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Are the EU New Member States Fiscally Sustainable? An Empirical Analysis

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Abstract: This paper discusses the theoretical aspects of fiscal sustainability and identifies the main sources of fiscal non-sustainability from the perspective of both general equilibrium models and partial equilibrium models. The study adopts the partial equilibrium approach to investigate empirically whether the EU New Member States are fiscally sustainable. The stationarity test and cointegration analysis are employed to examine this issue. According to the debt stationarity tests, countries such as Lithuania and Slovenia are the only ones that can be regarded as fiscally sustainable. According to a cointegration analysis of government revenues and expenditures none of the analysed countries is fiscally sustainable. However, analyses based on public debt stationarity test and intertemporal budget constraint do not account for the costs associated with the transition period, therefore the final conclusion of no sustainability in NMS should be put into a broader context of transformation from a centrally planned economy to a market oriented system. This, of course, should not be taken as an excuse for failing to pursue prudent fiscal policy aiming to ensure sustainability over the long-term. The policy implication of this is that the vast majority of the EU New Member States have to undertake significant corrective measures to ensure sustainability over the long-term: certainly more than is being done at the present time.

JEL classification: H62, E62, C52

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1 Introduction

The issue of fiscal sustainability returned to the centre of economic policy debate in the European Union, and more generally, in the 1980s. This was in response to the increasing role played by the public sector, reflected in the ratio of public sector expenditure to GDP, and as a consequence of unfavourable demographic trends. In some countries, fast growing implicit liabilities caused by an aging demographic structure of the population required a new framework. When plans for the Maastricht Treaty were being discussed it was necessary to incorporate into them projected future direction of deficits. This was an important element of the Treaty and its inclusion was subsequently confirmed by the Stability and Growth Pact (SGP).

The latest round of European Union enlargement in May 2004 added a new challenge for the financial stability of an enlarged Economic and Monetary Union because the ultimate goal of the New Member States (NMS) is to join the Eurozone. All EMU members lose the freedom to finance their deficits through money creation and cannot exploit higher tax rates extensively because of the increasing mobility of tax bases in the EU (Artis and Marcellino, 2000). In this context, vital and relevant questions are related to the fiscal sustainability of the NMS, as this will affect the fiscal stance of the extended Eurozone substantially.

The main purpose of this study is to test empirically the fiscal sustainability of the NMS as well as to critically survey recent advances in both the theoretical and empirical literature on fiscal sustainability. This is a very important issue, as NMS aim to enter Economic and Monetary Union. Thus, close monitoring of the fiscal stance of the candidate countries would seem to be an indispensable part of the future success of European Monetary Union. However, the empirical literature that might help in this assessment currently lacks quantitative analysis on fiscal sustainability with respect to the NMS. To the best of the author's knowledge no such study has yet been prepared for any of the NMS aiming to adopt the common currency in the coming years. The other purpose of this paper is to supplement the studies assessing the fiscal sustainability of OMS that were prepared by Uctum and Wickens (2000), Artis and Marcellino (2000) and Afonso (2004). This can give a broader perspective on the future of the EMU, consisting of both OMS and NMS. This paper therefore attempts to answer two questions. Firstly, are NMS fiscally sustainable? Secondly, is future European Monetary Union fiscally sustainable? The latter question is considered by combining the results obtained for NMS with those for Old Member States (OMS).

The paper is organised as follows. Section 2 relates the present paper to the economic literature on fiscal sustainability, while Section 3 introduces the basic framework for the analysis of sustainability. In Section 4 we survey previous studies that have tested for fiscal sustainability and present econometric methods employed in subsequent sections. Section 5 is devoted to a general introduction of fiscal policy in NMS as well as discussion of results. Section 6 concludes with a summary of the main results of the paper and provides suggestions for further research.

2 Survey of existing studies

2.1 General equilibrium models

An early paper analysing debt sustainability was written by Domar (1944), but the partial equilibrium nature of his model precluded analysis of the impact of debt on the economy with a feedback rule. This limitation is avoided in a seminal paper by Diamond (1965) who employs the overlapping generations model to analyse the effect of a positive stock of debt on the long-term competitive equilibrium of an economy with neoclassical technology.[2] He shows that government debt causes a decrease in utility when the economy is dynamically efficient, whereas utility may be increased if the economy is dynamically inefficient. [3] Ihori (1978) uses the same framework to examine the effects of government debt on long-term optimal conditions. He also considers alternative scenarios for government policies in order to analyse their impact on the paths of economic growth.

A recent set of papers has altered the perspective by analysing a life-cycle model. An important contribution is by Chalk (2000) who explores the sustainability of deficits financed by bond issues. He claims that a situation in which economic growth exceeds an interest rate is merely a necessary and not a sufficient condition for budget deficit sustainability. Public debt is incorporated into a two-period overlapping generation model by De la Croix and Michel (2002) who examine the impact of debt on the economy in a dynamic framework. Marin (2002) introduces a primary surplus budgetary rule to show how fiscal sustainability can be achieved within the framework of a small open economy.

A very important issue of maximum sustainable government debt based on the Diamond two-period overlapping generation model is analysed by Rankin and Roffia (2003). The authors show under which conditions maximum sustainable government debt can be achieved in both a closed and an open economy. They also provide a thorough analysis of stability conditions. Assuming a constant stock of debt, perpetuity bonds ensure better results compared to treasury bills, and treasury bills give better results than savings deposits. They also analyse the extent to which crowding out effects exists. Rankin and Roffia show that the steady state related to maximum sustainable interest-inclusive debt leads to the occurrence of greater crowding out effects in comparison with the steady state related to interest-exclusive debt.[4]

Annicchiarico and Giammarioli (2004) apply the overlapping generations models with endogenous growth under the assumption that the public sector is included in the model. They introduce a fiscal rule with an objective for both public debt and the primary fiscal deficit to converge towards

[2] Actually, Diamond's contribution draws on a paper by Samuelson (1958) who examined the determination of interest rates in a single-commodity world without durable goods.

[3] Dynamic efficient economies are those which have under-accumulated capital, as opposed to dynamic inefficient economies, which have over-accumulated capital (Blanchard and Fischer, 1989)

[4] Interest-exclusive debt is the outstanding value of government liabilities at the beginning of any period whereas interest-inclusive debt is such that includes current interest payments.

their target values. The government has two instruments at its disposal i.e. the tax rate or the benefits rate, but if it aims at stabilising output growth around the steady state level a combination of the two can be employed at the same time. The authors conclude that the fiscal rule with time invariant parameters may produce a non linear process of adjustment of the fiscal ratios in conjunction with endogenous fluctuations in the rate of growth of the economy.

2.2 Partial equilibrium models

The formal basis for an analysis of debt sustainability was proposed by Domar (1944) who grounded it in a partial equilibrium framework. This implies that both economic growth and interest rates are exogenous to fiscal policy. The model derived by Domar defined only a necessary condition for sustainability which made an infinite growth in tax rates non-sustainable. A sufficient condition was not defined because of the partial equilibrium nature of the model in which the interest rate as well as the rate of growth of GDP were set outside the model. This of course means that neither the debt ratio nor the tax rate allowed for any feedback rule (Balassone and Franco, 2000).

Buiter (1985) introduces a concept of net worth defined as the difference between public sector assets and debts plus the present value of taxes, seigniorage and public sector capital formation minus the present value of terminal net liabilities.[5] In his view a fiscal policy can be regarded as sustainable if it satisfies the condition under which the ratio of public sector net worth to GDP remains at the current level. Blanchard et al. (1990) introduce to the model two necessary conditions for sustainability. Firstly, the ratio of debt to GDP should finally converge to its initial level. Secondly, the present value of the ratio of the primary budget deficit to GDP should be equal to the negative of the current level of debt to GDP. Although the authors consider both conditions in an equivalent way, they point out what are the differences between them. In general terms, the first condition implies the second one, however the second is just a necessary but not a sufficient condition for the first to apply. This is due to the consistency that we can observe between (i) the convergence towards zero of the discounted value of the debt ratio, and (ii) the undiscounted debt ratio converging to its initial value, converging to any other finite value, or diverging at a rate of growth lower than the difference between the interest rate and the rate of growth of GDP.

Comparing the necessary condition for sustainability proposed by Domar with those proposed by Blanchard et al. one can conclude that the latter is stricter than the former. This is due to the fact that Domar's definition pertains to convergence of the undiscounted debt ratio to a finite value whereas Blanchard's definition also contains the maximum sustainable debt level.

[5] A full derivation of net worth concept is presented in Buiter (1983).

2.3 Discussion

The general equilibrium framework seems to be the most desirable tool for analysing fiscal sustainability, making endogenous not only debt levels and public deficits but also other crucial macroeconomic variables. However, the theory has not so far produced one empirically viable approach. Models based on overlapping generations are very informative tools for policy analysis, although they suffer from the computational problems related to calibration of parameters for a large number of generations. On the other hand, models that are based on partial equilibrium cannot provide us with the impact of debt on the whole economy, which is so important for policy analysis. Hence there still seems to be much scope for filling this gap in the theoretical literature. Reconciling these approaches would improve both our understanding of the impact of debt on the economy and the quality of empirical research on fiscal sustainability.

3 Analytical framework for the accumulation of debt

The main objective of this section is to set the theoretical framework for the empirical analysis presented in subsequent sections. The section commences with a review of basic fiscal accounting in order to provide an overview of the conditions based on the analytical approach for the next subsection presenting sustainable and non-sustainable cases graphically. It is followed by analysis of present value budget constraint and sustainability conditions that are important for the empirical part.

