A Global Perspective of Fiscal Sustainability: evidence from a panel of 20 OECD countries

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Abstract :

This paper aims at assessing the sustainability of fiscal policies in a panel of twenty OECD countries. First, using panel data unit-root tests proposed by Im, Pesaran and Shin (2003), Maddala and Wu (1999), and Choi (2001), econometric findings reveal that the variables of public expenditure and revenue in level are not stationary. However, employing panel co-integration tests designed by Pedroni (1999), it is found that government spending and revenue are co-integrated. This implies that fiscal policies in these countries are sustainable in the long run, i.e. they are consistent with inter-temporal budget balance in accordance with the present-value approach.

Keywords: fiscal sustainability, panel data unit-root and co-integration tests, OECD countries.

JEL classification: C23, E 62, H63.

1. INTRODUCTION

The concept of fiscal sustainability, which mainly appeared during the 1980s (through the budgetary crisis experienced by the majority of developed and developing countries), takes into consideration the inter-temporal budget constraint in the analysis of stabilization of budget deficits. As a consequence, the basic issue concerning the sustainability of fiscal policies gained in importance as well among political leaders as in the studies of academic economists or researchers in the International Organisations. The result was that a very extensive theoretical and empirical literature emerged on this topic.

In most cases, time-series methods have been employed to examine whether the governments effectively respect the inter-temporal budget constraint in present value terms. According to this conceptual approach initiated by Hamilton and Flavin (1986), if the present value budget constraint is not satisfied, then the fiscal policy is not sustainable in the long run.

Moreover, most of the empirical studies focused on the American case and other industrial countries[1]: the United States (Hamilton and Flavin, 1986; Trehan and Walsh, 1988; Kremers, 1988; Wilcox, 1989; Hakkio and Rush, 1991; Trehan and Walsh, 1991; MacDonald, 1992; Tanner and Liu, 1994; Ahmed and Rogers, 1995; Quintos, 1995; Haug, 1995; Crowder, 1997; Bohn, 1998; Martin, 2000; Cunado, Gil-Alana and Perez de Gracia, 2004; Llorca, 2006), member states of the European Union (MacDonald and Speight, 1990; Jondeau, 1992; Baglioni and Cherubini, 1993; Caporale, 1995; Vanhorebeek and Rompuy, 1995**;** Uctum and Wickens, 1997; Artis and Marcelino, 1998; Greiner, Koeller and Semmler, 1999; Papadopoulos and Sidiropoulos, 1999; Getzner, Glatzer and Neck, 2001; Bravo and Silvestre, 2002; Hatemi-J, 2002; Greiner, Koeller and Semmler, 2004; Afonso, 2005), Canada (Smith and Zin, 1991), G7 countries (Owoye, 1995; Payne, 1997; Fève and Henin, 1998), Australia (Elliot and Kearney, 1988; Olekalns, 2000), Japan (Llorca, 2005). In general, these previous studies have concluded for fiscal sustainability only in some countries[2].

However, very few papers (Lau and Baharumshah, 2005; Ehrhart and Llorca, 2006; Prohl and Schneider, 2006) have applied panel econometric tests to assess the sustainability of fiscal deficits in developed and developing countries. Firstly, Lau and Baharumshah (2005) investigated the issue of fiscal sustainability by adopting families of panel unit root tests for a panel of ten Asian countries. They found that four out of ten countries in the panel are

[1] However, very few papers (Buiter and Patel, 1992; Olekalns and Cashin, 2000; Jha, 2003; Berthomieu *et al.*, 2004) have applied similar econometric tests to assess the sustainability of fiscal deficits in developing countries. See Ehrhart and Llorca (2006) for a brief survey.

