

Sustainability of Fiscal Policy: A Comparison of Contemporary Models for Asian Developing Countries

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Abstract

This study compares two well-known models used for assessing the sustainability of fiscal policy. The Model-Based test, an OLS-based model of sustainability, either adds little value or is a potentially unreliable approach to assessing the sustainability of fiscal policy. We use panel unit root and cointegration tests for this purpose and find that the primary surplus and debt are nonstationary in levels for the Asian Developing countries in our sample. The existence of cointegration between the primary surplus-GDP and debt-GDP ratio determines the sustainability of fiscal policy without requiring the series to be regressed on each other.

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Chapter 1 : Introduction

The recent recession has caused widespread concern that it may develop into a global depression.¹ The inability of monetary policy to revive the economy has raised concerns about the need to rethink policy or at least the integration of monetary and fiscal policy.² Central banks have introduced reforms in financial institutions and have lowered interest rates almost to their zero bound but still the revival of the economy is uncertain. Moreover, monetary policy and the automatic stabilisers of fiscal policy have failed to cope with the recession. Therefore economists are emphasising a revival of activist fiscal policy (Feldstein, 2009; Jha, 2010; Auerbach, 2009). After the failure of financial reforms, lower interest rates and one-time reductions in taxes, fiscal stimuli are almost inevitable; hence many countries have announced high fiscal stimuli. The fiscal stimuli can well play their role if they are used at the right time, at the appropriate level, and for a suitable length of time. If the economy survives, the credit will go to the fiscal stimulus or fiscal policy.

The rigorous use of fiscal policy, however, might end up threatening some countries with insolvency, where countries might not be able to pay off their debt. For instance, Greece enjoyed an average growth of 4.2% in real GDP over the period 2000-2007 compared to 1.9% growth in real GDP for the Euro Zone (Athanassiou, 2009). The unemployment rate decreased by 2.9 percentage points, but the improvement in these indicators came at the cost of high public deficits; government debt remained between 98% and 104% of GDP (Athanassiou, 2009). At the time of writing, Athanassiou (2009) suggests that the Greek government should avoid the adoption of fiscal stimulus and remain passive in this regard, not only because of obligations as an EU member, but also because, the fiscal stimulus would be ineffective due to high public debt. The current literature focuses on the optimality of fiscal policy and fiscal stimuli.

The excess of government expenditures over government revenues in a given fiscal year is known as the budget deficit. Unlike an individual, the government usually has a set of options to equate expenditures to revenues including taxation, seignorage (monetization), and borrowing; therefore it enjoys the liberty of deciding on the level of expenditures in advance. The sources of income of government are limited to taxes and seignorage (monetization), leaving borrowing as a flexible source of funds in situations where the government's expenditures go beyond revenues.

¹ See Aiginger (2009a, 2009b), Eichengreen and O'Rourke (2009) and Romer (2009).

² See Freedman et al. (2009), for detailed discussion of the IMF's Global Integrated Monetary and Fiscal Policy Model (GIMF).

The government can borrow from domestic savers or from savers abroad. Bonds with short-term or long-term maturity (treasury bonds) can be used to borrow. Borrowing from domestic savers leads to some interesting questions, such as Barro (1974) quoting Tobin (1971, p. 91) in asking *“How is it possible that society merely by the device of incurring a debt to itself can deceive itself into believing that it is wealthier? Do not the additional taxes which are necessary to carry the interest charges reduce the value of other components of private wealth?”* Domestic borrowing and borrowing from abroad can significantly affect macroeconomic variables such as taxes, interest rates, prices, and the current account.

The reliance of governments on debt is not a big sin; in fact, many developed nations are heavily indebted these days. But it is important to monitor the structure of debt because the debt may build up to dangerous levels and may lead governments into crisis and eventually default. Ultimately, it becomes very difficult for governments to manage these debts, because high debt levels, on the one hand, weaken the country’s reputation in the international community, and, on other hand, make it impossible for developing countries to pay back the principal along with the interest payments on these debts. Debt has attracted significant attention since the time of Keynes’s (1923, p. 24) comments that *“the State’s contractual liabilities ... have reached an excessive proportion of the national income”* (Afonso, 2005). But the issue of sustainability in its present form has received attention only in recent years. Even then, developing countries have been neglected because most of the studies have focused on the sustainability of debt in developed countries, such as the US, Canada and other European countries. One of the reasons for this neglect is the scarcity of data for developing countries.