3.1 Basic fiscal accounting

Assuming that $r \geq 0$ dynamic government budget constraint can be expressed as an unstable non-homogenous difference equation

$$D_t = (1 + r) D_{t-1} + G_t - T_t \tag{1}$$

where D is the level of debt, G government expenditures, T tax revenues and r interest rate. The equation (1) informs us that the primary budget deficit can be financed by issuing new debt.[6] Multiplying out the expression in the brackets yields

$$D_t - D_{t-1} = rD_{t-1} + G_t - T_t \tag{2}$$

which is equivalent to

[6] It is assumed that monetary financing of the budget deficit is omitted due to the negligible effect of seigniorage in NMS in the second half of the 1990s (Cukrowski and Janecki, 2004), otherwise the formula would be extended to the following $D_t \, (1 + r) D_{t-1} + G_t - T_t - (M_t - M_{t-1})$ where M is money supply.

$$\Delta D_t = G_t - T_t + rD_{t-1} \tag{3}$$

Then suppressing the time subscripts gives

$$\Delta D = G - T + rD \tag{4}$$

In order to analyse the dynamics of debt we define GDP shares as $d = \frac{D}{Y}, g = \frac{G}{Y}, t = \frac{T}{Y}$ and plug them into (4)

$$\frac{\Delta D}{Y} = g - t + rd \tag{5}$$

It is now necessary to calculate the total derivative of $\frac{D}{Y}$

$$\partial \left(\frac{D}{Y} \right) = \frac{1}{Y} \partial D + \left(-\frac{D}{Y^2} \right) \partial Y \tag{6}$$

which can be approximated as

$$\Delta \left(\frac{D}{Y} \right) = \frac{\Delta D}{Y} - \frac{D}{Y} \frac{\Delta Y}{Y} \tag{7}$$

Then defining $y = \frac{\Delta Y}{Y}$ yields

$$\Delta d = \frac{\Delta D}{Y} - yd \tag{8}$$

and rearranging this becomes the following expression

$$\frac{\Delta D}{Y} = \Delta d + yd \tag{9}$$

Substituting (9) into (5)

$$\Delta d + yd = g - t + rd \tag{10}$$

and rearranging gives

$$\Delta d = g - t + (r - y)\, d \tag{11}$$

This is a difference equation that describes debt ratio dynamics i.e. how debt evolves over time. We subsequently assume that in equilibrium $\Delta d = 0$

$$0 = g - t + (r - y)\, d \tag{12}$$

then rearranging this yields

$$0 = \frac{g-t}{r-y} + d \tag{13}$$

solving for d gives the equilibrium debt ratio

$$d^* = \frac{g-t}{y-r} \tag{14}$$

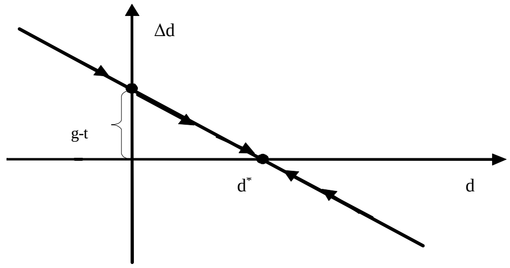
The sign of the equilibrium debt ratio is not determined a priori. It depends on the sign of budget balance, $g - t$, and the sign of the difference between the growth rate and interest rate, $y - r$. If the fraction in equation (14) is characterised by the same sign in numerator and denominator then the government to be in equilibrium needs to hold private sector financial assets. If the signs are different, the government is a creditor to the private sector (Carlin and Soskice, 2004).

3.2 Dynamics of debt and budget deficit

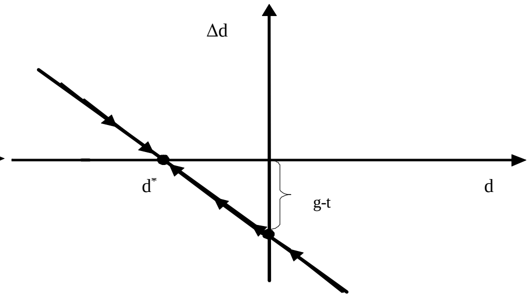
We can analyse FOUR cases of countries that are creditors and debtors to examine whether the situation is stable. In order to do so we employ phase diagrams based on the difference equation (11). The interest rate determines how quickly the debt grows as a result of interest payments exclusively, whereas the rate of growth of GDP determines how fast GDP grows. The comparison of the rate of growth of those two variables determines the stability of the steady-state ratio.

Let us first analyse two cases in which the equilibrium debt is stable. Assuming that the government runs a primary budget deficit the intercept term is positive, $g - t > 0$, implying that government expenditures are greater than government revenues $g > t$. We also assume that the slope of the line is negative, $r - y < 0$, so the interest rate is less than the rate of growth, $r < y$. This case is considered as stable because regardless of the debt level we start at we return to the equilibrium value of debt in the long-run, assuming any given primary deficit. In other words, the economy will remain in equilibrium at point d^* if the values of the deficit and growth and interest rates are unaltered. The government is a net borrower of private sector financial assets. This is illustrated in phase diagram 1.

A government running a primary budget surplus shifts an intercept down to negative values, $g - t < 0$, which means that now government revenues are greater than government spending $g < t$. Assuming also economic growth higher than the interest rate retains the negative slope of the line $r - y < 0$, which maintains the same inequality as in the previous case, $r < y$. This is a stable scenario depicted in phase diagram 2, allowing for convergence to the steady state debt ratio in case of moving away from equilibrium. The government is in this case a net holder of private sector financial assets.

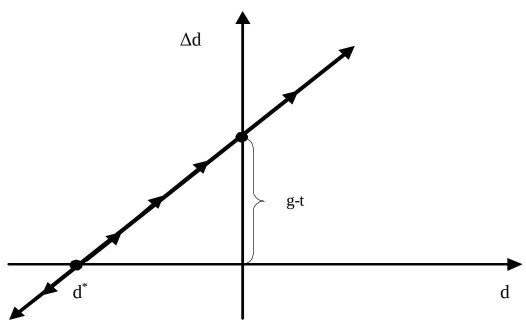


Phase diagram 1

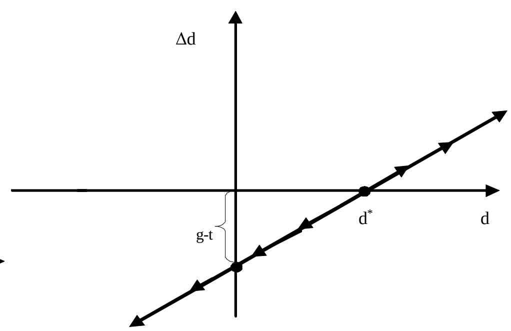


Phase diagram2

The analysis of unstable situations is based on the assumption that the slope of the line is positive, $r - y > 0$, so the interest rate exceeds economic growth, $r > y$. In the first case, government expenditures are greater than government revenues, $g > t$, leading to a primary budget deficit, therefore the intercept takes positive values, $g - t > 0$. A higher interest rate than the rate of growth, along with recording a primary deficit, can theoretically ensure a steady-state solution for the debt ratio, though any slippage from the equilibrium value at point d^* results in irrevocable divergence. This is illustrated in phase diagram 3. In the second scenario, the government runs a primary surplus, so government revenues exceeds government spending , $g < t$, shifting the intercept to negative values, $g - t < 0$. Now the steady-state debt ratio can still be achieved, but, again, if the debt ratio takes any value different than equilibrium the system is divergent. This is depicted in phase diagram 4.



Phase diagram 3



Phase diagram 4

3.3 Present Value Budget Constraint

A dominant approach to the modelling of fiscal sustainability is to apply a framework assuming that the government satisfies both a budget constraint within each period of time and an intertemporal budget constraint (Chalk and Hemming, 2000). Recalling a basic version of the dynamic budget constraint for a closed economy presented in equation (1)

$$D_t = (1+r)\, D_{t-1} + G_t - T_t \tag{15}$$

Dividing by $1+r$ and rearranging gives

$$D_{t-1} = -\frac{G_t - T_t}{1+r} + \frac{D_t}{1+r} \tag{16}$$

Subsequently relaxing the assumption about a constant interest rate and solving equation (16) forward results in the intertemporal budget constraint.

$$D_t = -\left(\sum_{i=0}^{\infty} \frac{G_{t+i}}{\prod_{j=0}^{i} (1+r_{t+j})} - \sum_{i=0}^{\infty} \frac{T_{t+i}}{\prod_{j=0}^{i} (1+r_{t+j})} \right) + \lim_{T\to\infty} \left(\frac{D_{t+T}}{\prod_{j=0}^{T} (1+r_{t+j})} \right) \tag{17}$$

The equation (17) shows that the sustainability of fiscal policy is met when the present value of primary surpluses exceeds the present value of primary deficits by the amount needed to balance the initial stock of debt and the present value of the terminal stock of debt. This equation is very similar to the general case presented by Blanchard et al. (1990) with the main difference being that they consider a constant interest rate, while equation (17) allows for a time-varying interest rate.

In order to make comparisons between countries of different sizes as well as between countries with growing GDP at different points in time we incorporate variables expressed as ratios to GDP into our budget constraint. Equation (17) is then reformulated in this spirit and extended with the inclusion of inflation.

$$d_t = -\left(\sum_{i=0}^{\infty} \frac{\prod_{j=0}^{i} \left(1 + \pi_{t+j} + \gamma_{t+j}\right)}{\prod_{j=0}^{i} (1 + r_{t+j})} g_{t+i} - \sum_{i=0}^{\infty} \frac{\prod_{j=0}^{i} \left(1 + \pi_{t+j} + \gamma_{t+j}\right)}{\prod_{j=0}^{i} (1 + r_{t+j})} \tau_{t+i} \right) + \lim_{T \to \infty} \left(\frac{\prod_{j=0}^{T} \left(1 + \pi_{t+j} + \gamma_{t+j}\right)}{\prod_{j=0}^{T} (1 + r_{t+j})} d_{t+T} \right) \tag{18}$$

The lower case letters in the equation (18) stand for the ratio of the corresponding variables to nominal GDP, therefore the formulas are the following: $d_t = \frac{D_t}{P_t Y_t}$, $\tau_t = \frac{T_t}{P_t Y_t}$, where P is the price level and Y is the real GDP. We also define the inflation rate as $\pi_t = \frac{P_t - P_{t-1}}{P_t}$ and the real growth of GDP as $\gamma_t = \frac{Y_t - Y_{t-1}}{Y_t}$. Incorporating ratios to the equation (18) allows us to analyse the impact of the performance of the economy on fiscal sustainability.

