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Public debt sustainability: An empirical study on OECD countries

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ABSTRACT

For a panel of 21 OECD heterogeneous countries from 1991 to 2015, we study governments' reactions to the accumulation of debt and look at whether governments voluntary take corrective measures when the debt-GDP ratio starts rising or they rather let the debt grow. We distinguish between discretionary and automatic response of primary balance of government actions, as captured by the structural component of public primary balance and by cyclical component of public primary balance. We show the existence of a systematic long-term relationship between debt and structural primary balance supporting the view that the long-term governments' discretionary response to increases in the debt-GDP ratio is negative, that is, governments are not currently taking long-term actions that counteract the increases in debts and do not satisfy the intertemporal budget constraint. In the short term, an asymmetric fiscal policy response exploiting the output gap, by part of the political class of the countries considered, seems to emerge: it intervenes with a new deficit and debt when the output gap is positive, but it does not adopt a symmetrical correction when the situation is reversed.

1. Introduction

In the wake of the recent global recession, given the worrying increase of public debt in the OECD economies, there has been a renewed twofold interest in governments' reaction to the debt accumulation dynamics. On the one hand, several theoretical and empirical papers (Bohn, 1995, 1998; Fincke and Greiner, 2012, and Greiner et al., 2007) have tried to provide support for both the existence and the sign and size of this reaction. On the other hand, the nature of governments' reactions to the accumulation of debt in terms of sustainability has become of paramount importance.

This issue has received considerable attention also at a policy level debate both in Europe, since the early 1990s with the Maastricht Treaty, and in the United States, mainly after the financial and economic crisis that began in the second half of 2007 and then spread to the entire world economy. In particular, in Europe, a persistent and solid growth of the public debt for some countries has been a common phenomenon often joint with an average low GDP growth since the early 1970s. The last financial and economic crisis created an environment characterized by a general concern for the public debt crisis that left several EU members (for example, Greece, Portugal, Ireland, Spain, and Cyprus) unable to repay or refinance their government debt or to bail out over-indebted banks under their national supervision without the assistance of third parties. Europe reacted in 2012 with the "Treaty on Stability, Coordination and Governance in the Economic and Monetary Union," whereby the EU member states agreed to bind themselves to several balanced budget rules.

In this paper, we study the governments' reactions to the accumulation of debt and look at whether governments take corrective measures when the debt-GDP ratio starts rising, or they let the debt grow, with important and well-known consequences for public

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debt (non)sustainability. With this purpose, for a panel of 21 OECD countries from 1991 to 2015 we investigate on the existence of a systematic relationship between debt and primary balance series.

This agenda raises questions regarding both the time series properties of the relevant variables and the critical assumption about the more likely relevant variables and determinants. Moreover, it requires to take into consideration the fact that unobserved factors affecting directly or indirectly governments' choice cause a heterogeneous response to the common shocks, even if the developed economies considered tend to share a common environment. We afford these issues by referring to the second-generation panel cointegration tests, which accounts for cross section dependence (Westerlund, 2007; Westerlund and Prohl, 2010; Mahdavi and Westerlund, 2011). Such tests allow for disentangling the crucial features of the relevant variables also taking into consideration the issue of cross-section dependence in the data.

The main novelty of the paper, however, is that unlike most of the traditional literature on this issue (Bohn, 1998, 2005; Mauro et al., 2015; Ghosh et al., 2013b; Weichenrieder and Zimmer, 2015; Fournier and Fall, 2015; Fincke and Greiner, 2011; 2012, and Greiner and Fincke, 2016), following Gali et al. (2003), we distinguish between discretionary and automatic response of primary balance of government actions, defined as "active" and "passive" fiscal policies. The former are captured quantitatively by the structural component of public primary balance, i.e. that part of primary surplus or deficit which is not influenced by the economic cycle and, therefore, better identify the nature of fiscal policy actions and intentions. The "passive" or automatic fiscal policies are, instead, quantitatively better captured by the nonstructural/cyclical component of public primary balance, which identifies the consequences of business cycle fluctuations and non-ordinary events of the economic activity. In order to avoid heteroscedasticity problems due to likely non-linearities of the fiscal policies, we refer our variables to potential output. As suggested by Giavazzi et al. (2000), dividing by actual rather than potential output would introduce a likely endogeneity bias due to the correlation between the error term and the right-hand side variables. If both debt and structural primary balance are both nonstationary and cointegrated - while both other likely determinants of primary balance and the error term are stationary -, we can directly test whether the measures taken by government are corrective or rather let the debt grow, without modelling explicitly the process related to stationary variables.

Even in presence of cross-section dependence in the data, due to heterogeneous socio-economic structure of the different economies – as mentioned, our empirical setup allows for slope heterogeneity across panel units in a nonstationary panel model - we show that a cointegrated univariate regression of structural primary balance on debt is significantly supported by the data. In other words, in the presence of cointegration between the two variables, even in the absence of a fully articulated equation for primary surpluses – that, among others, Bohn (1998), Fincke and Greiner (2012), and Greiner et al. (2007) had to motivate by Barro's (1979) tax-smoothing model[1] -, there is a significant conditional impact of debt on structural primary balance. We also show that the long-term response of the structural primary balance to changes in the debt-GDP ratio is negative, that is, governments are not currently taking long-term actions that counteract the increases in debts. As a consequence (see below Section 3), government policy is not sustainable in the sense of Bohn (1995, 1998, 2005).

