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Budgetary Constrained Governments: Drivers of Time Varying Fiscal Sustainability in OECD Countries

Abstract

We assess the drivers of fiscal sustainability in 20 OECD economies between 1950 and 2019. We find stable long-term relationships between government revenues and expenditures as well as between the primary budget balance and past public debt ratio for the full panel. Performing an expanding window analysis, we conclude that the differential between the long-term real interest rate and the real GDP growth rate (*r-g*) plays a crucial role in fiscal sustainability, as well as the existence of fiscal rules in terms of the budget balance, and also the output gap. The effects of inflation, external accounts balance and fiscal rules on sustainability coefficients à la Hakkio and Rush (1991) and Bohn (1998) are heterogenous. Furthermore, before the global financial crisis of 2008, the effects of the (*r-g*) differential were particularly strong, and depended on its sign as well as on past debt-to-GDP ratios.

JEL-Codes: C230, H610, H630, E620.

Keywords: fiscal sustainability, primary budget balance, public debt, panel data, expanding window, fiscal rules.

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1. Introduction

The sustainability of public finances is one of the fundamental elements of macroeconomic stability, and even of economic growth. The study of the existence of a stable long-term relationship between government revenues and expenditures (Hakkio and Rush, 1991) and the analysis of the response of the primary government budget balance to changes in the past debt-to-GDP ratio (Bohn, 1998) makes it possible to ascertain fiscal solvency of a particular economy as well as a panel of countries. From a theoretical point of view, if the intertemporal government budget constraint (IGBC) holds in present value terms, fiscal sustainability is assured.

In the empirical literature, some studies analyse this topic taking a long time horizon. For instance, Afonso and Jalles (2014) study fiscal sustainability for 19 economies between 1880 and 2009. Mauro and Zhou (2021), in turn, investigate the importance of the (*r-g*) differential in 55 countries over 200 years. Iorio and Fachin (2021) ascertain the existence of long-run fiscal reaction functions for 22 advanced economies between 1961 and 2019. On the other hand, Caselli *et al.* (2022) highlight the role of fiscal rules for the solvency of public finances, and European Commission (2022) addresses the relevance of interest rate-growth differentials as well as fiscal rules.

The aim of the article is to examine the topic of fiscal sustainability for 20 OECD countries in a long-time span (between 1950 and 2019), taking fiscal variables data from Mauro (2013)'s Historic Public Finance Dataset and using a panel framework. This analysis is justified, since, after the Second World War, and throughout the second half of the 20th century, OECD countries, and in particular the European Union countries, strengthened economic and financial links, integrated their capital markets and benefited from joint spillover effects, reinforcing institutional, economic and financial cross-section dependencies.

In this context, we empirically resort to the cointegration tests by Pedroni (2004) and Westerlund (2007) and the fully modified OLS (FMOLS) to investigate the existence of a panel and country-by-country cointegration relationships between government revenues and expenditures and between the primary government balance and the past public debt. In addition, we estimate time-varying responses of the government revenues to changes in the government expenditures and of the primary government balance to changes in lagged debt ratios. Among the explanatory factors of these marginal responses that we take as relevant emerge the fiscal rules (information taken from the IMF Fiscal Rules Dataset 1985-2021). Another crucial element in the analysis is the inclusion of the differential between the long-term real interest rate and the real GDP growth rate, the so-called (*r-g*) differential. We assume as a hypothesis

that this differential is a determining factor for the sustainability of public accounts since fiscal policy is not exogenous to the interest rate and economic growth. In fact, considering the dynamics of government debt, the coordinated interaction between the (r-g) differential and the primary government balance ensures the relative stabilization of the debt ratio, and, therefore, fiscal solvency.

From a point of view of the fiscal policy maker, it is relevant to monitor the evolution of the relationship between the long-term interest rate and the GDP growth rate, given that fiscal sustainability crucially depends on the (r-g) differential and policies of relative public debt stabilization will be more successful if the differential is favourable. Indeed, if (r-g) < 0 the differential is favourable, i.e., if the snowball effect is negative, and the fiscal authorities will have to carry out a smaller fiscal adjustment in order to reduce the debt-to-GDP ratio. Conversely, if (r-g) > 0, hence unfavourable, i.e., if the snowball effect is positive, the fiscal effort will have to be higher. Furthermore, the compliance with fiscal rules facilitates the objective of achieving a sustainable path for public finances.

Briefly, for 20 OECD countries, and for a long time span, between 1950 and 2019, we find that: the output gap improves fiscal sustainability; the inflation rate negatively influences the fiscal sustainability coefficients à la Hakkio and Rush (1991); the current account balance increases fiscal sustainability coefficients à la Bohn (1998); the existence of budget balance fiscal rules benefits fiscal sustainability; the validity of fiscal rules differ somewhat between approaches; and the differential between the long-term real interest rate and the real GDP growth rate (r-g) has a crucial role in fiscal sustainability.

The remainder of the paper is organised as follows. Section 2 presents a brief literature review. Section 3 explains the empirical strategy. Section 4 describes the data and reports and discusses the empirical results. Section 5 concludes.

2. Literature

The issue of fiscal solvency has been investigated, both from a theoretical and empirical point of view. The first analyses were carried out for developed countries, and, in particular, OECD and European Union economies, with countries taken individually or in a panel framework (Hamilton and Flavin, 1986; Trehan and Walsh, 1991; Olekalns, 2000; Hatemi, 2002; Afonso, 2008). Analyses for individual countries include unit root tests on public revenues and expenditures series, primary budget balance and lagged government debt, and cointegration and causality between pairs of variables. In turn, panel studies also have included unit root tests, cointegration and causality as well as the estimation of fiscal reaction functions.

For OECD economies, while Camarero *et al.* (2015) and Afonso and Jalles (2016) perform country-by-country assessments, Afonso and Jalles (2015), Beqiraj *et al.* (2018) and Everaert and Jansen (2018) carry out studies in a panel setup.

Afonso and Rault (2015) mention that notably in the context of 27 European Union (EU) countries seeking to pursue sound fiscal policies within the framework of the Stability and Growth Pact, cross-country dependence can be envisaged. Indeed, that can be the case either in the run-up to the EMU or via integrated financial markets. Cross-country spillovers in government bond markets are to be expected, and interest rates co-movements inside the EU have also gradually become more noticeable. For the period 1960-2012, they find that while public finances were not unsustainable for the EU panel, fiscal sustainability is an issue in most countries, with a below unit estimated coefficient of expenditure in the cointegration relation with government revenues.