3.4 Sustainability conditions

If the present value of the stock of debt is greater than zero then equation (18) is satisfied even if the government rolls over its debt entirely in every period to repay principal and interest debt. However, O'Connell and Zeldes (1988) show that a Ponzi game[7] does not apply to the representative agent model with a finite number of agents. This is due to the fact that such a game would require an individual to hold government bonds over an infinite horizon, reducing his consumption in at least one period of time. Since there is an assumption that individuals are rational a Ponzi game is precluded. This is taken into account in equation (18) by the transversality condition, which constrains the debt to grow no faster than the interest rate.

A Ponzi game is sometimes formulated in terms of an inequality (Agenor, 2000 and Romer, 2001) to express the transversality condition.

$$\lim_{T \to \infty} \left(\frac{\prod_{j=0}^{T} \left(1 + \pi_{t+j} + \gamma_{t+j}\right)}{\prod_{j=0}^{T} (1 + r_{t+j})} d_{t+T} \right) \leq 0 \tag{19}$$

However, as Chalk and Hemming (2000) argue this condition can also hold for an equality be-

[7] A Ponzi game takes place when a borrower issues debt and rolls it over indefinitely (Romer, 2001)

cause private agents are not allowed to terminate in debt to the government. Therefore a sustainable fiscal policy has to satisfy the present value budget constraint.

$$d_t = -\left(\sum_{i=0}^{\infty} \frac{\prod_{j=0}^{i} \left(1 + \pi_{t+j} + \gamma_{t+j}\right)}{\prod_{j=0}^{i} \left(1 + r_{t+j}\right)} g_{t+i} - \sum_{i=0}^{\infty} \frac{\prod_{j=0}^{i} \left(1 + \pi_{t+j} + \gamma_{t+j}\right)}{\prod_{j=0}^{i} \left(1 + r_{t+j}\right)} \tau_{t+i} \right) \tag{20}$$

According to McCallum (1984) permanent primary fiscal deficits are inconsistent with the present value budget constraint (PVBC), whereas permanent conventional deficits[8] can be sustainable. He discusses sustainable conventional deficits in comparison with non-sustainable primary fiscal deficits. He also gives examples of particular cases in which e.g. the transversality condition is violated to show that fiscal sustainability can be satisfied notwithstanding. The main critique of his paper is that the PVBC is not linked to other economic variables and take account only of the stock of debt, the present value of future deficits and the interest rate.

Having discussed four cases for sustainability conditions graphically in section (3.2.) we now follow Jha (2004) and present the analytical approach to this.

- Case 1: $r_t - \pi_t < \gamma_t$

The first term in this inequality represents the real interest rate on government debt, while the second term expresses the real GDP rate of growth. The debt ratio to GDP can be maintained stable allowing the economy to be solvent if the following condition is fulfilled

$$\lim_{t \to \infty} (d_t) = 0 \tag{21}$$

If the initial value of the debt to GDP ratio (d_0) is strictly positive then two conditions have to be met. The first sustainability condition is formulated such that $r_t - \pi_t < \gamma_t$ for all t which allows for consistency of the primary fiscal deficit with the debt to GDP ratio. It can also be interpreted as a condition ensuring non-explosiveness of the debt to GDP ratio. Secondly, the condition that enables the debt burden to be eventually liquidated must on average satisfy the following inequality $g_t - \tau_t \leq 0$.

The government remains solvent if these both necessary and sufficient conditions are satisfied which allows for full debt repayment.

- Case 2: $r_t - \pi_t > \gamma_t$

Under this condition the debt is non-sustainable because the debt stock will diverge towards infinity as opposed to the previous case. In this case the sequence of primary deficits is irrelevant if the growing debt stock is not balanced by increasing but discounted primary surpluses in the future. In this context, Jha (2004) proposes to solve the dynamic budget constraint forward to

[8] Conventional deficits include a primary balance plus interest payments on debt service (Agenor, 2000)

yield

$$d_t = -\left(\sum_{i=0}^{\infty} \frac{g_{t+i}}{\prod_{j=0}^{i}(1+\theta_{t+j})} - \sum_{i=0}^{\infty} \frac{\tau_{t+i}}{\prod_{j=0}^{i}(1+\theta_{t+j})} \right) + \lim_{T\to\infty} \left(\frac{d_{t+T}}{\prod_{j=0}^{T}(1+\theta_{t+j})} \right) \tag{22}$$

where $\theta_t = r_t - \pi_t - \gamma_t$ expresses the real interest rate minus the real GDP rate of growth, and the formula $\prod_{j=1}^{T} \frac{1}{(1+\theta_{t+j})}$ can be interpreted as a real discount factor that adjusts for real GDP growth.

The transversality condition equation (23) ensures that both necessary and sufficient conditions are met, therefore as T tends to infinity the discounted value of the debt to GDP ratio converges to zero. This can be formulated as follows

$$\lim_{T\to\infty} \left(\frac{d_{t+T}}{\prod_{j=0}^{T}(1+\theta_{t+j})} \right) \tag{23}$$

The non-explosiveness of the public debt is ensured by the transversality condition, which prevents a Ponzi game i.e. rolling over the debt in an infinite timespan. Thus, the present value budget constraint holds, as the sum of current and future discounted surpluses are sufficient to balance the current value of debt.

3.5 Discussion

There are various practical dilemmas pointed out by Chalk and Hemming (2000) about how to interpret a situation with respect to sustainability issues when a country runs a permanent primary surplus to pay the interest associated with the debt. The consequence is a permanent conventional deficit, which means that the interest rate will grow faster than the debt, satisfying the transversality condition that ensures sustainability. There may also be a situation in which, in accordance with the theory, the economy may be regarded as non-sustainable although the debt may be asymptotically falling to zero. This can occur when the economy is a growing one with a relatively low interest rate. More specifically, if the interest rate grows at a slightly slower rate than the debt, assuming higher output growth than debt growth, it will induce a declining debt ratio, although the transversality condition will be violated. Those examples clearly show that one has to be particularly careful when drawing conclusions based on the PVBC.

4 Empirical methodology

4.1 Previous empirical evidence on testing for fiscal sustainability

The main strand of the empirical literature on fiscal sustainability pertains to statistical methods of testing. In the early contributions, Aschauer (1985) and Seater and Mariano (1985) combine in their analysis both the present value budget constraint and a permanent income hypothesis. Barro (1984) analyses whether the government meets the present value budget constraint along with the assumption of optimal taxation over time. However, the principal theoretical concept underpinning currently used methods is owed above all to the work of Blanchard et al. (1990).

Early empirical contributions were based on direct testing of the transversality condition. Hamilton and Flavin (1986) have pioneered empirical work focused on fiscal sustainability by examining the present value budget constraint for the US.[9] The basic idea behind this concept is to test the transversality condition (23) against the alternative hypothesis of "speculative bubbles" through regressing a series of debt against an exponential term $(1+r)^t$ to check for the significance of the exponential. More specifically, they slightly modify the PVBC in such a way that the ex post real interest rate on government debt is replaced with the average real interest rate r. This can be expressed by rewriting equation (15)

$$D_t = (1 + r_t)\, D_{t-1} + B_t + (r_t - r)\, D_{t-1} \tag{24}$$

where $B_t = G_t - T_t$ and then defining the error term v_t as $(r_t - r)\, D_{t-1}$and solving forward gives

$$D_t = -\left[\sum_{i=0}^{\infty} \frac{G_{t+i}}{(1+r)^t} - \sum_{i=0}^{\infty} \frac{T_{t+i}}{(1+r)^t}\right] + \lim_{T\to\infty}\left[\frac{D_{t+T}}{(1+r)^t}\right] + n_t \tag{25}$$

where $n_t = \sum\limits_{i=0}^{\infty} \frac{v_{t+i}}{(1+r)^t}$ is assumed to be mean zero stationary. The authors examine whether the following expression is met:

$$\lim_{T\to\infty}\left[\frac{D_{t+T}}{(1+r)^t}\right] = 0 \tag{26}$$

or equivalently:

$$D_t = -\left[\sum_{i=0}^{\infty} \frac{G_{t+i}}{(1+r)^t} - \sum_{i=0}^{\infty} \frac{T_{t+i}}{(1+r)^t}\right] \tag{27}$$

which can be perceived as a null hypothesis for fiscal sustainability. If, then, it is assumed that

[9] The authors draw on the contribution to the price bubbles testing by Flood and Garber (1980).

the real interest rate on government debt is constant and r_t is uncorrelated with the budget balance and debt, the alternative hypothesis is as follows:

$$\lim_{T \to \infty} \left[\frac{D_{t+T}}{(1+r)^t} \right] = A > 0 \tag{28}$$

where A is a constant. In other words, fiscal policy is non-sustainable if the discounted value of debt has a finite positive limit. The PVBC can then be rewritten as follows:

$$D_t = \sum_{i=1}^{\infty} \frac{B_{t+i}}{(1+r)^t} + A(1+r)^t + \varepsilon_t \tag{29}$$

where ε_t is a regression disturbance. They then test the magnitude of A, under the null hypothesis $A = 0$. An Augmented Dickey-Fuller (ADF) test is used to check for unit roots in B. If the null is rejected then $A > 0$, which means that the fiscal policy is not sustainable. However, if the opposite is true then $A = 0$, and therefore fiscal policy can be regarded as sustainable. The results for the US suggest that fiscal policy is sustainable. Wilcox (1989) also employs the same set of data as Hamilton and Flavin but relaxes the assumption of a constant interest rate and allows for stochastic violation of the solvency condition. Wilcox claims that when the transversality condition holds, the present value of government debt is stationary and has an unconditional mean of zero. He finds mixed evidence on stationarity and rejects an unconditional mean of zero, thus concluding that post-war US fiscal policy has been non-sustainable.