This has been a controversial issue. Bohn (1998) shows that U.S. fiscal policy has historically been sustainable despite extended periods of primary deficits.[2] Referring to US data, he argues that the primary balance and the debt-GDP ratio do not have unit roots. Therefore, omitting other determinants of the primary surplus in his setup produces inconsistent estimates due to omitted variables bias. Because of the potential omitted variables problems, Bohn (1998) needed to base the empirical analysis on an explicit theoretical model of fiscal policy (i.e., Barro, 1979).[3] For OECD data, we find significant evidence that structural primary balance and the debt-GDP ratio do have unit roots and that the structural primary balance is a cointegrating and decreasing function of the debt, both taken as a ratio of potential GDP, for the 21 OECD economies considered from 1991 to 2015. Given the estimated long-term negative response of the structural primary balance to the debt, the government budget identity implies that the debt-potential GDP ratio should not be mean-reverting and therefore not sustainable in the sense of Bohn (1995, 1998).[4]

The principal feature of cointegrated variables is their responsiveness to any deviation from the long-run equilibrium. This asks for an error correction model, in which the short-term dynamics of the variables in the system are influenced by the deviation from

[1] Barro (1979) found a positive effect of temporary increases in government spending on debt, a counter-cyclical response on public debt to a temporary GDP variation and a one-to-one effect of expected inflation on nominal debt growth rate. Barro (1986a, 1986b), based on the estimated tax smoothing model for the US economy, provides statistical evidence that a shift toward a fiscal policy that generates either more real public debt on average or larger deficit response to recession is not supported by the empirical evidence, suggesting that the higher values of the deficits registered are a result of the response to substantial recession and expected inflation.

[2] More recently, however, Ghosh et al. (2013b) extending Bohn's "weak sustainability criterion" develop a measure of maximum debt that depends both on a country's 'fiscal response function' - how strongly its primary surplus responds to changes in the debt-to-GDP ratio - and on the country's ability to roll over its debt. Collard et al. (2016) introduce a new measure of government debt - maximum sustainable debt that considers the fact that a shortfall in growth naturally increases the probability of default. They show that without sufficient institutional constraints, governments will generally borrow up to a level close to the maximum that can be sustained. On this issue, see also Hamilton and Flavin (1986), Kremers (1989), Trehan and Walsh (1988, 1991), and Wilcox (1989)

[3] In particular, Bohn (1998) refers to Barro's (1979) tax-smoothing model that considers an optimizing government that minimizes the cost of tax collection by smoothing marginal tax rates over time. In his context, key features of the optimal policy are that tax rates should depend only on permanent government spending and on the level of debt. Indeed, the tax-smoothing model yields an equation for the primary surplus, if one subtracts noninterest government spending from tax revenues (all relative to GDP). The model implies that the non-debt determinants of the primary surplus are the level of temporary government spending and a business cycle indicator, both taken by Barro (1986a, 1986b).

[4] See Section 3.

the equilibrium. In modeling the short term, given our choice to refer the relevant variables to potential output, crucially important is the inclusion of a variable representing the *output gap,* which identifies and isolates the impact of cyclical factors not captured by the potential GDP (that is the denominator of the structural equation). A pick-up in economic activity may, thus, be reversed, as activity slows down, and should, therefore, not be seen as an underlying structural improvement. In the short run analysis, as a robustness check, we also test whether the assumption considered in the tax-smoothing model affects the public primary surplus dynamics. We show that, in the short run for all the different empirical specifications, the output gap coefficient is positive and statistically significant suggesting that the structural primary balance always responds positively to transitory changes in GDP. Furthermore, the first difference of public debt-to-GDP is shown to negatively and significantly affect the structural public primary balance-to potential GDP in the short run. Finally, as a robustness test, we find that the primary surplus is significantly and negatively affected by the variables considered in Barro analysis, i.e. GVAR and YVAR.

The paper is organized as follows. Section 2 reports a brief survey of the literature on the issues afforded. Section 3 develops the model studying the relationship of government debt and primary surpluses as decomposed in structural and cyclical surpluses. Section 4 is devoted to the empirical analysis for the 21 OECD countries and comments on the implications for the intertemporal budget constraint in the long and the short term. Section 5 concludes.

2. Survey of the literature

Fiscal sustainability requires the government has to be able to repay its debt at some point in the future. The primary budget balance is therefore a key determinant of government debt dynamics. The economic analysis has often tested fiscal sustainability of debt policies through the use of nonstationary time series analysis. In this respect, the first approach by Hamilton and Flavin (1986) focuses on the stochastic properties of the deficit inclusive of interest payments. Wilcox (1989), recalling that the intertemporal budget constraint of the government requires that the present value of public debt asymptotically converges to zero, focuses on the role of the interest rate to be resorted to in order to discount the stream of public debt.[5] Trehan and Walsh (1991) suggested the existence of a cointegration relationship between primary deficit and debt and the stationarity of the quasi-difference of the primary deficit are sufficient and necessary conditions for sustainability: any time series that grows linearly converges to zero if it is exponentially discounted, provided the real interest rate is positive (on cointegration tests see also Trehan and Walsh, 1988; and Ahmed and Rogers, 1995). More recently, Bohn (2007) showed that sustainability is compatible with any order of integration of the variables involved.

A further different test on sustainability is that proposed by Bohn (1995, 1998). It states that, if the primary surplus-GDP ratio is a positive function of the debt-GDP ratio, a given public debt policy can be shown to be sustainable. The plausible economic intuition is that if governments run into debt today, they have to take corrective actions in the future by increasing the primary surplus in order for public debt to be sustainable. From a statistical point of view, a rise in primary surpluses as a response to higher government debt implies that the series of public debt relative to GDP become mean-reverting: because higher debt-GDP ratio leads to an increase in the primary surplus relative to GDP, the debt-GDP ratio declines and returns to its mean. However, mean-reversion only holds if the reaction coefficient, determining how strongly the primary surplus reacts as public debt rises, is sufficiently large. Bohn (1998) has suggested that the analysis of the fiscal policy soundness should not be limited to the evaluation of stationarity of the debt-to-GDP ratio and provides a new sustainability test that does not require interest rate assumptions. To determine whether governments react to the evolution of debt by adjusting primary balances subsequently, the intuition is based on the use of fiscal policy reaction functions for the assessment of fiscal deficit sustainability. As he poses the issue, the key requirement is that the primary surplus increases at least linearly with debt/GDP at high debt-GDP ratios. This ensures that any upward movement in the debt-GDP ratio due to negative shocks is eventually reversed through primary surpluses. The strength of this sustainability test is that it does not require any assumptions about interest rates. It is valid in economies with uncertainty and risk aversion and for arbitrary debt management policies, whether or not government bond rates are above or below the growth rate. Greiner and Fincke (2016) elaborate on that test from a theoretical point of view, addressing the issues on whether (i) a sustainable debt policy is compatible with a rising debt to GDP ratio, (ii) sustainability can be given if the government does not react to rising debt ratios, and (iii) there exists a critical initial debt ratio that makes a sustainable debt policy impossible.