[2] Refer to the appendix for a detailed survey of the fiscal sustainability empirical results in developed countries.

stationary, suggesting little evidence of fiscal sustainability in these Asian countries. Secondly, Ehrhart and Llorca (2006) used recent econometric methods for panel data to check whether fiscal policies implemented in six South-Mediterranean countries (Egypt, Israel, Lebanon, Morocco, Tunisia and Turkey) are sustainable in the long-run. Several tests for panel unit-roots and cointegration have been performed. The estimation results show that fiscal policies in these countries are sustainable in the long term. Finally, Prohl and Schneider (2006) analysed the sustainability of fiscal policy of EU member countries. They apply the test for panel cointegration between the primary budget deficit and the public debt defined in GDP ratios and they conclude that the fiscal policy is sustainable in the panel of fifteen EU member countries over the period from 1970 to 2004.

As a result, the main purpose of this article is to assess the fiscal sustainability in 20 OECD countries by using first the panel unit-root tests developed by Im, Pesaran and Shin (2003), Maddala and Wu (1999) and Choi (2001) and second the panel co-integration tests proposed by Predoni (1999). To our best knowledge, no paper has tackled the issue of fiscal sustainability in a panel of OECD countries by applying recent econometric methods for panel data.

The paper is organised as follows: section 2 describes the present value constraint approach to sustainability of fiscal policies. Section 3 provides a data description, an overview of OECD countries fiscal stance and reports the econometric findings. Section 4 concludes the study.

2. THEORICAL FRAMEWORK: THE APPROACH OF THE GOVERNMENT INTER-TEMPORAL CONSTRAINT

Econometric tests of fiscal sustainability consist in studying whether the government's behaviour is consistent with its inter-temporal budget constraint. In other words, the underlying theoretical foundations of empirical studies are the approach of the government inter-temporal constraint. The one-period government budget constraint can be written in nominal terms as

$$G_t - T_t + r_t B_{t-1} = B_t - B_{t-1} \quad (1)$$

where G_t is the value of government expenditures, T_t is the government's tax revenue, $(G_t - T_t)$ is the primary budget deficit, B_t is the stock of government debt at the end of the period t and r_t is the one-period interest rate payable on government debt. Equation (1) means

that in the absence of money finance, the budget deficit inclusive of interest payments must be financed by new bond issues.

Dividing each term of (1) by nominal GDP we obtain the government's budget constraint in terms of ratios to GDP:

$$b_t = (1+r_t)(1+\eta_t)^{-1} b_{t-1} + (g_t - \tau_t) \quad (2)$$

where the lower-case letters denote the ratio of the corresponding upper-case variables to nominal GDP Y_t: $b_t = B_t/Y_t ; g_t = G_t/Y_t ; \tau_t = T_t/Y_t$. $\eta_t = (Y_t - Y_{t-1})/Y_{t-1}$ is the growth rate of nominal GDP between $t-1$ and t. Since $(1+r_t)(1+\eta_t)^{-1} = 1 + r_t - \eta_t$ the above equation is transformed into

$$b_t = (1+r_t-\eta_t) b_{t-1} + (g_t - \tau_t) \quad (3)$$

Let us assume that $\theta_t = r_t - \eta_t$. Equation (3) can then be re-written as follows:

$$b_t = (1+\theta_t) b_{t-1} + (g_t - \tau_t) \quad (4)$$

Equation (4) is an identity which holds *ex post* in time t. To obtain the inter-temporal budget constraint, first we re-write the previous identity in (4) for period $t+1$ in *ex ante* terms as

$$b_t = E_t\left[(1+\theta_{t+1})^{-1} b_{t+1}\right] - E_t\left[(1+\theta_{t+1})^{-1}(g_{t+1} - \tau_{t+1})\right] \quad (5)$$

where b_t is known in period t and E_t is the expectations operator, conditional on information at time t. For fiscal policy to be sustainable for one time period, eq. (5) must hold. Writing the budget constraint of (5) for subsequent time periods $t+1, t+2, ..., t+s$ and solving (5) forward yields the s-period inter-temporal budget constraint

$$b_t = E_t\left[\sum_{s=0}^{\infty}\prod_{i=1}^{s}(1+\theta_{t+i})^{-1}(\tau_{t+s} - g_{t+s})\right] + E_t\left[\prod_{i=1}^{s}(1+\theta_{t+i})^{-1} b_{t+s}\right] \quad (6)$$