For a sample of 28 EU countries between 1995 and 2021, and using quarterly data, Afonso *et al.* (2021) estimate panel fiscal reaction functions, introducing the differential between the long-term real interest rate and the economic growth rate into the analysis. The authors conclude that if it that differential is positive, improvements in the primary government balance result in greater decreases in the public debt ratio. Albeit, when the differential is negative, this effect disappears.

In addition, Afonso *et al.* (2023) using a sample of industrialized OECD countries in the period between 1981 and 2021, estimate the time-varying fiscal reaction function and find that higher inflation contributes to an increased level of fiscal sustainability; the difference between interest rate and GDP growth rate has a negative effect on fiscal sustainability; and core inflation and food inflation also have a positive effect on fiscal sustainability.

3. Methodological Framework

3.1. Debt dynamics

The sustainability of public finances and the respective debt dynamics, depend on the primary balance and on the difference between the long-term real interest rate and the real GDP growth rate, the so-called (*r-g*) differential. In order to better illustrate such dynamics, we can consider the usual government budget constraint, which can be written along the lines of notably Buiter (1985), as in (1):

$$\Delta b = (x - \rho) + b(r - g)\,, \tag{1}$$

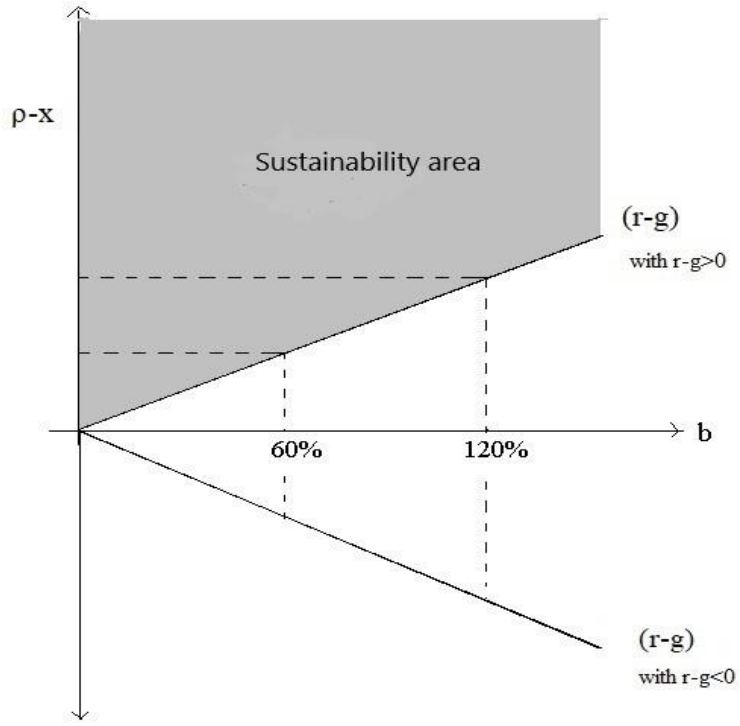
where *b* is the debt-to-GDP ratio, *x* is the primary government spending-to-GDP ratio, ρ is the government revenue-to-GDP ratio, *r* is the long-term real interest rate and *g* is the real economic growth rate. Therefore, in order to stabilise the debt ratio, Δb=0, from (1) we get:

$$b(r-g)=(\rho-x), \tag{2}$$

and the explosive path of the debt ratio would arise when $r > g$, ceteris paribus.

In Figure 1, equation (2) is represented with the primary balance as a percentage of GDP on the ordinate axis, the debt ratio on the abscissa axis and the difference between the real interest rate and the real growth of the economy being the slope of the straight line that delimits the sustainability area. The straight line with a positive slope is obtained when the real interest rate is higher than the real growth of the economy and, in this case, the primary balance must always be positive in order to ensure compliance with the condition $(\rho-x)\geq(r-g)b$. However, when it turns out that the real interest rate is lower than real GDP growth, $r\text{-}g < 0$, then it may be the case that the primary balance is negative and, even so, the previous condition is met, being in this case the sustainability area located to the right and upwards of the straight line with the negative slope (Pasinetti, 1998, provides a related illustration and discussion).

Figure 1 – Fiscal sustainability area (% of GDP)



Source: Authors'. For example, with a real GDP growth rate of 2.5 percent, a real interest rate of 5 percent and a debt-to-output ratio of 60 percent, the area of sustainability for the primary balance would then be, at this example, delimited by $(\rho-x)\geq(5-2.5)\times 0.6\geq 1.5$.

3.2. Cointegration and expanding window analysis

We implement the panel cointegration tests of Pedroni (2004) and Westerlund (2007), in order to find a cointegration relationship between government revenues and expenditures and the primary government balance and lagged public debt. The panel cointegration tests of Pedroni (2004) are a set of seven residual-based tests that assumes the null hypothesis of non-cointegration in heterogenous panels with one or more non-stationary regressors. The estimated tests admit heterogeneity in cointegration vectors and the dynamics of the underlying errors process across the cross-sectional units are estimated as residual tests. Nevertheless, these tests do not consider structural breaks in the cointegration relationship and cross-sectional dependence. There are two classes of statistics. The first (with four statistics) is based on pooling the residuals of the regression along the within-dimension of the panel. The second (with the latter three statistics) is based on pooling the residuals of the regression along the between-dimension of the panel permitting distinct slopes values.

The panel cointegration tests proposed by Westerlund (2007) enable the testing of the null hypothesis of non-cointegration against two separate alternatives, namely: (i) at least one cross-section is cointegrated and the panel is possibly heterogenous, and (ii) the panel is cointegrated in its entirety. In the second case, the long-run equilibrium relationship of the variables would be the same for all the cross-sections. In this regard, there are four tests to be carried out: G_t and G_a, corresponding to group mean tests which test the alternative hypothesis of at least one unit being cointegrated, and P_t and P_a, panel mean tests which test whether the panel is cointegrated.

In order to find the long-term relationships between government revenues and expenditures and between the primary government balance and the lagged government debt by individual country, we performed also the between-dimension panel fully modified OLS (FMOLS) (Pedroni, 2000). This methodology assumes the existence of cointegration between the variables under study, allows dealing with the endogeneity problem and provides unbiased estimates of the coefficients, which can be interpreted as long-term elasticities.