It is worth noticing that in the economic debate, the optimal degree of fiscal policy responsiveness to rising public debt and changing macroeconomic conditions has also been subject to intense discussion and diverging views. In line with the literature on fiscal reaction functions initiated by Bohn (1998), fiscal consolidation in case of a rapidly increasing public debt level has been seen as a way to restore fiscal sustainability. Some authors, however, have considered the risks of dampening economic activity, and of facing *fiscal fatigue* (Ghosh et al., 2013a, 2013b), especially when large and sustained fiscal consolidation appears to be required to ensure sustainability (see Eichengreen and Panizza, 2016). The study of how fiscal reaction functions can be used in fiscal sustainability analysis has recently received considerable attention. For example, Lukkezen and Rojas-Romagosa (2013, 2012), Medeiros (2012), Burger et al. (2012), Celasun et al. (2006) present stochastic debt projections integrating behavioural equations. In recent contributions, Fournier and Fall (2015), Ghosh et al., (2013a, 2013b) and European Commission (2011) have used fiscal reaction functions for the estimation of public debt sustainability thresholds and public debt limits aimed at providing possible measures of fiscal space. Finally, Checherita-Westphal and Žďarek (2017) also propose to use fiscal reaction functions to derive primary balance

[5] In the same line a multivariate perspective on this issue also examines the long-run properties of the flows of expenditures and revenues: see, among other others, Trehan and Walsh (1988), Hakkio and Rush (1991), Haug (1991) and Quintos (1995).

benchmarks used to identify fiscal fatigue risks. Berti et al. (2016) contributes to the existing fiscal reaction function literature by exploring if fiscal policy in EU Member States tend to react to a sufficient extent to increasing public debt or less supportive macro-financial conditions to ensure fiscal sustainability.

A great attention has been put on how to model the nature of the relationship between the primary balance and public debt. Initially specified as simple linear functions of debt, Lukkezen and Rojas-Romagosa, (2013, 2012), Celasun et al. (2006), Ghosh et al. (2013a, 2013b), Medeiros (2012), Bohn (2005) estimated the reaction functions using non-linear specifications. Fournier and Fall (2015), Legrenzi and Milas (2013), given the debt level dependent specifications, aim at capturing thresholds endogenously on the basis of regime-switching models. Other approaches, for example, Burger et al. (2012) and Fincke and Greiner (2012, 2011) have enabled time-varying debt coefficients using state-space modelling or penalized spline estimates. Checherita-Westphal and Žďarek (2017), Baldi and Staehr (2016) and Weichenrieder and Zimmer (2015), also test whether fiscal responsiveness has changed over time. Mauro et al. (2015) interact debt variables with macro-financial variables to determine if fiscal prudence/profligacy is influenced by macroeconomic conditions and financial market pressure. Finally, European Commission (2011) and Camarero et al. (2015) focus on the deficit-debt relationship, also called "the stock-flow adjustment," which relates to all other factors that affect the outstanding stock of debt but are not recorded as part of the primary balance.

3. The model

In order to setup our framework, the starting point of the present analysis is the relation between public debt, D_t, and public primary balance, S_t, given by the accounting identity $D_{t+1} \equiv (D_t - S_t)(1 + R_{t+1})$ where R_t denotes the nominal interest rate. The accounting identity can also be rewritten as follows: $D_{t+1} \equiv D_t(1 + R_{t+1}) - S_t(1 + R_{t+1})$. Notice here that the primary balance takes on positive sign in case of surplus and negative sign in case of deficit. Thus, in case of deficit, the accounting identity means that debt at time t + 1 is equal to the sum, at time t, of debt, interest on debt, primary deficit *and* the interests on primary deficit. In case of surplus, it means that debt at time t + 1 is equal to the debt at time t *plus* interest on debt at time t *minus* the primary surplus of time t *minus* the saved interests on primary surplus.[6]

We decompose S_t in a long-run component (the structural primary balance, S_t^s) and in a cyclical component (the non-structural primary balance, S_t^{ns}): $S_t \equiv S_t^s + S_t^{ns}$. Given this decomposition, then the debt law of motion can be rewritten as follows

$$D_{t+1} \equiv (D_t - S_t^s - S_t^{ns})(1 + R_{t+1})$$

In the presence of a growing economy with a non-zero growth rate, $\mu_t = Y_t/Y_{t-1} - 1$, the evolution of the relation in terms of debt to GDP ratio

$$\frac{D_{t+1}}{Y_{t+1}} \equiv \left(\frac{D_t}{Y_t} - \frac{S_t^s}{Y_t} - \frac{S_t^{ns}}{Y_t}\right)\frac{Y_t}{Y_{t+1}}(1 + R_{t+1})$$

that is

$$\frac{D_{t+1}}{Y_{t+1}} \equiv \left(\frac{D_t}{Y_t} - \phi_t\frac{S_t^s}{Y_t^*} - \frac{S_t^{ns}}{Y_t}\right)\frac{Y_t}{Y_{t+1}}(1 + R_{t+1})$$

which can be rewritten as

$$d_{t+1} \equiv (d_t - \phi_t s_t^s - s_t^{ns})x_{t+1} \tag{1}$$

where $\phi_t \equiv Y_t^*/Y_t$ denotes the output gap; Y_t and Y_t^* denote the actual and potential GDP, respectively; R_t is the nominal interest rate; $x_{t+1} \equiv (1 + R_{t+1})/(1 + \mu_{t+1})$ denotes the ratio of the gross return on government debt to the gross growth rate of GDP and $d_{t+1} = D_{t+1}/Y_{t+1}$, $s_t^s = S_t^s/Y_t^*$ and $s_t^{ns} = S_t^{ns}/Y_t$ denote the debt-GDP ratio, structural primary balance on potential GDP and cyclical primary balance-GDP ratio, respectively.

