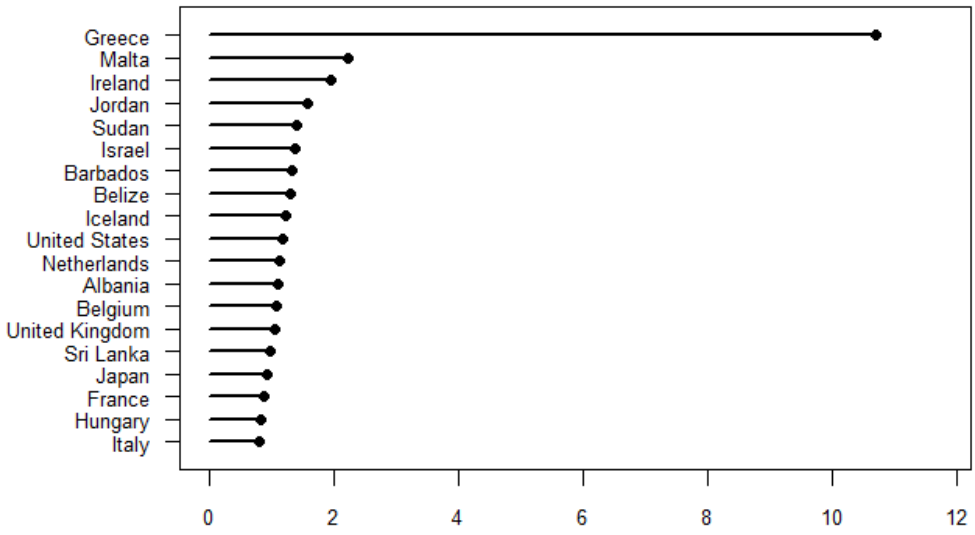

Figure 17: In-space placebo test Greece considering the world donor pool: Post-RMSPE / Pre-RMSPE

Country	Weight
Albania	0.000
Barbados	0.228
Belgium	0.000
Belize	0.097
France	0.000
Hungary	0.000
Iceland	0.593
Ireland	0.000
Israel	0.000
Italy	0.000
Japan	0.000
Jordan	0.000
Malta	0.000
Netherlands	0.000
Sri Lanka	0.000
Sudan	0.083
United Kingdom	0.000
United States	0.000

Table 14: Weights synthetic Greece, based on the world donor pool

Variable	Greece	Synthetic Greece	World sample
GDP	33355.37	33344.26	31482.15
DEPT	102.08	74.39	75.00
INFL	7.02	7.77	7.44
TRADE	46.51	73.40	84.95
IND_VAL	18.36	20.14	23.54
SCHOOL	47.92	48.46	56.30

Table 15: Averages of pre-treatment macroeconomic predictors for Greece, synthetic Greece and the world donor pool.
Note: GDP per capita, Debt-to-GDP, Inflation, Trade, and Industry share are averaged for the 1990-2010 period. School enrollment is averaged over the 5 year increments between 1990 and 2010.

4.5.2 World Donor Pool: Portugal

To keep the results comprehensive, the analysis of Portugal using the world donor pool will focus on whether including more countries in the donor pool can improve the control for the debt crisis. The estimated effect of austerity on GDP per capita for Portugal has a slightly lower significance for the world donor pool than for the OECD donor pool. This can be found in Appendix D.2 together with the countries included in synthetic Portugal and their weights, as well as the trajectory of GDP per capita and the placebo tests. Figure 19 displays the trajectory of debt-to-GDP for Portugal and synthetic Portugal using the world donor pool. When comparing the fit of the debt-to-GDP trajectory for the world donor pool with that of the OECD donor pool from Figure 15, it becomes clear that including non-OECD countries results in a better match in the pre-treatment debt between Portugal and synthetic Portugal. However, after the treatment in 2010, a significant difference between the debt-to-GDP of Portugal and synthetic Portugal