where $\prod_{i=1}^{s}(1+\theta_{t+i})^{-1}$ is the time-varying discount factor. A necessary and sufficient condition for sustainability of fiscal policy is that as $s \to \infty$ the discounted value of the expect debt-GDP ratio converges to zero. This transversality condition can be expressed as

$$\lim_{s\to\infty} E_t\left[\prod_{i=1}^{s}(1+\theta_{t+i})^{-1} b_{t+s}\right] = 0 \quad (7)$$

Equation (7) excludes a Ponzi scheme, meaning no new debt is issued by the government to meet interest payments. In other words, equation (7) implies that the government does not have the option of running perpetual primary deficits.

If this transversality condition holds, then the current debt – GDP ratio is offset by the sum of current and expected future discounted primary surpluses expressed as a percentage of GDP, implying that the inter-temporal government budget holds in present value terms with:

$$b_t = \lim_{s\to\infty} E_t\left[\sum_{s=0}^{\infty}\prod_{i=1}^{s}(1+\theta_{t+i})^{-1}(\tau_{t+s} - g_{t+s})\right] \quad (8)$$

In order to formally test equation (6), we will assume that the nominal interest rate adjusted for output growth, θ_t, is stationary with unconditional mean given by θ. Upon further mathematical manipulations (see Hakkio and Rush, 1991: 432), equation (6) can be rewritten as follows

$$g_t^* - \tau_t = \sum_{s=0}^{\infty}(1+\theta)^{-s+1}(\Delta\tau_{t+s} - \Delta g_{t+s}^* + \theta\Delta b_{t+s-1}) \quad (9)$$

where $g_t^* = g_t + \theta b_{t-1}$ with g_t^* denoting total government expenditure inclusive of spending on goods and services, transfert payments and interest on the debt and Δ is the first-difference operator.

Given the right-hand side variables from eq. (9) are I(1) (first-difference stationary) implies that the left-hand side of eq. (9) must be stationary in order to satisfy the present-value budget constraint. Thus g_t^* and τ_t must be examined for stationarity. If g_t^* and τ_t are I(1), (non-stationary in level), then they must be cointegrated, so that the left-hand side of eq. (9), i.e. the public deficit, is stationary. Thus a test for sustainability of the public debt would check for the cointegration of these two variables g_t^* and τ_t if they are I(1). This cointegration regression would take the following form:

$$\tau_t = \alpha + \beta g_t^* + u_t$$

Formally, if g_t^* and τ_t are I(1), the null hypothesis is that g_t^* and τ_t are cointegrated and that $\beta = 1$. If the null hypothesis is not rejected, then the public debt is sustainable.

3. EMPIRICAL INVESTIGATION

3.1 Sample and data

The sustainability of fiscal policy is assessed in a sample of 20 OECD countries, namely Australia, Austria, Belgium, Canada, Denmark, Finland, France, Germany, Greece, Iceland, Ireland, Italy, Japan, Korea, the Netherlands, Norway, Spain, Sweden, the United Kingdom and the United States. We use annual data collected from OECD's *Economic Outlook*. The

sample covers the period 1975-2005 for the following variables: the public expenditure and revenue, the budget balance.

In the empirical assessments of fiscal sustainability, it is possible to opt for several alternative definitions of the public debt variables. Indeed, Balassone and Franco (2000) argue that the public debt measure could be either net or gross of assets. There are arguments both in favour and against the use of each of the measures. Since the government could sell a part of its assets to repay the debt, the net debt will be the relevant measure in this case. However, there are several practical difficulties in the valuation of government assets, especially non-interest bearing ones, making the measure of net debt rather unreliable and very volatile. Therefore, the gross and net debt measure will be alternatively used.