The approach to testing for fiscal sustainability proposed by Hamilton and Flavin (1986) and then developed by Wilcox (1989) is criticised in the literature and numerous modifications have been proposed. Kremers (1989) argues that the results obtained by Hamilton and Flavin are subject to misspecification in the ADF test due to the occurrence of serial correlation. This is a result of not including enough lags of dependent variables in the ADF specification. The inclusion of a second lag reverses the conclusion regarding the fiscal sustainability of the US claimed by Hamilton and Flavin. Balassone and Franco (2000) point out another three drawbacks of this approach. Firstly, Hamilton and Flavin use a small sample, which reduces the power of the Dickey-Fuller test. Furthermore, the authors assume a constant interest rate, which may be questionable. Finally, the alternative hypothesis is of subjective nature, as it violates the solvency condition. Trehan and Walsh (1991) extend Hamilton and Flavin's research in two directions. Firstly, the authors show that the Hamilton and Flavin approach is the relevant one to use as long as the government debt series is an ARIMA process and there is no need for equation (28) to be met. They subsequently prove that if the budget balance is stationary then equation (27) holds if and only if the debt series is stationary as well. Secondly, Trehan and Walsh propose a test for cases in which the budget balance is a non-stationary process.

There are also very important contributions based on testing of PVBC through examining the unit root and cointegration among fiscal variables. Trehan and Walsh (1988) test the intertemporal budget constraint by employing cointegration analysis based on both the Engle and Granger procedure and Stock and Watson approach. They estimate the following equation:

$$T_t = \alpha + \beta GG_t + \varepsilon_t \tag{30}$$

where GG is the expenditures including interest payments. The results based on the data for the US support the hypothesis of cointegration between expenditures including interest payments and revenues. Hakkio and Rush (1991) also apply the cointegration analysis to test for the existence of cointegrating relationship for the US. However, the outcome here shows that US fiscal policy has been non-sustainable since the 1980s. Bohn (1991) proposes an alternative approach by checking for cointegration of non-interest government expenditures, revenues and government debt. He also contributes to the analysis of fiscal sustainability through pointing out the issue of uncertainty (1991, 1995). The application of the Johansen method to the intertemporal solvency condition is derived from Liu and Tanner (1995). Quintos (1995) introduces to the cointegration analysis a rank test for structural breaks in long-run relationships. She concludes that US fiscal policy was sustainable until the early 1980s and then there was a structural break.

There is also empirical work that augments the previous studies on fiscal sustainability with analysis of OMS. Uctum and Wickens (1997, 2000) examine the developments of the debt to GDP ratio for members of EMU and the US. They also extend the research of Wilcox (1989) with a time-varying stochastic discount rate, showing that a necessary and sufficient condition for fiscal sustainability prevails if the discounted debt to GDP ratio is a stationary zero-mean process. The empirical results for the period 1965-1994, with an extension for forecasts to 2000, indicate that fiscal policy in Denmark, the Netherlands and Ireland was sustainable, whereas in such countries as Belgium, Portugal and the US it was not. The authors find that sustainability is improved in all countries when the data are extended for assumed fiscal adjustment programmes. Artis and Marcellino (2000) point out that the discounted debt ratio converging to zero is in principle not sufficient for convergence of the undiscounted debt ratio. The dataset used is similar to Uctum and Wickens (1997) and covers both the US and EMU members. The difference lies in the approach to empirical work, as Artis and Marcellino do not include forecasts in their analysis, employing instead past data. They advocate analysing both the discounted and undiscounted values of debt as more appropriate for testing fiscal sustainability. Empirical findings demonstrate stable debt-to-GDP ratios, implying fiscal sustainability. Visual inspection of the results obtained by Wilcox (1989) and Uctum and Wickens (2000) inclines one to draw the conclusion that although the values of discounted and undiscounted debt are significantly different the trends exhibited are very similar. Afonso (2004) uses the data for OMS, extending previous studies on fiscal sustainability in EU countries with the use of tests for structural breaks. He concludes that the results obtained suggest fiscal sustainability among EU countries, with the exception of just a few countries.

4.2 Discussion

Artis and Marcellino (1998) review the various empirical studies pointing out that their differentiated results depend heavily on the econometric methodology applied and the data used. Balassone and Franco (2000) emphasise the importance of the definitions adopted, particularly in terms of the difference between the market values of debt and the nominal value data. Another very important issue is assumptions regarding the future path of the debt. This is an extremely relevant matter from a policymaking perspective, as it takes no account of possible regime changes and exogenous factors such as demographic trends. Assuming that the data generating processes for deficit and debt are not likely to alter provides no suggestions for required fiscal adjustment that would make public finances sustainable. Therefore, all the above discussed studies suffer from a backward-looking approach, which limits to a certain extent the applicability of the results obtained.

One study that does derive from and test for fiscal sustainability with respect to future policies is by Uctum and Wickens (2000), who provide a framework for medium term fiscal policy that is consistent with the PVBC. They argue that in practice governments conduct their fiscal policy with a medium term perspective in mind and aim at balancing the budget over the medium term. However, one should remember that whenever forecasted values are included in the testing procedure it conditions the whole analysis upon the feasibility of a certain fiscal programme and thus suffers from the critique made by Rankin and Roffia (2003).

4.3 Econometric methods

Following the methodology used by Hamilton and Flavin (1986) and subsequently developed by Trehan and Walsh (1988, 1991) the ADF test and a cointegration analysis are applied, respectively. The first step is to check for stationarity of debt by employing the ADF test to examine a sufficient condition for sustainability. The second step is to use the cointegration analysis based on the Johansen procedure to explore whether government revenues and expenditures share common trends, which in conjunction with a sufficient condition ensures sustainability.

4.3.1 Augmented Dickey-Fuller test

Macroeconomic time series are essentially perceived as non-stationary, which implies that the limiting distributions of t-ratios and other statistics are different from those offered by standard theory. A preliminary step in dealing with the problem of spurious regression is to pursue a test for stationarity of the variables.

A stochastic process y_t is weakly (or covariance) stationary if it satisfies the following conditions: (i) $E(y_t)$ is independent of time , (ii) variance is a finite positive constant $0 < Var(y_t) < \infty$ that does not depend on t, (iii) $Cov\left(y_t, y_{t-k}\right)$ is a function of k but not of t, which in other words means that covariance depends only on how far apart are two variables, but not on the specific point in time.

If a series is stationary after differencing it is said to be integrated of order 1, $I(1)$. This a different situation from an $I(0)$ series, which fluctuates around its mean with a finite variance, exhibiting a tendency to return to its mean in the long run. In contrast, an $I(1)$ series deviates widely and the impact of a shock is permanent.

A commonly employed test for stationarity is the Dickey-Fuller test (DF). This is represented by the following expression:

$$y_t = \delta_0 + \delta_1 t + \phi y_{t-1} + \varepsilon_t \tag{31}$$

Subtracting y_{t-1} from both sides gives

$$\Delta y_t = \delta_0 + \delta_1 t + (\phi - 1)\, y_{t-1} + \varepsilon_t \tag{32}$$

then defining $\gamma = \phi - 1$

$$\Delta y_t = \delta_0 + \delta_1 t + \gamma y_{t-1} + \varepsilon_t \tag{33}$$

In order to determine whether the series has a unit root one needs to estimate for $\phi = 1$ in equation (32) or for $\gamma = 1$ in equation (33). The null hypothesis is that y_t is non-stationary, therefore $\gamma = 0$ or $\phi = 1$, and is rejected if $\gamma < 0$ or $\phi - 1 < 0$ implying $\phi < 1$. The test is based on the t-ratio, but the distribution is not t. This is due to the fact that under the null the series is non-stationary i.e. containing a unit root, therefore the standard asymptotic theory does not apply to this case. Special tables of critical values were proposed by Dickey and Fuller (1981) and subsequently developed by McKinnon (1996) to conclude on the nature of a particular series. This allows us to conduct the Dickey-Fuller (DF) test, which is estimated via OLS based on equation (33).

There is, however, one important assumption associated with an estimation of (33) i.e. the error term has to be independently and identically distributed or, in short, ε_t is iid. This condition may not hold if only the AR(1) process is assumed, which poses the risk of an autocorrelation existence in (33). This is a situation where the extension to the DF test, the Augmented Dickey-Fuller test (ADF), comes in handy. The general representation of ADF(p) model with a deterministic trend can be expressed by the following formula:

$$\Delta y_t = \delta_0 + \delta_1 t + \gamma y_{t-1} + \sum_{j=1}^{p} \beta_j \Delta y_{t-j} + \varepsilon_t \tag{34}$$

Common procedures that attempt to select the optimal lag length are the Akaike Information Criterion (AIC) and the Schwartz Bayesian Criterion (SBC)[10]

4.3.2 Johansen procedure

The general representation of VECM can be presented in the following form

$$\Delta y_t = \alpha + \Pi y_{t-k} + \sum_{i=1}^{k-1} \Gamma_i \Delta y_{t-i} + \varepsilon_t \tag{35}$$

where $\Pi = \sum_{j=1}^{k} A_j - I$ and $\Gamma_i = \sum_{j=1}^{i} A_j - I$. The matrix Π informs how many linear combinations are prevalent amongst variables. This will be associated with the identification of the rank of Π, r. Assuming that there are n variables, three different cases can be analysed.

