How to assess debt sustainability? Some theory and empirical evidence for selected euro area countries

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Abstract

Testing for sustainability of public debt by analyzing how the primary surplus reacts to variations in debt, as suggested by Bohn (1998), has received great attention in the economics literature. In this contribution we elaborate on that test and argue that it should be complemented by additional tests for countries with rising debt to GDP ratios. We, then, apply that test to some countries of the euro area where we allow for a time-varying reaction coefficient. In addition, we perform stationarity tests with respect to the real deficit inclusive of interest payments in order to gain additional insight. We conclude that there is empirical evidence that the chosen paths of fiscal policies are sustainable for the countries we consider, although there are country specific differences in debt policies.

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1 Introduction

The growth of the public debt level is an important factor that affects the budget plan of a government. Without balanced budgets the ensuing deficits accumulate and lead to a rise of public debt in individual countries. Over the last decades a lot of European countries have suffered from permanent and in part high public deficits. This trend has represented a serious problem from the economic and political point of view, especially for members of the European Monetary Union. Those countries have to stick to the Convergence Criteria of the Maastricht Treaty of the European Union and to the Stability and Growth Pact that imposes limitations with respect to fiscal policies.

In order to account for the size of the different countries in the European Union, public debt is usually expressed in terms of ratios, mostly relative to GDP. This measurement is also resorted to in the Convergence Criteria of the Maastricht Treaty of the European Union, which limits public deficits to three percent of GDP and public debt to 60 percent of GDP.[1] In the early 2000s these criteria had been frequently violated by France, Germany and Portugal for example.

An important aspect in this context is the question of whether governments are able to respond in a sustainable way to the above mentioned tendency of persistent budget deficits and growing levels of debt. Here, it is important to recall that the concept of sustainability is well compatible with indebtedness in the short run but it requires that the present value of debt converges to zero asymptotically. This raises the question of how governments react to higher debt levels, which options they have to respond and if these actions are still effective.

In the economics literature several approaches can be found to test for sustainability of public debt (for a survey see e.g. [Afonso, 2005]). In this paper, we start with the approach by Bohn [Bohn, 1998] that has received great attention in economics. There, it is tested how the primary surplus relative to GDP reacts to variations in public debt

[1] See [EU, 1992] Title VI Chap. 1, Art. 104c, Sect. 2. and Protocol 5 on the excessive deficit procedure.

relative to GDP. If this response of the primary surplus to public debt is positive and statistically significant a given fiscal policy can be shown to satisfy the inter-temporal budget constraint of the government. An alternative test is proposed by Trehan and Walsh [Trehan, 1991]. There, it is suggested that with a variable but strictly positive real interest rate, a stationary deficit inclusive of interest payments is sufficient for sustainability of public debt. The idea behind this reasoning is that a stationary deficit implies that public debt rises linearly and, consequently, discounted public debt converges to zero. This holds because a time series that grows linearly always converges to zero when multiplied by an exponential discount factor.

Starting point of our analysis is the paper by Greiner et al. [Greiner et al., 2007], where the response of the primary surplus to public debt has been estimated by OLS. In contrast to that contribution, however, we allow for a time varying coefficient giving the reaction of the primary surplus to GDP ratio to variations in the debt ratio[2] and we take data until 2006. Thus, we are able to find whether the response of governments with respect to public debt have changed over time besides detecting whether the coefficient is positive at all. In addition to that, we argue that performing that test alone may not be sufficient to answer the question of whether a given fiscal policy is sustainable. This holds because a positive reaction coefficient does not necessarily imply that the debt ratio remains bounded which, however, must hold asymptotically. Therefore, we analyze in addition whether the total deficit of the government is stationary which is a sufficient condition for sustainability of public debt if the interest rate is positive.

The countries we consider in our study are Austria, France, Germany, Italy, the Netherlands and Portugal. France, Germany and Italy are included because they are the largest economies in the euro area. Austria and Portugal are included because the evolution of their debt ratios with a sharp increase during the 1970s and a stabilization in the 1990s can be seen as characteristic for many euro area countries. The Netherlands, finally, have

[2] For Germany, that has already been done rudimentarily in Greiner et al. [Greiner et al., 2006] and additionally for Iatly in Greiner and Kauermann [Greiner, 2006].

undertaken substantial macroeconomic reforms in the mid 1980s to early 1990s.

The remainder of the paper is organized as follows. Section two briefly describes the theoretical approach and the background of the test. In section three the results of the empirical estimations are presented, where we first analyze how the primary surplus relative to GDP reacts to variations in the debt-GDP ratio and, then, test whether the deficit inclusive of interest payments is stationary. Section four, finally, summarizes the central arguments.

2 Theoretical background

Starting point of the test introduced by Bohn [Bohn, 1998] is that discounting public debt with a given interest rate may be crucial as to the result whether a given time path of public debt is sustainable or not. Since interest rates in the future are not known tests on sustainability should be independent of the discount factor applied in computing the present value of public debt. One test that achieves this is to analyze whether the primary surplus relative to GDP is a positive function of public debt relative to GDP, i.e. a positive function of the debt ratio. The idea behind this test is that a such a policy makes the debt to GDP ratio a mean reverting process. Hence, rising debt ratios lead to higher primary surplus relative to GDP that exerts a tendency towards mean reversion.

In order to see this we consider a deterministic economy in continuous time. The evolution of public debt, then, is given by

$$\frac{dB(t)}{dt} = r(t)B(t) + G(t) - T(t) = r(t)B(t) - S(t), \tag{1}$$

with $B(t)$ public debt, $r(t)$ the interest rate and $S(t)$ the primary surplus that consists of public revenues, $T(t)$, minus public spending, $G(t)$. All variables are real and continuous functions of time t. A given path of public debt is said to be sustainable if it satisfies the

inter-temporal budget constraint,

$$\lim_{t\to\infty} B(t)\, e^{-\int_{t_0}^{t} r(\tau)d\tau} = 0 \Leftrightarrow B(t_0) = \int_{t_0}^{\infty} e^{-\int_{t_0}^{\tau} r(\mu)d\mu} S(\tau)d\tau\,. \tag{2}$$

Now, assume that the primary surplus relative to GDP,[3] S/Y, is given by,

$$\frac{S(t)}{Y(t)} = \alpha + \beta(t)\left(\frac{B(t)}{Y(t)}\right), \tag{3}$$

with $\alpha \in \mathbb{R}$ a constant and $\beta \in \mathbb{R}$ the coefficient that gives the reaction of the primary surplus to public debt relative to GDP, respectively, and that may be time varying. Using (3), the evolution of public debt can be written as,

$$\frac{dB(t)}{dt} = (r(t) - \beta(t))B(t) - \alpha Y(t). \tag{4}$$

Solving (4) and multiplying both sides by $e^{-\int_{t_0}^{\tau} r(\mu)d\mu}$ to get present values leads to

$$e^{-C_3(t)}B(t) = e^{-C_1(t)}B(t_0) - \alpha Y(t_0)e^{-C_1(t)}\int_{t_0}^{t} e^{C_1(\tau)}e^{C_2(\tau)}e^{-C_3(\tau)}d\tau, \tag{5}$$

with

$$\int_{t_0}^{\tau}\beta(\mu)d\mu \equiv C_1(\tau), \int_{t_0}^{\tau}\gamma(\mu)d\mu \equiv C_2(\tau), \int_{t_0}^{\tau} r(\mu)d\mu \equiv C_3(\tau), \tag{6}$$

where γ gives the growth rate of GDP.