Given the derived public debt-to-GDP law of motion analytically described by Eq. (1), in order to shed some light on the public debt time-series proprieties, and hence on public debt sustainability, a main assumption on the functional form of s_t^s, i.e., the structural public primary balance on potential GDP, must be considered.[7] We borrow from Bohn (1998) and, in the light of the above decomposition of the primary balance, we assume the following relation:

$$s_t \equiv \phi_t s_t^s + s_t^{ns} = \tilde{\theta}d_t + \alpha_1 F_t + \varepsilon_t = \tilde{\theta}d_t + \eta_t$$

[6] This is the general accounting identity often used in the literature, for example it is used in Bohn (1998), because one cannot exclude a priori that governments, also when promptly reacting to increases of public debt, are for whatever reason induced/obliged to run primary deficits. In case of permanent primary surplus (when the whole series takes on positive sign), however, the accounting identity that considers the potential saving of interests on surplus might be seen as quite odd. Indeed, in the literature we also find - for example Bohn (2007), Fincke and Greiner (2011, 2012) and Grainer e Fincke (2016) – the reference to the accounting identity that exclude the potential saving of interest on primary balance, i.e., $D_{t+1} \equiv D_t(1 + R_{t+1}) - S_t$. The change of the reference accounting identity that consider this special case, however, does not change the results of the model. The proof is available from authors upon request. Here, we prefer to stick to the most general form.

[7] A large body of literature, among others Bohn (1998, 2005), Ghosh et al. (2013a), when studying the public debt sustainability rely on an econometric model where a systematic relationship between the debt-GDP ratio, d_t, and the primary balance, s_t, is considered.

where $\tilde{\theta}$ denotes the "Bohn" response of primary surplus to the public debt, F_t represents the determinants of primary surplus-GDP ratio, ε_t denotes the error term and $\eta_t = \alpha_1 F_t + \varepsilon_t$. In so doing, we have considered in the government reaction function of (Bohn, 1998) the fundamental distinction between discretionary and automatic response of primary balance to fiscal policy, as suggested by Gali et al. (2003). Both are referred to potential output, in order to identify the fiscal authority reaction and avoid heteroscedasticity problems due to likely non-linearities of the fiscal policies as suggested by Giavazzi et al. (2000). In this context, once a cointegrated panel approach, based on long run relationship, is implemented, the automatic or "passive" fiscal policy, represented quantitatively by the nonstructural component of primary public balance, s_t^{ns}, should not be considered as a part of the dependent variable. This is supported by the statistical propriety of the variable s_t^{ns}. In fact, the cyclical part of the primary balance is, by construction and definition, stationary and results to be able to influence and determine only the short run dynamics. In a cointegrated panel set-up, all the stationary and cyclical zero mean variables, which show only short-run dynamics, end up in the residual term and hence do not influence the estimated coefficients responsible in identifying the long-run relationship between the structural part of the government primary balance on potential GDP and debt on potential GDP. Thus, if debt and structural primary balance are both non-stationary, then the cointegration regression of s_t^s on d_t^* does not require to account for s_t^{ns} explicitly.

For these reasons, we concentrate on the existence of a systematic relation between debt to potential GDP ratio and structural primary balance to potential GDP of the form

$$s_t^s = \theta d_t^* + \alpha_1 F_t^* + \varepsilon_t^* = \theta d_t^* + \eta_t^* \tag{2}$$

where $d_t^* = D_t/Y_t^*$ denotes the debt to potential output ratio, θ is the response of structural primary balance to public debt, F_t^* represents the determinants of structural primary surplus-potential GDP ratio, ε_t^* denotes the error term and $\eta_t^* = \alpha_1 F_t^* + \varepsilon_t^*$.

In the light of Eq. (2), if both the government debt and structural primary balance to potential GDP results nonstationary and a long-term relationship between them does exist, there is no need for an economic model to identify the stochastic process η_t^*.

The consideration of a systematic relation between debt to potential GDP ratio and structural primary surplus or deficit of the form described analytically by Eq. (2), yields a more detailed representation of the law of motion of public debt-to-GDP, represented by Eq. (1) that can be rewritten with the aim of shedding some light on the (non)stationarity and hence on the public debt sustainability. In the present theoretical setup, once the (estimated) structural primary surplus (deficit) to potential GDP, Eq. (2), is replaced into Eq. (1), the latter can be rewritten as:

$$\Delta d_{t+1} = -[1 - x_{t+1}(1 - \theta)]d_t - x_{t+1}\zeta_t \tag{3}$$

where $\zeta_t = \eta_t + s_t^{ns}$.[8] Eq. (3) implies that the change in the debt-GDP ratio depends on the lagged level of debt-GDP ratio as from the debt-GDP Eq. (1) and on both the determinants of primary balance-GDP ratio η_t *plus* s_t^{ns}. Thus, the key role for the (non)stationarity and for the public debt sustainability is played by both the sign and the size of estimated response of structural primary balance to public debt, θ, provided by the long-run relationship represented by Eq. (2). Given that x_{t+1} results stationary,[9] then the public debt-GDP ratio results stationary if $\bar{x}(1 - \theta) < 1$, where $\bar{x}$ is the average value of $x_t \equiv (1 + R_t)/(1 + \mu_t)$. Therefore, the sign and the size of the response of structural primary balance to the public debt, θ, turns out to be crucial for some conclusions on fiscal policy, in general, and debt sustainability, in particular.

