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Monetary-fiscal policy relations in the euro area: The impact on the primary balance

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Abstract

With this paper, our objective is to empirically study public debt sustainability by estimating a fiscal reaction function where the primary balance relative to GDP is assumed to be a function of the public debt to GDP ratio of the previous year and of other macroeconomic variables. In particular, we take into account the effects of monetary policy on the primary budget of the government by including the real long term interest rate and the inflation rate, measured as the change in the GDP price deflator. We resort to the fixed effects and to the random effects models for a panel of 12 euro area economies from 1996 to 2020. We find statistical evidence for sustainable debt policies and detect that both monetary policy variables are positively correlated with the primary balance to GDP ratio. This holds both for the fixed and for the random effects estimation, when those variables are included simultaneously.

Keywords: Monetary policy, fiscal policy, euro area, primary balance, public debt, sustainability, interest rate, inflation rate

JEL Classification: E43; E52; E62; E63; H61; H62; H63

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1 Introduction

The last couple of years have been quite challenging, not only for private households and for the productive sector of (European) countries, but for the governments, too. The economies have suffered a lot from the various crises - the financial crisis of 2007/08, the refugee crisis in 2015, the current Covid-19 crisis and the latest Russian invasion of Ukraine - that have lined up and the countries are literally slipping from one crisis into the next. In order to alleviate the negative consequences, the aid of the government often is the first request. Therefore, rescue and recovery programs to support specific sectors in the economies are put up in order to ease the dramatic situations. Possible ways out of those crises do not only concern economists and politicians, but, interested citizens would like to know possible solutions for these problems, too.

To overcome an economic downturn and to stabilize the economy, governments often react by increasing government spending via public deficits. This can lead to public debt crises with drastically rising national debt to GDP ratios in some countries when several economies cannot repay or refinance their government debt or in the case they do not stick to sustainable debt policy rules and need help from other countries. Especially for European countries taking part in the EU Monetary Union, the relation between fiscal and monetary policies to find adequate solutions for a stable primary balance is more important than ever before. Here, a central role is played by the European Central Bank (ECB) whose primary objective is to ensure price stability, to define and implement the common monetary policy and by the other European institutions, like the European Council who formulated clear guidelines, fixed in the Maastricht treaty stating that the public deficit and the public debt relative to GDP must not exceed 3% and 60%, respectively, to guarantee fiscal sustainability for the countries of the European Economic and Monetary Union. The convergence criteria refer to budget deficits, to public debt ratios, to the inflation rate and to interest rates close to those three economies with the lowest rate of inflation. However, the criteria of the Maastricht treaty have been frequently violated by many EU countries (see e.g. Greiner and Fincke (2015)). Thus, the euro area does not only bring advantages for the participating countries, but, limitations with respect to fiscal policies, too. Further, euro zone member countries cannot conduct independent monetary policies, since there is a unique monetary policy for the whole euro zone. This suggests that the monetary-fiscal policy relations are quite complex. Therefore, we focus on economies of the EU Monetary Union that have introduced the euro and investigate interactions between fiscal and monetary policies for some of those countries which share the same currency.

Fiscal and monetary policy depend on each other and an efficient coordination of these two policies by controlling inflation and the level of government debt cannot always be realized. Here, central banks and the governments play a crucial role. Sargent and Wallace (1981) investigated the dominance of both authorities. A dominance of monetary policy over fiscal policy results in a permanent inflation control by the monetary authority, due to the freedom of setting the base level for money, but, when fiscal policy dominates monetary policy, the monetary sector loses some of its control over inflation.

In this context, it is important to point out the difference between Ricardian and non-Ricardian regimes. A Ricardian regime is characterized by the monetary authority's determination of the money stock and of the price level. The government's task is to achieve a certain primary budget surplus guaranteeing that the budget constraint is consistent with the repayment of the initial stock of outstanding debt, thus, ensuring fiscal solvency. In a non-Ricardian regime, the government freely sets the primary budget balances and the intertemporal government's budget constraint endogenously determines the price level. As the debt is not completely financed by future primary surpluses, monetary financing is used (Aiyagari and Gertler, 1985).

Leeper (1991), Sims (1994) and Woodford (1994, 1995) introduced the Fiscal Theory of the Price Level (FTPL) in a non-Ricardian regime which states that fiscal policy can determine the price level. Here, the government autonomously decides on the fiscal balance and public debt. The monetary sector endogenously fixes the supply of money and the government sets the primary balance independent of the level of outstandig public debt. To fulfill the intertemporal budget constraint of the government, money and prices have to adapt to the level of the government debt.[1]

Concerning monetary policy an important contribution is the Taylor rule stating that central banks set the interest rates depending on the inflation rate and on the output gap (Taylor, 1993). The main objective of the monetary policy that follows the Taylor rule is to stabilize inflation and to reduce the output gap (see e.g. Ghatak and Moore (2011)). After

[1]Buiter (2002) criticized the FTPL as it confuses budget constraints and equilibrium conditions in models of a market economy. The FTPL assumes that the intertemporal budget constraint of the government has to be satisfied only in equilibrium which is a misspecification.

the establishment of the EU Monetary Union, the Taylor rule for conducting monetary policy in the euro area seems to be an appropriate instrument (Gerlach and Schnabel, 2000).

In the literature on monetary policy, reaction functions typically build on interest rates. Altavilla (2003) studied reaction functions to evaluate the ECB's control of interest rates when real output, inflation or the exchange rate changes and Ruth (2007) analyzed European monetary policy with a Taylor rule reaction function based on panel data. In the short run, Ruth (2007) only finds that in cases of are-wide inflation, the ECB reacted to inflation differentials by deviating from the interest rate path. The study of Huchet (2003) states that a common monetary policy change can lead to asymmetric reactions, as the national economic structures of the eight major countries of the European Monetary Union (EMU) considered are quite heterogeneous.

The pioneering investigations to test whether the intertemporal budget constraint of a government is fulfilled were implemented by Hamilton and Flavin (1986) and by Trehan and Walsh (1991) for the United States. According to Hamilton and Flavin (1986) fiscal sustainability is given if the value of current public debt equals the sum of expected future primary government surpluses wich is equivalent to requiring that the present value of public debt converges to zero in infinity. Hamilton and Flavin (1986) found that the US federal debt policy was sustainable from 1960 to 1984. However, Wilcox (1989) criticized the test by Hamilton and Flavin as they do not account for a stochastic interest rate. Thus, Wilcox (1989) implemented the test to the same time series and his result was an unsustainable US federal debt. The interest rate with which the series of public debt is discounted plays an important role as regards the results in those types of tests.

Often, the empirical literature on fiscal policy and sustainability focuses on the relation that exists between the public debt and the primary balance. A key question in this context is whether the governments respond in a sustainable way to increasing public debt to GDP ratios. The concept of sustainability is compatible with indebtedness in the short run, but, in the long-run the present value of debt has to converge to zero asymptotically. The contributions by Bohn (1995, 1998) illustrate how public debt sustainability can be assessed by studying the reaction of the primary balance to changes in the public debt to GDP ratio and to other macroeconomic variables that serve as control variables. The debt policy is sustainable if governments react to an increase in the public debt ratio by actively adjusting its discretionary fiscal policy in terms of higher primary surpluses.