In the case of the variables of gross public debt and primary budget balance, the data are only available for a sample of 14 OECD countries (namely Austria, Canada, Finland, France, Germany, Greece, Ireland, Italy, Japan, Korea, Norway, Sweden, the United Kingdom and the United States) over the period 1975-2005. Finally, for availability reasons, within the same period (1975-2005), we are constrained to employ a restricted sample of 12 OECD countries (namely Canada, Finland, France, Germany, Greece, Ireland, Italy, Japan, Korea, Sweden, the United Kingdom and the United States) for the variable of net public debt. All the previous variables are measured in terms of their ratio to nominal GDP.

3.2 Evolution of public finance in OECD countries: an overview

The study of our sample of twenty OECD countries reveals interesting features about mean government size which is measured by the average level of public expenditures in percentage of GDP between 1975 and 2005.

Using the classification proposed by Tanzi and Schuknecht (2000), the countries in the sample can be divided in three groups, depending on the average government size in percentage of GDP (see table 1). Firstly, Korea, Japan, the United States, Australia and Spain, with public spending below 40 percent of GDP, represent the group of “small governments”. Secondly, Iceland, Greece, Ireland, United Kingdom, Canada, Germany, Italy, Norway and Finland, with public expenditure between 40 and 50 percent of GDP, constitute the group of “medium-sized governments”. Finally, France, the Netherlands, Austria, Belgium, Denmark and Sweden, where public spending exceeds 50 percent of GDP, constitute the group of “big governments”.

Table 1: Average Government Size in OECD countries between 1975 and 2005

Government Size (in % of GDP)	**Countries**	**Types of governments**
Below 40	Korea (21,7 %) Japan (33,8 %) United States (35,8 %) Australia (36 %) Spain (38,7 %)	*Small governments*
Between 40 and 50	Iceland (40,2 %) Greece (43,6 %) Ireland (44,4 %) United Kingdom (44,6 %) Canada (44,9 %) Germany (46,9 %) Italy (48 %) Norway (48,3 %) Finland (49 %)	*Medium-sized governments*
Above 50	France (50,3 %) Netherlands (51,2 %) Austria (51,7 %) Belgium (53,8 %) Denmark (54,9 %) Sweden (61,3 %)	*Big governments*

Source : authors 'calculations from OECD database (*Economic Outlook)*

In addition, concerning the fiscal stance of our 20 OECD countries during the whole period considered, if the deficit criteria defined by the Stability and Growth Pact is taken as a reference, we can notice that in our database of 620 observations on budget balance, 17,2 % of the data (that is 107) present a budget surplus, 30,1 % of the observations (that is 186) indicate a "low" budget deficit (i.e. below the 3 per cent of GDP deficit criteria) and 52,7 % of the data (that is 327) reveal an "excessive" budget deficit (i.e., above the threshold of 3 %).

3.3 Empirical Results

From the above analysis it is clear that sustainability of the public debt is essentially an inter-temporal question. In particular, every temporary fiscal deficit can be sustainable as long as it matched by an adequate future budgetary surplus. Most empirical tests on sustainability ask whether the observed characteristics of the debt-related variables satisfy the solvency condition in eq. (7). As in time-series studies, in the case of panel data analysis, the

econometric methodology employed to test this solvency condition consists mainly of two steps. In the first step, the stationary properties of government expenditure, revenue, and the stock of public debt are studied by using unit-root tests for panel data. Fiscal sustainability requires that fiscal variables (government expenditure, revenue, balance budget and public debt) are integrated of order zero. Our estimation procedures incorporate the non-stationary panel unit-root tests advocated by Im, Pesaran and Shin, (2003) (IPS) Maddala and Wu (1999) and Choi (2001) (MWC)[3].

Let us begin by considering the following model:

$$\Delta y_{it} = \alpha_i + \delta_{it} + \rho_i . y_{i,t-1} + \sum_{l=1}^{\rho i} \phi_{il} \Delta y_{i,t-l} + \varepsilon_{it} \qquad i = 1,...,N; t = 1,...,T \qquad (10)$$

where y_{it} is the value for panel member i in period t, ε_{it} is assumed to be independent and identically distributed IID $(0, \sigma_\varepsilon^2)$ across i and Δ denotes the first-difference operator.