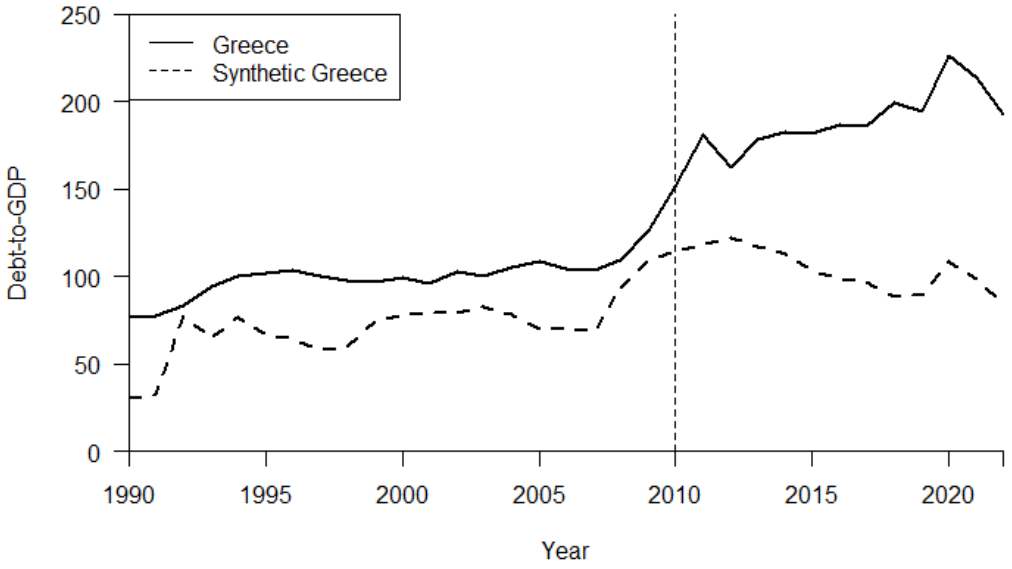

Figure 18: Debt-to-GDP of Greece and Synthetic Greece considering the world donor pool

is shown. This indicates that the post-treatment debt-to-GDP is not sufficiently controlled for. Similar to Greece, the world donor pool is unable to perfectly isolate the effect of austerity due to the difference in post-treatment debt-to-GDP between Portugal and synthetic Portugal.

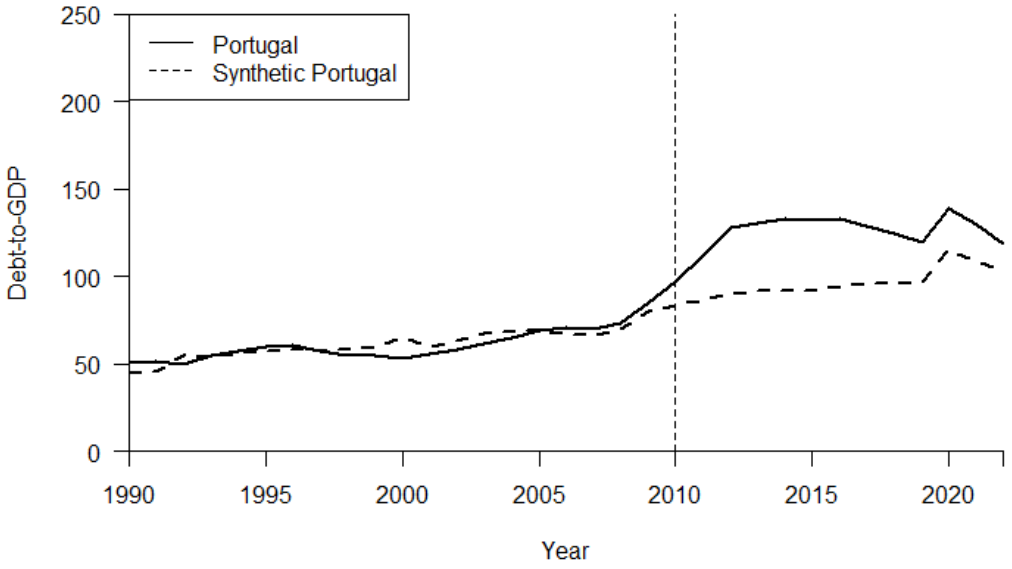

Figure 19: Debt-to-GDP of Portugal and Synthetic Portugal considering the world donor pool

4.6 Leave-One-Out Robustness

Besides validating the results using in-space and in-time placebo tests, this research also employs a robustness test to analyze the sensitivity of the results to the countries included in the synthetic control. For each synthetic control outcome of the three target countries, the analysis is repeated by iteratively excluding the positively weighted countries from the donor pool. This approach clarifies whether both the pre-treatment fit and the estimated effect are robust to the exclusion of specific countries in the donor pool.

Figure 20 displays the leave-one-out synthetic Greece where the countries that are in the original synthetic control are iteratively excluded from the donor pool. This figure displays that the pre-treatment fit remains similar when excluding Hungary and the United States. Interestingly, the synthetic Greece that results from leaving out Israel in Figure 20 (indicated by one of the three gray lines) even more accurately follows the pre-treatment GDP per capita of Greece than the original synthetic Greece. This raises the question of why Israel was included in the synthetic control in the first place, considering it seems to worsen the pre-treatment fit of synthetic Greece and Greece. However, it is important to note that the pre-treatment average GDP per capita is matched, so the average pre-treatment fit of GDP per capita for the synthetic Greece that excludes Israel is similar to that of the original synthetic Greece. Additionally, the synthetic control method not only aims to match the pre-treatment GDP per capita but also seeks to align with macroeconomic indicators that predict GDP per capita in the pre-treatment period. Even though the pre-treatment fit between Greece and the synthetic Greece (leave Israel out) is better for the target variable GDP per capita than for the original synthetic Greece, this is not the case for the remaining macroeconomic predictors (see Appendix E), which supports the reason why Israel is included in the original synthetic control. Figure 20 also displays that the post-treatment negative effect of austerity on GDP per capita is robust to the exclusion of any of the three countries from the donor pool, as demonstrated by the similar trajectory of synthetic Greece (leave-one-out) and synthetic Greece post-treatment.