Bohn (1998) found that the U.S. primary budget surplus is an increasing function of the debt-to-GDP ratio, i.e. the intertemporal budget constraint of U.S. fiscal policy is met suggesting a Ricardian regime. The fiscal response function approach by Bohn (1995, 1998) has been applied in various ways. Beqiraj et al. (2018) provides a recent exhaustive overview of the literature.

Fiscal solvency for several European Union countries has been analyzed by Vanhorebeek and van Rompuy (1995), Papadopoulos and Sidiropoulos (1999) and Afonso (2005), for example. Afonso and Rault (2010) found evidence for a sustainable fiscal policy between 1970 and 2006 in a panel of 15 European Union countries and Lee et al. (2018) observed fiscal sustainability for five regional groups of countries for a period between 1950 and 2014 and a panel of 26 European Union economies. For Eastern and Southern European countries, fiscal solvency is not given, whereas Benelux, Northern and Western European countries satisfy this condition. Fiscal sustainability is weaker for Eurozone countries compared to non-euro zone economies. Galí et al. (2003) investigated the effects of the Maastricht Treaty and of the stability and growth pact (SGP) with respect to fiscal policies in EMU countries. They found that an increase of government debt leads to a decrease in cyclical primary deficits. Then, Afonso (2005) illustrated by testing for causality between the primary balance and government debt ratios that the 15 EU governments increased their primary budget surpluses when the outstanding stock of government debt rises and, apparently, the reduction of the debt-to-GDP ratio is achieved by using primary budget surpluses. Thus, there is evidence for Ricardian fiscal regimes in the economies under consideration.

Since monetary and fiscal policies interact, several authors analyzed the combined effects of those. Beetsma and Jensen (2005) investigated the effects of fiscal policy rules by considering a monetary union with sticky prices. Haga (2015) identified that a non-independent central bank has a passive monetary role considering an expansionary fiscal policy. Afonso et al. (2019) demonstrated that inflation is crucial for monetary policy and that there is a positive reaction of the primary balance to a rise in government debt. When countries are confronted with high budget deficits, then the monetary policy is stricter. With the introduction of the euro, the budget deficits of the countries increased and, therefore, this event had a greater negative effect on fiscal policies. Nevertheless, the negative impact of the crises on monetary and fiscal policies is smoothed out for the countries of the euro zone. Afonso and Coelho (2022) identified a Ricardian fiscal regime (or monetary predominance regime) in the euro zone as Bohn (1998) and Canzoneri et al. (2001) noticed, too. The primary government balance increases, when government debt ratios rise. Fiscal authorities uses the primary government surplus to reduce government debt.

With our paper we want to contribute to the question whether economies of the euro zone have pursued sustainable debt policies by analyzing how the primary balance relative to GDP reacts to the debt to GDP ratio. The second aim is to examine the impact of the monetary policy on the primary balance by means of the effects of the real long term interest rate and of the inflation rate, measured as the change in the GDP price deflator. The common monetary policy of the EU Monetary Union has been adapted in a way such that the countries who find themselves in a recession have enough scope to overcome it by expansionary fiscal measures in order to reverse precarious economic situations. Therefore, it seems appropriate to account for the interest rate and for the inflation rate when analyzing the primary balance.

In particular, we would like to address the following research questions with this paper: How does the debt to GDP ratio of European economies taking part in the EU Monetary Union affect the primary balance? How does monetary policy, reflected by the real long term interest rate and by the inflation rate, influence the government primary budget? To answer those questions we empirically study public debt sustainability and the effect of monetary policy on it with the help of the fixed and of the random effects models for a panel of 12 EU Monetary Union economies from 1996 to 2020 (AMECO database)[2] by estimating the response of the primary surplus to lagged debt relative to GDP, taking into account the effects of the interest rate and of the inflation rate. In applied macroeconomics research, panel studies have become quite popular as econometricians require large data sets to improve statistical inference and to analyze the dynamic relationships between variables. Therefore, our methodology and our approach to get insights into those relationships seems to be justified.

Our paper has been written in honor of Peter Flaschel whose research dealt with questions of sustainability, too, besides many other topics. In particular, the question how capitalism and social protection can be made compatible such that economies benefit

[2] We have left out those countries for which AMECO data are not available for some explanatory variables during this time period.

from the efficiency of free markets, on the one hand, without neglecting social problems resulting from unleashed capitalism, on the other hand, has been at the center of his research (see e.g. Flaschel and Greiner (2011, 2012)). Only if that synthesis can be achieved, market economies will be sustainable. In the medium- to long-run, however, fiscal sustainability is indispensable to achieve such a situation. In 2021 Peter Flaschel (posthum), together with Hermann Haken, has been awarded the Friede-Gard-Prize for Sustainable Economics, in order to honor the lifework of those two scientists in that field of research. As the focus of our paper is on public debt sustainability and on monetary-fiscal policy relations, it fits quite well in Peter Flaschel's research agenda.

In the rest of the paper we proceed as follows. Section 2 briefly discusses the theoretical background. In section 3, we introduce the econometric methods, estimate the models and present the outcome. Finally, section 4 summarizes our main results and concludes.

2 Theoretical Background

To gain deeper insight into the theoretical relation that exists between monetary and fiscal policy, we consider the period budget constraint of the government describing the accumulation of public debt in real terms (see e.g. Greiner and Fincke (2015)) that is given by,

$$\dot{B}(t) + \dot{M}(t) = r(t)B(t) - S(t) - \pi(t)\, M(t),\; B(t_0) \geq 0, M(t_0) > 0, \tag{1}$$

where t denotes time,[3] t_0 is the initial period, B stands for real government bonds (or real public debt), M for real money holdings and r is the real interest rate, i.e. the nominal interest rate, r^n, minus the inflation rate denoted by π. The variable S denotes the real primary surplus, i.e. government surplus exclusive of net interest payments and the dot gives the derivative with respect to time.

The intertemporal budget constraint of the government is fulfilled if

$$\lim_{t\rightarrow\infty} e^{-\int_{t_0}^{t} r(\mu)d\mu} B(t) = 0 \leftrightarrow B(t_0) = \int_{t_0}^{\infty} e^{-\int_{t_0}^{t} r(\mu)d\mu} S(t)dt \tag{2}$$

holds. Equation (2) states that the present value of the real government debt must converge to zero asymptotically which is equivalent to requiring that the initial value of outstanding public debt equals the present value of future primary surpluses.

[3]The time index t will be deleted in the following.

The intertemporal budget constraint of the government, more concretely the right hand side of (2), illustrates that a rise of outstanding public debt requires higher future primary surpluses. Consequently, the primary surplus must rise as public debt grows to guarantee sustainability (cf. Bohn (1995, 1998)). Hence, one strategy to analyze empirically whether a given time series of public debt fulfills the intertemporal budget constraint is to test if the primary surplus is a positive function of public debt relative to GDP, respectively. Starting point of the analysis is the following equation

$$S = \phi Y + \psi B, \tag{3}$$

with Y denoting the real GDP. The parameter ψ determines how strong the primary surplus reacts to changes in public debt and will be denoted as the reaction coefficient and ϕ determines whether the level of the primary surplus rises or falls with an increase in GDP. In case of a strictly positive reaction coefficient ψ the debt to GDP ratio becomes a mean-reverting process and it can be shown that such a process implies sustainability of public debt (for a rigorous proof see Greiner and Fincke (2015), p. 71-74).