The IPS test examines the null hypothesis

$H_0 : \rho_1 = \rho_2 = ... = \rho_N = 0$ (each individual time series in the panel contains a unit root)

against

$H_A : \rho_i < 0$ for at least one i (at least one of the individual series in the panel is stationary).

IPS suggest taking the average $\bar{t}_{N,T}$ of separate unit-root tests for N individual cross-sectional units of ADF t-ratios $t_{i,T}$. IPS *t*-bar is $\bar{t}_{N,T} = \frac{1}{N} \sum_{i=1}^{N} t_{i,T}$ where $t_{i,T}$ denotes the i[th] individual t-statistic for testing H_0 (unit roots). IPS assume that $t_{i,T}$ are IID and have finite mean and variance. Then

$$\bar{t}_{IPS} = \frac{\sqrt{N}\left\{\bar{t}_{N,T} - N^{-1}\sum_{i=1}^{N} E\left(t_{i,T} / \rho_i = 0\right)\right\}}{\sqrt{N^{-1}\sum_{i=1}^{N} Var\left(t_{i,T} / \rho_i = 0\right)}}$$

which is compared with critical values from the lower tail of a standard normal distribution.

The basic idea of the MWC is very simple. In MWC test, the null and alternative hypothesis are the same as those of the IPS test. Let ρ_i be the asymptotic p-value of a unit-root test for

[3] In Levin and Lin (1993) test, the null hypothesis is that each series in the panel contains a unit root ($H_0 : \rho_i = \rho = 0, \forall i$) against the alternative hypothesis that all individual series in the panel are stationary ($H_1 : \rho_i = \rho < 0, \ \forall$i). This null hypothesis is shared by other panel unit-root tests, the alternative hypothesis, however, is too restrictive for practical purposes.

cross-section i. MWC proposed a Fisher-type test $P = -2\sum_{i=1}^{N} \ln P_i$ which combines the p-values from unit-root tests for each cross section i to test for unit roots in panel data. P has a χ^2 distribution with 2N degrees of freedom.

In addition, Choi (2001) presents another test statistic besides Fisher's inverse chi-square test statistic P. This author proposes an inverse normal test $Z = \frac{1}{\sqrt{N}} \sum_{i=1}^{N} \phi^{-1}(p_i)$ where ϕ is the standard normal cumulative distribution function. Since $0 \leq p_i \leq 1$, $\phi^{-1}(p_i)$ is an N(0,1) random variable and as $T_i \to \infty$ for all i, $Z \Rightarrow N(0,1)$.

The results from the unit-root and stationarity tests for panel data using a sample of twenty OECD countries are detailed in table 2.

Table 2: *Panel Unit Root and Stationary Findings*

Tests / Ratios (in % of GDP)	**IPS**		**MW-ADF-Fisher Chi-square**		**Choi-PP-Fisher Chi-square**	
	Trend and intercept	*Intercept*	*Trend and intercept*	*Intercept*	*Trend and intercept*	*Intercept*
Public Expenditure	-0,667 (0,252)	-1,125 (0,130)	46,450 (0,223)	47,029 (0,206)	22,258 (0,989)	43,523 (0,323)
Revenue	-0,055 (0,478)	-1,290 (0,098)	38,336 (0,545)	56,121* (0,046)	28,867 (0,904)	64,203** (0,008)
Budget Balance	-3,593** (0,000)	-2,499** (0,006)	80,037** (0,000)	62,190* (0,013)	38,430 (0,541)	49,439 (0,145)

Notes: IPS, MW and Choi represent the Im, Pesaran and Shin (2003), Maddala and Wu (1999) and Choi (2001) panel unit root tests. All the three tests examine the null hypothesis of non-stationarity. The alternative hypothesis is that at least one of the individual series in the panel is stationary. The p-values are in parenthesis. * Statistically significant at 5% level, ** Statistically significant at 1% level. For a more detailed and technical description of the various tests employed, refer to Baltagi (2001) or Hsiao (2003). The estimation and the calculation of the previous panel procedures were carried out in E-views version 5.1.