For Spain, the exclusion of the positively weighted countries in the synthetic control yields a very similar pre-treatment fit to that of synthetic Spain, as displayed in Figure 21. Post-treatment, all the outcomes of leave-one-out synthetic Spain show a negative effect of austerity on GDP per capita. Only the exclusion of Ireland ($w = 0.073$) results in a post-treatment estimated effect that is smaller than the effect estimated by synthetic Spain, where all the remaining exclusions indicate a larger estimated effect. The negative estimated effect of austerity on GDP per capita is thus robust to the exclusion of countries for Spain.

For Portugal, similar results for the leave-one-out robustness are displayed in Figure 22. Again, a similar pre-treatment fit of the synthetic Portugal to actual Portugal is obtained for the outcomes of leave-one-out Portugal. Additionally, the negative estimated effect of austerity is robust to the exclusion of countries in the donor pool, which is evident from the gap between the GDP per capita outcome for Portugal and the GDP per capita outcomes of all leave-one-out synthetic Portugal.

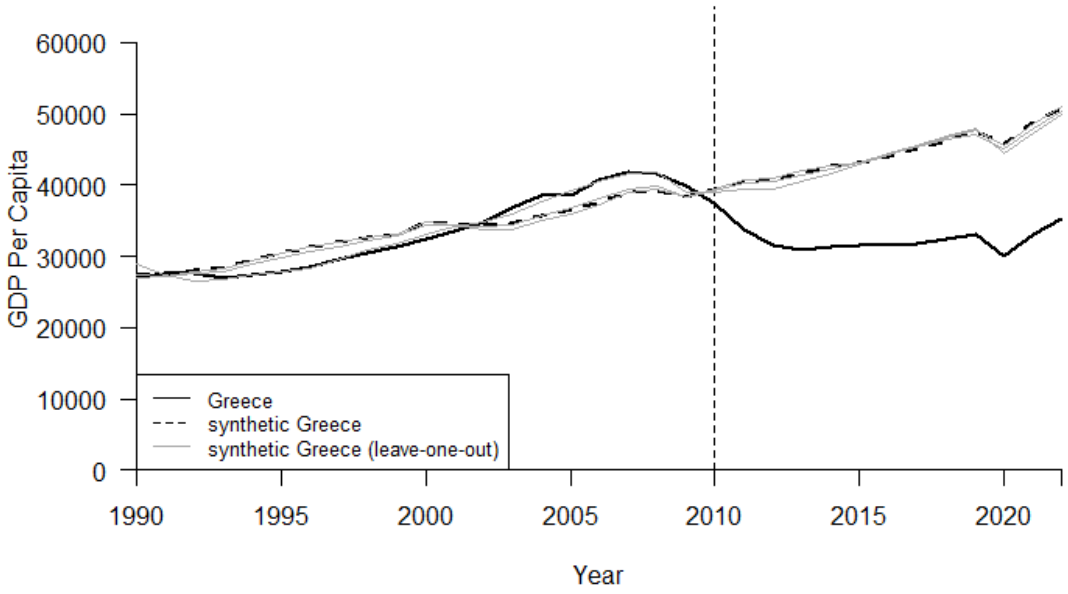

Figure 20: Leave-One-Out Robustness of the synthetic control for Greece
Note: The leave-one-out synthetic controls exclude Hungary ($w = 0.151$), Israel ($w = 0.695$), or the United States ($w = 0.149$).