From equation (1) one realizes that the interest rate and the inflation rate affect the evolution of public debt. Thus, the central bank determines to a certain extent the evolution of real public debt and the question arises whether policy makers take this into account in their decisions with respect to the primary surplus. Therefore, in the next section we analyze the effect of the inflation rate and of the interest rate on the primary surplus, besides the question how the latter reacts to changes in public debt relative to GDP, respectively.

3 Empirical Analysis

We model a fiscal reaction function based on Bohn (1998) where the primary balance relative to GDP is assumed to be a linear function of the public debt to GDP ratio of the previous year and of other macroeconomic variables, especially monetary ones as the real long term interest rate and the inflation rate. We study how the primary balance reacts to the debt to GDP ratio of the previous year and we investigate the impacts of the real long term interest rate and of the inflation rate, measured as the change in the GDP price deflator, on the government primary budget.

To empirically analyze public debt sustainability and the effects of monetary policy, we resort to the fixed and to the random effects model for a panel of 12 economies of the Economic and Monetary Union (EMU) of the European Union - Austria, Belgium, Finland, France, Germany, Greece, Ireland, Italy, Luxembourg, Netherlands, Portugal, Spain - from 1996 to 2020, hence a total of 300 observations in annual frequency were generated. The data set for the empirical study is taken from the European Union AMECO website (AMECO database).[4] In applied macroeconomics research, panel studies have become quite popular as econometricians require large data sets to improve statistical inference and to analyze the dynamic relationships between variables. The difference between the fixed and the random effects model is briefly explained.

The fixed effects model explores the relationship between predictor and outcome variables within an entity/country. Each country has its own individual characteristics which can influence the predictor variables. For the fixed effects model, it is assumed that something within the country may impact or bias the predictor or outcome variables and needs to be controlled for. The fixed effects model eliminates the effect of those time-invariant characteristics so we can assess the net effect of the predictors on the outcome variable. The time-invariant characteristics are unique to the country and should not be correlated with other individual characteristics. Each country is different, thus the country's error term and the constant should not be correlated with the others. The fixed effects model is not appropriate for data for which within-cluster variation is minimal or for slow changing variables over time.

The random effects model assumes that the variation across countries is random and uncorrelated with the predictor or independent variables included in the model. If differences across countries impact the dependent variable then the random effects model is suitable. In a random effects model, time invariant variables can be included, whereas for the fixed effects model these variables are absorbed by the intercept. The country's error term is not correlated with the predictors which allows for time-invariant variables to play a role as explanatory variables. For the random effects model, the individual characteristics have to be specified which may or may not influence the predictor variables. One problem here is the availability of variables which can lead to omitted variable bias

[4]We have left out those countries of the EMU for which AMECO data are not available or missing for some explanatory variables.

in the model (Baltagi, 2021).

We estimate the response of the primary balance (surplus) to lagged debt relative to GDP, taking into account the effects of the interest rate and of the inflation rate by the following equation,

$$\begin{aligned} pbratio_{i,t} &= \phi_i + \psi\, b_{i,t-1} + \phi_1\, YVAR_{i,t} + \phi_2\, GVAR_{i,t} + \gamma_1\, interestRate_{i,t} + \\ &\quad \gamma_2\, inflationRate_{i,t} + \epsilon_{i,t} \end{aligned} \tag{4}$$

where i denotes the individual country within the panel and t is the year from 1996 to 2020.

Next, we depict the variables in detail. The variable $pbratio_{i,t}$ is the response/dependent variable, in our model the primary balance to GDP ratio. We use the cyclically adjusted primary balance of the governments.[5] It represents the structural aspect of the primary balance that depicts the behavior of the policymakers as shocks or one-off fluctuations are extracted. Positive (negative) values indicate surpluses (deficits) or net lending (net borrowing). $b_{i,t-1}$ is the debt to GDP ratio of the previous year $t-1$. It is lagged general government gross debt as a percentage of GDP.[6] Motivated by the tax smoothing hypothesis of Barro (1979), we include the business cycle variable, $YVAR_{i,t}$, and the public expenditure gap, $GVAR_{i,t}$, as control variables. To obtain $YVAR_{i,t}$, we take the gross domestic product at current market prices[7] divided by the GDP price deflator[8] to get real GDP. Then, we calculated $YVAR_{i,t}$ which is also known as the real output gap. It is computed as the deviation of actual real output from its long-term trend, obtained by applying the Hodrick-Prescott (HP) filter on real GDP. For $GVAR_{i,t}$ we take the real total expenditure of general government.[9] As for $YVAR_{i,t}$, we compute $GVAR_{i,t}$ as the deviation of actual real total government expenditure from its long-term trend, where the latter is again obtained by applying the HP filter on real total expenditures of the general government.

The explanatory variables that represent the monetary policy are the $interestRate_{i,t}$

[5]UBLGBP of the AMECO database

[6]UDGG of the AMECO database

[7]UVGD of the AMECO database

[8]PVGD of the AMECO database

[9]OUTG of the AMECO database

which is the real long-term interest rate[10] and $inflationRate_{i,t}$ is the rate at which the price level rises. We take the GDP price deflator[11] and calculate $\pi_t = (P_t - P_{t-1})/P_{t-1}$. ψ is the feedback parameter of the lagged public debt to GDP ratio. ϕ_1 and ϕ_2 measure the impact of the regressors $YVAR_{i,t}$ and $GVAR_{i,t}$ on the response variable and γ_1 and γ_2 give the influence of the regressors that represent the monetary sector on the primary balance ratio. $\epsilon_{i,t}$ is the uncorrelated error term assumed to be centered around zero with a constant variance. As the real interest rate plays an important role for the evolution of the debt to GDP ratio, we have checked the correlation between those variables for our panel and get a value of 0.3037858 which indicates that there is only a weak correlation between the debt to GDP ratio of the previous year $t-1$ and the real long-term interest rate. Therefore, we can include the interest rate as an explanatory variable.[12]

Before we present our estimation results, we display the summary statistics of the variables of our data set in table 1. It can be observed that the average primary balance to GDP ratio is positive, but rather small. The minimum value of the pbratio-variable is negative and is observed for Ireland in the year 2010 and Greece has the maximum value in 2016. As regards the general government gross debt as a percentage of GDP, we see that the average value for this panel is around 75.71% in the period under consideration. The maximum amounts to 186.41% for Greece in 2019 whereas the minimum value occurs in Luxembourg in 2004. The business cycle variable, $YVAR_{i,t}$, has a high variability among the countries due to the fact that our panel consists of bigger and of smaller economies. The variable $GVAR_{i,t}$ reveals variability, too, as the deviation of actual real total government expenditures from its long term trend differs to a great degree in the countries considered. As regards the monetary variables we can see that the average $interestRate_{i,t}$ is 1.96%. The maximum value amounts to 22.4% in Greece in 2012. With respect to the $inflationRate_{i,t}$, we observe that the average is around 1.75% and we have a maximum of more than 13% for Italy in 1996.

[10] ILRV of the AMECO database

[11] PVGD of the AMECO database

[12] We computed the correlation matrix containing all explanatory variables. None of the coefficients exceeds 50% so that the problem of multicollinearity does not arise.