Equation (5) demonstrates that $\lim_{t\to\infty} C_1(t) = \lim_{t\to\infty}\int_{t_0}^{t}\beta(\tau)d\tau = \infty$ must hold so that the first term in that equation converges to zero. The second term on the right hand side in (5) can be written as

$$\frac{\int_{t_0}^{t} e^{C_1(\tau)}e^{C_2(\tau)}e^{-C_3(\tau)}d\tau}{e^{C_1(t)}} \equiv C_4(t), \tag{7}$$

where we have set $\alpha\, Y(t_0) = 1$.

[3] In the following we delete the time argument t if no ambiguity arises.

If $\int_{t_0}^{\infty} e^{C_1(\tau)} e^{C_2(\tau)} e^{-C_3(\tau)} d\tau$ remains bounded $\lim_{t\to\infty} C_1(t) = \infty$ guarantees that C_4 converges to zero. Boundedness of $\int_{t_0}^{\infty} e^{C_1(\tau)} e^{C_2(\tau)} e^{-C_3(\tau)} d\tau$ is given for $\lim_{t\to\infty}(C_1(t) + C_2(t) - C_3(t)) = -\infty$. If $\lim_{t\to\infty} \int_{t_0}^{t} e^{C_1(\tau)} e^{C_2(\tau)} e^{-C_3(\tau)} d\tau = \infty$, applying l'Hôpital gives the limit of C_4 as

$$\lim_{t\to\infty} C_4(t) = \lim_{t\to\infty} \frac{e^{C_2(t)} e^{-C_3(t)}}{\beta(t)}\,. \tag{8}$$

In a dynamically efficient economy the interest rate exceeds the growth rate of GDP so that $r > \gamma$. This shows that C_4 converges to zero in the limit if $\lim_{t\to\infty} C_1(t) = \infty$ holds. It should be noted that $\lim_{t\to\infty} C_1(t) = \infty$ excludes the possibility that $\beta(t)$ converges to zero exponentially.

From an economic point of view, theses considerations have demonstrated that a positive reaction coefficient on average, that implies $\lim_{t\to\infty} \int_{t_0}^{t} \beta(\tau) d\tau = \infty$, guarantees that the present value of public debt converges to zero. Hence, the reaction of the government to the debt ratio may well be zero or even negative for some time periods, however, on average it must be positive. Otherwise, no sustainable policy is given.

A reaction coefficient that is positive on average guarantees that the present value of public debt converges to zero asymptotically. However, it does not guarantee that the debt ratio remains bounded. To see this, we define by $b = B/Y$ the debt to GDP ratio. Using the rule defined in (3) the rate of change of the debt ratio is easily derived as,

$$\frac{db(t)}{dt} = (r(t) - \beta(t) - \gamma(t))b(t) - \alpha. \tag{9}$$

With the constants defined in (6) the solution of this equation can be written as

$$b(t) = e^{-C_1(t)-C_2(t)+C_3(t)} b(t_0) - \alpha e^{-C_1(t)-C_2(t)+C_3(t)} \int_{t_0}^{t} e^{C_1(\tau)} e^{C_2(\tau)} e^{-C_3(\tau)} d\tau. \tag{10}$$

Proceeding as above, it is readily shown that the debt to GDP ratio remains bounded for $\lim_{t\to\infty} \int_{t_0}^{t} \beta(\tau) d\tau \geq \lim_{t\to\infty} \int_{t_0}^{t} (r(\tau) - \gamma(\tau)) d\tau$. This implies that the reaction coefficient need not only be positive but larger than the difference between the interest rate

and the growth rate of GDP for the debt to GDP ratio to remain bounded.[4] Again, with time-varying coefficients this inequality must only hold on average.

With these considerations one could conclude that a rising debt ratio can be compatible with a sustainable policy. This may hold true for a certain time period, however, in the long-run this possibility is not given. This is simply due to the fact that the primary surplus to GDP ratio cannot exceed a certain value because the primary surplus in a certain time period is always smaller than GDP. Hence, the theoretical upper bound for the primary surplus ratio relative to GDP is one, but the actual bound will of course be definitely smaller.

To elaborate further on this point assume that a government performs a debt policy such that the reaction coefficient is strictly positive for a certain time period, say from t_0 up to t_1, but not large enough so that the debt ratio rises in that period. If the primary surplus to GDP ratio reaches its upper bound at t_1, testing for sustainability of public debt would lead to the conclusion that the given path of public debt is sustainable, in spite of a rising debt ratio. However, from t_1 onward the reaction coefficient β equals zero or is even negative because the primary surplus relative to GDP has reached its upper bound. Suppose that the reaction coefficient is zero at all times from t_1 onwards. Then, equation (5) shows that the present value of public debt converges to the value $B(t_1) - \alpha Y(t_1) \int_{t_1}^{\infty} e^{C_2(\tau)-C_3(\tau)} d\tau$, which can be positive or negative implying that the time path of public debt may not be sustainable.[5] Hence, a rising debt ratio may be compatible with a sustainable policy, however, in the long-run the debt to GDP ratio should be constant. As a consequence, testing how the primary surplus reacts to variations in GDP should be complemented by additional tests on sustainability, in case of rising debt to GDP ratios.

Nevertheless, testing the reaction of the primary surplus to variations in public debt is

[4] Recall that in a dynamic efficient economy $r > \gamma$ holds.

[5] A negative value for public debt would imply that the government becomes a lender which is of less relevance for countries in the euro area.

a powerful test that yields important information on debt policies of economies. Therefore, in the next section we perform that test for some European countries. To gain additional insight, we then test whether the deficit inclusive of interest spending is stationary.

3 Empirical Evidence

3.1 The primary surplus and public debt

In this subsection we apply a test that implies the theoretical considerations to data for six selected euro area countries. We analyze the correlation between the primary surplus and the public debt all measured as ratios to GDP. For each selected country we begin with a description of its public debt ratio and its primary surplus ratio. Subsequently we estimate the empirical equation and present the results. For the selected countries it has been checked in advance whether the long-term interest rate exceeds the growth rate of GDP. For the countries under consideration, this holds at least on average so that the approach with the theoretical idea of dynamic efficient deterministic countries is valid and can be applied.[6]

To implement the test we estimate the following equation,

$$s(t) = \beta(t)\, b(t) + \alpha^T Z(t) + \epsilon(t), \tag{11}$$

with $s(t)$ the primary surplus to GDP ratio and $b(t)$ the public debt to GDP ratio at time t. $Z(t)$ is a vector of variables that includes 1 in its first element, for the intercept, and additional variables in its other elements, that influence the primary surplus ratio. $\epsilon(t)$ is an error term, which is assumed to be i.i.d. $N(0, \sigma^2)$.

The variables included in $Z(t)$ are motivated by the tax smoothing hypothesis according to which public deficits should be used in order to keep tax rates constant which

[6] See also [Sachverständigenrat, 2007] Chap. 3, page 43 picture 7 for Germany.

minimizes the excess burden of taxation. Hence, normal expenditures should be financed by regular revenues and deficits should be incurred to finance unexpected spending. Therefore, we include a business cycle variable, $YVar$, that accounts for fluctuations in revenues. In addition, we include the surplus of the social insurance system relative to GDP, Soc, because governments often subsidize social insurances when revenues of social insurances fall short of expenditures. Finally, the real long-term interest rate, int, can affect the primary surplus ratio, too, although it does not affect the primary surplus ratio directly. But, since the government cannot run overall deficits arbitrarily, the interest payments of the government will also affect the primary surplus. Thus, high real interest rates imply that the debt service of the government is large which tends to reduce the primary surplus ratio. On the other hand, high real interest rates may characterize booms with high tax revenues which tend to raise the primary surplus ratio. Therefore, the sign of the coefficient of the real interest rate cannot be determined theoretically.