As shown in table 2, unit-root tests for panel data indicate first that the ratios of public expenditure and revenue in level are not stationary. Second, the budget balance variable expressed as a percentage of nominal GDP is integrated of order zero only in the case of the IPS and MW tests. All the preceding results lead us to examine whether ratios of public expenditure and revenue are co-integrated in a panel perspective.

In fact, in the second step, since government spending and revenue are found to be non-stationary, it is important to investigate whether there is a cointegration relationship between these two fiscal variables. Cointegration among the fiscal variables is a necessary condition for the fiscal sustainability. So several tests for panel cointegration must be conducted. The cointegration regression is given by

$$\tau_{it} = \alpha_i + \beta_i g_{it}^{*} + \varepsilon_{it} \qquad i = 1,...,N; t = 1,...,T \qquad (11)$$

We consider here the panel cointegration tests proposed by Pedroni (1999). These tests are based on the null hypothesis of no-cointegration. From the seven tests developed by Pedroni (1999), four are classified as panel cointegration statistics, which presume a common value for the unit-root coefficient (the tests are based on within-dimension statistics), whereas the group mean panel cointegration tests allow for differences in this parameter (the tests are based on between-dimension statistics). Formally, Pedroni's various tests take the following forms:

$H_0 : \beta_i = 1$ for all i

versus

$H_1 : \beta_i = \beta < 1$ for all i panel cointegration tests (within-dimension statistics)

or

$H_1 : \beta_i < 1$ for all i group mean cointegration tests (between-dimension statistics).

The tests are different versions of the Phillips and Perron rho and t-statistics, as well as panel version of the ADF[4]. The findings from Pedroni's tests for panel cointegration are summed up in table 3.

Table 3: *Panel Cointegration Test Results for Public Expenditure and Revenue Ratios based on Pedroni Tests*

Panel variance test	**Panel ρ test**	**Panel *t*-test (non-parametric)**	**Panel *t*-test (parametric)**	**Group ρ test**	**Group *t*-test (non-parametric)**	**Group *t*-test (parametric)**
0,52	-0,45	-1,52*	-2,69***	0,86	-0,79	-3,51***

Notes: One, two and three asterisks denote rejection of the null hypothesis of no-cointegration at 10 %, 5 % and 1 % respectively. All the tests have been normalized, with the exception of the Group *t*-test in its non-parametric version. Since the tests are one-sided the 1% critical value is -1,96, the 5% critical value is -1,64 and the 10% critical value is -1,28. The estimation and the calculation of the previous panel cointegration statistics procedures were carried out in Rats version 6.

[4] See Pedroni (1999) for a detailed description of these statistics.

The null hypothesis of no-cointegration is rejected by the panel t- and group t-statistics at the 1 % significance level and by the panel t-test (non-parametric) at the 10 % significance level. It was accepted by the four other test statistic. However, Monte Carlo simulations carried out by Pedroni (2004) show that, in short samples (T=31, as in our case), panel t- and group t-statistics generally performed best. According to these results, we can conclude that the null hypothesis of no-cointegration is rejected in our study. The findings imply that, in a panel perspective, government spending and revenue are cointegrated, so that fiscal policies are sustainable in the long run.

Moreover, several complementary tests were carried out to study in-depth the sustainability of fiscal policies in OECD countries. Firstly, the stationary properties of primary budget balance and gross public debt (expressed in percentage of GDP) were examined in a panel of fourteen OECD countries. The results from these unit-root tests are reported in the table 4.