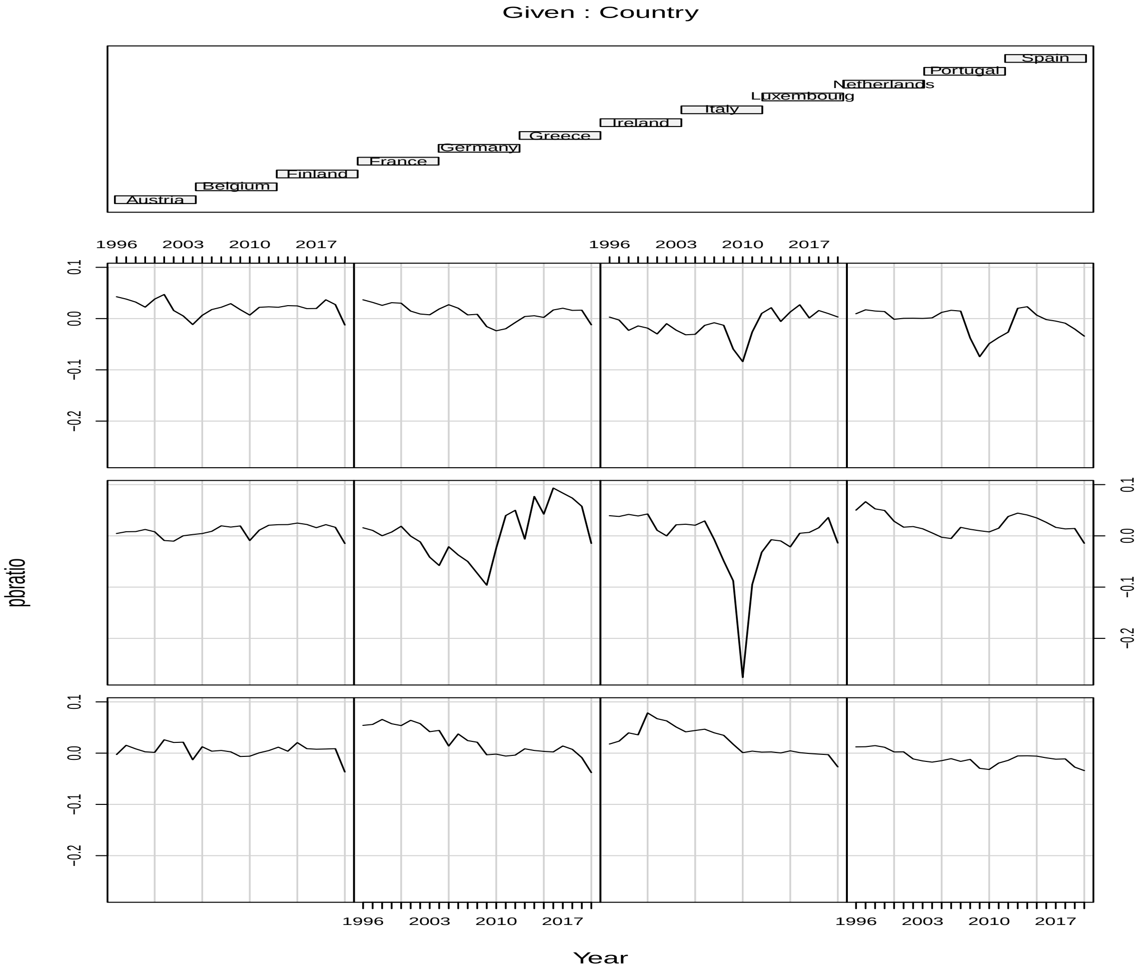
Table 1: Summary Statistics

Statistic	pbratio	b_{t-1}	YVAR	GVAR	interestRate	inflationRate
Min.	-0.276213000	0.0743920	-6.212272e-02	-7.151993e-02	-0.060540146	-0.046198892
Median	0.008362500	0.6732775	-1.394825e-03	-1.968702e-03	0.017388981	0.016762836
Mean	0.007111803	0.7570665	1.433333e-10	5.000000e-11	0.019564220	0.017561927
Max.	0.093314000	1.8641390	8.157732e-02	2.828509e-01	0.228379720	0.136398234

In a next step we would like to explore the panel data by presenting four different figures that illustrate the response/dependent variable and our three covariates of interest, the lagged general government gross debt as a percentage of GDP and our two monetary policy variables, the real long-term interest rate and the inflation rate. We depict the evolution of the variables for the different economies from 1996 to 2020 in the following figures 1 - 5. The bars at the top indicate the corresponding graph, here the countries, from left to right starting on the bottom row.

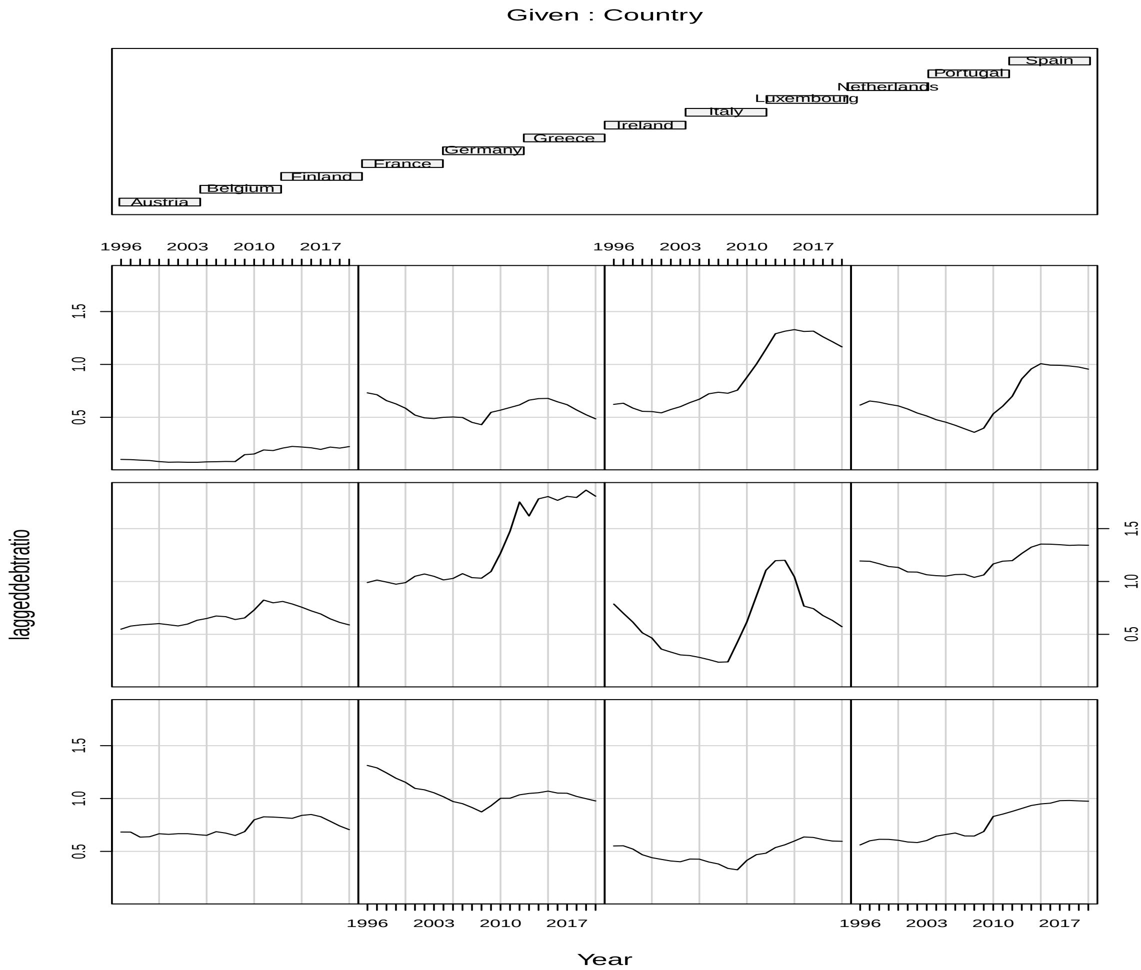
In figure 1, we can identify that the financial crisis of 2007/08 had a strong negative impact on the primary balance ratio of Greece, of Ireland, of Portugal and of Spain. In the aftermath of this crisis, the primary balance ratio decreased fast, but, after some years it recovered to a certain degree. For other countries, as for example Luxembourg, we cannot see such a sharp decline, quite on the contrary, the primary balance ratio stayed moderately positive. At the point in time when the countries enter the EMU, we observe a surplus, a primary balance ratio of zero or only a slight deficit for all the countries while it drops sharply in the last year we consider, the year 2020.