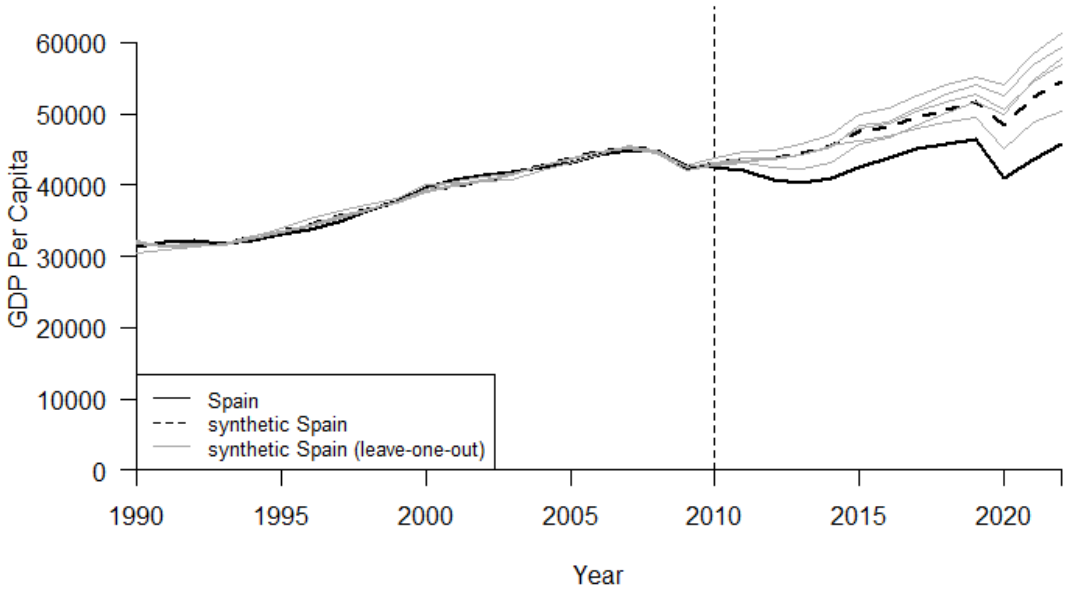

Figure 21: Leave-One-Out Robustness of the synthetic control for Spain
Note: The leave-one-out synthetic controls exclude Hungary (w= 0.207), Ireland (w=0.073), Israel (w=0.037), Japan (w=0.211), or the United Kingdom (w=0.468).

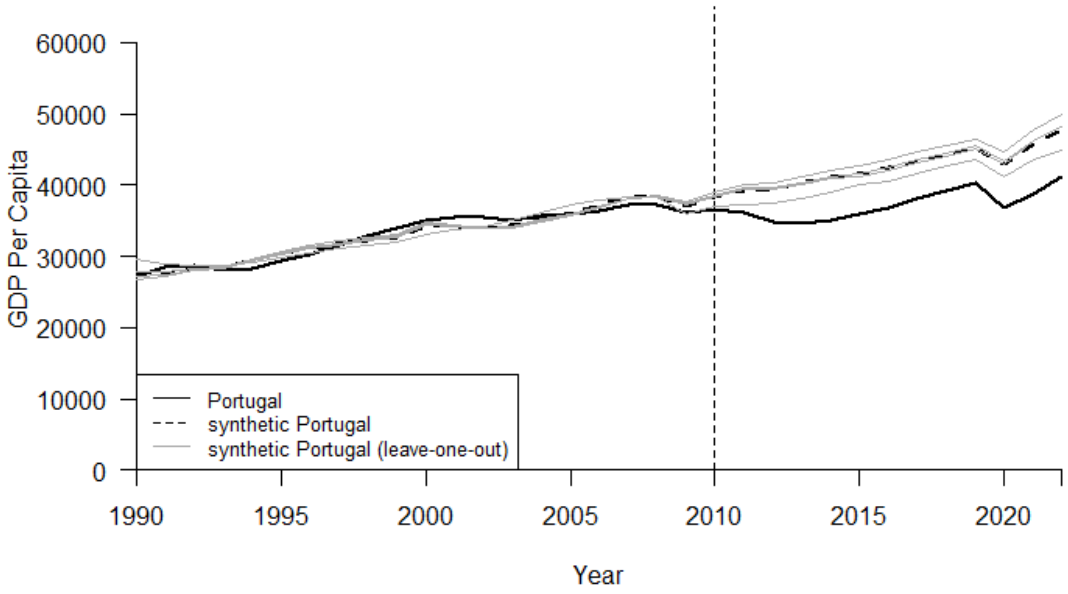

Figure 22: Leave-One-Out Robustness of the synthetic control for Portugal
Note: The leave-one-out synthetic controls exclude Hungary (w= 0.139), Israel (w=0.565), Japan (w=0.157), or the United Kingdom (w=0.137).

5 Conclusion

This paper investigates the causal effects of austerity measures on the gross domestic product (GDP) per capita of Greece, Spain, and Portugal in the immediate aftermath and on longer term after the European debt crisis. Austerity measures were one of the main policies governments implemented to reduce their debt following the Euro crisis. The study focuses on austerity measures in terms of cuts in public expenditure. There has been a lot of discussion regarding the socioeconomic effects of these measures. By applying the Synthetic Control Method (SCM), a counterfactual is constructed based on a set of Organisation for Economic Co-operation and Development (OECD) countries that did not implement austerity measures. In doing so, the effect on the target country if these measures were not taken is investigated, and thus a potential causal effect of austerity can be found. Several macroeconomic indicators are selected that predict GDP per capita to match the synthetic control with the target country in the pre-austerity period. The most important macroeconomic predictor is debt-to-GDP. This research aimed to control for this variable in two manners: In addition to controlling for debt as a pre-treatment macroeconomic predictor, it also controlled for the debt crisis post-treatment. When examining the early post-austerity years, a threshold of 60% debt-to-GDP was followed to determine which countries are suitable to be included in the donor pool. This research aimed to answer the following question: What was the causal effect of cuts in public expenditure on the economic performance of southern EU countries struggling during the debt crisis, both in the immediate aftermath and over an extended period?