Table 4: *Panel Unit Root and Stationary Findings*

Tests / Ratios (in % of GDP)	**IPS**		**MW-ADF-Fisher Chi-square**		**Choi-PP-Fisher Chi-square**	
	Trend and intercept	*Intercept*	*Trend and intercept*	*Intercept*	*Trend and intercept*	*Intercept*
Gross public debt	0,765 (0,778)	0,203 (0,580)	28,232 (0,452)	31,660 (0,288)	6,539 (1,000)	21,134 (0,819)
Primary budget balance	-3,202** (0,000)	-2,777** (0,002)	59,159** (0,000)	51,917** (0,003)	33,882 (0,204)	49,928** (0,006)

Notes: see table 2.

As indicated in table 4, the ratio of primary budget deficit is generally stationary in level whereas this is not the case for the measure of gross public debt. We can not employ the tests for the panel-cointegration between these two variables since both series are not of the same order of integration.

Finally, we examined whether the variables of primary budget balance and net public debt (measured in percentage of GDP) are integrated of order zero using a sample of twelve OECD countries. The findings from this last set of tests are summed-up in the table 5.

Table 5: *Panel Unit Root and Stationary Findings*

Tests / Ratios (in % of GDP)	**IPS**		**MW-ADF-Fisher Chi-square**		**Choi-PP-Fisher Chi-square**	
	Trend and intercept	*Intercept*	*Trend and intercept*	*Intercept*	*Trend and intercept*	*Intercept*
Net public debt	1,471 (0,929)	0,212 (0,584)	18,369 (0,784)	21,865 (0,587)	11,195 (0,987)	12,248 (0,977)
Primary budget balance	-3,127** (0,000)	-2,810** (0,002)	52,072** (0,000)	47,545** (0,002)	29,817 (0,190)	45,761** (0,004)

Notes: see table 2.

As in the previous case, it is not possible to conduct panel-cointegation tests between the primary budget balance and the net public debt because the order of integration of these variables is not identical.

4. CONCLUSION

This study makes use of the recent econometric methods for panel data to check whether fiscal policies implemented in twenty OECD countries are sustainable in the long-run. Several tests for panel unit- roots and cointegration have been performed. The estimation results show that the public finance-related variables (public expenditure and revenue expressed as a percentage of GDP) are not stationary (integrated of order one). However, the tests for panel cointegration provide empirical support that government spending and revenue are cointegrated. The data therefore support the assumption that fiscal policies in these countries are sustainable in the long term, i.e. the governments' behaviours are coherent to their inter-temporal budget constraints. Even though the fiscal policy of the OECD countries is sustainable, a long-term fiscal problem persists in developed countries: facing the increase in the entitlement expenditures and health care costs, especially associated with programmes for the aged, either taxes will have to be increased or the budget deficit will balloon early in the next decade.

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APPENDIX

Fiscal sustainability in developed countries: a survey of the empirical literature

Authors	Data frequency	Sample	Tests performed	Is the fiscal policy sustainable?
Hamilton and Flavin (1986)	Annual	1962-1984 United States	Budget balance and public debt stationarity	Yes
Trehan and Walsh (1988)	Annual	1890-1983 United States	Budget balance stationarity	Yes
Kremers (1988)	Annual	1920-1985 United States	Public debt stationarity	Yes, until 1981
Elliot and Kearney (1988)	Annual	1953-1987 Australia	Cointegration between public expenditure and revenue	Yes
Wilcox (1989)	Annual	1960-1984 United States	Public debt stationarity	No
MacDonald and Speight (1990)	Annual	1961-1986 United Kingdom	Public debt stationarity; Cointegration between deficits and debt	Inconclusive
Hakkio and Rush (1991)	Semi-annual	1950: II – 1988:IV United States	Cointegration between public expenditure and revenue	No
Smith and Zin (1991)	Monthly	1946:1-1984: 12 Canada	Stationarity and cointegration between budget balance and public debt	No
Trehan and Walsh (1991)	Annual	1960-1984 United States	Budget balance and public debt stationarity	Yes
Jondeau (1992)	Quarterly	1965:1-1990:2 France	Budget balance and public debt stationarity; Cointegration between public expenditure and revenue	No
MacDonald (1992)	Monthly	1951:1-1984:12 United States	Budget balance and public debt stationarity; Cointegration between debt and deficits	No