Figure 1: The primary balance to GDP ratio (pbratio)



For one of the main explanatory variables, the debt to GDP ratio of the previous year $t-1$, we identify in figure 2 that the financial crisis of 2007/08 was noticeable for nearly all countries, as it leads to an increase of the debt to GDP ratio. For some countries, such as Austria or Germany, we identify the existence of the Maastricht treaty guideline stating that the public debt relative to GDP must not exceed 60%, as their debt to GDP ratios settle around this level. Nevertheless, in times of crisis it is difficult to stick to the Maastricht criteria. For Greece, Italy, Portugal and Spain the economies have not recovered well from the financial crisis and the debt to GDP ratio stayed at high levels in those economies. Only a few years before 2020, before the start of the Covid-19 crisis, the economies seem to have been able to reduce their debt to GDP ratios, at least to a minor degree. However, that evolution did not last long, as the next crisis began, the Covid-19 crisis.[13] For Ireland, we identify that this country could reduce its debt to GDP ratio in a drastic way some years after the financial crisis. Other countries such as Belgium or Luxembourg did not have to reduce the debt to GDP ratio to the same extent, as their debt to GDP ratios had not risen that much during the crisis.

Figure 2: The lagged debt to GDP ratio (laggeddebtratio)

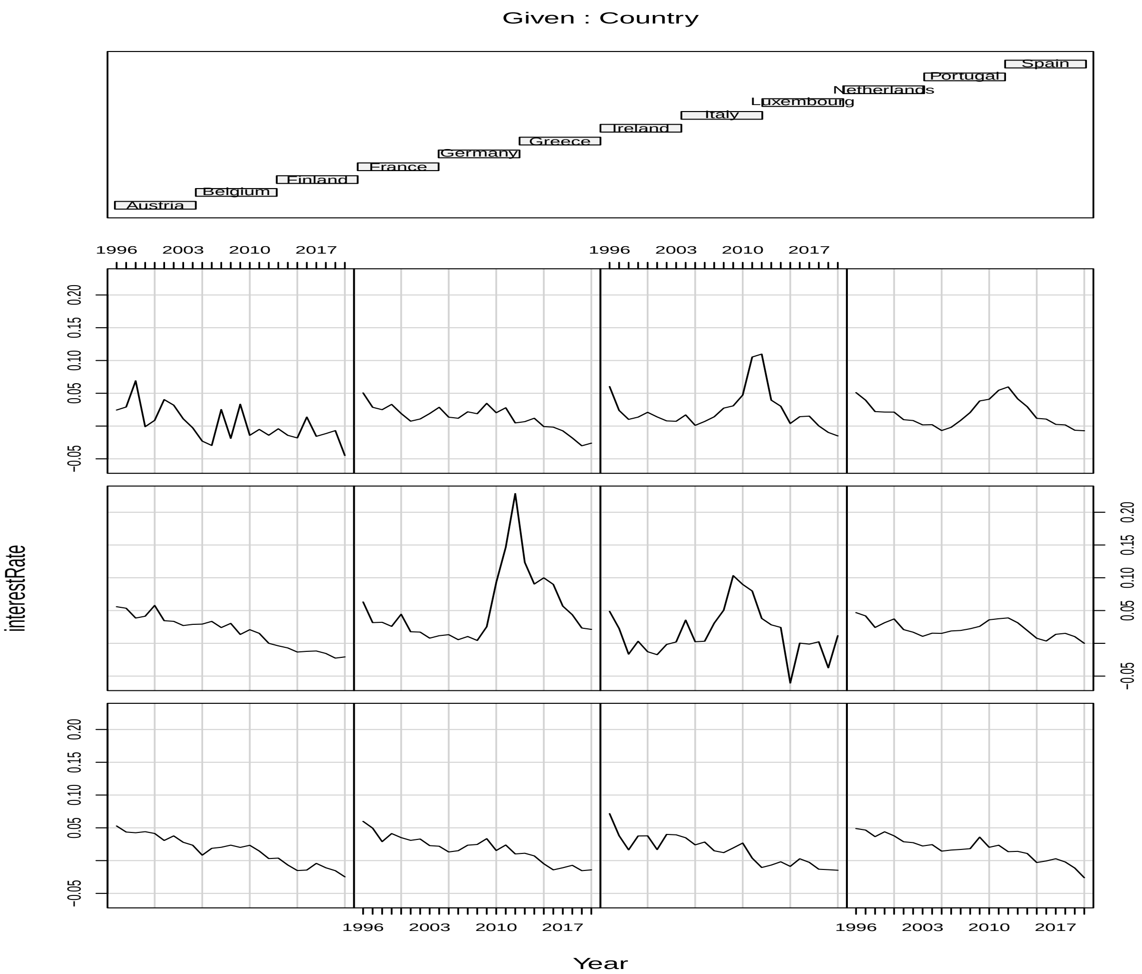


Regarding our monetary policy variable, the real long-term interest rate, we realize

[13]As we investigate the time period from 1996 to 2020, we cannot make statements as to the impact of the Covid-19 crisis. Further, the debt to GDP ratio refers to the previous year $t-1$, i.e. in 2020 we see the value of 2019.