In the present study, data for 10 Asian countries (Pakistan, India, Bhutan, Sri Lanka, Maldives, Bangladesh, Malaysia, Indonesia, Thailand and Singapore) have been collected from different sources (the details are given in the data section). Before exploring the issue of sustainability for these countries we had to collect central government data for these countries. The sustainability of debt for some of the above countries in a pool of emerging countries has been addressed by Mendoza and Ostry (2008). Mendoza and Ostry (2008) have explained that the data for industrialised countries is for general government that is the sum of consolidated general government and public sector. While there is no explanation given for developing countries data. The data on central government are more readily available for the developing countries. In addition, most of the studies using tests of unit roots and

cointegration have used central government data for developed countries. Therefore, we have chosen to examine the central government data. Our objective is to examine the sustainability of fiscal policy for developing countries and also to compare the models of sustainability. Therefore central government data serve best for this purpose. Moreover, central government debt data are nonstationary in levels as will be shown in this thesis. This might also be the case for general government debt of industrialised countries; for example, Mendoza and Ostry (2008) and Ghatak and Fung (2007) have assumed general government debt data to be stationary in levels, while at the same time accepting the possibility of nonstationary behaviour in levels (see Mendoza and Ostry, 2008 p.1084).

We have chosen to focus on the East Asian Countries, specifically, Pakistan, India, Bhutan, Sri Lanka, Maldives, Bangladesh, Malaysia, Indonesia, Thailand and Singapore. These countries have not been analysed in terms of the sustainability of fiscal policy compared to developed countries. Some countries remained under debt due to an increase in their defence budget, for instance, Pakistan and India have been involved in conflicts. Whereas, others have been trapped by over population and poverty such as Bangladesh, Sri Lanka including Pakistan and India.

The choice of these countries lead us to choose countries with similar characteristics or belonging to the same economic groupings, such as SAARC (South Asia Association for Regional Cooperation) and IMT-GT (Indonesia, Malaysia and Thailand Growth Triangle). The countries in IMT-GT are higher income countries compared to SAARC; it will help in comparing the sustainability of fiscal policy of lower and higher income countries.

The next section is organised as follows. Section 2.1 introduces the unit root tests and cointegration tests used for sustainability of fiscal policy. Section 2.2 introduces Model Based Sustainability tests for fiscal policy.

Tests of sustainability of fiscal policy include tests of unit roots and cointegration and tests of Model Based Sustainability. To our knowledge, so far no one has attempted to compare these models on a common data set. Our objective is twofold; first, we want to compare these models of sustainability, and, second, we want to focus on the fiscal policy of Asian developing countries as these countries have been considered in very few studies (as shown in Table 17 at the end of this thesis). Our sample includes ten countries from Asia that includes Pakistan, India, Bhutan, Sri Lanka, Maldives, Bangladesh, Malaysia, Indonesia, Thailand and Singapore. The sustainability of fiscal policy is evaluated both for cross-sectional and

panel data. In addition the countries are grouped in their regional economic cooperation, such as, SAARC (South Asia Association for Regional Cooperation), and IMT-GT (Indonesia, Malaysia and Thailand Growth Triangle).

The empirical section starts with a discussion on unit root tests for individual series and their results. This is followed by Section, which contain the discussion on the panel unit root test and applicability of MBS. The next section focuses on explaining and analysing the panel cointegration tests and their results for debt and primary surplus series. This is followed by the Section that discusses results for the ad hoc sustainability tests. The following section discusses the comparison between the ad hoc and MBS test of sustainability.

Chapter 2 : Literature Review

The sustainability of debt addresses the question of whether the government will be able to generate surpluses in future in order to pay off the previous debt or whether it will carry on playing a Ponzi game³, as is possible in some dynamically inefficient economies. According to Abel et al. (1989, p.1), the economy is dynamically inefficient “in situations where the population growth exceeds the steady state marginal product of capital, or equivalently the economy is consistently investing more than it is earning in profit.”. Sustainability requires government expenditures and revenues to be in equilibrium in the long run. The ability of government to equate its present debt to the discounted sum of future surpluses is known as ‘dynamic efficiency’ and every dynamically efficient economy is subject to a constraint known as the Intertemporal Budget Constraint (IBC henceforth). The sustainability tests are based on the IBC. Therefore the derivation of the IBC becomes necessary for further analysis.

The starting point for analyzing the government budget constraint is the period by period identity linking revenues, spending and debt⁴:

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

where G is government expenditures, excluding interest payments in period t , r the one-period real interest rate, B the real funding raised by issuing new government

³ The government plays a Ponzi game when it finances the debt and interest payments by issuing new debt (Bergman, 2001).