- Rank $\Pi = 0$, so is a null matrix implying that there is no cointegration in the system, thus no long-term relationships exist. In this case the VAR system is estimated in first differences.
- Rank $\Pi = n$, therefore is of full rank. There are n cointegrating vectors in the system, and all cointegrating relationships are stationary, indicating that right-hand side variables are stationary as well. This implies estimating VAR in levels.
- Rank $\Pi = r$, hence matrix Π is of reduced rank, $0 < r < n$. There are r cointegrating vectors amongst n variables and the rank is equal to the number of non-zero eigenvalues. There will be r stationary linear combinations and the VECM presented in equation (35) is considered.

The method to determine the rank of matrix Π comes from Johansen (1988) and Johansen and Juselius (1990). They propose two tests to investigate the rank of Π. The first is the Trace test, which examines whether the smallest $n - r$ estimated eigenvalues are significantly different from zero. The null hypothesis is $H_0 : rank \leq r$ tested against the alternative $H_1 : rank \geq r + 1$. The Maximum eigenvalue test determines the rank of Π based on hypothesis testing, where the null hypothesis $H_0 : rank \leq r$ remains the same as in the case of the trace test, while it is tested against different alternative $H_1 : rank = r + 1$. The idea behind this alteration is to increase the power of the test by restraining the alternative to a cointegration rank just one more than under the null hypothesis.

Once the number of cointegrating vectors, r, is determined the next stage of the procedure is to estimate the cointegrating relationships. However, if there is more than one cointegrating

[10] The inclusion of too many lags reduces the efficiency of the estimator, while too few lags lead to the occurrence of the autocorrelation in residuals. The latter has serious consequences, as it leads to a violation of the assumption concerning the disturbance error that has to be a white-noise process. Common procedures that attempt to select the optimal lag length are the Akaike Information Criterion (AIC) and the Schwartz Bayesian Criterion (SBC). The former is more appropriate when the sample is small, as it ensures that the probability of selecting too few lags tends to zero, although the chosen lag length may be too large. On the other hand, the latter is more suitable for large samples because as the number of observations goes to infinity this criterion selects the proper lag length with probability one. Clearly, the prevalence of inefficient estimators implying larger standard errors is more preferable to the occurrence of dynamic misspecification.

vector, $r > 1$, applying OLS as estimation procedure is not correct. One approach that allows us to estimate the cointegrating relationships under such circumstances is due to Johansen and Juselius (1990) who propose the employment of the maximum likelihood (ML) estimator.

As mentioned above, if the rank of Π is of reduced rank, $0 < r < n$, there are r cointegrating vectors, so matrix Π can be broken down into the product of two matrices, α and β.

$$\Pi = \alpha\beta^{'} \tag{36}$$

The matrix β gives the cointegrating vectors representing long-term coefficients, whereas matrix α gives the speed of adjustment towards equilibrium coefficients expressing loading weights associated with cointegrating vectors.

5 Testing for fiscal sustainability in NMS

5.1 Fiscal policy in transition

The collapse of the communist system around 1989 generated the need to design modern market-oriented economic systems in Central and Eastern Europe. One of the crucial issues was to create public finances that would actively assist in the process of transformation from the centrally planned system towards the different needs of a market economy. From almost the very beginning of the transformation process, most Central and Eastern European states decided to link their economies to the European Union. This in turn led to a series of Treaties of Association and subsequently ended with European Union enlargement on May 1, 2004.

This period has seen a rapid reorientation in public debt management towards a market-based deficit financing strategy that explicitly recognises the negative consequences of excessive deficits and debt. Domestic financial markets have developed dynamically, allowing for a change from budget deficit financing based on money and short-term instruments towards financing based on long-term ones (Siwinska, 1999). Negotiations with the European Union made it possible to extend budget deficit financing with larger foreign inflows. There were, however, no binding constraints imposed on public finances until the moment of accession (Antczak et al. 2004). From May 1 2004 the NMS have been subject to fiscal rules stemming from the Maastricht Treaty and the SGP, which make manoeuvres in fiscal policy more difficult. This is because the NMS have to fulfil fiscal criteria regarding both their debt-to-GDP ratio and deficit-to-GDP ratio as well as three other nominal criteria in order to be admitted to Economic and Monetary Union.

The fiscal stances of the NMS vary. Slovenia and the Baltic states perform relatively well, whereas the Czech Republic, Hungary, Poland and Slovakia have not so far undertaken far-reaching fiscal reforms that would stabilise their economies in the long-term. This shows that lack of fiscal adjustment tends to result in later poorer performance.

The first group of countries, comprised of Estonia, Latvia, Lithuania and Slovenia, has already fulfilled all the Maastricht criteria and with the exception of Latvia have all joined the ERM II system. If the countries are able to retain their currencies in a +/- 15 percent band of fluctuations within a period of two years they will be allowed to adopt the euro. Assuming that fast track adoption of the euro leads to a positive balance of benefits over costs, fiscal adjustment demonstrates how rewarding a prudent fiscal policy may be. Estonia has recorded a debt-to-GDP ratio as low as 6 percent over the last five years, which in conjunction with budgetary surpluses over the last three years makes it as the best performer in this group. Lithuania and Latvia retained their debt levels in a range of 21-24 percent and 10-17 percent, respectively. Their budget balances have improved substantially over the last five years, bringing down their deficits from 5.7 percent in 1999 to 2.6 percent in 2003 in the case of Lithuania and from 5.3 percent in 1999 to 2.7 in the case of Latvia. Slovenia has kept its budget deficit and debt within the limits indicated by the Maastricht criteria. Estonia, Lithuania and Slovenia have fulfilled all the Maastricht criteria and are now participating in the ERM II system. The data are presented in Table 1 and Table 2 in Appendix 1.

The second group of countries, comprised of the Czech Republic, Hungary, Poland and Slovakia, still has a long way to go in terms of fiscal adjustment. The only country amongst them that has recently adopted an appropriate fiscal package is Slovakia, which has attempted to simplify its tax code along with a substantial reduction in tax rates and significant steps towards the reform of the expenditure side of the budget. The results are not yet fully visible. Reducing the budget deficit to 5.1 percent in 2003 leaves it still far above the targeted 3 percent. However, the level of debt has remained under control at around 50 percent of GDP. The remaining countries from the second group have struggled with political constraints and recorded no significant progress. The situation of the Czech Republic has even deteriorated over the last few years, with the budget deficit soaring to 8.0 percent in 2003, while the debt increased from 14.3 percent in 1999 to 30.7 percent in 2003. Fiscal discipline has not been maintained by the Hungarian economy, where debt oscillates around the 60 percent level required by the Maastricht criteria and substantially exceeds budgetary criteria, recording 5.4 percent in 2003 compared to 9.5 percent in 1999. Poland has attempted some fiscal reform, but their scope is very limited and not therefore reflected in fiscal adjustment progress. The budget deficit has grown from 2.0 percent in 1999 to 4.3 percent in 2003 and debt continued its upward trend from 42.7 percent in 1999 to 45.1 percent in 2003. The lack of visible fiscal adjustment in all these countries delays their participation in EMU, in turn not only posing risks to their currencies but also creating adverse effects stemming from higher interest rates and the accumulation of debt (Antczak et al., 2004). The data are presented in Table 3 and Table 4 in Appendix 1.

5.2 Definitions of variables

An appropriate measurement of public debt and deficits is a very important issue from a practical perspective for assessing fiscal sustainability. This is emphasised by Balassone and Franco (2000) as well as Artis and Marcellino (2000), who survey the empirical literature on fiscal sustainability. They claim that the results are sensitive to the definitions used and therefore that one has to be very careful when choosing variables for sustainability analysis.

The definition of the public sector should be broad and also include local government and state-owned companies. Therefore, an appropriate measure would be the general government. However, estimates using the general government definition are available for only some NMS and usually cover a very short period of time, which precludes any sensible econometric evaluations. Hence, data encompassing central government accounting have been adopted in this paper, although this measure seems to be exposed to several manipulations aimed at concealing some government liabilities.

A crucial point in estimating fiscal sustainability is to take proper account of pension liabilities and, in particular the public pay-as-you-go system (PAYG). This can be analysed if the government publishes its so-called "economic deficit", which treats contributions to PAYG as a financing item, while pensions are considered as a loan repayment or an interest payment. This is a particularly indispensable element for countries facing unfavourable demographic trends, as in the case of the most OMS (Kotlikoff, 1984, and Blejer and Cheasty, 1991). Data also covering pension-related liabilities are not available for all NMS, therefore there is no adjustment for this.

Another very important factor is whether we use gross or net debt. The latter includes assets owned by the government that can be sold, therefore the balance of debt should be adjusted by this if we want to use a broader term. This is particularly problematic in the case of NMS, as it would be difficult to find any reasonable estimates of assets based on the same consistent methodological framework for all countries. Therefore, in practice there are severe difficulties with a proper valuation of assets for even OMS. As such it is more common to apply gross debt rather than net debt.

Another key element in assessing fiscal sustainability is to choose between face values and market prices (of debts and assets). Face values are more commonly used by governments, as market prices are volatile and can reflect a temporarily unfavourable situation on the financial markets. However, market participants prefer to employ market values in their analysis. A solution reconciling both is provided by Uctum and Wickens (2000), which discounts the debt expressed in face value by the yield on government debt. The procedure of calculating this is not straight-forward because government debt is sold at a discount and redeemed at face value. Unfortunately, such detailed data are not available for all NMS, so we follow a standard approach to this by examining the undiscounted value of debt.