Further, for the estimation the lagged debt ratio $b(t-1)$ is used in order to take account of causality. Thus, equation (11) can be written as

$$s(t) = \alpha_0 + \beta(t)b(t-1) + \alpha_1 Soc(t) + \alpha_2 int(t) + \alpha_3 YVar(t) + \epsilon(t). \tag{12}$$

All equations are estimated with R (Version 2.5.0) with the package *mgcv* (Version 1.3-28) that uses penalized spline smoothing, which leads to more robust results than OLS estimation.[7] This allows to estimate the reaction coefficient $\beta(t)$ in equation (12) as a function of time.

3.1.1 Austria

Graphics 1 and 2 show the public debt to GDP ratio, measured as general government gross financial liabilities as percentage of GDP, and the primary surplus ratio for the years

[7] See for further information e.g. [Hastie, 1999].

Figure 1: Public debt to GDP ratio for Austria (1975-2005).

Figure 2: Primary surplus to GDP ratio for Austria (1975-2005).

from 1975 to 2005 for Austria.[8]

As the figures 1 and 2 show, Austria has faced a steady increase of public debt within the last 30 years. Especially we recognize a sharp rise from 1975 to the late 1980s. Possible reasons for this might be the aftermath of the first and second oil crisis and the recessions they initiated.[9] For that time period the trend is accompanied by persistent primary deficits. This stage is followed by a period of fiscal discipline and a decline in public debt relative to GDP approximately until 1992 and positive primary surpluses. Afterwards another steep rise of the public debt ratio begins which ends in 1996. This may be due to the recession in the early nineties. From about that time onwards, the debt level has stayed around 70 percent of GDP. This comes along with primary surpluses for the corresponding period.

8 For the data source see [OECD, 2007b].

9 For a more detailed analysis of Austria see the extensive studies by Neck and Getzner [Neck, 2001] and Haber and Neck [Haber, 2006].

Estimating equation (12) with Austrian data[10] from 1975 until 2005 yields the results shown in table (1).

	Coefficient	**Stand. error (t-stat)**	**Pr(>t)**
Constant	-0.006	0.024 (-0.241)	0.812
$b(t-1)$	0.115	0.052 (2.208)	0.039
$Soc(t)$	2.685	0.471 (5.695)	$1.44 \cdot 10^{-5}$
$int(t)$	0.274	0.144 (1.903)	0.072
$YVar(t)$	-0.804	0.542 (-1.482)	0.154
sm(t)	edf 6.083	F 6.327	p-value 0.00031
	R^2(adj): 0.841	DW: 1.88	

Table 1: Coefficients for equation (12) for Austria.

As table 1 illustrates the coefficient for public debt $b(t-1)$ is positive and significant at the 5 percent level. The estimated parameter of interest $\beta(t)$ represents the mean of this coefficient and $sm(t)$ shows the deviation from that mean over time. This allows the conclusion that for the analyzed sample the reaction coefficient has been positive on average so that sustainability of public debt is given. In addition to that, the estimation result presents a highly significant positive effect of the social security surplus on the primary surplus. The coefficient for the real interest is positive and significant at the 10 percent level. These effects imply a rise in primary surplus if the interest rate or the social security surplus increases. Further table 1 shows that the coefficients for the intercept and for the business cycle variable not statistically significant. When the estimation is done without the interest rate or without the business cycle variable, the estimated average coefficient for public debt $b(t-1)$ remains positive at the 10 percent significance level.[11]

The estimated degrees of freedom, *edf*, of $sm(t)$ provide information on possible time-dependencies. Table 1 shows for the Austrian data $edf = 6.083$ and the smooth term $sm(t)$ is significant at the 1 percent level. The goodness of fit of the model is expressed by $R^2(adj)$. For Austria with $R^2(adj) = 0.841$ a high goodness of fit is given. Applying

[10] See [OECD, 2007b], [OECD, 2007a] and [International Statistical Yearbook, 2006] for the data.
[11] Details of these estimations are available on request.

the Durbin-Watson test, it is possible to check whether the residuals are correlated. For Austria this test statistic does not show any evidence for correlation of the residuals.

The information in table 1 as concerns the smooth term shows that it varies over time and the hypothesis that it is constant can be rejected. Figure (3) illustrates the time path of the smooth term, where the two dashed lines represent the 95 percent confidence interval and the solid line shows the point estimate of the smooth term.[12] It can be realized that the reaction of the primary surplus to public debt has declined in the 1970s, before it began to rise again in the late 1990s.

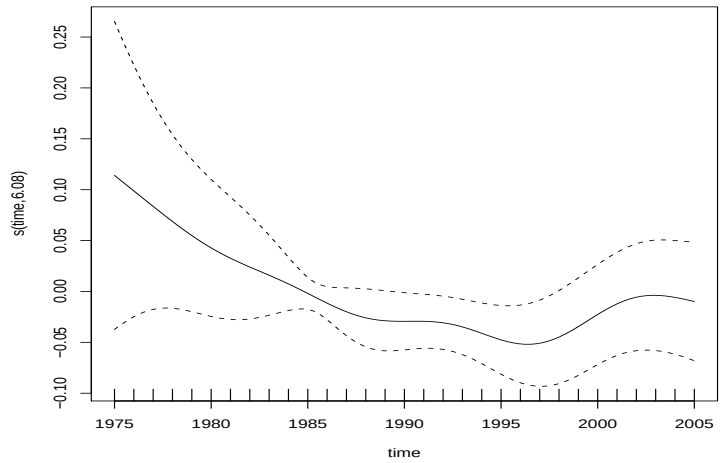

Figure 3: Deviation sm(t) from the average coefficient for $b(t-1)$ for Austria.

3.1.2 France

For France, the evolution of public debt and of the primary surplus relative to GDP are illustrated in figures 4 and 5 for the period from 1975 to 2006.[13]

Figure 4 presents the debt ratio which stays around 30 percent from 1975 until the early eighties. After that three remarkable steps of debt ratio increases are obvious. Firstly, a moderate rise in the 1980s can be observed. Then, during the nineties the

[12] See also [Wood, 2001] especially page 23.
[13] For the data source see [OECD, 2007b].

Figure 4: Public debt to GDP ratio for France (1975-2006).

Figure 5: Primary surplus to GDP ratio for France (1975-2006).

debt ratio grows rapidly with a peak in 1998 of about 70 percent, which might be due to the recession at the beginning of the 1990s. After a slight decline, possibly due to fiscal discipline in preparation of the European Monetary Union with the Convergence Criteria, the debt to GDP ratio increased again with the beginning of the new century. Except for the years around the 1980s, 1989 and the period around 2000 figure 2 shows merely primary deficits.

With a picture of the French situation in mind the sustainability test is to be applied. We estimate equation (12) with data for France for the period from 1975 to 2006.[14] Table (2) presents the results.

[14] See [OECD, 2007b] and [OECD, 2007a] for the data.

	Coefficient	**Stand. error (t-stat)**	**Pr(>t)**
Constant	-0.079	0.023 (-3.354)	0.003
$b(t-1)$	0.102	0.054 (1.882)	0.075
$Soc(t)$	1.171	0.227 (5.166)	$4.86 \cdot 10^{-5}$
$int(t)$	-0.080	0.096 (-0.830)	0.416
$YVar(t)$	0.601	0.336 (1.789)	0.089
sm(t)	edf 7.215	F 23.02	p-value $1.31 \cdot 10^{-8}$
	R^2(adj): 0.874	DW: 2.48	

Table 2: Coefficients for equation (12) for France.