In the last step of the empirical analysis, we estimate the marginal responses of the government revenues to unit changes in the government expenditures (based on Hakkio and Rush, 1991) and of the primary government balance to unit changes in the lagged government debt (following Bohn, 1998). To do this, we use the expanding window method, by introducing the assumption that the regression coefficients may vary over time.

Therefore, we start with the following equations estimated for each country *i* in year *t*:

$$R_{i,t} = \alpha + \beta_{i,t} G_{i,t} + \mu_{i,t} \quad (3)$$

$$s_{i,t} = \delta + \gamma_{i,t} d_{i,t-1} + \varphi_{i,t} \quad (4)$$

where: $R_{i,t}$ corresponds to the government revenues as a percentage of GDP in country *i* in year *t*; $G_{i,t}$ corresponds to the government expenditures as a percentage of GDP in country *i* in year *t*; $s_{i,t}$ is the primary government balance-to-GDP ratio in country *i* in year *t*; $d_{i,t-1}$ corresponds to the public debt-to-GDP ratio lagged by one period in country *i*; and μ_{it} and $\varphi_{i,t}$ are the random disturbance terms of country *i* in year *t*. The equations (3) and (4) are estimated using a time-varying parameter model. We use an expanding window that weights historical data equally of 35 years. More specifically, for each country, we estimate series of β and γ for the periods 1950-1985, 1950-1986, 1950-1987, and, lastly, 1950-2019.

Bohn (1998) highlights that there is reversion to the mean of the public debt-to-GDP ratio, since the primary budget balance responds positively to past public debt (there are corrective actions in this sense). In turn, Bohn (2007) shows that compliance with the IGBC is compatible with any order of integration of the public debt series and government revenues and expenditures. Hence, the rejection of stationarity and cointegration is consistent with the IGBC, and an integrated process is not necessarily synonymous with a violation of the IGBC.

In the second step of the time-varying analysis, we use the computed expanding window estimates as dependent variables and identify explanatory factors for these marginal responses. The equations that identify the explanatory factors of the expanding window fiscal sustainability coefficients are estimated using Weighted Least Squares (WLS) with country and time fixed effects. The use of WLS is justified because the dependent variable is based on estimates, and the estimates of marginal responses are weighted by the respective standard deviations.

4. Empirical Analysis

4.1. Data

The sample of this study comprises 20 OECD countries, namely: Australia, Austria, Belgium, Canada, Denmark, Finland, France, Germany, Greece, Ireland, Italy, Japan, the Netherlands, New Zealand, Norway, Portugal, Spain, Sweden, the United Kingdom, and the United States, using annual data between 1950 and 2019.

We consider the following fiscal variables: government revenues (REV), government expenditures (EXP), primary government balance (PGB) and public debt (d), as a percentage of GDP. These variables were obtained based on Mauro (2013)'s Historic Public Finance

Dataset and OECD.Stat data. The country output gaps, as a percentage of potential GDP (OUTGAP) are retrieved from the World Economic Outlook. The data of the differential between real long term interest rate and real GDP growth rate (*r-g*) are based on Mauro (2013)'s Historic Public Finance Dataset until 2011, and afterwards were calculated using OECD. Stat, World Bank and Penn World Table, version 10.0 data.

Moreover, we estimate the expanding window coefficients of the response of the government revenues to a unit change in the government expenditures (REV-EW) and of the response of the primary government balance to a unit change in the lagged public debt (PGB-EW). The variables are expressed as a percentage of GDP.

The main aim of this empirical analysis is to investigate the drivers of fiscal sustainability, notably fiscal rules. Hence, the variables that capture the existence of fiscal rules are the following: a dummy variable that takes the value of 1, if an expenditure rule is in place (ER); a dummy variable that takes the value of 1, if a revenue rule is in place (RR); a dummy variable that takes the value of 1, if a budget balance rule is in place (BBR); a dummy variable that takes the value of 1, if a debt rule is in place (DR). This information is retrieved from the IMF Fiscal Rules Dataset 1985-2021. In addition to the output gap and the (*r-g*) differential, we use the inflation rate and the current account balance as control variables, based on the World Bank and World Economic Outlook. Finally, we distinguish the cases in which the (*r-g*) differential is positive or negative, following Afonso *et al.* (2021), and we also analyse their effects on fiscal sustainability coefficients, controlling for the level of the lagged public debt-to-GDP ratio.

4.2. Results

4.2.1. Cointegration relationships

Table 1 shows that, according to Padroni's (2004) panel cointegration tests, there is a cointegration relationship between government revenues and expenditures as well as between the primary government balance and lagged public debt. These results mean that there are long-term relationships between the fiscal series under study.

The Westerlund (2007) panel cointegration tests for the relationship between government revenues and expenditures and the primary government balance and lagged public debt are presented by Tables 2 and 3. The *p-values* and bootstrap *p-values* (columns four and five) suggest the existence of a panel cointegration relationship between government revenues and expenditures and between the primary government balance and lagged public debt (the null

of no cointegration is rejected). Moreover, even when short-run dynamics is maintained fixed, cointegration relationships exist and are highly significant.

Table 4, in turn, reports the estimates obtained using fully modified OLS (FMOLS) of the relationship between government revenues and expenditures and between the primary government balance and lagged public debt. For most countries, the β coefficient, which measures the sensitivity of government revenues to government expenditures, is close to 1, except for Ireland, Japan, the United Kingdom and the United States. For Finland and Norway, the estimated coefficient is higher than 1. These results indicate that, for the countries under analysis, government revenues strongly adjust to government expenditures (for the panel, the estimated coefficient is 0.86). Regarding the relationship between the primary government balance and the lagged public debt, measured by θ, the response of the primary government balance to lagged public debt, this is positive for Belgium, Greece, Ireland, Italy, Norway, Portugal and Sweden, which suggests the verification of a Ricardian fiscal regime. The θ coefficient has negative values in the cases of France, Japan and the United States, which means that the primary government balance reacts negatively to the increase in lagged public debt. For the remaining countries, the θ coefficient is non-significant. This evidence suggests that, for around half of the countries in our sample, the prevailing fiscal regime is non-Ricardian, although, considering the panel, the relationship between the primary government balance and lagged public debt is positive and highly significant (θ = 0.03).