One may also consider if the real values of debt are the relevant concept or whether it is better to use a ratio of debt to GDP as an alternative measure. The criteria could be to choose a definition that is more appropriate to measure the bearability of the tax cost induced by the debt. Artis and Marcellino (2000) claim that a debt-to-GDP ratio is a better measure since it is set as a target in the Maastricht criteria and the SGP, and is as such closely followed by financial markets and policy makers. But the problem with this in terms of NMS is that it would require employing quarterly data, as the level of debt should be divided by GDP. There are two important issues that arise in this context. Firstly, the number of observations in terms of quarterly data is very limited for some countries because of problems with quarterly accounting of GDP, which practically precludes any econometric analysis. Secondly, even if the quarterly data were available for the whole period of time for all the countries it would still be superior to use monthly data ensuring more robust estimations

All the data we use are therefore monthly and seasonally adjusted, taken from the International Monetary Fund's International Financial Statistics database, combined with the Government Financial Statistics. The time span covers different periods for analysed countries, which is due to the availability of comparable data. The justification for using monthly data relates to their great benefit in terms of number of observations, which is crucial for robust estimates. Furthermore, transition economies are characterised by faster adjustments towards equilibrium (Kelm, 2004) than in more developed countries. Monthly data have a much better chance of picking this up.

5.3 Empirical results

A conventional approach based on assumptions regarding economic growth, interest rates and inflation may not be a reasonable solution to examine fiscal sustainability, as the level of uncertainty related to NMS is very high. A simple extrapolation of current trends in expenditures does not seem to be appropriate either because it involves estimating financial obligations related to the application of the acquis communitaire (Antczak et al., 2004, Hughes Hallett and Lewis, 2004). It is very difficult to predict the future paths of expenditures and revenues in the context of European Union enlargement, therefore the approach based on a time series analysis seems to be a relevant choice. Although it may be criticised for its backward-looking perspective it does not suffer from the critique made by Rankin and Roffia (2003) who label any analysis prepared based on assumptions as "accounting exercises". This expression genuinely encompasses the scope of the use of this method, although leaves a very important role for this method in performing the scenario analysis. It can also act as a warning signal to the fiscal authorities on the extent to which they should correct policy back onto a track consistent with the Maastricht and SGP fiscal criteria.

5.3.1 Public debt stationarity test

Recalling that a public debt stationarity test provides the information on sufficient conditions for the solvency of public finances, a formal approach to this is to test a government debt series for unit roots. In order to investigate this issue an ADF test is employed. A constant is included in the regression and the lag length is chosen based upon the Akaike information criterion, as it is more suitable for small samples. The detailed results for debt stationarity are presented in Table 1 in Appendix 2.

The results demonstrate that the null hypothesis of a unit root can be rejected in two countries only, Lithuania and Slovenia. This means that the solvency condition is satisfied in these countries, which is in line with expectations as those states are unquestionable leaders among the NMS with respect to fiscal criteria.[11] Their real debt has been kept relatively stable over the last few years and therefore the results based on the ADF test seem to be consistent with the visual inspection of the debt. The remaining countries do not meet the solvency condition because the null hypothesis of unit root is not rejected. It is not surprising if one analyses debt dynamics in these states. Although none of them have significantly exceeded the debt criteria required by the Maastricht Treaty the pace at which debt has grown in the Czech Republic and Poland indicates potential problems in the near future. An interesting case in this context is Latvia, which is conducting a prudent fiscal policy, but still seeing an increasing level of debt. This probably induces instability, which is reflected in the fact that this variable is stationary in first differences only.

One should, however, remember that, as Trehan and Walsh (1991) and Afonso (2004) claim, a public debt stationarity test provides information only on sufficient conditions for solvency of public finances and not necessary conditions. Therefore, a rejection of debt stationarity should not be interpreted as a situation in which a given fiscal policy is non-sustainable. This may be the case, but it has to be confirmed by cointegration analysis, which is the second stage of our empirical research.

5.3.2 Cointegration analysis of intertemporal budget constraint

The second stage is to employ a cointegration analysis to examine whether there exists a long-term relationship between real revenues and expenditures in NMS. In other words this means determining if real revenues and expenditures share a common trend. The cointegration approach, along with the previous one based on stationarity tests, forms the basis for drawing conclusions with respect to fiscal sustainability in the NMS.

First of all, one needs to test both revenues and expenditures for the prevalence of unit roots. The approach here is to use the ADF test, which allows us to test for unit root formally. The results show that both variables are non-stationary in levels for Hungary, Lithuania, Slovakia and Slovenia.

[11] The best performer is Estonia, but there is no monthly data on debt available for this country.

There is, therefore, a need to check for the stationarity of both variables in first differences for these countries. The outcome is that all the variables are I(0) in first differences, so they are I(1) in levels. The other countries analysed, including the Czech Republic, Latvia and Poland, contain one of the variables being nonstationary in levels. The implication of this is the non-sustainability of fiscal policy in these countries. Again, slightly surprising is the case of Latvia, which is widely regarded as conducting prudent fiscal policy. The summary results for this part of the analysis are presented in Table 2 in the Appendix 2.

The next step is to carry out cointegration analysis based on the Johansen procedure that involves cases in which both variables are I(1) in levels. The outcomes demonstrate that there is no cointegration for Hungary, as both the Trace test and the Maximum eigenvalue test indicate that the rank of matrix Π is zero, implying no long-term relationship between revenues and expenditures. The conclusion, therefore, is that fiscal policy in Hungary may be non-sustainable. The tests for cointegration rank indicate that a cointegrating vector can be found for Lithuania and Slovenia. However, although the Trace test indicates cointegration for Lithuania, the Maximum eigenvalue test shows no cointegration at the 5 percent significance level. Since the literature suggests that the Trace test has better properties we follow this approach and conclude that there is one cointegrating vector in this case. Nonetheless, in both cases a parameter b in the cointegrating vector $(1, -b)$ is not $(1, 1)$, implying potential problems with fiscal sustainability. This is because if $0 < b < 1$ holds then government expenditures grow faster than revenues, which poses a threat to the solvency of public finances in the longer term.

There is also the case of Slovakia, where the Johansen procedure shows that two cointegrating vectors exist among two variables. This is the case when the rank is full, and there are two independent linear combinations, suggesting that two variables are stationary at levels. Strictly speaking there is no cointegration in this case because cointegration refers to linear combinations of $I(1)$ variables being stationary, whereas the Johansen test for Slovakia implies that both variables are I(0) in levels. We adopt the explanation that the obtained results indicate no cointegration, therefore this country seems to fall into the non-sustainable camp.

5.4 Discussion of results

The results based on debt stationarity tests demonstrate that such countries as Lithuania and Slovenia, which have undertaken fiscal adjustment programmes, are in principle fiscally sustainable. The exception is Latvia, but this may be the result of growing debt from a very low level, not posing any immediate risk to the solvency of public finances. The remaining analysed NMS have not so far reformed their public finances sufficiently. This is reflected in the results indicating no rejection of null hypothesis of a unit root in public debt series. However, the results obtained from a cointegration analysis show no country to be fiscally sustainable among NMS, which may be perceived as contradictory to the results from public debt stationarity tests. One should, however, remember that public debt stationarity is only a sufficient condition for fiscal sustainability and therefore does not have to be satisfied in order to ensure fiscal sustainability.

There are also important issues that need to be addressed with respect to the second stage of empirical research, namely the cointegration analysis. Firstly, if there are two cointegrating vectors describing a given two-dimensional vector, that is equivalent to claiming that each vector is $I(0)$, contradicting in some cases the other results reported from the ADF tests for government revenues and expenditures. There is, however, a difference between the outcome of a statistical test and what may really be true. The Johansen cointegration test may be falsely rejecting the null hypothesis of only one cointegrating vector, or the ADF univariate test may be falsely accepting the null of a unit root. This may be an important issue in the light of the relatively small number of observations that are available in the NMS. Furthermore, one could argue that equating in terms of statistical implications a case where rank is full with one where rank is zero may be questionable and therefore the results for Slovakia should be treated cautiously. Finally, the outcome of the cointegration tests is often very sensitive to lag lengths. In order to tackle this problem different lags were used, but the results in the vast majority of cases remained similar.

The results that show no fiscal sustainability among the NMS can to a certain extent be explained by the fact that these countries have had to actively assist in the transformation process. The costs of introducing necessary reforms to stabilise public finances over the longer term are estimated as very high and this may be why analysis of a short period of time may be biased towards non-sustainability. Nonetheless, the costs incurred by some NMS corresponding to reforms in pension system, health sector and administration as well as those related to special programmes for the mining and steel industries should lead to benefits in the long-run. Crucial for the NMS is building up infrastructure, which is so important for economic growth in the long-term (Easterly and Rebelo, 1993) and catching-up with EU standards more generally. However, the above-mentioned costs are not taken into account in the empirical research, which may to a certain degree distort the results.

6 Conclusions

6.1 Concluding remarks

Although a general equilibrium framework seems to be the most desirable tool for analysing fiscal sustainability, since it treats as endogenous not only debt and public deficits but also other crucial macroeconomic variables, the theory has not so far produced one viable approach. Models based on overlapping generations are very informative tools for policy analysis, however they suffer from the computational problems related to calibration of parameters for a large number of generations. On the other hand, models that are based on the partial equilibrium approach cannot provide us with the impact of debt on the overall economy, which is so important for policy analysis. There still seems to be much scope for filling this gap in the theoretical literature and reconciling this would improve both our understanding of the impact of debt on the economy and the quality of empirical research on fiscal sustainability.