In response to the research question, it was found that austerity measures taken in 2010 had a negative causal effect on the economic performance of Greece, Spain, and Portugal. The cuts

in public expenditure in these countries resulted in significant decreases in GDP per capita, both immediately and over a prolonged period, thus highlighting the severe negative impacts of such fiscal policies. For Greece, the short-term (3 years) estimated causal effect of austerity measures in 2010 on GDP per capita showed an impact of -25.66%, while the longer-term (12 years) causal effect indicated an even more severe impact of -30.38% on GDP per capita. Similarly, Spain and Portugal both exhibited short-term estimated causal effects of -9.22% and -14.00%, respectively, on GDP per capita after three years. In the long run (12 years), this effect increased for Spain, with an estimated impact of -15.93%, while it remained quite similar for Portugal, with an estimated impact of -13.47%. To validate these findings, placebo tests were conducted both in terms of time and space.

An important note needs to be made regarding the results for Greece and Portugal in relation to the post-treatment debt-to-GDP ratio. Although the countries included in the donor pool all have a debt-to-GDP ratio above a specified threshold after the treatment, the synthetic Greece and synthetic Portugal do not fully match the magnitude of post-austerity debt-to-GDP ratios of the respective countries. Therefore, it cannot be concluded based on this research that the effect on GDP per capita in 2010 was solely caused by the implementation of austerity measures in Greece and Portugal. To address this issue and the possibility of a spillover effect, the OECD donor pool was expanded to also include non-OECD countries that still met the donor pool requirements. The results from the expanded donor pool showed better controlling for the debt-to-GDP ratio after the treatment for both Greece and Portugal, but do not support a stronger conclusion regarding the causal effects of austerity on GDP per capita for these countries compared to the OECD donor pool. For Spain, the synthetic control has a higher post-treatment debt-to-GDP and thus the issue of potential negative effects that can be caused by the debt crisis is not the case for Spain. This research thus makes an even stronger conclusion for Spain that austerity measures in 2010 have a negative causal effect on GDP per capita. In addition to the results considering the OECD donor pool, a leave-one-out analysis demonstrated that the results for Greece, Spain, and Portugal remained robust even when specific countries in the donor pool are excluded.

There are several limitations to address in this research. Firstly, a key decision was made to compare the percentage change in public expenditure for 2009 to the average expenditure from 2010-2015 to determine if a country implemented austerity measures. However, austerity encompasses not only reductions in public expenditure but also increases in taxes. To accurately evaluate whether a country adopted austerity policies, multiple time-dependent policy interventions could have been considered to improve the distinction between treated and non-treated units. Secondly, the method of controlling for the debt crisis post-austerity in this research may have resulted in including countries in the donor pool that arguably were not experiencing a debt crisis. A strong assumption was made by defining a threshold of 60% debt-to-GDP for the three years following the treatment to determine if countries were considered to be in a debt crisis post-treatment. Although including only countries with a higher debt-to-GDP ratio than the defined threshold, such as Greece, might result in better control for the debt-to-GDP variable, this approach significantly limits the synthetic control's donor pool. Lastly, this research assumed no interference between countries, even though the GDP per capita of OECD countries

could arguably be influenced by the austerity measures taken by the target countries. If there is interference, the synthetic control is less valid since the control group is a less accurate representation of what would have happened to the treated country in the absence of the austerity measures. By extending the OECD donor pool to the world donor pool, this issue can be partly mitigated. However, when considering the world donor pool, a significant number of OECD countries still contribute to the synthetic control for Greece, Spain, and Portugal, necessitating the assumption of no interference between these countries.

The practical implications of this study highlight the importance for policymakers to consider the broader socioeconomic consequences of austerity measures, particularly during economic crises. The findings suggest that instead of improving the GDP per capita of these countries, such policies can actually worsen and prolong economic downturns. By examining the impacts of austerity, this research contributes to a more comprehensive understanding of fiscal policies during financial crises, providing valuable insights for future economic policy-making and helping to prevent the mistakes observed during the European debt crisis. Theoretically, this study contributes to the ongoing debate about the effectiveness of austerity measures in crisis management, questioning the assumption that fiscal consolidation through austerity is a viable strategy for economic recovery.

Further research could explore alternative strategies for economic recovery that do not depend on austerity measures. This could involve evaluating their causal effect on economic performance using synthetic control analysis. Moreover, to determine the countries that did or did not adopt austerity measures, further research could focus more on tax policies rather than cuts in public spending, as this is also a prominent component of austerity policies. Future studies may consider a multiple treated unit application of SCM, where a single synthetic control is obtained that fits the pre-treatment aggregate macroeconomic predictors of the treated countries. This approach is similar to Hainmueller (2012) and Robbins et al. (2017). For such research, one could also consider including Croatia and Cyprus as additional target countries, considering the fact that they meet both the austerity requirement and the debt-to-GDP threshold, just like Greece, Spain, and Portugal. Additionally, investigating the long-term social impacts of austerity, such as changes in inequality, could provide a more comprehensive understanding of the effects of these policies.

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A Appendix - Programming Code

This analysis is performed using the `Synth` package in the programming language R (Hainmueller et al., 2011). The `Synth` package implements the synthetic control method for comparative case studies and the implementation of this packages in the research is inspired by Abadie et al. (2015). Included with this report is a zip file containing all the code and data necessary for the reader to reproduce the figures and tables.