⁴ The discussion in this section follows Afonso (2005).

debt⁵, and R is real government revenues. The basic definition of the IBC requires the existing stock of public debt to be equal to the present value of future primary surpluses⁶; therefore, solving equation (1) recursively for the future period leads to the IBC:

$$B_t = \sum_{i=1}^{\infty} \frac{R_{t+i} - G_{t+i}}{\prod_{j=1}^i (1+r_{t+j})} + \lim_{i \rightarrow \infty} \prod_{j=1}^i \frac{B_{t+i}}{(1+r_{t+j})} \quad (2)$$

If the second term on the right hand side of (2) is zero, the stock of debt is equal to the sum of all the discounted future surpluses:

$$B_t = \sum_{i=1}^{\infty} \frac{R_{t+i} - G_{t+i}}{\prod_{j=1}^i (1+r_{t+j})} \quad (3)$$

and

$$\lim_{i \rightarrow \infty} \prod_{j=1}^i \frac{B_{t+i}}{(1+r_{t+j})} = 0 \quad (4)$$

Equation (4) is a transversality condition and is often known as a ‘bubble’ term in the literature (Hamilton and Flavin, 1986). The current value of debt in (3) is equal to the present value of the future surpluses provided that (4) holds. In other words, the absence of the bubble term in (2) rules out the Ponzi scheme or game, where government repays the debt by issuing new debt.

Although we have outlined the specification of the IBC, equation (2) is still not appropriate for empirical testing. In order to make (2) meaningful for empirical testing, the real interest rate is assumed to be stationary with mean ‘ r ’ and defining G_t^r as:

$$G_t^r = G_t + (r_t - r)B_{t-1} \quad (5)$$

Here G_t^r , is government spending inclusive of interest payments taken around a zero mean (Quintos, 1995). It is the sum of government expenditures and interest paid on debt accumulated at the end of the previous period. Using (1) and (5) and solving for future periods gives:

$$B_{t-1} = \sum_{i=0}^{\infty} \frac{R_{t+i} - G_{t+i}^r}{(1+r)^{i+1}} + \lim_{i \rightarrow \infty} \frac{B_{t+i}}{(1+r)^{i+1}} \quad (6)$$

⁵ $\Delta B_t (= B_t - B_{t-1})$ For simplicity, public debt is assumed to be issued as one-period bonds.

⁶ Primary surplus is the difference between government revenue and government expenditures net of interest payments.

Defining G_t^r enables us to eliminate r_t from the discount factor and replace it with a constant r . The transversality condition implies that the second term in (6) goes to zero at infinity imposing a condition that the growth of debt should be slower than the growth of the real interest rate (Afonso, 2005). The transversality condition implies the absence of the Ponzi game and fulfilment of the IBC. Therefore, the government ought to attain future primary surpluses whose present value adds up to the current value of the stock of public debt.

The IBC was initially used by Hamilton and Flavin (1986). They applied a Dickey-Fuller unit root test to the discounted debt and surpluses series. The discounted debt and surpluses series for the US for the period 1960-1984 were examined for a unit root under the null hypothesis of a zero bubble term or transversality condition. As the mean and variance of stationary series remain constant, stationarity guarantees that debt is stable over time. Hamilton and Flavin (1986) showed that both the discounted debt and surpluses series were stationary in levels implying that the series are mean reverting. They therefore concluded that the government was executing public policy subject to the IBC. However, Haug (1991) pointed out that the unit root tests used by Hamilton and Flavin were misspecified by not including enough lags.

The non-rejection of the null hypothesis of a unit root means the government is not fulfilling the IBC, because a time dependent mean or variance (i.e. covariance nonstationarity) violates the definition of stationarity.

Some later studies showed that the results of deficit sustainability depend on the existence of structural breaks in the series. For example, Wilcox (1989) extended the Hamilton and Flavin (1986) analysis for the same sample and found significant evidence for shifts in the structure of fiscal policy. Wilcox (1989) extended the Hamilton and Flavin (1986) study in the following respects: i) the real interest rate was allowed to be stochastic, ii) surpluses were allowed to be nonstationary, whereas Hamilton and Flavin required the surplus to be stationary, and iii) the series were tested for structural shifts. Wilcox (1989) divided the data used by Hamilton and Flavin (1986) into two sub-samples and concluded that the deficits were sustainable only in the pre-break period, which is before 1974.