Table 2 shows a positive average coefficient for public debt that, however, is significant only at the 10 percent level. Estimating the equation without the interest rate or the business cycle variable does neither change the sign of the coefficient nor its significance. The intercept is negative and significant, whereas for the coefficient of the social security surplus a highly significant and positive value is obtained. That indicates that a rise in social security surplus also goes along with an increase in the primary surplus. Further, the included real interest rate is not statistical significant but the positive coefficient for the business cycle variable is significant at the 10 percent level. This expresses the positive effect of the business cycle parameter on the primary surplus.

The deviation of the reaction coefficient from its mean, given by $sm(t)$, with $edf = 7.215$ indicates a time varying smooth term that is highly significant. As to the goodness of fit of the model, the decision criterion $R^2(adj) = 0.874$ attests a good fit. The Durbin-Watson test statistic shows no evidence of correlation of the residuals. The results in table 2 reveal that the smooth term changed over time. Figure (6) depicts $sm(t)$. Again adding together the time varying smooth parameter and the mean of the coefficient for $b(t-1)$ given in table 2 results in a positive $\beta(t)$, which allows the conclusion from the results of the estimation that the primary surplus ratio raised in response to a growing debt ratio.

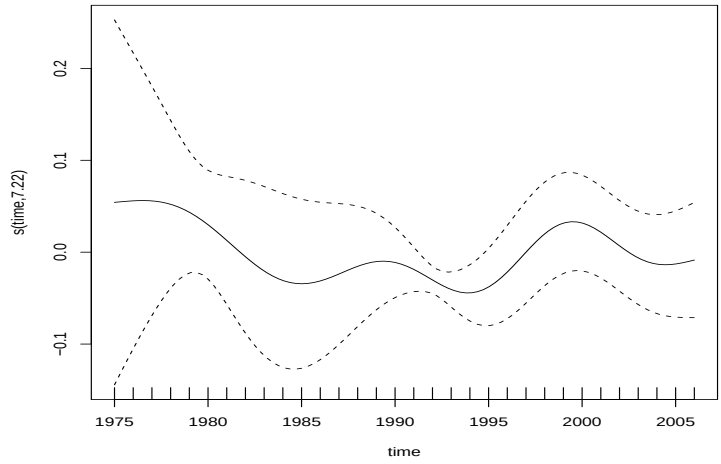

Figure 6: Deviation sm(t) from the average coefficient for $b(t-1)$ for France.

3.1.3 Germany

Figures 7 and 8 show the evolution of German public debt and of the primary surplus relative to GDP for the period from 1971 to 2006.[15]

As figure 7 shows, Germany has suffered from high debt ratios since the middle of the 1970s. There are three major sections of debt ratio growth. First, in the mid-seventies until the late 1980s the debt ratio increased, which might have been due to the oil crisis and its aftermath and the following recession. That period is characterized by persistent primary deficits as picture 8 shows. After that the time up to 1990 was characterized by fiscal discipline with a declining debt ratio and primary surpluses. After German unification until the beginning of the new century another rapid increase in the debt ratio can be observed bringing that ratio from around 40 percent up to more than 60 percent. This comes along with primary deficits. The next increase starts in 2002 with a maximum of 71.3 percent of the debt ratio in 2006. The primary balance shows deficits for this period.

[15] For the data source see [OECD, 2007b]. Please note that until 1990 data for Western Germany and with 1991 data for entire Germany is used.

Figure 7: Public debt to GDP ratio for Germany (1971-2006).

Figure 8: Primary surplus to GDP ratio for Germany (1971-2006).

	Coefficient	**Stand. error (t-stat)**	**Pr(>t)**
Constant	-0.061	0.016 (-3.778)	0.0008
$b(t-1)$	0.145	0.049 (2.972)	0.006
$Soc(t)$	1.995	0.352 (5.674)	$4.99 \cdot 10^{-6}$
$int(t)$	0.192	0.117 (1.694)	0.111
$YVar(t)$	-0.523	0.243 (-2.154)	0.040
sm(t)	edf 3.977	F 4.28	p-value 0.0020
	R^2(adj): 0.712	DW: 2.11	

Table 3: Coefficients for equation (12) for Germany.

Estimating equation (12) with German data for the years from 1971 to 2006[16] gives results as shown in table (3).

The coefficient of interest for public debt $b(t-1)$ is positive and significant at the 1 percent level. Again, this gives the mean of the coefficient for the time period under consideration so that we can conclude that German fiscal policy has followed a sustainable path. This also holds if the equation is estimated without the interest rate or without the business cycle variable. The intercept shows a negative sign and is highly significant. The

[16] See [OECD, 2007b], [OECD, 2007a] and [International Statistical Yearbook, 2007] for the data.

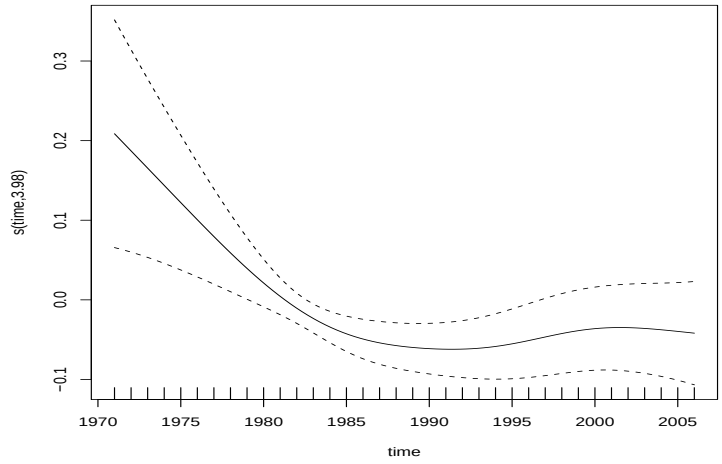

Figure 9: Deviation sm(t) from the average coefficient for $b(t-1)$ for Germany.

business cycle has a negative sign suggesting that the government pursues a pro-cyclical fiscal policy, whereas the coefficient for the social security surplus ratio shows a positive sign and is highly significant. For the real interest rate no significant effect can be noticed.

Again, the variable $sm(t)$ gives the deviation of the coefficient for the debt ratio. Its estimated degrees of freedom are calculated with $edf = 3.977$. This smooth term with a p-value of 0.0020 is significant at the 1 percent level. Concerning the goodness of fit of the model $R^2(adj) = 0.721$ shows a high value and the Durbin-Watson test statistic $DW = 2.11$ shows no evidence for autocorrelation. These results lead to the conclusion that the coefficient for the debt ratio has not been constant for the observed period.

Figure (9) displays the path of the deviation from the mean of the reaction coefficient. In combination with the value given in table 3 this picture shows that the time varying coefficient $\beta(t)$, that is given by the mean and the deviation from that mean, has been strictly positive for the years from 1971 until 2006.

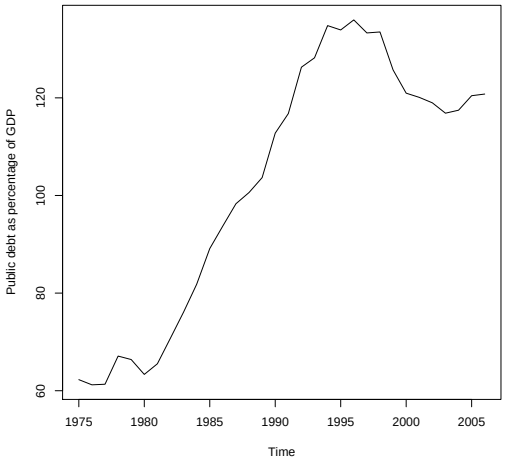

Figure 10: Public debt to GDP ratio for Italy (1975-2006).