Table 1: Pedroni (2004) Panel Cointegration Tests, 1950-2019

	Relation	**Revenues and expenditures**		**Primary balance and lagged debt**	
		No trend	Trend	No trend	Trend
Within-dimension	Panel *v*	4.224	2.528	8.522	4.205
	Panel *p*	-7.206	-6.821	-10.38	-8.265
	Panel ADF	-4.923	-5.598	-6.932	-6.328
	Panel PP	-5.937	-6.512	-7.464	-7.527
Between-dimension	Group *p*	-7.621	-5.747	-8.930	-6.227
	Group ADF	-6.285	-5.946	-7.318	-6.269
	Group PP	-6.916	-6.545	-7.724	-7.052

Notes: (a) The series are assessed as a percentage of GDP; (b) The null hypothesis is non-cointegration; (c) Under the null hypothesis all the statistics follow a standard normal distribution.

Table 2: Westerlund (2007) Panel Cointegration Tests, government revenues and expenditures, 1950-2019

Statistic	Value	Z-Value	P-Value	Robust P-Value
G_t	-3.141	-4.261	0.000	0.000
G_a	-17.683	-3.730	0.000	0.000
P_t	-12.513	-3.505	0.000	0.000
P_a	-14.306	-3.919	0.000	0.000
Fixed short-run dynamics				
Statistic	**Value**	**Z-Value**	**P-Value**	**Robust P-Value**
G_t	-3.080	-3.926	0.000	0.000
G_a	-17.248	-3.444	0.000	0.000
P_t	-12.315	-3.279	0.000	0.000
P_a	-13.933	-3.647	0.000	0.000

Notes: (a) The null hypothesis is non-cointegration; (b) The tests are all normally distributed and are carried out with a constant and a linear time trend; (c) The average Akaike Information Criterion (AIC) selected lag length is 1.05 and the average AIC selected lead length is 0.05; (d) Short run dynamics is restricted to one lag and one lead; (e) The critical values are a one-sided test, based on normal distribution; (f) The robust *p-values* are a one-sided test, based on 100 bootstrap replications.

Table 3: Westerlund (2007) Panel Cointegration Tests, primary government balance and lagged government debt, 1950-2019

Statistic	Value	Z-Value	P-Value	Robust P-Value
G_t	-3.721	-7.456	0.000	0.000
G_a	-21.531	-6.260	0.000	0.000
P_t	-12.329	-3.295	0.001	0.020
P_a	-19.788	-7.918	0.000	0.000
Fixed short-run dynamics				
Statistic	**Value**	**Z-Value**	**P-Value**	**Robust P-Value**
G_t	-3.754	-7.635	0.000	0.000
G_a	-24.814	-8.419	0.000	0.000
P_t	-15.814	-7.280	0.000	0.000
P_a	-22.263	-9.723	0.000	0.000

Notes: (a) The null hypothesis is non-cointegration; (b) The tests are all normally distributed and are carried out with a constant and a linear time trend; (c) The average AIC selected lag length is 1.1 and the average AIC selected lead length is 0.85; (d) Short run dynamics is restricted to one lag and one lead; (e) The critical values are a one-sided test, based on normal distribution; (f) The robust *p-values* are a one-sided test, based on 100 bootstrap replications.

Table 4: Panel estimates of the cointegrating relationship (FMOLS), 1950-2019

Country/Relation	Revenues and expenditures		Primary balance and lagged debt	
	β	*t*-statistic	θ	*t*-statistic
Australia	0.88***	27.91	-0.01	-0.56
Austria	0.89***	26.13	0.01	0.88
Belgium	0.87***	13.30	0.05***	6.65
Canada	0.86***	18.00	0.04	1.25
Denmark	0.96***	82.62	0.04	1.52
Finland	1.02***	27.85	-0.03	-0.84
France	0.92***	46.57	-0.02***	-3.14
Germany	0.83***	40.53	0.01	0.57
Greece	0.89***	18.18	0.03***	2.48
Ireland	0.67***	7.63	0.03***	2.65
Italy	0.85***	14.65	0.04***	6.94
Japan	0.62***	42.03	-0.03***	-4.20
Netherlands	0.90***	186.98	-0.00	-0.01
New Zealand	0.87***	10.83	-0.04	-1.52
Norway	1.13***	10.36	0.31***	4.40
Portugal	0.88***	29.51	0.02**	1.91
Spain	0.86***	62.16	0.01	0.44
Sweden	0.99***	14.68	0.08***	9.78
United Kingdom	0.67***	10.79	0.00	0.18
United States	0.68***	18.49	-0.03*	-1.75
Panel	0.86***	158.58	0.03***	6.18

Notes: (a) The series are assessed as a percentage of GDP; (b) *, ** and *** denote statistical significance at the 10%, 5% and 1% level, respectively.

4.2.2. Expanding window Analysis

In this subsection, Tables 5 to 8 report the results of the estimations where we seek to investigate the role of the (*r*-*g*) differential and of the fiscal rules on the fiscal sustainability coefficients, considering the relationships between government revenues and expenditures and between the primary government balance and lagged public debt.

In order to investigate the role of the (*r*-*g*) differential on fiscal sustainability, we distinguish the cases in which it is favourable ($r-g < 0$) and unfavourable ($r-g > 0$), in Tables 5 and 7. Table 5 shows that, controlling for the sign of the (*r*-*g*) differential, the effect of this variable on the reaction of government revenues to government expenditure is not statistically significant. However, based on Table 7, when the differential is unfavourable, the primary budget balance reacts to the lagged public debt, i.e., the response is positive, whereas if the differential is favourable, its effect is null. This result is expected according to the public debt dynamics equation. More specifically, and in order to ensure the relative stabilization of public

debt, the primary budget balance reacts positively to an increase in lagged public debt in the scenario in which the (*r-g*) differential is unfavourable, with the real interest rate higher than the real growth rate ($r-g > 0$).

We also assess the effect of the (*r-g*) differential on fiscal sustainability coefficients, controlling for the level of the lagged debt-to-GDP ratio, in Tables 6 and 8. In Table 6, when the debt-to-GDP ratio is equal to or less than 60%, increases in the (*r-g*) differential translate into an attenuation of the response of government revenues to government expenditure. On the other hand, if the debt-to-GDP ratio is greater than 90%, increases in the (*r-g*) differential translate into an amplification of the reaction of the primary budget balance to government debt (see Table 8).

When the real long-term interest rate is higher than the growth rate of real GDP, public debt service increases, the interest burden on public debt is higher and, consequently, the public interest expenditure is higher. In this scenario (with a positive snowball effect), fiscal authorities face greater pressure in order to obtain budget surpluses to reduce the debt-to-GDP ratio, especially if the debt ratio is already high. In addition, with lower public debt ratios, public finance management is easier, the action capacity of fiscal policy authorities is greater, and the requested fiscal effort is smaller, which benefits the sustainability of public accounts.