In the light of the above theoretical setup, i.e. in the presence of a fiscal authority reaction function, suggests what follows:

Proposition 1. *Once the upper bound of the primary surplus to GDP ratio is not binding, a strictly positive reaction coefficient,* $\theta > 0$*, guarantees sustainability of public debt. Furthermore, for* $\theta > (R - \mu)/(1 + R)$ *the debt to GDP ratio converges to a constant, otherwise,* i.e., *for* $\theta \leq (R - \mu)/(1 + R)$*, it diverges to infinity as* $t \to \infty$.[10]

Before moving to the empirical analysis testing for co-integration between cyclically adjusted primary balance and public debt, in order to account for the country specific unobserved factors that cause a heterogeneous response to the common shocks, i.e., the issue of cross-section dependence in the data, the setting of Eq. (2), must be modified as follows:

$$s_{it}^s = \theta_i d_{it}^* + \gamma_i f_{it} + \upsilon_i + \varepsilon_{it} \tag{4}$$

where, recall that d_{it}^* denotes the debt to potential output ratio, and

$$d_{it}^* = \alpha_i + \varphi_i f_{it} + \psi_i g_{it} + u_{it} \tag{5}$$

where f_{it} and g_{it} are unobserved factors affecting s_{it}^s directly or indirectly (i.e., impacting on the set of variables d_{it}^*); φ_i and ψ_i are the country specific factor loads which cause a heterogeneous response to the common shocks, α_i denotes the country intercept, u_{it} represents the white noise errors, $i = 1, 2, ..,N$ *and* $t = 1, 2, ..,T$ denote the country and time indexes, respectively. The failure to detect cross-section correlation and, thus, to take it into account when producing estimates will give rise the omitted variables problems, thus causing bias in estimates and erroneous inference.

We will refer to as "long-run" empirical effects of public debt in the context of a stochastic autoregressive distributed lag (ARDL) model where the "long-run" describes the equilibrium relationship (see Pesaran, 1997). If the variables in Eqs. (4) and (5) are I(1) and cointegrated, the error term is an I(0) process for all i. The principal feature of cointegrated variables is their responsiveness to any

[8] Recall that $d_t^* = D_t/Y_t^* = d_t/\phi_t$.

[9] Further details on the stationarity test of x_{t+1} are available upon request.

[10] The proof of Proposition1 can be provided from authors upon request also for the case in which the reference accounting identity is $D_{t+1} \equiv D_t(1 + R_{t+1}) - S_t$.

Table 1
Summary statistics of the considered variables.

Variable	Obs.	Mean	Std. Dev.	Min	Max
Cyclically-adjusted general government primary balances	535	0.165	3.170	− 26.116	14.481
General government debt-to-GDP ratio	535	64.196	37.864	8.243	242.113
General government debt-to-potential GDP ratio	535	63.491	37.033	8.483	241.062
YVAR	535	0.332	2.330	− 12.010	12.996
GVAR	535	0.370	2.776	− 14.550	15.124
Output gap	535	1.007	0.027	0.9110	1.128

deviation from the long-run equilibrium. This implies an error correction model, in which the short-term dynamics of the variables in the system are influenced by the deviation from the equilibrium. In the light of the above considerations, we postulate the dynamic panel specification as follows:

$$\Delta s_{it}^{s} = \omega_i + \Phi_i[\zeta_{i,t-1}] + \delta_i Z_{it} + \varepsilon_{it}$$

where ω_i is the constant term, the term within the brackets are the residuals from Eq. (4), Φ_i is the error-correction speed of adjustment parameter, ε_{it} are white noise errors, Z_{it} is a vector of stationary variables entering the dynamic specification, and δ_i are the corresponding coefficients. In particular, we postulate the presence of short-term factors that affect its annual dynamics. Given our interest on debt (non)stationarity, and given our empirical strategy dictated by the statistical proprieties of the variables involved in the analysis, the consideration of a cointegration regression of s_t^s on d_{it}^* permits us to overcome the potential problems related to omitted variables and avoid to explicitly consider a theoretical model of fiscal policy, such as the already mention Barro's (1979) tax-smoothing model used in Bohn (1998), Fincke and Greiner (2012), and Greiner et al. (2007). For this reason, our reference model, both theoretically and empirically, will be represented by the long-run relation identified by cointegration regression between s_{it}^s and d_{it}^* (i.e. Eq. (4)), providing necessary and sufficient information for debt (non)stationarity, i.e. θ. At the same time, in order to shed some light in the residual short run dynamics left by the long-run relationship, we consider an error correction model. In this respect, the output gap can be considered as the main driver of the short-run dynamics. Indeed, the output gap identifies and isolates the impact of cyclical factors not captured by the general government debt-to-potential GDP ratio. Short-term improvements in GDP growth rate may be reversed, as activity slows down, and should, therefore, not be seen as an underlying structural improvement. Finally, in order to account for the potential dynamic effects on the change of cyclically-adjusted general government primary balances of the general government debt-to-GDP ratio the first difference of the latter variable is considered.

As a robustness check, however, for the short-run dynamics we shall also consider, as in Bohn (1998), the level of the temporary government spending, GVAR, and a business cycle indicator, YVAR. Both variables GVAR and YVAR are taken from Barro (1986a, 1986b) and obtained for 21 OECD countries from 1991 to 2015.

Table 1 reports the summary statistics of the variables relevant for the analysis presented here. Data on the considered variables are obtained from OECD sources. The 21 countries considered are Australia, Austria, Japan, Canada, Iceland, Norway, Korea, Belgium, Denmark, Finland, France, Germany, Ireland, Italy, Netherlands, New Zealand, Portugal, Spain, Sweden, Switzerland and UK. The panel spans the years from 1991 to 2015 with annual frequency. Notice here that the structural primary deficit or surplus would be identified either by the cyclically adjusted or by the underlying primary balance. In our analysis, we refer to the OECD definition of *Cyclically-Adjusted General Government Primary Balances* (OECD, 2018 p.14¸ see also Girouard and André, 2005) as obtained from the underlying fiscal position when cyclical or automatic movements are removed from the fiscal components. Under fiscal policy, in fact, this is the correct measure of the public finance stance, being given by the difference between government revenues and expenditures corrected by the effects that could be attributed to the economic cycle and, thus, providing useful information to identify the structural trends and to assess whether the fiscal policy of a country is expansionary, neutral or restrictive for a given period. *Potential GDP* is identified by the output level associated to a constant inflation rate. *Output Gap* is defined as the deviations of actual GDP from *Potential GDP* (OECD, 2016).