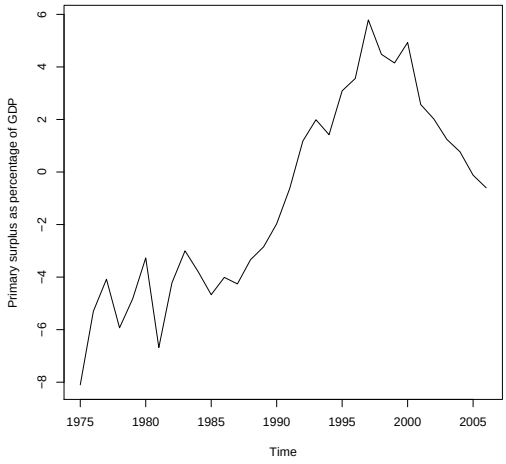

Figure 11: Primary surplus to GDP ratio for Italy (1975-2006).

3.1.4 Italy

Within Europe the Italian public debt situation is one of the most challenging. As depicted in figure 10, Italy faces an extraordinary high public debt to GDP ratio. For the estimation, again general government gross financial liabilities as percentage of GDP and the primary surplus relative to GDP for the years 1975 to 2006 are used.[17]

Figure 10 shows that starting at an initial value of about 60 percent the Italian debt ratio rapidly grew from the early eighties until the middle of the 1990s. It almost doubled to about 130 percent in the middle of the 1990s. The primary balance ratio in figure 11 shows permanent deficits until the early nineties. That changed for the years from 1992 until 2004, when surpluses could be realized. With the European Monetary Union ahead and the attained surpluses, a reduction in the debt ratio can be observed from 1997 onwards, although since 2004 the debt ratio started growing again accompanied by primary deficits.

[17] For the data see [OECD, 2003] and [OECD, 2007b]. The debt ratio data is taken from the first source until 1998 and from the second source from 1999 on.

Estimating equation (12) for the years from 1975 to 2006[18] gives results as shown in table (4).

	Coefficient	**Stand. error (t-stat)**	**Pr(>t)**
Constant	-0.124	0.048 (-2.594)	0.017
$b(t-1)$	0.121	0.051 (2.382)	0.027
$Soc(t)$	0.934	0.361 (2.591)	0.017
$int(t)$	0.118	0.126 (0.939)	0.358
$YVar(t)$	0.648	0.196 (3.306)	0.003
sm(t)	edf 5.387	F 7.67	p-value $5.42 \cdot 10^{-5}$
	R^2(adj): 0.957	DW: 2.16	

Table 4: Coefficients for equation (12) for Italy.

The estimated mean of the parameter for the debt ratio is significantly positive at the 5 percent level which also holds when estimated without the interest rate or without the business cycle variable. Hence, in spite of the strongly rising debt ratio in the 1970s and 1980s, Italian fiscal policy would be sustainable. Besides the intercept, the coefficients for the social security surplus and for the business cycle variable have a positive sign and are statistically significant while the parameter for the real interest rate is not significant.

Again, $sm(t)$ measures the deviation from the mean of the coefficient for the public debt ratio. The estimated degrees of freedom for the smooth term are given with $edf = 5.387$ and a high significance is shown for it in table 4. Evidently, the model fits quite good based on $R^2(adj) = 0.957$. The Durbin-Watson test statistic does not suggest that the residuals are correlated.

The time path $sm(t)$ is shown in figure (12). The sum of the mean of the coefficient and the score of the smooth parameter is strictly positive for the entire sample period. These results imply that the Italian primary surplus ratio has increased with a growing debt to GDP ratio.

[18] See [OECD, 2007b], [OECD, 2007a] and [OECD, 2003] for the data.

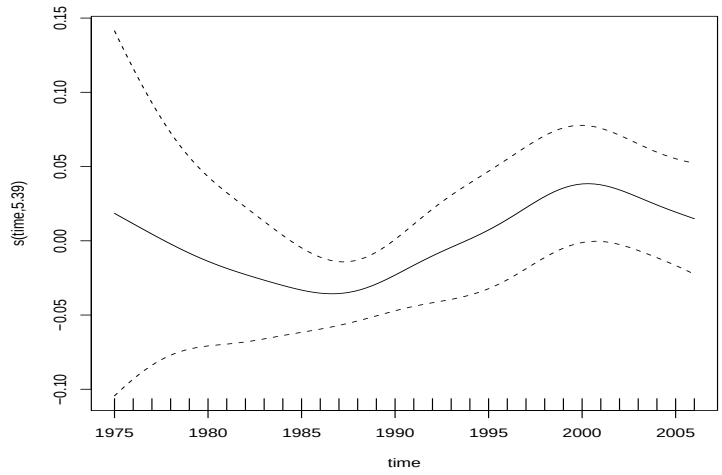

Figure 12: Deviation sm(t) from the average coefficient for $b(t-1)$ for Italy.

3.1.5 The Netherlands

The public debt situation of the Netherlands is illustrated in figures 13 and 14. For the data the information on general government gross financial liabilities as percentage of GDP and the primary surplus relative to GDP for the years from 1980 until 2006 is used.[19]

The graph in figure 13 shows a fast growing debt to GDP ratio in the early eighties that stays around 85 percent from the middle of the 1980s to the middle of the 1990s with a peak in 1993 of 93.7 percent. A possible reason for this might be the aftermath of the second oil crisis. The primary balance in figure 14 shows deficits from 1986 onwards. That trend changed in 1991 to surpluses. A sharp decline in the debt ratio can be observed starting around 1996. The ratio dropped to a level of 59.4 percent. Except for 2003 only surpluses are shown, that are well above the average value for the period with the abrupt fall in debt to GDP ratio. This might explain the fast reduction.

Next we implement the sustainability test on the Dutch data. Equation (12) is esti-

[19] For the data see [OECD, 2007b].

Figure 13: Public debt to GDP ratio for the Netherlands (1980-2006).

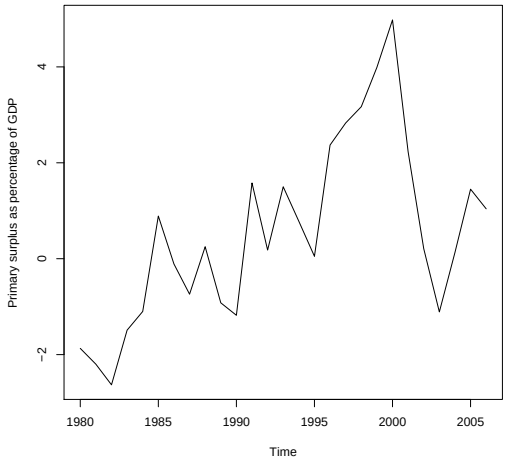

Figure 14: Primary surplus to GDP ratio for the Netherlands (1980-2006).

mated for the period from 1980 to 2006.[20] Table (5) shows the results.

	Coefficient	**Stand. error (t-stat)**	**Pr(>t)**
Constant	-0.064	0.018 (-3.614)	0.002
$b(t-1)$	0.110	0.022 (4.908)	$7.45 \cdot 10^{-5}$
$Soc(t)$	0.311	0.202 (1.544)	0.137
$int(t)$	-0.403	0.290 (-1.388)	0.180
$YVar(t)$	0.925	0.741 (1.248)	0.226
sm(t)	edf 1	F 0.188	p-value 0.669
	R^2(adj): 0.709	DW: 1.51	

Table 5: Coefficients for equation (12) for the Netherlands.