The existence of fiscal rules within the scope of government revenues and expenditures, overall budget balance and public debt, differently influence fiscal sustainability responses. For instance, the existence of government revenues and expenditures rules has a negative effect on the coefficients of the response of the primary government balance to the lagged public debt. Nevertheless, these fiscal rules do not influence the coefficients of the response of government revenues to government expenditures. In turn, the validity of public debt rules positively influences the coefficients of the response of government revenues to government expenditures, although does not influence the coefficients of the response of the response of the primary government balance to the lagged public debt. Finally, the existence of budget balance rules has a positive effect on both fiscal sustainability coefficients.

Moreover, the output gap has a positive effect on both fiscal sustainability coefficients, especially regarding the responses of the primary budget balance to changes in past government debt. The output gap improves fiscal sustainability, since in periods when the output gap is positive, government revenues increase, and government expenditures decrease due notably to the action of automatic stabilizers. In these periods, in general, there is less use of discretionary fiscal policies, and public savings increase. Alternatively, in periods when the output gap is negative, government revenues decrease, government expenditures increase and there is a

greater need of discretionary fiscal policies in order to stabilize economic activity, diminishing public savings. Therefore, if GDP is above (below) its potential, the adjustments of government revenues to government expenditures and of the primary government budget balance to lagged public debt are larger (smaller).

Moreover, the inflation rate has a negative and highly significant effect on the responses of government revenues to government expenditures. However, the inflation rate has no effect on the responses of the primary budget balance to changes in government debt. Although inflation reduces the real value of the stock of government debt and translates into increased tax revenues, it worsens the level of public expenditure, which deteriorates public accounts and makes it more difficult to adjust government revenues to government expenditures. The effects of the external accounts balance also differ somewhat depending on the fiscal sustainability coefficients. Still, they are mostly positive and significant.

Additionally, Tables 9 to 12 restrict the empirical analysis to the period between 1985 and 2008, i.e., pre-global financial crisis (GFC) of 2008.[1] Based on the obtained results, we conclude that: (i) the output gap contributed to the increase in fiscal sustainability, while inflation has an adverse effect, more pronounced on the coefficients à la Hakkio and Rush (1991); (ii) the balance of external accounts positively influences the response of the primary budget balance to lagged government debt, but not the adjustment of revenues to government expenditures; (iii) the existence of fiscal rules within the scope of the budget balance has a positive effect on both types of fiscal sustainability coefficients; (iv) the verification of fiscal rules within the scope of public debt reinforces the adjustment of revenues to government expenditures; (v) the response of the primary budget balance to past government debt is attenuated by the existence of fiscal rules on the revenue side.

Regarding the role of the (r-g) differential, we can conclude that: (i) if (r-g) < 0, the adjustment of revenues to government expenditures is lower, and the response of the primary government balance to lagged public debt is also lower (although this effect is weaker); (ii) if (r-g) > 0, the response of the primary government balance to lagged public debt is larger; (iii) when the public debt-to-GDP ratio of the previous year is above 90%, the adjustment of revenues to government expenditures is lower (probably because the share of public interest expenditure is higher, and, therefore, it becomes more difficult for government revenues to accommodate greater higher public expenditure); (iv) the effects of the (r-g) differential on the

[1] The period 2009-2019 was also the subject of empirical analysis, however, the obtained results were not satisfactory. These results are available upon request.

response of the primary budget balance to lagged government debt are increasing for public debt-to-GDP ratios lagged up to 90%, from this threshold the differential has no influence.

Table 5: Determinants of fiscal sustainability coefficients, government revenues and expenditures, 1985-2019, controlling for the sign of the *(r-g)* differential

Regressors/Specification	(1)	(2)	(3)	(4)	(5)
OUTGAP	0.321*	0.319*	0.321*	0.299*	0.306*
	(0.170)	(0.170)	(0.170)	(0.173)	(0.172)
INF	-0.822***	-0.824***	-0.819***	-0.769***	-0.782***
	(0.127)	(0.125)	(0.127)	(0.131)	(0.128)
CA	0.181**	0.184**	0.181**	0.128	0.163*
	(0.091)	(0.090)	(0.092)	(0.094)	(0.090)
$(r-g)*d(r-g)^{+}$	-0.093	-0.095	-0.093	-0.083	-0.069
	(0.193)	(0.193)	(0.193)	(0.193)	(0.193)
$(r-g)*d(r-g)^{-}$	0.032	0.031	0.033	0.048	0.043
	(0.087)	(0.087)	(0.087)	(0.083)	(0.086)
ER		-0.002			
		(0.007)			
RR			-0.003		
			(0.006)		
BBR				0.026***	
				(0.008)	
DR					0.028***
					(0.010)
Observations	689	689	689	689	689
R-squared	0.832	0.832	0.832	0.835	0.834

Notes: (a) Weighted Least Squares (WLS) with fixed effects Estimates. The weights are given by the inverse of the standard errors of the estimated expanding window coefficients; (b) The dependent variable is the response of the government revenues to a unit change in government expenditures, both variables as a percentage of GDP; (c) Robust standard errors in brackets; (d) Constant term estimated, but omitted for reasons of parsimony; (e) *, ** and *** denote statistical significance at the 10%, 5% and 1% level, respectively; (f) $d(r-g)^{+}$ and $d(r-g)^{-}$ are dummy variables that take the value 1, when the (*r-g*) differential is positive and negative, and 0, otherwise, respectively.