4. The empirical analysis for the 21 OECD countries

The first step in our analysis is to test whether the variables are nonstationary or not. Notice that the presence of cross-section dependence within the framework of our dataset is highly likely. Developed economies tend to be hit by globally common shocks even though they are affected in a heterogeneous manner, i.e., the impact varies according to their institutions and to their fiscal framework.[11] Here we investigate this issue by implementing the most commonly used test for cross section dependency (Pesaran, 2004 and 2007) and the results of cross-section dependence test are reported in Table 2.

The above tests reject the null of lack of cross-section dependence. We thus proceed by testing for unit root and for the presence of cointegration and finally estimating cointegrating relationships in the presence of cross section dependence.

We first test for unit roots in heterogeneous panels with cross-section dependence (CADF), proposed by Pesaran (2007), which is the homologous of Im et al. (2003) test. This test is based on the mean of individual DF (or ADF) t-statistics of each unit in the panel

[11] For a review of the panel time series literature, see Eberhardt and Teal (2011).

Table 2
Average correlation coefficients and Pesaran CD test.

Variables series tested	CD-test	P-value	Corr.	Abs. (Corr.)
Cyclically-adjusted general government primary balances	20.07	0.000	0.265	0.367
General government debt-to-GDP ratio	16.53	0.000	0.227	0.512
General government debt-to-potential GDP ratio	14.56	0.000	0.200	0.516

Notes: Pooled variables. Group variable: Country; Number of groups: 21. Test performed on 21 OECD countries. Under the null hypothesis of cross-section independence CD ~ N(0,1).

Table 3
Panel unit root tests, Pesaran (2007).

Cyclically-adjusted general government primary balances constant and trend

Test statistic	P=1	P=2	P=3	P=4	P=5	P=6
CIPS	−2.695	−2.162	−2.108	−1.765	−2.146	−2.256
*CIPS**	−2.695	−2.162	−2.108	−1.765	−2.157	−1.949

Cyclically-Adjusted General Government Primary Balances constant

Test Statistic	P=1	P=2	P=3	P=4	P=5	P=6
CIPS	−2.385	−2.065	−2.174	−2.040	−2.144	−2.643
*CIPS**	−2.385	−2.065	−2.174	−2.040	−2.144	−2.178

General Government debt-to-GDP ratio constant and trend

Test Statistic	P=1	P=2	P=3	P=4	P=5	P=6
CIPS	0.118	−0.395	−0.819	0.922	3.815	
*CIPS**	0.118	−0.395	−0.777	0.922	3.815	9.339

General Government debt-to-GDP ratio constant

Test Statistic	P=1	P=2	P=3	P=4	P=5	P=6
CIPS	1.169	1.133	−0.092	1.302	2.236	
*CIPS**	1.169	1.133	0.171	1.302	2.236	0.790

General Government debt-to-potential GDP ratio constant and trend

Test Statistic	P=1	P=2	P=3	P=4	P=5	P=6
CIPS	0.335	0.335	−0.591	−0.506	1.460	
*CIPS**	−0.236	0.335	−0.591	0.400	1.460	6.464

General Government debt-to-potential GDP ratio constant

Test Statistic	P=1	P=2	P=3	P=4	P=5	P=6
CIPS	2.205	3.278	0.368	3.409	2.363	
*CIPS**	2.205	3.278	0.795	3.132	2.191	1.716

Notes: Rejection of the null hypothesis indicates stationarity at least in one region. The considered critical values are at 1%. CIPS – Cross-section augmented Im-Pesaran-Shin test, CIPS* – Truncated Cross-section augmented Im-Pesaran-Shin test.

and it assumes as the null hypothesis that all series are non-stationary.[12] We consider also the statistics of a truncated version of CADF statistics, which has finite first and second order moments. It allows to avoid size distortions, especially in the case of models with residual serial correlations and linear trends (Pesaran, 2007). Given that the time series dimension, t, is fixed (and is not large enough to rely on asymptotic properties), the test is applied to the deviations of the variable from initial cross-section mean assuring that the CADF statistics do not depend on the nuisance parameters. Lags of the dependent variable are introduced with the aim at controlling for serial correlation in the errors. All bandwidths and lag lengths are chosen according to $4(T/100)^{2/9}$ criterion. The number of lags chosen according to the Akaike criterion is three. However, we have investigated results for several lags spanning from 1 to 6, with the ensuing statistics Z[t-bar] follows a standard normal distribution under the null hypothesis of non-stationarity. Most of the statistics, reported in Table 3 in grey, confirm the non-stationarity already found under the assumption of cross section independence.

This result prompts a test to confirm that the variables are cointegrated. To provide evidence in favor of the cointegration hypothesis we apply the Westerlund (2007) (see also Persyn and Westerlund, 2008) tests on co-integration. These tests lift a restriction, embedded in previous tests for cointegration, requiring the long-term parameters for the variables in their levels to be equal to the short-term parameters for the variables in their differences; when this restriction is not correct, it causes a significant loss of power and the failure to reject the null of no cointegration.

Table 4 reports the outcome of four tests; in the first two cases the alternative hypothesis to the null is that the panel is

[12] To eliminate the cross dependence, the standard DF (or ADF) regressions are augmented with the cross-section averages of lagged levels and first-differences of the individual series.

Table 4
Westerlund ECM panel co-integration tests on structural primary surplus/potential GDP and general government debt-to-potential GDP ratio.

Constant Statistic	Value	*Z*-value	*P*-value
Gt	−3.183	−7.170	0.000
Ga	−12.483	−4.496	0.000
Pt	−13.710	−7.117	0.000
Pa	−12.624	−8.665	0.000
Constant and trend Statistic	Value	*Z*-value	*P*-value
Gt	−3.522	−6.515	0.000
Ga	−13.576	−1.054	0.146
Pt	−17.821	−9.308	0.000
Pa	−14.727	−4.331	0.000

Notes: Average AIC selected lag length: 0.9. Average AIC selected lead length: 0. Results with 21 series and 1 covariate for H0: no cointegration.

Table 5
Westerlund ECM panel cointegration tests on structural primary surplus/potential GDP and general government debt-to-potential GDP ratio.