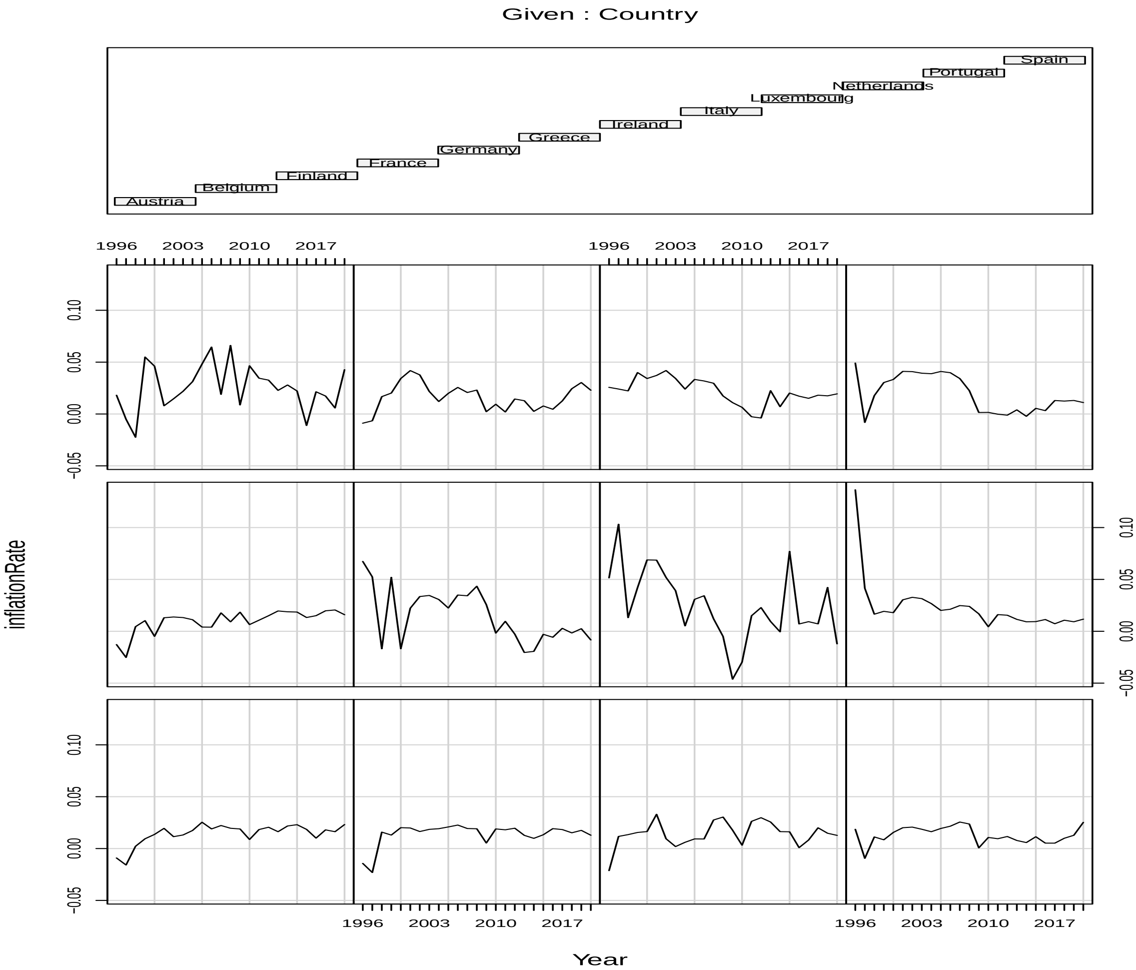
from figure 3 that in most of the countries, apart from Greece, Ireland, Portugal and Spain, it declines over the time period considered with some fluctuations which occur in particular during the financial crisis of 2007/08. The effects of the monetary policy of the European Central Bank (ECB) over the last couple of years can be detected here that aimed at lowering interest rates to stimulate economic activity in the euro area. For Greece, Ireland, Portugal and Spain, we recognize that there was a sharp rise of the real long-term interest rate after the financial crisis of 2007/08 followed by a strong decline in the following years approaching the zero level.

Figure 3: The real long-term interest rate (interestRate)



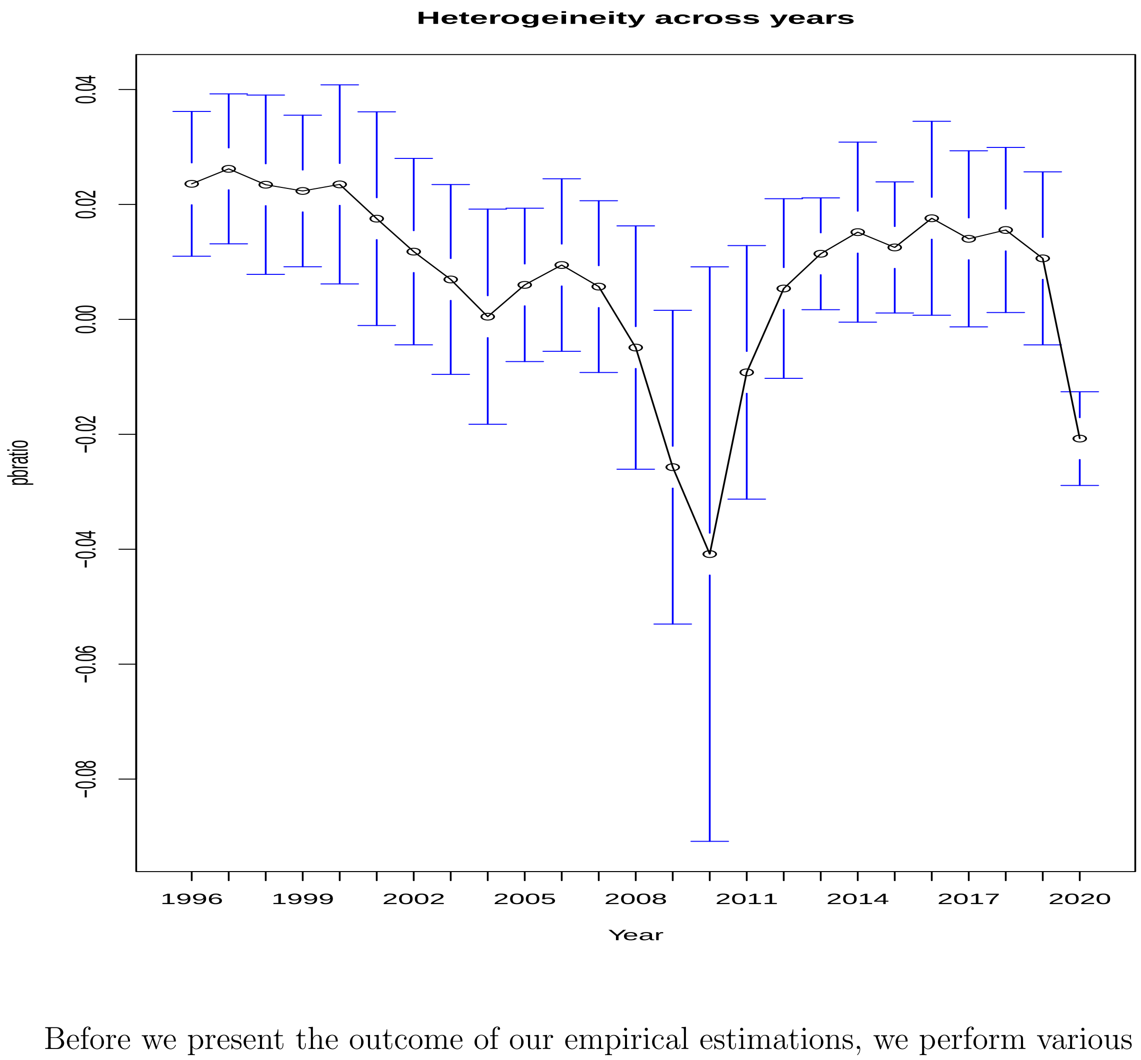
With respect to our other explanatory variable representing monetary policy, the inflation rate, we cannot detect a uniform trend for all the countries in figure 4. Each economy is different as regards its evolution of the inflation rate. Countries like Austria, Belgium, Finland and France reveal small fluctuations, whereas other economies like Greece, Irleand, Spain and Luxembourg are characterized by strong oscillations of this variable. As mentioned above, we identify the maximum value of inflation for Italy in 1996, the beginning of our time period.