Table 6: Determinants of fiscal sustainability coefficients, government revenues and expenditures, 1985-2019, controlling for the level of the lagged public debt-to-GDP ratio

Regressors/Specification	(1)	(2)	(3)	(4)	(5)
OUTGAP	0.271*	0.270*	0.271*	0.252*	0.256*
	(0.149)	(0.150)	(0.149)	(0.152)	(0.151)
INF	-0.862***	-0.864***	-0.859***	-0.813***	-0.827***
	(0.139)	(0.137)	(0.138)	(0.142)	(0.138)
CA	0.149	0.151	0.149	0.101	0.136
	(0.095)	(0.093)	(0.095)	(0.096)	(0.093)
(r-g)*dbelow60	-0.425**	-0.425**	-0.425**	-0.387**	-0.382**
	(0.171)	(0.171)	(0.171)	(0.168)	(0.167)
(r-g)*dbetween6090	-0.015	-0.018	-0.017	0.004	-0.001
	(0.217)	(0.217)	(0.218)	(0.223)	(0.220)
(r-g)*dabove90	0.077	0.077	0.078	0.082	0.082
	(0.060)	(0.060)	(0.060)	(0.062)	(0.062)
ER		-0.001			
		(0.007)			
RR			-0.003		
			(0.006)		
BBR				0.025***	
				(0.008)	
DR					0.025**
					(0.010)
Observations	670	670	670	670	670
R-squared	0.842	0.842	0.842	0.844	0.844

Notes: (a) WLS with fixed effects Estimates. The weights are given by the inverse of the standard errors of the estimated expanding window coefficients; (b) The dependent variable is the response of the government revenues to a unit change in government expenditures, both variables as a percentage of GDP; (c) Robust standard errors in brackets; (d) Constant term estimated, but omitted for reasons of parsimony; (e) *, ** and *** denote statistical significance at the 10%, 5% and 1% level, respectively; (f) dbelow60, dbetween6090 and dabove90 are dummy variables that take the value 1, when the lagged public debt-to-GDP ratio is below 60%, between 60% and 90%, and above 90%, and 0, otherwise, respectively.

Table 7: Determinants of fiscal sustainability coefficients, primary government balance and lagged government debt, 1985-2019, controlling for the sign of the *(r-g)* differential

Regressors/Specification	(1)	(2)	(3)	(4)	(5)
OUTGAP	0.448***	0.433***	0.445***	0.348***	0.451***
	(0.118)	(0.115)	(0.117)	(0.113)	(0.119)
INF	-0.141	-0.151	-0.113	-0.005	-0.149
	(0.137)	(0.137)	(0.140)	(0.123)	(0.138)
CA	0.489***	0.502***	0.479***	0.327***	0.488***
	(0.084)	(0.084)	(0.083)	(0.084)	(0.083)
$(r-g)*d(r-g)^{+}$	0.275**	0.250*	0.272**	0.236*	0.269**
	(0.135)	(0.131)	(0.134)	(0.126)	(0.134)
$(r-g)*d(r-g)^{-}$	-0.107	-0.104	-0.092	-0.060	-0.108
	(0.165)	(0.158)	(0.162)	(0.141)	(0.165)
ER		-0.012*			
		(0.006)			
RR			-0.023***		
			(0.007)		
BBR				0.053***	
				(0.007)	
DR					-0.005
					(0.009)
Observations	689	689	689	689	689
R-squared	0.807	0.809	0.809	0.828	0.808

Notes: (a) WLS with fixed effects Estimates. The weights are given by the inverse of the standard errors of the estimated expanding window coefficients; (b) The dependent variable is the response of the primary government balance to a unit change in government debt lagged by one period, both variables as a percentage of GDP; (c) Robust standard errors in brackets; (d) Constant term estimated, but omitted for reasons of parsimony; (e) *, ** and *** denote statistical significance at the 10%, 5% and 1% level, respectively; (f) $d(r-g)^{+}$ and $d(r-g)^{-}$ are dummy variables that take the value 1, when the (*r-g*) differential is positive and negative, and 0, otherwise, respectively.

Table 8: Determinants of fiscal sustainability coefficients, primary government balance and lagged government debt, 1985-2019, controlling for the level of the lagged public debt-to-GDP ratio

Regressors/Specification	(1)	(2)	(3)	(4)	(5)
OUTGAP	0.405***	0.395***	0.405***	0.325***	0.409***
	(0.123)	(0.120)	(0.121)	(0.116)	(0.124)
INF	-0.155	-0.169	-0.125	-0.031	-0.163
	(0.151)	(0.149)	(0.154)	(0.133)	(0.151)
CA	0.444***	0.463***	0.435***	0.296***	0.442***
	(0.086)	(0.086)	(0.085)	(0.085)	(0.085)
(r-g)*dbelow60	0.039	0.028	0.047	0.068	0.029
	(0.149)	(0.143)	(0.148)	(0.132)	(0.148)
(r-g)*dbetween6090	0.096	0.055	0.080	0.070	0.096
	(0.149)	(0.144)	(0.143)	(0.136)	(0.147)
(r-g)*dabove90	0.123*	0.116*	0.134**	0.107*	0.123*
	(0.064)	(0.062)	(0.065)	(0.059)	(0.064)
ER		-0.015**			
		(0.006)			
RR			-0.024***		
			(0.007)		
BBR				0.054***	
				(0.007)	
DR					-0.007
					(0.009)
Observations	670	670	670	670	670
R-squared	0.806	0.808	0.808	0.828	0.806

Notes: (a) WLS with fixed effects Estimates. The weights are given by the inverse of the standard errors of the estimated expanding window coefficients; (b) The dependent variable is the response of the primary government balance to a unit change in government debt lagged by one period, both variables as a percentage of GDP; (c) Robust standard errors in brackets; (d) Constant term estimated, but omitted for reasons of parsimony; (e) *, ** and *** denote statistical significance at the 10%, 5% and 1% level, respectively; (f) dbelow60, dbetween6090 and dabove90 are dummy variables that take the value 1, when the lagged public debt-to-GDP ratio is below 60%, between 60% and 90%, and above 90%, and 0, otherwise, respectively.

Table 9: Determinants of fiscal sustainability coefficients, government revenues and expenditures, 1985-2008, controlling for the sign of the *(r-g)* differential

Regressors/Specification	(1)	(2)	(3)	(4)	(5)
OUTGAP	0.518***	0.461**	0.518***	0.477***	0.482***
	(0.182)	(0.185)	(0.182)	(0.183)	(0.184)
INF	-0.691***	-0.673***	-0.694***	-0.637***	-0.660***
	(0.130)	(0.125)	(0.130)	(0.134)	(0.129)
CA	-0.032	-0.088	-0.032	-0.101	-0.047
	(0.130)	(0.119)	(0.131)	(0.132)	(0.128)
$(r-g)*d(r-g)^{+}$	0.094	0.133	0.095	0.106	0.126
	(0.264)	(0.262)	(0.265)	(0.261)	(0.261)
$(r-g)*d(r-g)^{-}$	-0.530**	-0.548**	-0.532**	-0.469**	-0.491**
	(0.232)	(0.233)	(0.233)	(0.234)	(0.233)
ER		0.020*			
		(0.010)			
RR			0.002		
			(0.005)		
BBR				0.021***	
				(0.006)	
DR					0.019**
					(0.008)
Observations	469	469	469	469	469
R-squared	0.864	0.866	0.864	0.866	0.865

Notes: (a) WLS with fixed effects Estimates. The weights are given by the inverse of the standard errors of the estimated expanding window coefficients; (b) The dependent variable is the response of the government revenues to a unit change in government expenditures, both variables as a percentage of GDP; (c) Robust standard errors in brackets; (d) Constant term estimated, but omitted for reasons of parsimony; (e) *, ** and *** denote statistical significance at the 10%, 5% and 1% level, respectively; (f) $d(r-g)^{+}$ and $d(r-g)^{-}$ are dummy variables that take the value 1, when the (*r-g*) differential is positive and negative, and 0, otherwise, respectively.