Constant Statistic	Value	*Z*-value	*P*-value	Robust *P*-value
Gt	−3.183	−7.170	0.000	0.000
Ga	−12.483	−4.496	0.000	0.000
Pt	−13.710	−7.117	0.000	0.000
Pa	−12.624	−8.665	0.000	0.000
Constant and Trend Statistic	Value	*Z*-value	*P*-value	Robust *P*-value
Gt	−3.595	−6.929	0.000	0.000
Ga	−13.692	−1.132	0.129	0.005
Pt	−17.821	−9.308	0.000	0.004
Pa	−14.727	−4.331	0.000	0.006

Notes: Bootstrapped critical values (1000 replications). Results (with 21 series and 1 covariate) for H0: no cointegration.

cointegrated, while the other two test the alternative that at least one unit is cointegrated. The values of the statistics suggest that we can reject the null hypothesis of no cointegration at the 1% level for both cases. These results strongly reject the hypothesis that the series are not cointegrated at least in the case of constant only. Therefore, we further test for cross-sectional independence in the residuals assuming the same dynamics. Based on 20 complete observations, the Breusch-Pagan LM test of independence strongly indicate the presence of common factors affecting the cross-sectional units. In the case of constant only the Breusch-Pagan LM test provides $\chi^2_{210} = 435.20$, $p = 0.00$. In the case of constant and trend the Breusch-Pagan LM test of independence gives $\chi^2_{210} = 374.43$, $p = 0.00$. We, therefore, bootstrap (1000 replications) robust critical values for the test statistics related to the Westerlund ECM panel cointegration tests. The outcome in Table 5 shows that, when we account for cross-sectional dependencies, the tests reject the null hypothesis of no cointegration in both cases of constant only and constant and trend.

Based on this outcome we estimate the long-term coefficients by means of the augmented mean group estimator.[13] Results are reported in Table 6, where all coefficients represent averages across groups (countries) coefficient computed as outliers-robust means.[14]

[13] The estimator chosen forms part of the panel time-series (or nonstationary panel) literature of second generation, which emphasizes variable nonstationarity, cross-section dependence, and parameter heterogeneity (in the slope parameters, not just time-invariant effects). For discussion and illustration of the application of panel time-series methods, see Eberhardt and Teal (2010, 2011) Eberhardt et al. (2013), and Moscone and Tosetti (2010).

[14] The objection might arise that the economies in the sample have their own legislation and, if some of them attains budget surpluses, it is difficult to imagine that they have unsustainable time series of public debt. Indeed, when a panel estimate of the fiscal response is performed, the advantage of relatively short time series has to be compared with the disadvantage that a single fiscal reaction rule is estimated over a panel of countries giving rise to the relatively strong assumption of country-invariant fiscal behavior. However, in our analysis, as in Eberhardt and Tail (2010) and Eberhardt et al. (2013), this assumption is in some dimensions relaxed by performing the Augmented Mean Group estimator which, differently form the standard panel estimation, accounts for parameter heterogeneity in macro panel data and allows a group-specific coefficients analysis. The full results from group-decomposition AMG estimation - available from authors upon request – actually show that the chosen estimator

Table 6
Augmented mean group estimator. dependent variable: structural primary surplus/potential GDP.

	Coefficient	Standard Error	95% Confidence Interval	
General Government debt-to-potential GDP ratio	− 0. 058***	0.018	− 0.093	− 0.023
Common Dynamic Process *(c.d.p.)*	1.020***	0.197	0.633	1.407
Time trend	0.110***	0.0414	0.0289	0.1912
Constant	0.758	1.757	− 2.685	4.202
Nr. of Observations	539			
Nr. of Groups	21			

The results show a negative and significant impact of General Government debt/Potential GDP on the Structural Primary Surplus/Potential GDP. In the long-run, an increase in the General Government debt-to-potential GDP reduces, by 0.058, the Structural Primary Surplus/Potential GDP. As reported previously, it can be easily noted that the key role for the (non)stationarity and hence for the public debt sustainability is played by the sign and size of estimated response of structural primary surplus to the public debt, θ, provided by the long-run relationship represented by Eq. (4) and Proposition 1. Given that the gross interest rate on government debt to gross growth rate of GDP, i.e. $x_{t+1} = (1 + R_{t+1})/(1 + \mu_{t+1})$, results stationary, the public debt - potential GDP ratio results stationary if $\bar{x}(1 - \theta) < 1$. For the 21 OECD economies considered in our empirical setup, the results suggest that, with $\theta < 0$, the debt-to-GDP results nonstationary and not sustainable in the long term.

In other words, given that x_{t+1} results stationary, the public debt-GDP ratio results stationary if $\bar{x}(1 - \theta) < 1$, and given the (non) stationarity condition, the sign and the size of the response of structural primary surplus to the public debt, θ results to be crucial for debt sustainability. A quick investigation on the dataset of 21 OECD countries, for the 1991–2015 sample, suggests that the interest rate on government debt is $\bar{R} = 5.15\%$ while the average GDP growth rate is $\bar{\mu} = 2.24\%$ yielding an average gross interest rate on government debt, $1 + \bar{R}$, to GDP-growth rate, $1 + \bar{\mu}$, ratio of $\bar{x} = 1 + \bar{R}/1 + \bar{\mu} = 1.03$. In the light of this evidence, given that the average interest rate on government debt results greater than the normalized, by $(1 - \theta)$, sum of average growth rate of GDP, $\bar{\mu}$, and the estimated response of structural primary surplus to the public debt, θ, i.e. $\bar{R} > (\bar{\mu} + \theta)/(1 - \theta)$, unlike what suggested by Bohn (1998) for the US fiscal policy and by Westerlund and Prohl (2010) for rich OECD economies, not only the sign but also the size of the response of structural primary surplus to the public debt is the main determinant of public debt (non)sustainability in the case of 21 OECD countries, for the 1991–2015.

We now turn to the short-run error correction term representation. We perform a Mean Group Regression for 21 OECD countries onto which we impose the long-run specification estimated in Table 6.[15] The results are reported in Table 7.