The use of partial equilibrium models also creates practical dilemmas about how to interpret a situation where a country runs a permanent primary surplus to pay the interest on the debt. The consequence is a permanent conventional deficit, which means that the interest rate will grow faster than the debt, satisfying the transversality condition that ensures sustainability. There may also be a situation in which, in accordance with theory, the country may be regarded as non-sustainable, although the debt could be asymptotically falling to zero. This may occur when the economy is a growing one with a relatively low interest rate. Such situations clearly show that one has to be particularly careful when drawing conclusions based on the PVBC.

The results based on debt stationarity tests demonstrate that countries such as Lithuania and Slovenia that have undertaken serious fiscal adjustment programmes are in principle fiscally sustainable, with the exception of Latvia. The other NMS have not so far reformed their public finances sufficiently and this is reflected in the results indicating no rejection of null hypothesis of a unit root in public debt series. However, the results obtained from cointegration analysis show no country to be fiscally sustainable among the NMS, which may be perceived as contradictory to the results from public debt stationarity tests. One should, however, remember that public debt stationarity is only a sufficient condition for fiscal sustainability, therefore it does not have be satisfied in order to ensure fiscal sustainability.

Analysis based on public debt stationarity tests and intertemporal budget constraint does not account for the costs associated with the transition period, therefore the final conclusion of no sustainability in NMS should be put into a broader context of transformation from a centrally planned economy to a market oriented system. This, of course, should not be taken as an excuse for failing to pursue prudent fiscal policy aiming to ensure sustainability over the long-term.

Combining the outcome for the NMS with those for the OMS obtained by Uctum and Wickens (2000) and Afonso (2004) one can conclude that the outlook for future European Monetary Union is rather gloomy. There are very few countries which are fiscally sustainable. The policy implication for the vast majority of both OMS and NMS is therefore to undertake some corrective measures to ensure sustainability over the long-term: certainly more than is being done at the present time.

6.2 Further research

Unlike the traditional approach one can analyse fiscal sustainability issue by employing non-linear methods. Chortareas et al. (2003) argue that a traditional methodology is not appropriate for countries which experience regime shifts and the analysed fiscal variables reveal certain thresholds.

The consequence in those cases is that a traditional approach may reject unit roots. The authors claim that the reaction of fiscal authorities to an increase in debt may be characterised by different attitude when debt is close to an imposed threshold from the behaviour when debt is well below this threshold. Chortareas et al. (2003) propose a stationarity test that includes the non-linearity to the alternative hypothesis. They find that results based on the traditional approach may be frequently reversed in favour of fiscal sustainability for Latin American countries. Therefore, it would be interesting to investigate whether non-linearity is prevalent in NMS because if confirmed a traditional approach may have distorted to a certain extent the results towards non-sustainability.

References

[1] Afonso, A. (2004). "Fiscal Sustainability: the Unpleasant European Case", Macro Money and Finance Annual Conference 2004, September, London, http://www.cass.city.ac.uk/conferences/mmf2004/Day2.html

[2] Agenor, P-R. (2000). The Economics of Adjustment and Growth, Academic Press

[3] Agenor, P-R., and Montiel, P. (1999). Development Macroeconomics, Princeton University Press.

[4] Annicchiarico, B. and Giammarioli, N. (2004). "Fiscal Rules and Sustainability of Public Finances in an Endogenous Growth Model", ECB Working Paper No. 381, August

[5] Antczak, M., Dabrowski, M., Gorzelak, M. (2004). "Fiscal Challenges Facing the New Member States", A Workshop organised by the European Commission Directorate General for Economic and Financial Affairs, November, Brussels http://europa.eu.int/comm/economy_finance/events/2004/events_brussels_1104_en.htm

[6] Artis, M. and Marcellino, M. (2000). "The Solvency of Government Finances in Europe", in Balassone, F. and Franco, D., eds, Fiscal Sustainability, Research Department Public Finance Workshop, Banca d'Italia

[7] Aschauer, D. (1985). "Fiscal Policy and Aggregate Demand", American Economic Review, March, 75, pp. 117-27.

[8] Balassone, F. and Franco, D. (2000). "Assessing Fiscal Sustainability: a Review of Methods with a View to EMU", in Balassone, F. and Franco, D., eds, Fiscal Sustainability, Research Department Public Finance Workshop, Banca d'Italia

[9] Barro, R.J. (1974). "Are Government Bonds net Worth?", Journal of Political Economy, No. 82, Vol. 6, pp. 1095-117.

[10] Barro (1984). "The Behaviour of U.S. Deficits", NBER Working Paper, No. 1309, March.

[11] Blanchard, O. and Fischer, S. (1989). Lectures on Macroeconomics, Cambridge, MA: The MIT Press

[12] Blanchard, O., Chouraqui, J.; Hagemann, R. and Sartor, N. (1990). "The sustainability of fiscal policy: new answers to an old question," OECD Economic Studies, 15, Autumn, 7-36.

[13] Blejer, M.I. and A. Cheasty (1991). "The Measurement of Fiscal Deficits: Analytical and Methodological Issues", Journal of Economic Literature, vol. 29, No. 4, pp. 1644-78.

[14] Bohn, H. (1991). "The Sustainability of Budget Deficits with Lump-Sum and with Income-Based Taxation," Journal of Money, Credit, and Banking, 23 (3), Part 2, pp. 581-604.

[15] Bohn, H. (1995). "The Sustainability of Budget Deficits in a Stochastic Economy," Journal of Money, Credit, and Banking, 27 (1), pp. 257-271.

[16] Bratkowski, A. and Rostowski, J. (2002). "The EU Attitude to Unilateral Euroization: Misunderstandings, Real Concerns and Sub-optimal Admission Criteria", Economics of Transition, vol. 10, no. 2, 2002, pp. 445-68

[17] Buiter W. (1983), "Measurement of the Public Sector Deficit and Its implication for Policy Evaluation and Design", IMF Staff Papers, No. 30 (2), pp. 306-49.

[18] Buiter (1985). "A Guide to Public Sector Debt and Deficits", Economic Policy, No. 1, pp. 612-35.

[19] Chalk, N. (2000). "The Sustainability of Bond-Finance Deficits: An Overlapping Generations Approach", Journal of Monetary Economics, 45(2), pp. 293-328

[20] Chalk, N. and Hemming, R. (2000). "Assessing Fiscal Sustainability in Theory and Practice," IMF Working Paper, 00/81, April.

[21] Carlin, W. and Soskice, D. (2004) "Macroeconomics: Rigidities, Institutions, and Politics", mimeo, http://www.ucl.ac.uk/~uctpa36/book.htm

[22] Chortareas, G.; Kapetanios, G.; Uctum, M. (2003). "A Nonlinear Perspective on Public Finance Sustainability in Latin America", Workin Paper Series, Department of Economics, Queen Mary College.

[23] Cukrowski, J. and Janecki, J. (2005). "Generation of Seigniorage Wealth Before and After Euro Area Accession: Case of Poland", in Jaworski, P. and Mickiewicz, T., eds, Polish Accession to the European Union: Macroeconomics and Financ, University College London

[24] De la Croix, D. and Michel, P. (2002). A Theory of Economic Growth – Dynamics and Policy in Overlapping Generations, Cambridge University Press.

[25] Diamond, P. (1965). "National Debt in a Neoclassical Growth Model", American Economic Review, 55(5), pp. 1126-150

[26] Dickey, D. and Fuller. W. (1981). "The Likelihood Ratio Statistics for Autoregressive Time Series with a Unit Root," Econometrica, 49, pp. 1057-1072.

[27] Domar, E.D. (1944). "The burden of the debt and the national income", American Economic Review, December, pp. 798-827.

[28] Easterly W., Rebelo S. (1993). “Fiscal Policy and Economic Growth”, Journal of Monetary Economics vol. 32.

[29] Flood, R. and Garber, P. (1980). “Market Fundamentals versus Price-Leve Bubbles: The First Tests”, Journal of Political Economy, Vol. 88, August, pp. 745-70.

[30] Hakkio, G. and Rush, M. (1991). “Is the budget deficit "too large?"” Economic Inquiry, 29 (3), pp. 429-445.

[31] Hamilton, J. and Flavin, M. (1986). “On the Limitations of Government Borrowing: A Framework for Empirical Testing,” American Economic Review, 76 (4), pp. 808-816.

[32] Hughes Hallett, A. and Lewis, J. (2004). “Hansa vs. Habsburg: Debt, Deficits and the Entry of the Accession Countries into the Euro”, CEPR Discussion Paper no. 4500

[33] Ihori, T. (1978). “The Golden Rule and the Role of Government in a Life Cycle Growth Model”, American Economic Review, 68(3), pp. 389-396

[34] Jha, R. (2004). “Macroeconomics of Fiscal Policy in Developing Countries”, in Addison, T. and Roe, A., eds, Fiscal Policy in Developing Countries, Palgrave.

[35] Johansen, S. (1988). “Statistical Analysis of Cointegration Vectors”, Journal of Economic Dynamics and Control, 12, pp. 231-254.

[36] Johansen, S. and Juselius, K. (1990) “Maximum likelihood estimation and inference on cointegration – with applications to the demand for money”, Oxford Bulletin of Economics and Statistics, 52, pp. 169–210.

[37] Johansen, S. (1995). Likelihood Based Inference in Cointegrated Vector Autoregressive Models, Oxford University Press.

[38] Karp, P. and Kelm, R. (2004). Fiscal Deficits and Exchange Rate Misalignment in Poland: An Econometric Analysis, mimeo.

[39] Kotlikoff, L.J. (1984), “Economic Impact of Deficit financing”, Staff Papers, International Monetary Fund, Vol. 33, pp. 549-81.