Table 10: Determinants of fiscal sustainability coefficients, government revenues and expenditures, 1985-2008, controlling for the level of the lagged public debt-to-GDP ratio

Regressors/Specification	(1)	(2)	(3)	(4)	(5)
OUTGAP	0.505***	0.438**	0.505***	0.462**	0.465**
	(0.193)	(0.201)	(0.193)	(0.195)	(0.197)
INF	-0.608***	-0.583***	-0.611***	-0.559***	-0.577***
	(0.136)	(0.129)	(0.135)	(0.138)	(0.134)
CA	-0.029	-0.085	-0.029	-0.104	-0.045
	(0.124)	(0.113)	(0.125)	(0.124)	(0.121)
(r-g)*dbelow60	0.100	0.107	0.101	0.131	0.147
	(0.212)	(0.210)	(0.212)	(0.211)	(0.211)
(r-g)*dbetween6090	-0.216	-0.145	-0.212	-0.214	-0.200
	(0.201)	(0.215)	(0.203)	(0.201)	(0.203)
(r-g)*dabove90	-0.497***	-0.503***	-0.501***	-0.438**	-0.457***
	(0.163)	(0.163)	(0.164)	(0.173)	(0.171)
ER		0.018*			
		(0.010)			
RR			0.002		
			(0.006)		
BBR				0.024***	
				(0.006)	
DR					0.022***
					(0.009)
Observations	450	450	450	450	450
R-squared	0.869	0.871	0.869	0.872	0.871

Notes: (a) WLS with fixed effects Estimates. The weights are given by the inverse of the standard errors of the estimated expanding window coefficients; (b) The dependent variable is the response of the government revenues to a unit change in government expenditures, both variables as a percentage of GDP; (c) Robust standard errors in brackets; (d) Constant term estimated, but omitted for reasons of parsimony; (e) *, ** and *** denote statistical significance at the 10%, 5% and 1% level, respectively; (f) dbelow60, dbetween6090 and dabove90 are dummy variables that take the value 1, when the lagged public debt-to-GDP ratio is below 60%, between 60% and 90%, and above 90%, and 0, otherwise, respectively.

Table 11: Determinants of fiscal sustainability coefficients, primary government balance and lagged government debt, 1985-2008, controlling for the sign of the *(r-g)* differential

Regressors/Specification	(1)	(2)	(3)	(4)	(5)
OUTGAP	0.389***	0.380***	0.383***	0.322***	0.379***
	(0.113)	(0.116)	(0.112)	(0.110)	(0.117)
INF	-0.200*	-0.195*	-0.165	-0.127	-0.191*
	(0.111)	(0.111)	(0.114)	(0.105)	(0.112)
CA	0.617***	0.607***	0.603***	0.525***	0.619***
	(0.097)	(0.101)	(0.095)	(0.093)	(0.096)
$(r-g)*d(r-g)^{+}$	0.395***	0.408***	0.390***	0.365**	0.402***
	(0.146)	(0.144)	(0.146)	(0.143)	(0.145)
$(r-g)*d(r-g)^{-}$	-0.354*	-0.357*	-0.338	-0.292	-0.346*
	(0.209)	(0.209)	(0.206)	(0.197)	(0.210)
ER		0.007			
		(0.007)			
RR			-0.027***		
			(0.008)		
BBR				0.024***	
				(0.005)	
DR					0.006
					(0.007)
Observations	469	469	469	469	469
R-squared	0.871	0.871	0.874	0.876	0.871

Notes: (a) WLS with fixed effects Estimates. The weights are given by the inverse of the standard errors of the estimated expanding window coefficients; (b) The dependent variable is the response of the primary government balance to a unit change in government debt lagged by one period, both variables as a percentage of GDP; (c) Robust standard errors in brackets; (d) Constant term estimated, but omitted for reasons of parsimony; (e) *, ** and *** denote statistical significance at the 10%, 5% and 1% level, respectively; (f) $d(r-g)^{+}$ and $d(r-g)^{-}$ are dummy variables that take the value 1, when the (*r-g*) differential is positive and negative, and 0, otherwise, respectively.

Table 12: Determinants of fiscal sustainability coefficients, primary government balance and lagged government debt, 1985-2008, controlling for the level of the lagged public debt-to-GDP ratio

Regressors/Specification	(1)	(2)	(3)	(4)	(5)
OUTGAP	0.374***	0.365***	0.364***	0.314***	0.365***
	(0.111)	(0.116)	(0.109)	(0.110)	(0.114)
INF	-0.151	-0.147	-0.114	-0.085	-0.143
	(0.129)	(0.129)	(0.132)	(0.120)	(0.129)
CA	0.577***	0.569***	0.560***	0.488***	0.580***
	(0.093)	(0.098)	(0.091)	(0.089)	(0.092)
(r-g)*dbelow60	0.254**	0.256**	0.253**	0.244**	0.263**
	(0.115)	(0.114)	(0.115)	(0.110)	(0.113)
(r-g)*dbetween6090	0.318*	0.340*	0.254	0.281	0.316*
	(0.175)	(0.180)	(0.164)	(0.181)	(0.178)
(r-g)*dabove90	-0.185	-0.182	-0.146	-0.166	-0.179
	(0.126)	(0.128)	(0.124)	(0.111)	(0.124)
ER		0.004			
		(0.007)			
RR			-0.028***		
			(0.008)		
BBR				0.024***	
				(0.005)	
DR					0.006
					(0.007)
Observations	450	450	450	450	450
R-squared	0.871	0.871	0.874	0.877	0.871

Notes: (a) WLS with fixed effects Estimates. The weights are given by the inverse of the standard errors of the estimated expanding window coefficients; (b) The dependent variable is the response of the primary government balance to a unit change in government debt lagged by one period, both variables as a percentage of GDP; (c) Robust standard errors in brackets; (d) Constant term estimated, but omitted for reasons of parsimony; (e) *, ** and *** denote statistical significance at the 10%, 5% and 1% level, respectively; (f) dbelow60, dbetween6090 and dabove90 are dummy variables that take the value 1, when the lagged public debt-to-GDP ratio is below 60%, between 60% and 90%, and above 90%, and 0, otherwise, respectively.