In table 5 the estimated coefficient for the public debt ratio is positive and significant at the 0.1 percent level. This does not change when the model is estimated without the interest rate or without the business cycle variable. Further, the outcome does not change when the model is estimated with a linear approach, since the smooth parameter, with $edf = 1$, shows no evidence for a change over time.[21] Further table 5 shows significance

[20] See [OECD, 2007b] and [OECD, 2007a] for the data.

[21] In that case the estimation is performed with *lm* in R (Version 2.5.0). See appendix A.

Figure 15: Public debt to GDP ratio for Portugal (1978-2006).

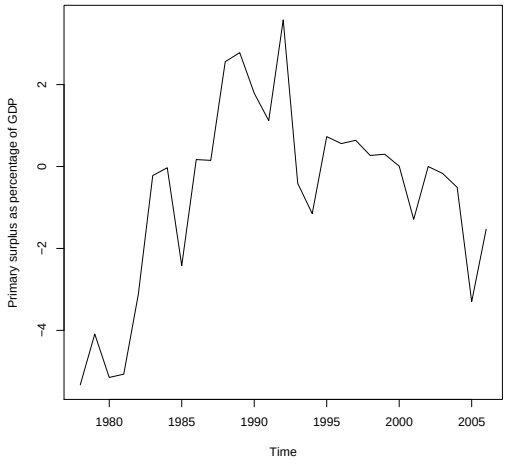

Figure 16: Primary surplus to GDP ratio for Portugal (1978-2006).

of the intercept with a negative sign. As concerns the other parameters, both the social surplus ratio and the business cycle variable are associated with a positive coefficient while for the real interest rate a negative parameter is obtained. But neither of the coefficients is statistically significant. Regarding the goodness of fit $R^2(adj) = 0.709$ indicates a good fit. With the Durbin-Watson test statistic of $DW = 1.51$ no statement relating to autocorrelation of the residual can be made.

3.1.6 Portugal

For Portugal figures 15 and 16 show the public debt and primary balance position for the years from 1978 to 2006.[22]

In figure 15 a sudden rise in the debt to GDP ratio begins with the early 1980s. As shown in figure 16, until 1986 merely primary deficits relative to GDP were realized. Around 1990, the debt ratio remained around 60 percent. This period is accompanied by positive primary surplus ratios. Another episode of debt ratio increase begins in the

[22] See [OECD, 2003] and [OECD, 2007b] for the data. The debt ratio data is taken from the first source until 1995 and from the second source from 1996 on.

	Coefficient	**Stand. error (t-stat)**	**Pr(>t)**
Constant	-0.073	0.026 (-2.821)	0.0097
$b(t-1)$	0.125	0.047 (2.647)	0.014
$Soc(t)$	0.811	0.375 (2.162)	0.041
$int(t)$	0.039	0.118 (0.330)	0.744
$YVar(t)$	0.455	0.295 (1.544)	0.136
sm(t)	edf 1	F 0.041	p-value 0.842
	R^2(adj): 0.798	DW: 2.01	

Table 6: Coefficients for equation (12) for Portugal.

middle of the 1990s. After that the debt ratio declines. With the beginning of the new century the public debt to GDP ratio grows again, which comes along with primary deficit ratios.

We estimate equation (12) for Portugal for the years from 1978 to 2006.[23] The results are summarized in table (6).

As for the Dutch estimation results in table 5, for Portugal the estimated coefficient of the debt ratio is significant and there seems to be no evidence for a change in that coefficient over time. If a linear approach for the estimation is used, the parameter for the debt ratio remains positive and is significant at the 0.1 percent level.[24] Again, this result is independent of whether the interest rate or the business cycle variable is included or not. Further, the intercept and the social security surplus ratio are positive and statistically significantly correlated with the primary surplus to GDP ratio. This remains valid when a linear approach is estimated. The coefficients for the real interest rate and for the business cycle variable are positive but insignificant. With $R^2(adj) = 0.798$ the fit is relatively good and the Durbin-Watson test statistic shows no evidence for autocorrelation. Based on these empirical results there is evidence that the primary surplus ratio increases as the public debt ratio rises.

[23] See [OECD, 2003], [OECD, 2007b] and [OECD, 2007a] for the data.

[24] In that case, the estimation is performed with *lm* in R (Version 2.5.0). See also the appendix A.

3.2 Analysis of the deficit inclusive of interest payments

In the last section we tested how the primary surplus relative to GDP reacts to variations in the debt ratio. We found that in all countries the primary surplus to GDP ratio is a positive function of the debt ratio to GDP. However, all debt ratios are increasing over time, except for the Netherlands.

Therefore, we want to get additional insight into the question of whether debt policies in the euro area are sustainable by looking at stationarity properties of the deficit inclusive of interest payments. To get the real deficit inclusive of interest payments, we first divide public debt by the GDP deflator, $B_n(t)/P(t) = B(t)$ and, then, we calculate first differences of this series, which gives the real budget deficit or the deficit inclusive of interest payments, $B(t) - B(t-1) = \Delta B(t) = DEF(t)$. The plots of these series are given in appendix B.

As proposed by Trehan and Walsh [Trehan, 1991] we check if the deficit inclusive of interest payments is a stationary process which is sufficient for the inter-temporal budget constraint to hold, provided the time varying interest rate is positive on average which is the case for the euro area countries under consideration.

One possibility to test for stationarity of a time series is to resort to unit root tests if it fluctuates around a constant mean and returns to that mean after a finite period of time. For our approach we resort to the augmented Dickey-Fuller test.[25] The null hypothesis states that a time series contains a unit root, whereas the alternative hypothesis indicates that the series is a stationary process. Starting point of the analysis is an autoregressive process of the form,

$$y_t = \beta_1 y_{t-1} + \epsilon_t. \tag{13}$$

Here it is of interest whether $\beta_1 = 1$ that indicates a non-stationary process or whether $\beta_1 < 1$ that would imply a (weak) stationary process.[26] For testing with Dickey-Fuller y_{t-1}

[25] See for example [Enders, 1995] pages 221 et seqq. .

[26] The possible case $\beta_1 > 1$ is neglected here.

is subtracted from both sides of equation (13) to get the difference, that is $\Delta y_t = \pi y_{t-1} + \epsilon_t$ with $\pi = \beta_1 - 1$. That substantiates the hypotheses to:

$$H_0 : \pi = 0 \quad \text{versus} \quad H_1 : \pi < 0.$$

Further, three different types of regression models are specified:

$$\Delta y_t = \pi y_{t-1} + \epsilon_t, \tag{14}$$

$$\Delta y_t = \beta_0 + \pi y_{t-1} + \epsilon_t, \tag{15}$$

$$\Delta y_t = \beta_0 + \pi y_{t-1} + \beta_2 t + \epsilon_t, \tag{16}$$

which express the regression without drift and trend (14), the regression with only a drift (15) and the model with both drift and trend (16). The choice of the type of model depends on the data generating process, which is mostly unknown, but there is a guideline for the model selection, which is described for example in [Enders, 1995] or in [Pfaff, 2006].[27]

To be sure that the residuals possess the White Noise characteristics, the augmented Dickey-Fuller test includes lagged endogenous regressor variables to account for the problem of possible autocorrelation in the residuals. Thus, equations (14), (15) and (16) change to:

$$\Delta y_t = \pi y_{t-1} + \sum_{j=1}^{k} \gamma_j \Delta y_{t-j} + \epsilon_t, \tag{17}$$

$$\Delta y_t = \beta_0 + \pi y_{t-1} + \sum_{j=1}^{k} \gamma_j \Delta y_{t-j} + \epsilon_t, \tag{18}$$

$$\Delta y_t = \beta_0 + \pi y_{t-1} + \beta_2 t + \sum_{j=1}^{k} \gamma_j \Delta y_{t-j} + \epsilon_t, \tag{19}$$

For the correct estimation the appropriate amount of lags k is to be determined and the

[27] See especially [Enders, 1995] pages 254 to 258 and [Pfaff, 2006] pages 27 et seqq. .