B Appendix - Data Cleaning

Country	**Reason for Exclusion**
Andorra	Austerity measures
Montenegro	Austerity measures
Cyprus	Austerity measures
Croatia	Austerity measures
St. Vincent and the Grenadines	Austerity measures
Libya	Austerity measures
Jamaica	Austerity measures
San Marino	Austerity measures
Singapore	Austerity measures
Antigua and Barbuda	Austerity measures

Table 16: List of countries excluded due to austerity measures

Reason for Dropping	**Countries**
Missing 'gdp' values	Eritrea
Missing 'inflation' values for the entire prediction period	Lebanon, Nauru
Missing 'trade' values for the entire prediction period	Dominica, Grenada, St. Kitts and Nevis
Missing 'dept' values for the entire prediction period	Aruba
Missing 'schooling' values for the entire prediction period	Bhutan, Cabo Verde, Seychelles

Table 17: Countries dropped due to missing data

C Appendix - Placebo Results

C.1 Greece

unit	pre_rmspe	post_short_rmspe	post_long_rmspe	post_long/pre
Greece	2086.63	7875.72	12299.63	5.90
Belgium	16618.00	16761.69	15188.94	0.91
France	12753.96	10555.70	8486.07	0.67
Hungary	11755.69	12665.36	11110.82	0.95
Iceland	13352.26	14821.91	16617.28	1.24
Ireland	15861.92	17242.25	41900.85	2.64
Israel	16925.72	16319.93	32133.53	1.90
Italy	7560.87	6124.30	27358.40	3.62
Japan	11485.58	13379.63	31673.31	2.76
Netherlands	7977.90	6374.31	14863.01	1.86
United Kingdom	5871.91	5920.17	24618.52	4.19
United States	9260.63	7618.04	12002.78	1.30

Table 18: In-space placebo test for Greece: RMSPE Values

Country	Weight	Country	Weight
Belgium	0.011	Israel	0.609
France	0.020	Italy	0.005
Hungary	0.186	Japan	0.049
Iceland	0.045	Netherlands	0.001
Ireland	0.022	United Kingdom	0.036
United States	0.017		

Table 19: Weights in-time placebo synthetic Greece with austerity backdated to 2005

C.2 Spain

unit	pre_rmspe	post_short_rmspe	post_long_rmspe	post_long/pre
Spain	521.76	2665.98	5326.92	10.21
Belgium	4323.15	4844.74	4112.05	0.95
France	2115.91	1401.25	3087.38	1.46
Hungary	22521.15	23814.09	22245.07	0.99
Iceland	7575.44	9386.41	11184.87	1.48
Ireland	10637.19	11783.83	37306.61	3.51
Israel	10914.39	9464.16	10407.15	0.95
Italy	7912.99	1885.36	4936.61	0.62
Japan	4630.06	6142.18	9187.74	1.98
Netherlands	15100.56	17774.16	16242.25	1.08
United Kingdom	7679.39	9186.89	7791.35	1.01
United States	17280.80	20886.89	21503.13	1.24

Table 20: In-space Placebo test for Spain: RMSPE Values

Country	Weight	Country	Weight
Belgium	0.018	Israel	0.039
France	0.049	Italy	0.020
Hungary	0.255	Japan	0.278
Iceland	0.037	Netherlands	0.024
Ireland	0.146	United Kingdom	0.100
United States	0.033		

Table 21: Weights in-time placebo synthetic Spain with austerity backdated to 2005

C.3 Portugal

unit	pre_rmspe	post_short_rmspe	post_long_rmspe	post_long/pre
Portugal	903.93	4043.47	5345.16	5.91
Belgium	1660.58	5349.02	6225.92	3.75
France	2528.03	1154.00	988.25	0.39
Hungary	25264.42	23357.95	20211.77	0.80
Iceland	4595.93	8142.50	11652.87	2.54
Ireland	9067.18	10416.97	37916.83	4.18
Israel	13859.95	9511.27	7474.48	0.54
Italy	13391.61	6885.56	4111.42	0.31
Japan	4524.14	757.04	2826.38	0.62
Netherlands	20341.54	22175.71	21699.80	1.07
United Kingdom	11992.96	11775.55	11132.03	0.93
United States	21515.36	23465.60	25023.04	1.16

Table 22: In-space placebo test for Portugal: RMSPE Values

Country	Weight	Country	Weight
Belgium	0.000	Israel	0.569
France	0.000	Italy	0.000
Hungary	0.141	Japan	0.057
Iceland	0.002	Netherlands	0.000
Ireland	0.005	United Kingdom	0.226
United States	0.000		

Table 23: Weights in-time placebo synthetic Portugal with austerity backdated to 2005

D Appendix - World Donor Pool

D.1 Spain

Country	Weight
Albania	0.028
Barbados	0.001
Belgium	0.000
Belize	0.159
France	0.000
Hungary	0.001
Iceland	0.001
Ireland	0.000
Israel	0.001
Italy	0.000
Japan	0.000
Jordan	0.001
Malta	0.000
Netherlands	0.000
Sri Lanka	0.002
Sudan	0.001
United Kingdom	0.689
United States	0.115