5. Conclusions

The article studies fiscal sustainability for 20 OECD countries from a long-term perspective, using annual data between 1950 and 2019. Taking the sample as a whole, there is a stable long-term relationship between government revenues and expenditures as well as between the primary government budget balance and past government debt. For most countries, the long-term coefficient of adjustment of government revenues to government expenditures is close to 1, which suggests rather a situation close to fiscal solvency. In the cases of Belgium, Greece, Italy, Norway, Portugal and Sweden, the prevalence of a Ricardian fiscal regime is found.

The expanding window analysis shows that the (*r*-*g*) differential is crucial to ensure fiscal sustainability. If $r > g$, the primary government balance is more responsive to changes in the past public debt. Therefore, when (*r*-*g*) differential is unfavourable, fiscal authorities will have to carry out more pronounced fiscal adjustments in order to guarantee via the IGBC the sustainability of public accounts, especially if the level of the public debt-to-GDP ratio is high. Also, we corroborate that lower public debt-to-GDP ratio facilitates public finances management and more easily ensures fiscal solvency.

Furthermore, we can conclude that: (i) the output gap improves fiscal sustainability; (ii) the inflation rate negatively influences the fiscal sustainability coefficients à la Hakkio and Rush (1991); (iii) the current account balance increases fiscal sustainability coefficients à la Bohn (1998); (iv) the existence of budget balance fiscal rules benefits fiscal sustainability; and (v) the validity of fiscal rules in terms of government revenues and expenditures and public debt exhibits a differentiated effect on the fiscal sustainability coefficients à la Hakkio and Rush (1991) and à la Bohn (1998).

Until 2009, the difference between the long-term real interest rate and the real GDP growth rate assumed greater relevance in the sustainability of public accounts, and its effects on the fiscal sustainability coefficients depended on its sign and the public debt-to-GDP ratio. With the outbreak of the GFC of 2008, developed countries faced sharp increases in the public debt-to-GDP ratio, and the (*r*-*g*) differential lost its function as an automatic corrector in order to guarantee fiscal solvency. Even in the face of increases in the (*r*-*g*) differential (with an unfavourable snowball effect), the budgetary authorities found themselves so constrained in their ability to manage public accounts that they had great difficulties in adjusting revenues to growing government expenditures, and the response of the primary budget balance to the past government debt was weakened.

Regarding economic policy implications and recommendations, this paper has important insights. First, the (*r-g*) differential plays a relevant role in fiscal sustainability, by functioning as a corrective mechanism that ensures compliance with the intertemporal budget constraint. With a positive snowball effect ($r > g$), authorities undertake greater fiscal efforts, which may allow for a faster reduction in the public debt-to-GDP ratio, thus contributing way for fiscal solvency. Second, the validity of fiscal rules, namely in terms of budget balance, results in improved sustainability of public accounts. Then, the existence of fiscal rules is suggested.

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Appendix

Table A1: Variables, definitions, and data sources

Variable	Definition	Source
REV	government total revenues as a percentage of GDP	Mauro (2013)´s Historic Public Finance Dataset and OECD.Stat
EXP	government total expenditures as a percentage of GDP	Mauro (2013)´s Historic Public Finance Dataset and OECD.Stat
PGB	primary government balance as a percentage of GDP	Mauro (2013)´s Historic Public Finance Dataset and OECD.Stat
d	ratio of the public debt as a percentage of GDP	Mauro (2013)´s Historic Public Finance Dataset and OECD.Stat
REV-EW	expanding window coefficient of the response of the government revenues to a unit change in the government expenditures	Author´s estimations
PGB-EW	expanding window coefficient of the response of the primary government balance to a unit change in lagged government debt	Author´s estimations
OUTGAP	output gap as a percentage of potential output	World Economic Outlook, October 2003
INF	inflation rate, based on GDP deflator	World Bank
CA	current account balance as a percentage of GDP	World Economic Outlook, October 2003
r-g	differential between real long term interest rate and real GDP growth rate	Mauro (2013)'s Historic Public Finance Dataset; Author´s calculations based on OECD. Stat, World Bank and Penn World Table, version 10.0 data
ER	dummy variable that takes the value of 1, if an expenditure rule is in place	IMF Fiscal Rules Dataset 1985-2021
RR	dummy variable that takes the value of 1, if a revenue rule is in place	IMF Fiscal Rules Dataset 1985-2021
BBR	dummy variable that takes the value of 1, if a budget balance rule is in place	IMF Fiscal Rules Dataset 1985-2021
DR	dummy variable that takes the value of 1, if a debt rule is in place	IMF Fiscal Rules Dataset 1985-2021

Table A2: Descriptive Statistics, Time-Varying Analysis

Variable	Obs.	Mean	Std. Dev.	Maximum	Minimum
REV-EW	700	0.830	0.123	1.231	0.550
PGB-EW	700	0.032	0.064	0.349	-0.231
OUTGAP	689	-0.004	0.028	0.103	-0.183
INF	700	0.028	0.031	0.217	-0.051
CA	700	0.002	0.045	0.166	-0.199
r-g	700	0.008	0.041	0.276	-0.470

Table A3: Correlation matrix, Time-Varying Analysis

	REV-EW	PGB-EW	OUTGAP	INF	CA	r-g	ER	RR	BBR	DR
REV-EW	1.000									
PGB-EW	0.193	1.000								
OUTGAP	0.083	0.051	1.000							
INF	-0.138	0.034	0.289	1.000						
CA	0.308	0.245	-0.019	-0.124	1.000					
r-g	0.039	-0.067	-0.360	-0.094	-0.097	1.000				
ER	0.102	-0.120	-0.192	-0.303	0.283	-0.200	1.000			
RR	0.145	-0.044	0.007	-0.067	0.115	-0.058	0.344	1.000		
BBR	0.007	0.061	-0.114	-0.352	0.204	-0.179	0.352	0.229	1.000	
DR	0.121	-0.046	-0.141	-0.238	0.059	-0.153	0.417	0.274	0.737	1.000