For the sake of completeness, and as a robustness test, Table 7 reports, in the different columns, six different specifications for the error correction representation by the Mean Group Regression, characterizing the short-run estimation model. More precisely, the first difference of debt to potential GDP ratio, the output gap and the constant term accompany all the regressions carried out in our analysis; the first group of models, i.e. [1] to [3], differs from the second one, i.e. [4] to [6], because it does not account for the presence of the trend, which we use as control. Within each group of models, different specifications are considered. More specifically, [1] and [4] constitute the baseline estimation model, without and with trend, respectively. In columns [2], [5] and [3], [6] we account for the presence of GVAR and YVAR, respectively.

As expected, in all the reported regressions, the estimated cointegrating vector (i.e. the EC term) is negative and statistically significant. However, in the presence of a disequilibrium, the speed of convergence, represented by the parameter EC, to the long-run equilibrium relationship, represented by Z, is higher in the presence of the trend as compared to the regressions performed in the absence of the trend, implying relatively contained different short-term dynamics. Moreover, in the short-run, for all the different empirical specifications, the output gap produces a positive and statistically significant response. The positive output gap estimated coefficients suggest that the structural primary balance always responds positively to transitory changes in GDP. Also, the first difference of public debt-to-GDP is shown to negatively and significantly affect the structural public primary balance-to potential GDP. Finally, as a robustness test, we find that the primary surplus is significantly and negatively affected by the variables considered in Barro analysis, i.e. GVAR and YVAR. That is, both the temporary government spending component, GVAR, and the temporary component of output, YVAR, negatively and significantly affect the first difference debt to potential GDP ratio.

5. Conclusions

At the middle-end of the great recession, fiscal rules of budget balance over the cycle have been introduced, more or less intensively in different countries, to counteract the debt accumulation. Thus, a natural question arises: Have the fiscal policy of different OECD economies been sustainable in both the long and the short terms? To answer this question, we have disentangled

(*footnote continued*)
is able to capture the different peculiarity of the countries considered individually. In this respect, it would be also interesting to compare our results with the results of individual countries using a time varying parameter approach. We have also carried out the individual fiscal response using the time varying Kalman filter. These results are available upon request.

[15] We impose a long-run specification $Z = 0.758 + 1.02\ c.\ d.\ p. + 0.110\ trend - 0.058\ debt/potential\ GDP$, estimated previously in Table 6.

Table 7
Mean group estimation: error correction form, constrained long term pooled mean group regression. dependent variable Δ primary surplus.

	[1]	[2]	[3]	[4]	[5]	[6]
Long Term						
Z	−1	−1	−1	−1	−1	−1
Short Term						
EC	− 0. 553*** (0.059)	− 0. 565*** (0.060)	− 0. 558*** (0.062)	− 0. 631*** (0.052)	− 0. 636*** (0.055)	− 0. 635*** (0.055)
D.Debt/GDP*	− 0. 249*** (0.034)	− 0. 249*** (0.034)	− 0. 247*** (0.034)	− 0. 227*** (0.034)	− 0. 220*** (0.032)	− 0. 219*** (0.032)
Output Gap	0.209*** (0.059)	0.571*** (0.154)	0.653*** (0.184)	0.221*** (0.063)	0.655*** (0.188)	0.728*** (0.210)
GVAR		− 0. 615*** (0.225)			− 0. 734*** (0.313)	
YVAR			− 0. 894*** (0.334)			− 0. 986*** (0.392)
Trend	*non included*	*non included*	*non included*	*included*	*included*	*included*
Constant	*included*	*included*	*included*	*included*	*included*	*included*

discretionary from automatic response of primary deficit to government actions. The former are captured quantitatively by the structural component of primary public surplus, which is not influenced by the economic cycle. The latter are captured by the nonstructural component of primary public surplus. In order to avoid heteroscedasticity problems due to likely non-linearities of the fiscal policies, we have also referred our variables to potential output. Finally, in order to consider the heterogeneous responses to the common shocks by part of the governments of the country involved, we allow for cross-section dependence in the data.

Showing that public debt-GDP ratio and structural primary surplus are cointegrated, we found a sort of general empirical law of policy behavior valid for the OECD countries according to which, on the one side, the long-term governments' reaction to the accumulation of debt in terms of sustainability is negative, i.e., the fiscal policies are not sustainable. On the other side, in the short term, an asymmetric fiscal policy response, exploiting the output gap, by part of the political class of the countries considered seems to emerge: it intervenes with a new deficit and debt when the output gap is positive, but it does not adopt a symmetrical correction when the situation is reversed. These results may be taken as evidence that the politicians in power, at least in most OECD countries considered, have a shorts-sighted perspective. A reason is often being found in the politicians' need to be re-elected. New research may prove to be useful to ascertain whether the empirical law found also implies that the electors – who matter for the political class to be re-elected – have, in turn, a short sight view because of a myopic discount of the future. Alternatively, possibly, high transaction and information costs of the agency relations of the electors with the politicians, in the budgetary matters, allow an opportunistic behavior of the agents.

In any case, the results of our research may help in focusing on asymmetrical long-sighted monetary and fiscal policies, working in reverse, to counteract the short sighted asymmetric policies of the politicians made possible by the present rules and behaviors of fiscal and monetary policies. In this respect, Buchanan (1958, 1966) maintains that public debt, properly defined, is a burden on the future generations because it shifts to them the onus of covering with fresh resources a debt made in the present, for which there are not present resources. To the objection that, in the case of an unutilized economic capacity, resources to cover the public debt are available in the present, Buchanan argues that this public debt is not a true public debt, as an issuance of money could (and should) replace it.

At that time, the non-conventional monetary policies of the central Banks were not available. Now, however, these same arguments may give a theoretical foundation to the policy of the Central Banks, in periods of positive output gap, consisting in purchasing on the secondary market public debt issued in the past to expand the quantity of money available on the market to finance public investments. This stock of public debts enters in the portfolio of the Central Bank, which shall put it back on the market in period of negative output gap to reduce the quantity of money available for new public debts and/or renewal of the old one. By this long-run monetary-fiscal policy one may displace the short sighted asymmetrical fiscal policy that prevails in the OECD countries, which one can deduce from the cointegration between structural primary surplus and public debt /GDP ratio.

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