Figure 4: The inflation rate computed from the GDP deflator (inflationRate)



Finally, we want to analyze our response/dependent variable, the primary balance to GDP ratio, over the time period considered. Figure 5 illustrates the 95% confidence interval around the means of all the countries for each year. Here, we observe that the primary balance ratio sharply drops as a result of the financial crisis in 2007/08 and it becomes negative indicating primary deficits. In the year 2010, we see that the 95% confidence interval around the means of all the countries is extremely large. Thus, the countries differ quite a lot from each other in copying with the crisis and in their deficit policies. Then, the primary balance gradually rises and enters the positive range in 2013. But, in 2020 we again see a sharp decrease of that variable due to the Covid-19 crisis.

Figure 5: Heterogeneity in the primary balance-GDP ratio



Before we present the outcome of our empirical estimations, we perform various tests with respect to all explanatory variables in our panel. In a first step, we test for the presence of a unit root in the data. The result is that for both the dependent variable,

$pbratio_{i,t}$, and all the covariates of interest, $b_{i,t-1}$, $YVAR_{i,t}$, $GVAR_{i,t}$, $interestRate_{i,t}$ and $inflationRate_{i,t}$, the hypothesis of non-stationarity can be rejected.

Next, we test for heteroskedasticity by using the Breusch-Pagan test, where the null hypothesis is homoskedasticity, and we detect heteroskedasticity. Further, we identify serial correlation, too, by resorting to the Breusch-Godfrey/Wooldridge test for serial correlation in panel models. Therefore, we use a robust, i.e. heteroskedasticity and autocorrelation consistent (HAC), covariance matrix by applying the Newey and West (1987) Robust Covariance Matrix Estimator.

An important aspect here is that when testing for cross-sectional dependence by applying the two appropriate tests, the Breusch-Pagan LM test for cross-sectional dependence in panels, and the Pesaran CD test for cross-sectional dependence in panels, we get cross-sectional dependence that induces the use of the Driscoll and Kraay (1998) Robust Covariance Matrix Estimator. Since the results of the estimates are the same and the standard errors and the significance level do not differ much when applying the Driscoll and Kraay (1998) Robust Covariance Matrix Estimator compared to the Newey and West(1987) Robust Covariance Matrix Estimator, we present in table 2 the results for the different models when utilizing the Newey and West(1987) Robust Covariance Matrix Estimator.

The table 2 presents the outcomes of our estimations for all models, for the fixed and for the random effects estimation for our panel of 12 EU Monetary Union economies from 1996 to 2020 comprising 300 observations. We can see that model 1 and model 4 contain all the explanatory variables for the two types of estimation. In model 2 and 5, we have left out the $inflationRate_{i,t}$ in each case and in model 3 and 6, we have left out the $interestRate_{i,t}$. We notice that the response coefficient of the debt to GDP ratio of the previous year $t-1$, i.e. $b_{i,t-1}$, is positive and statistically significant at the 5% level in model 1, 3 and 4, while it is statistically insignificant in the other models. Hence, even if the empirical evidence is not too strong, we can identify sustainable debt policies for the full panel, according to Bohn (1995, 1998) who depicts how public debt sustainability can be assessed by studying the reaction of the primary balance to changes in the public debt to GDP ratio and as briefly demonstrated in section 2. The debt policy is sustainable if governments react to an increase in the public debt ratio by actively adjusting its discretionary fiscal policy in terms of higher primary surpluses. For our panel, this is the case when all variables are included in the estimation which yields the highest Adj R^2.

Further, we detect that the business cycle variable, $YVAR_{i,t}$, is weakly negative and it is not statistically significant. A reason for this result could be the use of the cyclically adjusted primary balance of the governments[14] which represents the structural aspect of the primary balance that depicts the behavior of the policymakers as shocks or one-off fluctuations are extracted. Therefore, we have estimated the models exclusive of that variable, but, inclusive of all other variables. The results are identical to those in table 2 from a qualitative point of view and are given in the Appendix. The public expenditure gap, $GVAR_{i,t}$, computed as the deviation of actual real total government expenditure from its long-term trend, has a negative impact on the $pbratio_{i,t}$, the primary balance to GDP ratio, and is highly statistically significant for all specifications. This is not too surprising since higher public spending leads to a smaller or even negative primary balance to GDP ratio, $pbratio_{i,t}$.

[14] UBLGBP of the AMECO database

Table 2: Estimation results

	Response variable: pbratio					
	Fixed Effects (Within Estimator)			Random Effects		
Variables	1	2	3	4	5	6
$(Intercept)$	/	/	/	−0.022028·	−0.0095650	−0.015062
	/	/	/	(0.011786)	(0.0097888)	(0.011716)
b_{t-1}	0.034836*	0.025816·	0.032592*	0.025950*	0.0190308·	0.025099·
	(0.014745)	(0.013609)	(0.014732)	(0.012487)	(0.0115305)	(0.012783)
YVAR	−0.096497	−0.073234	−0.135042	−0.110419	−0.0881068	−0.143493
	(0.096486)	(0.095671)	(0.101369)	(0.103715)	(0.1030730)	(0.107539)
GVAR	−0.707144***	−0.733320***	−0.705592***	−0.716147***	−0.7383153***	−0.713543***
	(0.097048)	(0.102214)	(0.090815)	(0.100608)	(0.1054248)	(0.095548)
interest	0.226940*	0.127643		0.202345*	0.1159885	
Rate	(0.093446)	(0.098535)		(0.092730)	(0.1003783)	
inflation	0.359349**		0.204356	0.315198**		0.180649
Rate	(0.117458)		(0.127157)	(0.114899)		(0.133834)
Adj R^2	0.43775	0.40441	0.40491	0.43581	0.40878	0.40984
Observ.	300	300	300	300	300	300

Standard errors in parenthesis; significance levels: *: $p < 0.05$, **: $p < 0.01$, ***: $p < 0.001$

In a next step, we discuss the impact of the monetary policy on the primary balance by means of the effects of the real long term interest rate and of the inflation rate, measured as the change in the GDP price deflator, on the primary balance to GDP ratio. We do this for the fixed effects and for the random effects model and for different combinations of the covariates. In a first step, we again include all explanatory variables, then we leave out the $inflationRate_{i,t}$ and, finally, the $interestRate_{i,t}$ is not taken into account.