	Aug. Dickey-Fuller	**Est. model type**
Austria	-4.78***	Trend and Drift,Lags: 1
France	-3.27*	Trend and Drift,Lags: 2
Germany	-3.71**	Trend and Drift,Lags: 3
Italy	-1.07	None,Lags: 1
The Netherlands	-4.64***	Trend and Drift,Lags: 0
Portugal	-6.30***	Trend and Drift,Lags: 0
H_0 is rejected at	***(1% level)	**(5% level) *(10% level)

Table 7: Unit root test results for the selected countries.

suitable model type for the data needs to be specified. Below, this process is assigned to the deficit series and used to analyze the data for the selected countries.

Table 7 shows the results on testing for unit roots with the augmented Dickey-Fuller Test.[28]

Concerning the appropriate estimation we first checked how many lags are necessary to obtain a model that shows no autocorrelation in the residuals. For the choice of the lag length, the *general-to-specific* method is used, i.e. the individual model is estimated with a relative high number of lags, that is gradually reduced until the t-statistic on the last lag is significant.[29] Further, this lag length is judged based on the autocorrelation and partial autocorrelation function of the residuals as well as on the Box-Ljung test in order to strengthen the decision on the number of lags.

Moreover, staying close to the model type selection guideline mentioned above, we first of all estimated all models in the least restrictive way, that is inclusive of a trend and a constant. If the computed test statistic value is smaller than the $\hat{\tau}$ critical value[30] it is sufficient to stop the analysis at this point and accept H_1 that there is no unit root

[28] All tests are performed with the package *urca* in R (Version 2.5.0). See [OECD, 2007b], [OECD, 2003], [International Statistical Yearbook, 2006] and [International Statistical Yearbook, 2007] for the data. The time period of the estimations above is retained. Concerning Germany's deficit until 1990 data for Western Germany is used. For Italy and Portugal the change of source is after 1998 and 1995. For the critical values see for example [Fuller, 1976] Table 8.5.2 on page 373 or [Enders, 1995] Table A on page 419.

[29] See for example [Enders, 1995], especially pages 226 et seqq. and [Pfaff, 2006], especially page 27.

[30] See for example [Fuller, 1976] Table 8.5.2. on page 373.

indicating that the analyzed time series is a stationary process.[31] This is possible for the deficit series inclusive of interest payments for Austria, France, Germany, the Netherlands and Portugal.

In case of Italy the H_0 hypothesis $\pi = 0$ cannot be rejected. Hence, it needs to be checked, if a trend is actually at hand. Therefore, it is to test if $\beta_2 = 0$ given $\pi = 0$. This is possible with an F-test related statistic ϕ_3. If the computed test statistic value is larger than the critical value[32] the alternative hypothesis is accepted, that the restriction is binding. Estimating with a trend, an intercept and one lag for Italy, we get $\phi_3 = 1.78$, which is smaller than the critical value at the 10% level (5.61 for 50 observations, 5.91 for a sample size of 25). Consequently, the regression without the trend but only an intercept is estimated. Again, the H_0 Hypothesis $\pi = 0$ cannot be rejected. For that reason it needs to be checked if the intercept term is significant, $\beta_0 = 0$ given $\pi = 0$ with the ϕ_1 statistic. $\phi_1 = 1.47$, so H_0 cannot be rejected (critical value at 10% is 3.94 for 50 and 4.12 for 25 observations) for Italy. Finally, the equation with neither an intercept nor a trend variable, equation (17), needs to be estimated. This results in a test statistic of -1.07 compared with the 10% critical value of $\hat{\tau} = -1.61(-1.60)$ for a sample size of 50 (25). Hence, it is possible to conclude that for the Italian budget deficit series the hypothesis of containing a unit root cannot be rejected.

However, looking at the series of the Italian deficit it can be realized that it is extremely oscillating. Figure 17 shows a simple p-spline estimation giving Italian public deficit as a function of time, where the average is normalized to zero. The estimation suggests that there is a positive trend in the deficit during the 1980s and a negative trend in the 1990s. Hence, the fact that the Italian budget deficit is not stationary should not be misinterpreted that it is characterized by a positive trend throughout the sample period.

[31] See also [Enders, 1995] Figure 4.7 on page 257 and [Pfaff, 2006] Figure 2.3 on page 29.

[32] The critical values for the ϕ_1, ϕ_2, ϕ_3 are for example given in [Dickey, 1981] table IV, V, VI on page 1063.

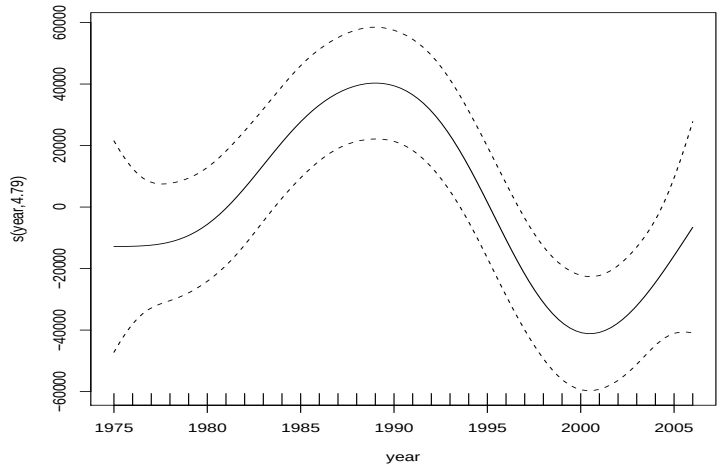

Figure 17: Italian budget deficit as a function of time.

Summarizing the results of this section, table 7 shows that the null hypothesis of containing a unit root is rejected in almost all cases for suitable significance levels. These test results indicate that the series of the budget deficit inclusive of interest payments are stationary processes.[33] These findings are consistent with the results from the estimations above using the regression approach. It implies that for the countries under consideration the inter-temporal budget constraint holds and they act in a sustainable way, although they show high or growing debt ratios and budget deficits.

4 Conclusion

In this paper we have analyzed whether selected countries of the euro area have followed sustainable debt policies over the last 30 years. We did this by analyzing the reaction of the primary surplus to GDP ratio to variations in the debt to GDP ratio which is a powerful test. However, we also argued that a positive reaction does not guarantee that the debt ratio remains bounded which is necessary for a sustainable policy in the long-run,

[33] Additionally, the Phillips-Perron test can be applied. If the application is possible, it confirms the above stated outcomes for the selected countries.

unless the government becomes a lender. Therefore, we also tested for stationarity of the public deficit inclusive of interest payments in order to gain additional insight.

Our results suggest that three different groups can be distinguished. First, the Netherlands have undergone substantial economic reforms in the 1980s that also stabilized public debt. The Netherlands is the only country with a declining debt ratio and clearly follows a sustainable debt policy. The second group of countries consists of Austria, Germany and Portugal. Although these countries have experienced rising debt ratios over the period under consideration both types of tests suggest that these governments have followed sustainable policies. Finally, France and Italy seem to pursue sustainable debt policies, too. But for France, the statistical significance of the estimation results is clearly smaller than for the countries of the second group. Italy is characterized by strongly oscillating public deficits that first rise and then decline.