Table 24: Weights of the synthetic Spain based on the world donor pool

Variable	Spain	Synthetic Spain	Sample Mean
GDP	38269.63	38281.38	31482.15
DEBT	42.92	44.69	75.00
INFL	3.51	3.29	7.44
TRADE	49.57	54.98	84.95
IND_VAL	27.07	22.11	23.54
SCHOOL	48.77	52.46	56.30

Table 25: Averages of pre-treatment macroeconomic predictors for Spain, synthetic Spain and the sample mean of the world donor pool

Note: GDP per capita, Debt-to-GDP, Inflation, Trade, and Industry share are averaged for the 1990-2010 period. School enrollment is averaged over the 5 year increments between 1990 and 2010.

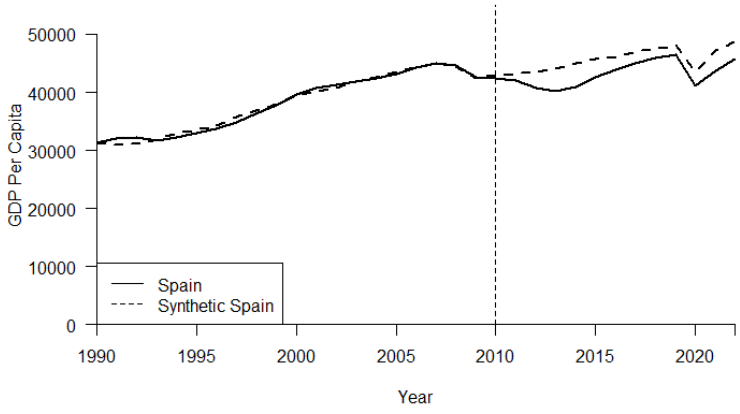

Figure 23: GDP per capita trend of Spain and Synthetic Spain based on World donor pool

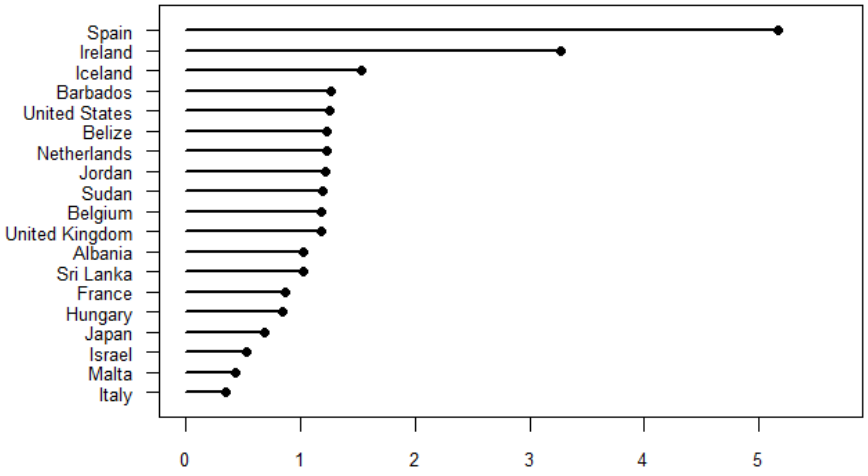

Figure 24: In space placebo test Spain based on world donor pool: Post-RMSPE / Pre-RMSPE

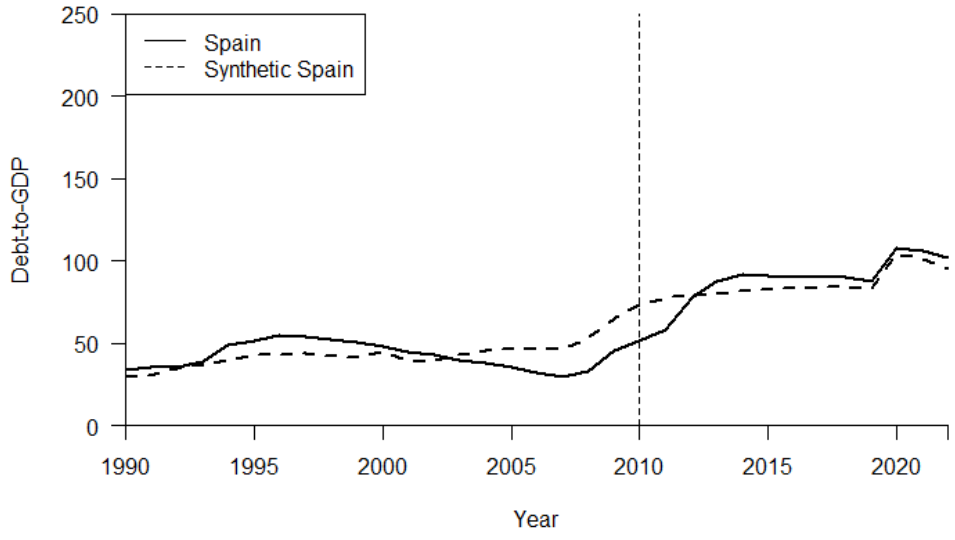

Figure 25: Debt-to-GDP of Spain and Synthetic Spain based on world donor pool

D.2 Portugal

Country	Weight
Albania	0.028
Barbados	0.032
Belgium	0.010
Belize	0.187
France	0.212
Hungary	0.025
Iceland	0.018
Ireland	0.016
Israel	0.026
Italy	0.017
Japan	0.113
Jordan	0.026
Malta	0.021
Netherlands	0.004
Sri Lanka	0.035
Sudan	0.019
United Kingdom	0.088
United States	0.125