We find that both monetary policy variables are positively correlated with the primary balance to GDP ratio both for the fixed and for the random effects model, when those variables are included simultaneously. Moreover, both are statistically significant, even if it is not at the highest level. In the fixed effects model, the coefficients of the monetary policy variables indicate how much the primary balance to GDP ratio, $pbratio_{i,t}$, changes over time, on average per country, when the monetary policy covariate increases by one unit. For the fixed effects model, we find that the primary balance to GDP ratio,

$pbratio_{i,t}$, increases by 22.69% when the $interestRate_{i,t}$ rises by one unit. With a rise in the $interestRate_{i,t}$, the government is confronted with a higher debt service since interest payments on outstanding debt go up. In order to avoid further increases in the public debt to GDP ratio the government has to take countermeasures meaning that it must raise the primary surplus. Thus, we can identify a disciplining effect of higher interest rates as the coefficient of $interestRate_{i,t}$ has a positive sign. Higher interest charges have to be compensated by lower public expenditures or/and by higher taxes which increase the revenues of the government. For the random effects model, we get a coefficient of 20.23% which does not differ much compared to the fixed effects model. In the random effects model, we see the average effect of the monetary policy variables over the primary balance to GDP ratio, $pbratio_{i,t}$, when the monetary policy covariates change across time and between countries by one unit.

As regards the inflation, we identify a positive sign for the $inflationRate_{i,t}$, too, both for the fixed effects model and for the random effects model. For the fixed effects model, we find that a one unit increase of the $inflationRate_{i,t}$ goes along with a rise of the primary balance to GDP ratio, $pbratio_{i,t}$, by 35.93%. The random effects model gives a value of 31.52%. Hence, we can state that an increase in the $inflationRate_{i,t}$ leads to a higher primary surplus to GDP ratio in the two models containing all variables. The economic mechanism behind that result can be seen in the fact that a higher $inflationRate_{i,t}$ induces a higher nominal tax revenue that grows fast, increasing the revenues of the government more than public spending and, thus, raises the primary balance to GDP ratio, $pbratio_{i,t}$. Another aspect may be seignorage which can be one source of inflation and a way to finance public expenditures and to increase the revenues of the government, if everything else remains unchanged. It should be noted that changes in interest rates impact the fiscal stance to a lower degree than variations in the $inflationRate_{i,t}$.

For the models 2 and 5, when we leave out the $inflationRate_{i,t}$, we see that we get a positive sign for the coefficient of the $interestRate_{i,t}$, both for the fixed and for the random effects model, but, it is not statistically significant. When we omit the $interestRate_{i,t}$ and include the $inflationRate_{i,t}$, as we have done in model 3 and 6, we obtain a positive sign for the $inflationRate_{i,t}$ that, however, is again not statistically significant. We can conclude here that only in the models that contain both monetary policy variables as covariates, we get statistically significant results. The $interestRate_{i,t}$ and the $inflationRate_{i,t}$ are both important for the analysis of the primary balance to GDP ratio, $pbratio_{i,t}$. Furthermore, on the basis of the Adj R^2 we can state that the models containing all explanatory variables and, especially, both monetary policy variables, achieve a higher Adj R^2 and, therefore, yield a better picture of the true data generating process than the models that include only one monetary policy covariate. Our results for the monetary-fiscal policy relations in the euro area are to some extent consistent with those presented in for example Afonso et al. (2019).

Finally, we compare the fixed and the random effects model containing all explanatory variables (Models 1 and 4) by running a Hausman Test where the null hypothesis is that the preferred model is the random effects model versus the alternative hypothesis which is that the model to decide for is the fixed effects model. It tests whether the unique errors are correlated with the regressors, the null hypothesis says that they are not. As the $p - value = 0.2179$, we decide for the random effects model. This means that for each country considered, an individual deviation (to be determined by means of a regression) from the panel mean is a normally distributed random variable. However, as identified above, the estimates, the significance levels and the Adj R^2 of both models do not differ much. A robustness analysis for the models 1 and 4 can be found in the Appendix, where we have left out the business cycle variable, $YVAR_{i,t}$, as it is not statistically significant.

4 Conclusion

This paper contributes an empirical analysis of public debt sustainability and of the effects of monetary policy by estimating a fiscal reaction function based on Bohn (1995, 1998) where the primary balance relative to GDP is assumed to be a positive function of the public debt to GDP ratio of the previous year and of other macroeconomic variables. Further, we take into account the effects of monetary policy by means of the real long term interest rate and by means of the inflation rate, measured as the change in the GDP price deflator. We study how the primary balance reacts to the debt to GDP ratio of the previous year and we investigate the impacts of the real long term interest rate and of the inflation rate on the government primary budget. We resort to the fixed and to the random effects models for a panel of 12 EU Monetary Union economies from 1996 to 2020.

We identify sustainable debt policies and we find that deviations of the public expenditures from its long-run trend has a negative impact on the primary balance to GDP ratio, and is highly statistically significant. Higher public spending leads to a smaller or even negative primary surplus which is plausible. Further, we detect that both monetary policy variables are positively correlated with the primary balance to GDP ratio, both for the fixed effects and for the random effects model when those variables are included simultaneously in the estimations. Hence, the interest rate and the inflation rate are important factors determining the primary balance. On the basis of the Adj R^2 we can state that the models containing all explanatory variables, especially, both monetary policy variables yield the best fit.

Further, the primary balance to GDP ratio increases when the interest rate rises. A higher interest rate means that the government is confronted with a higher debt service since interest payments on outstanding debt go up. To avoid further increases in the public debt to GDP ratio the government takes countermeasures and raises the primary surplus, i.e. the interest rate exerts a disciplining effect on governments. Higher interest charges have to be compensated by lower public expenditures or/and by higher taxes which increase the revenues of the government. In addition, we find that an increase in the inflation rate goes along with a rise of the primary balance to GDP ratio. A higher inflation rate often goes along with higher GDP growth that induces a higher tax revenue that grows fast, increasing the revenues of the government more than public spending and, thus, raises the primary balance to GDP ratio. Another aspect may be seignorage which can be one source of inflation and a way to finance public expenditures and to raise the revenues of the government, if everything else remains unchanged. Changes in interest rates impact the fiscal stance to a lower degree than variations in the inflation rate.

As regards policy implications we should like to point out that the governments of the euro area should not be tempted to reduce their efforts to lower their public debt to GDP ratios. It is true that we found evidence for sustainable debt policies, the statistical significance for that outcome, however, is not overwhelmingly high. Further, given the disciplining function of the interest rate the current policy measures of the ECB aiming to reduce the interest burden for some highly indebted euro area economies are to be seen critical.

Appendix

Robustness of the results

Table A1: Estimation results without $YVAR$, Response variable: pbratio

	Fixed Effects (Within Estimator)	Random Effects
Variables	1	4
$(Intercept)$	/	$-0.022688^{\cdot}$
	/	(0.011842)
b_{t-1}	0.035887^{*}	0.026834^{*}
	(0.014638)	(0.012310)
GVAR	-0.694750^{***}	-0.702216^{***}
	(0.094741)	(0.098164)
interest	0.234997^{*}	0.210888^{*}
Rate	(0.093021)	(0.091985)
inflation	0.351759^{**}	0.305175^{**}
Rate	(0.116569)	(0.114227)
Adj R^2	0.43663	0.43383
Observ.	300	300

Standard errors in parenthesis; significance levels: *: $p < 0.05$, **: $p < 0.01$, ***: $p < 0.001$

Database

AMECO

2022. European Commissions Directorate General for Economic and Financial Affairs macro-economic database,

Available at `https://ec.europa.eu/info/business-economy-euro/indicators-statistics/economic-databases/macro-economic-database-ameco/ameco-database_en`, [Accessed on 04.03.2022].

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