Comparing our study with other studies in the literature (for a survey see Afonso [Afonso, 2005]) one realizes that earlier studies that performed time series analysis with respect to the series of public debt or discounted debt rather favoured the conclusion that debt policies in Europe are not sustainable. More recent studies, in particular those that test how the primary surplus reacts to public debt, tend to conclude that debt policies are sustainable. This may be due to the methodology applied but it may also be the result of stabilization policies in Europe in the late 1990s.

But it should be noted that there are additional aspects that have to be considered. Sustainability of debt policy in the past does not necessarily lead to sustainable future fiscal policies. Due to the decline of the European population, the burden of debt service for future generations can become a severe problem if public debt will not be effectively reduced in the near future. Therefore, primary surpluses are required to reduce the public debt, which needs higher revenues or a cut in spending. For the countries analyzed in this study a reduction of productive public spending for the time period under consideration can be observed, that is all of them face a decrease in public investment, which is illustrated

in appendix C. In some cases now it is less than half of the initial value of the period considered. All in all, although sustainable fiscal policies seem to be given, for politicians this result rather should be a challenge or a chance for the future than an evidence for relief and settling back at the moment.

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A Estimation results with linear models

Tables 8 and 9 present the results of equation (12) for the Netherlands and Portugal if a linear model is assumed. They are estimated in R (Version 2.5.0) with function *lm*.

The Netherlands

	Coefficient	**Stand. error (t-stat)**	**Pr(>t)**
Constant	-0.061	0.016 (-3.822)	0.0009
$b(t-1)$	0.110	0.022 (5.038)	$4.81 \cdot 10^{-5}$
$Soc(t)$	0.350	0.178 (1.967)	0.062
$int(t)$	-0.500	0.182 (-2.740)	0.012
$YVar(t)$	0.723	0.564 (1.280)	0.214
	R^2(adj): 0.720	DW: 1.51	

Table 8: Estimation results for the Netherlands.

Portugal

	Coefficient	**Stand. error (t-stat)**	**Pr(>t)**
Constant	-0.069	0.017 (-4.135)	0.0004
$b(t-1)$	0.117	0.027 (4.409)	0.0002
$Soc(t)$	0.826	0.361 (2.288)	0.031
$int(t)$	0.044	0.112 (0.393)	0.698
$YVar(t)$	0.482	0.258 (1.872)	0.074
	R^2(adj): 0.807	DW: 2.02	

Table 9: Estimation results for Portugal.

B Budget deficits

These graphs show the real public deficit inclusive of interest payments in millions of euro (of the year 2000) of the selected countries, where the same period is considered as for the estimations.[34]

[34] See [OECD, 2007b], [OECD, 2003] and [International Statistical Yearbook, 2006] and [International Statistical Yearbook, 2007] for the data. Concerning Germany's deficit until

Figure 18: Budget deficit for Austria.

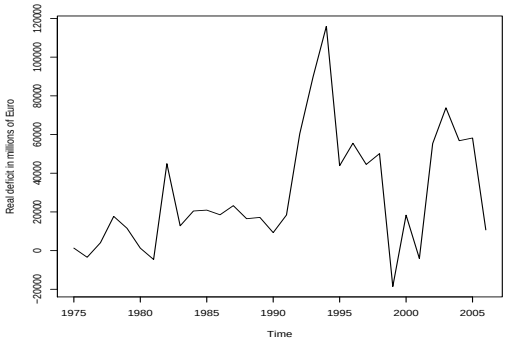

Figure 19: Budget deficit for France.

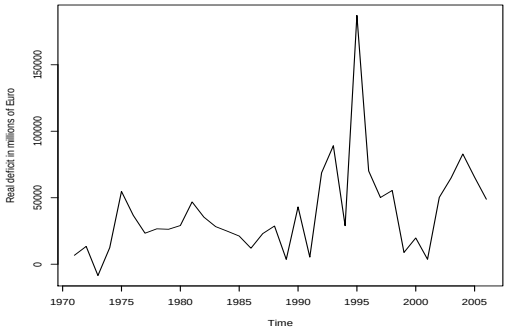

Figure 20: Budget deficit for Germany.

Figure 21: Budget deficit for Italy.

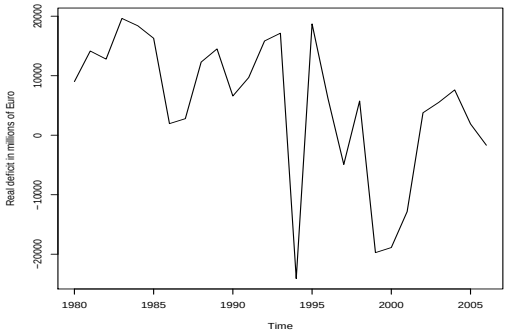

Figure 22: Budget deficit for the Netherlands.

Figure 23: Budget deficit for Portugal.

1990 data for Western Germany is used. For Italy and Portugal the change of source is after 1998 and 1995. The outlier in the German deficit in 1995 is due to the take-over of the debt of the Treuhandanstalt and of the former East German housing sector by the public sector.

C Public spending

The following figures give public investment expenditures relative to GDP for the countries in our sample[35].

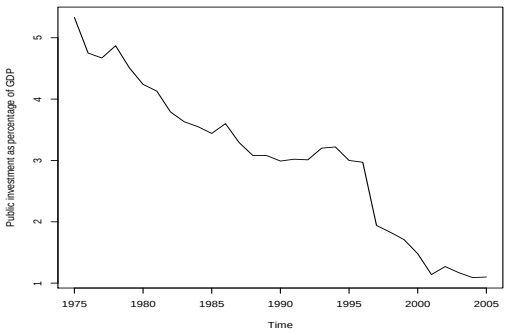

Figure 24: Public investment expenditures relative to GDP for Austria.

Figure 25: Public investment expenditures relative to GDP for France.

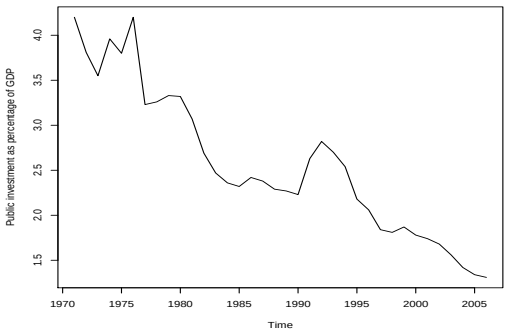

Figure 26: Public investment expenditures relative to GDP for Germany.

Figure 27: Public investment expenditures relative to GDP for Italy.

[35] See [OECD, 2007b] and [OECD, 2007a] for the data. Public investment is measured as government fixed capital formation. Concerning Germany's public investment until 1990 data for Western Germany and from 1991 on for entire Germany is used.

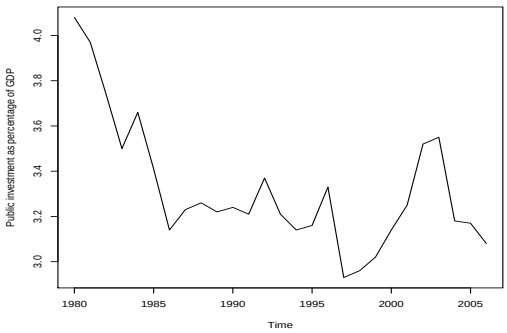

Figure 28: Public investment expenditures relative to GDP for the Netherlands.

Figure 29: Public investment expenditures relative to GDP for Portugal.