Table 26: Weights synthetic Portugal based on the world donor pool

Variable	Portugal	Synthetic Portugal	Sample Mean
GDP	33095.88	33095.96	31482.15
DEBT	62.67	62.96	75.00
INFL	4.25	4.26	7.44
TRADE	63.08	63.38	84.95
IND_VAL	22.94	22.94	23.54
SCHOOL	33.55	54.57	56.30

Table 27: Averages of pre-treatment macroeconomic predictors for Portugal, synthetic Portugal and the sample mean of the world donor pool
Note: GDP per capita, Debt-to-GDP, Inflation, Trade, and Industry share are averaged for the 1990-2010 period. School enrollment is averaged over the 5 year increments between 1990 and 2010.

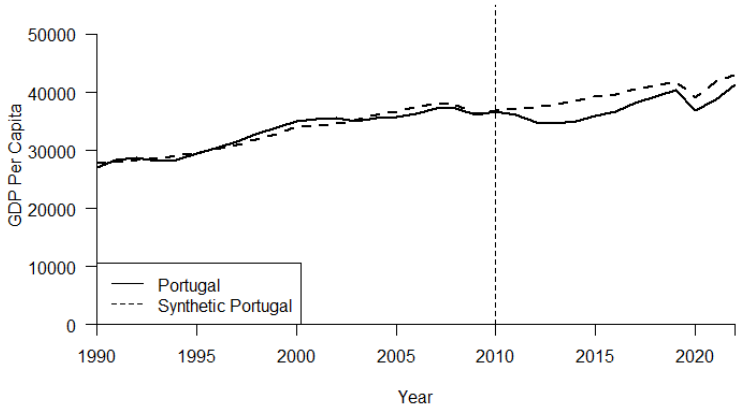

Figure 26: GDP per capita trend of Portugal and Synthetic Portugal based on world donor pool

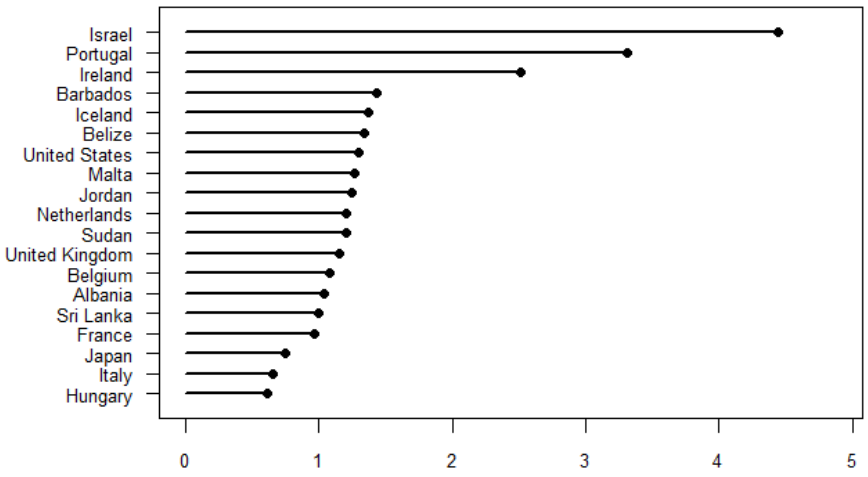

Figure 27: In space placebo test Portugal based on world donor pool: Post-RMSPE / Pre-RMSPE
Note: This test finds that the probability of another country having a Post/Pre-RMSPE ratio equal to or greater than that of Portugal in both the short and long term is 0.11.

E Appendix - Leave-one-out Robustness

Variable	Greece	Synthetic Greece	Synthetic Greece (leave Israel out)
GDP	33355.37	33534.38	33453.10
DEPT	102.08	79.55	62.57
INFL	7.02	6.97	9.51
TRADE	46.51	66.23	89.93
IND_VAL	18.36	22.65	24.74
SCHOOL	47.92	47.86	58.85

Table 28: Averages of pre-treatment macroeconomic predictors for Greece, synthetic Greece, and Synthetic Greece (leave Israel out)
Note: GDP per capita, Debt-to-GDP, Inflation, Trade, and Industry share are averaged for the 1990-2010 period. School enrollment is averaged over the 5 year increments between 1990 and 2010.
Note: The fit between Greece and the synthetic Greece (leave Israel out) is better for the target variable GDP per capita, but not for the remaining macroeconomic predictors.