[40] Kremers, J. (1988). “The Long-Run Limits of U. S. Federal Debt,” Economics Letters, 28 (3), pp. 259-262.

[41] Liu, P. and Tanner, E. (1995). “Intertemporal solvency and breaks in the US deficit process: a maximum-likelihood cointegration approach,” Applied Economics Letters, 2 (7), pp. 231-235.

[42] Marin, J. (2002)."Sustainability of Public Finances and Automatic Stabilisation under a Rule of Budgetary Discipline", ECB Working Paper No. 193

[43] McCallum, B. (1984). "Are Bond-Financed Deficits Inflationary? A Ricardian Analysis," Journal of Political Economy, 92 (1), pp. 123-135.

[44] McKinnon, J. (1996). "Critical Values for Cointegration Tests" in Engle, R. and Granger, C., eds, Long-run Economic Relationships, Oxford University Press.

[45] O'Connell, S. and Zeldes, S. (1988). Rational Ponzi Games, International Economic Review 29 (3), pp. 431-450.

[46] Quintos, C. (1995). "Sustainability of the Deficit Process With Structural Shifts," Journal of Business & Economic Statistics, 13 (4), pp. 409-417.

[47] Rankin, N. and Roffia, B. (2003). "Maximum Sustainable Government Debt in the Overlapping Generations Model", The Manchester School, 71(3), pp. 217-241.

[48] Romer, D. (2001). Advanced Macroeconomics, McGraw Hill.

[49] Rostowski, J. (2002). "When Should Central Europeans Join EMU?", CASE Studies and Analyses, No. 275.

[50] Samuelson, P. (1958). "An Exact Consumption-Loan Model of Interest with or without the Social Contrivance of Money", Journal of Political Economy, 66, pp. 467-82.

[51] Seater, J.J. and R.S. Mariano (1985), "New Tests of the Life Cycle and Tax Discounting Hypotheses", Journal of Monetary Economics, No. 15, March, pp. 195-215.

[52] Shaviro, D. (1997), Do Deficits Matter?, The University of Chicago Press.

[53] Siwinska, J. (1999). "Public Debt Structure and Dynamics in the Czech Republic, Hungary, Poland, and Romania", CASE Studies and Analyses, No. 162.

[54] Trehan, B. and Walsh, C. (1988). "Common trends, the government's budget constraint, and revenue smoothing," Journal of Economic Dynamics and Control, 12 (2/3), pp. 425-444.

[55] Trehan, B. and Walsh, C. (1991). "Testing Intertemporal Budget Constraints: Theory and Applications to U.S. Federal Budget and Current Account Deficits," Journal of Money, Credit, and Banking, 23 (2), pp. 206-223.

[56] Uctum, M. and M. Wickens (1997). "Debt and Deficit Ceilings, and Sustainability of Fiscal Policies: An Intertemporal Analysis", CEPR Discussion Papers, No. 1612.

[57] Uctum, M. and Wickens, M. (2000). "Debt and deficit ceilings, and sustainability of fiscal policies: an intertemporal analysis," Oxford Bulletin of Economic Research, 62 (2), pp.197-222.

[58] Wilcox, D. (1989). "The Sustainability of Government Deficits: Implications of the Present-Value Borrowing Constraint," Journal of Money, Credit, and Banking, 21 (3), pp. 291-306.

Appendix 1

Table 1 Budget deficit as a share of GDP

	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003
Estonia	3.1	-0.6	-2.0	2.1	-0.9	-5.4	-1.6	0.3	0.9	0.0
Latvia	-1.5	-2.3	-0.5	1.6	-0.7	-5.3	-2.7	-1.6	-3.0	-2.7
Lithuania	-0.9	-2.0	-3.7	-1.2	-3.0	-5.7	-2.3	-2.2	-1.7	-2.6
Slovenia	-1.5	-1.1	-0.9	-2.3	-2.2	-2.1	-3.1	-1.3	-2.3	-2.2

Source: Hughes Hallett and Lewis (2004)

Table 2 Debt as a share of GDP

	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003
Estonia				6.9	6.0	6.5	5.0	4.7	5.7	5.4
Latvia	11.2	16.2	14.5	12.9	10.6	13.7	13.9	15.7	15.2	16.7
Lithuania						23.0	24.3	23.4	22.8	21.9
Slovenia	18.5	17.9	21.7	22.4	23.9	25.1	26.4	25.9	27.0	27.4

Source: Hughes Hallett and Lewis (2004)

Table 3 Budget deficit as a share of GDP

	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003
Czech Republic	-3.4	-12.3	-1.9	-2.4	-4.7	-3.7	-4.0	-5.8	-7.1	-8.0
Hungary	-13.6	-16.2	-9.8	-16.4	-12.7	-9.5	-2.0	-4.2	-9.2	-5.4
Poland	5.8	-2.5	-2.9	-2.8	-2.3	-2.0	-2.5	-3.1	-3.9	-4.3
Slovakia	-6.1	-0.9	-7.4	-6.2	-5.2	-7.8	-13.5	-7.2	-7.2	-5.1

Source: Hughes Hallett and Lewis (2004)

Table 4 Debt as a share of GDP

	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003
Czech Republic	16.4	15.6	13.6	12.9	13.7	14.3	16.6	23.3	27.1	30.7
Hungary	88.2	86.3	72.8	64.2	61.9	61.2	55.5	53.4	56.3	57.9
Poland	54.6	48.2	47.2	46.9	41.6	42.7	37.2	37.2	41.6	45.1
Slovakia			24.9	28.6	28.6	43.8	46.9	48.8	44.3	45.1

Source: Hughes Hallett and Lewis (2004)

Appendix 2

Table 1 Stationarity test for debt

	Period	k	ADF(k)
Czech Republic	1994:01-2002:12	4	-1.3419
Hungary	1997:01-2002:11	0	-1.8246
Latvia	1996:01-2002:12	5	-1.6268
Lithuania	1998:01-2003:01	2	-2.6099*
Poland	1997:01-2003:12	5	0.8021
Slovenia	1998:01-2002:12	4	-3.8274**

The symbols *, **, *** indicate that a series is stationary at 10%, 5%, and 1% significance level, respectively

Table 2 Stationarity test for government revenues and expenditures

	Level				First difference		
Country	Variable	Period	k	ADF(k)	Variable	k	ADF(k)
Czech Republic	REV	1993:01-2003:01	0	-14.165***	ΔREV	9	-6.6624***
	G		6	-0.687	ΔG	5	-8.7572***
Hungary	REV	1997:01-2002:11	2	-2.567*	ΔREV	9	-4.6743***
	G		11	-2.548	ΔG	10	-4.6524***
Latvia	REV	1995:01-2002:12	7	-3.267**	ΔREV	4	-5.7806***
	G		2	-1.376	ΔG	1	-9.6903***
Lithuania	REV	1999:01-2003:12	5	0.827	ΔREV	4	-3.2795**
	G		4	-2.070	ΔG	1	-9.8054***
Poland	REV	1997:01-2003:12	4	-2.963**	ΔREV	3	-8.2684***
	G		5	-2.532	ΔG	8	-5.2755***
Slovakia	REV	1995:01-2004:09	12	-1.447	ΔREV	11	-4.5841***
	G		12	-1.849	ΔG	11	-4.5264***
Slovenia	REV	1993:01-2002:12	10	-1.012	ΔREV	9	-6.7919***
	G		5	-0.958	ΔG	4	-8.8239***

The symbols *, **, *** indicate that a series is stationary at 10%, 5%, and 1% significance level, respectively

Cointegration of government revenues and expenditures

Czech Republic

null	altern	trace stat	95% quantile	null	altern	Max-Eigen stat	95% quantile
r=0	r≥1	44.7361	15.4947	r=0	r=1	38.3333	14.2646
r≤1	r≥2	6.4028	3.8415	r≤1	r=2	6.4028	3.8415

Hungary

null	altern	trace stat	95% quantile	null	altern	Max-Eigen stat	95% quantile
r=0	r≥1	7.7711	15.4947	r=0	r=1	5.7345	14.2646
r≤1	r≥2	2.0366	3.8415	r≤1	r=2	2.0366	3.8415

Latvia

null	altern	trace stat	95% quantile	null	altern	Max-Eigen stat	95% quantile
r=0	r≥1	8.5377	15.4947	r=0	r=1	7.2663	14.2646
r≤1	r≥2	1.2714	3.8415	r≤1	r=2	1.2714	3.8415

Lithuania

null	altern	trace stat	95% quantile	null	altern	Max-Eigen stat	95% quantile
r=0	r≥1	26.4506	25.8721	r=0	r=1	15.1017	19.3871
r≤1	r≥2	11.3489	12.5183	r≤1	r=2	11.3489	12.5183

1.0000*RREV_SA-0.4182*REXPEND_SA

Poland

null	altern	trace stat	95% quantile	null	altern	Max-Eigen stat	95% quantile
r=0	r≥1	15.3008	15.4947	r=0	r=1	10.4882	14.2646
r≤1	r≥2	4.8126	3.8415	r≤1	r=2	4.8126	3.8415

Slovakia

null	altern	trace stat	95% quantile	null	altern	Max-Eigen stat	95% quantile
r=0	r≥1	33.8688	15.4947	r=0	r=1	25.9644	14.2646
r≤1	r≥2	7.9043	3.8415	r≤1	r=2	7.9043	3.8415

Slovenia

null	altern	trace stat	95% quantile	null	altern	Max-Eigen stat	95% quantile
r=0	r≥1	26.6217	15.4947	r=0	r=1	24.0142	14.2646
r≤1	r≥2	2.6075	3.8415	r≤1	r=2	2.6075	3.8415

1.0000*RREV_SA-0.7331*REXPEND_SA