Baglioni and Cherubini (1993)	Monthly	1979:1-1991:5 Italy	Budget balance and public debt stationarity	No
Tanner and Liu (1994)	Annual	1950-1989 United States	Cointegration between public expenditure and revenue	Yes, with a break in 1982
Caporale (1995)	Annual and Semi-annual	1960-1991 10 EU coutries	Budget balance and public debt stationarity	No for Italy, Greece, Denmark and Germany
Quintos (1995)	Quarterly	1947:II- 1992:III United States	Cointegration between public expenditure and revenue	Yes, until 1980
Haug (1995)	Quarterly	1950:I-1990:IV United States	Cointegration between public expenditure and revenue	Yes
Ahmed and Rogers (1995)	Annual	1972-1992 United States 1792-1992 United Kingdom	Cointegration between public expenditure and revenue	Yes
Vanhorebeek and van Rompuy (1995)	Annual	1970-1994 8 EU countries 1870-1993 (Belgium)	Primary budget balance and public debt stationarity	Yes, for Germany and France
Owoye (1995)	Annual	1961-1990 G7 countries	Causality between taxes and spending	Bi-directional in five G7 countries
Uctum and Wickens (1997)	Annual	1965-1994 United States and 11 European countries	Public debt stationarity	Yes for Denmark, Netherlands, Ireland and France
Payne (1997)	Annual	1949-1997 G7 countries	Cointegration between public expenditure and revenue	Yes, for Germany
Crowder (1997)	Quarterly	1950:I-1994:II United States	Cointegration between public expenditure and revenue	Yes, until 1982
Artis and Marcelino (1998)	Annual	1963-1994 EU countries	Public debt stationaritiy	Yes, for Austria, Netherlands and United Kingdom
Bohn(1998)	Annual	1916-1995 United States	Cointegration between primary surpluses and public debt	Yes
Fève and Hénin (1998)	Semi-annual	G7 countries	Public debt stationarity	Yes for the USA, the UK and Japan

Greiner and Semmler (1999)	Annual	1955-1994 Germany	Public debt stationarity	No
Makrydakis (1999)	Annual	1958-1995 Greece	Public debt stationarity	No
Papadopoulos and Sidiropolous (1999)	Annual	1961-1994 Spain, Belgium, Greece, Italy and Portugal	Cointegration between public expenditure and revenue	Yes, for Greece, Spain and Portugal
Martin (2000)	Annual	1947-1992 United States	Cointegration between public expenditure and revenue	Yes, with breaks in the 1970s and 1980s
Olekalns (2000)	Annual and quarterly	1900/01-1994/95 1978:3-1997:4 Australia	Cointegration between public expenditure and revenue	No
Getzner, Glatzer and Neck (2001)	Annual	1960-1999 Austria	Public debt stationarity	Yes, for 1960-1974, no for 1975-1999
Bravo and Silvestre (2002)	Annual	1960-2000 11 EU countries	Cointegration between public expenditure and revenue	No, for Belgium, Denmark, Finland, Ireland, Italy and Portugal.
Hatemi-J (2002)	Quarterly	1963:1-2000:1 Sweden	Cointegration between public expenditure and revenue	Yes
Cunado, Gil-Alana and Perez de Gracia (2004)	Quarterly	1947:2-1992:3 United States	Fractional integration and cointegration between public expenditure and revenue	*Cunado, Gil-Alana and Perez de Gracia (2004)*
Greiner, Koeller and Semmler (2004)	Annual	1960-2003 (Germany, France, Italy, Portugal and United States)	Cointegration between primary budget balance and public debt	Yes
Afonso (2005)	Annual	1970-2003 15 EU countries	Cointegration between public expenditure and revenue	No, except few exceptions
Llorca (2005)	Annual	1970 – 2004 Japan and the United States	Cointegration between public expenditure and revenue;and between primary bud. balance and gross public debt (then with net public debt)	No

Source: Ayadi (2004) and a survey from the authors.