Some of the later studies, including Trehan and Walsh (1988; 1991), Haug (1991), and Smith and Zin (1991), adopted an alternative approach for testing sustainability of fiscal policy and showed that, if government revenues and expenditures inclusive of interest payments are nonstationary in levels and are

integrated of order 1, then the presence of cointegration would imply that the government is not violating the IBC. The two series are said to be cointegrated if there is an equilibrium relationship between them such that they do not drift apart from each other over a long period of time (Engle and Granger, 1987). The notion behind tests of cointegration is that the difference between government expenditures and revenues (deficit) is financed by debt. Therefore, the current period deficits should be financed by the change in debt in the current period, i.e., $\Delta B_t = G_t^r - R_t$, where G_t^r is government expenditures inclusive of interest payments. Hence, if the change in debt on the left hand side is stationary then the particular linear combination of government expenditures and revenues should also be stationary. Cointegration between expenditures and revenues implies that the first difference of debt is stationary.

Hence, an alternative procedure for examining the bubble term or transversality condition in (4) is to test the following cointegrating equation:

$$R_t = \mu + bG_t^r + \varepsilon_t \quad (7)$$

where R_t is government tax revenue and $G_t^r = G_t + r_t B_{t-1}$. Again using $G_t^r = G_t + (r_t - r)B_{t-1}$ in the IBC gives (Afonso, 2005):

$$G_t^r - R_t = \sum_{i=0}^{\infty} \frac{\Delta R_{t+i} - \Delta G_{t+i}^r}{(1+r)^{i+1}} + \lim_{i \rightarrow \infty} \frac{B_{t+i}}{(1+r)^{i+1}} \quad (6)^*$$

The intuition behind (7) is to see if government expenditures and revenues share some common trend. If government expenditures (G_t) and revenues (R_t) are each integrated of order one, i.e. I(1), with cointegrated vector (1, -1) imposed and their linear combination (ΔB_t) is stationary, then the series are cointegrated. Thus the government is following the IBC. This approach is more flexible in the sense that it incorporates both government expenditures and revenues in the test. If government expenditures and revenues are not drifting apart over the long run, then government is assumed to be following the IBC.

Smith and Zin (1991) used a cointegration test under the assumption that real interest rates are constant or have constant one-step-ahead forecasts for the data for the US and Canada. They tested for cointegration between real surpluses exclusive of interest payments and real debt. Their results suggested that the joint behaviour of real debt and real surpluses is inconsistent with the IBC of government. This can be

interpreted as the payment of debt by acquiring more loans or the sale of physical assets for this purpose by government.

Trehan and Walsh (1988) used US annual data from 1890 to 1986 and, applying cointegration tests, concluded that Federal Government finances satisfied the IBC for this period. In their later work, Trehan and Walsh (1991) extended their study and suggested that, if expected real interest rates are constant, then a stationary linear combination of the stock of debt and the net-of-interest deficit is a necessary and sufficient condition for the IBC, as long as the quasi difference of the net-of-interest deficit is stationary. Moreover, the stationarity of the deficit including interest payments is a sufficient condition for the IBC.

Haug (1991) used unit root and cointegration tests for the sustainability of the deficit processes and performed Monte Carlo studies to obtain the correct size of these tests. The tests of cointegration were carried out for quarterly US data from 1960 to 1987. He concluded that the present value borrowing constraint or IBC holds. Since then, the IBC has been used by various studies. Hakkio and Rush (1991) developed the cointegration tests allowing for stochastic real interest rates and normalised the variables by dividing by GNP or population in order to include the effect of a growing economy. Their results were similar to the results of Haug (1991, 1995) implying that government may encounter problems in future if fiscal policy were to remain unchanged.

Whenever shocks within the economy or outside the economy, such as wars, natural disasters or massive deficits, were observed, the need to recheck the IBC was regarded as important. In some cases, the validity of the IBC is considered similar to a medical check-up, which should be carried out at regular intervals. Structural shift models were introduced in order to examine the change in public deficit policy after or before wars. Haug (1995) conducted tests of stability of cointegrating parameters along with structural shifts. His tests were designed such that they did not require the regime breaks to be specified in advance. He concluded that although the Reagan regime possibly violated the IBC, his tests of parameter instability suggested no change in budget policy. Further, consistent with the prediction by Hakkio and Rush (1991), Haug (1995) claimed that the series would tend to become more explosive if the same policies were to be continued, so there may be a problem for the government to market its debt in future. In other words, the diverging behaviour may lead to the violation of the IBC in future.

Similarly, structural shifts were addressed by Ahmed and Rodgers (1995), Haug (1991, 1995), Hakkio and Rush (1991) and Quintos (1995). Ahmed and Rodgers (1995) analysed the issue of sustainability for both budget deficits and trade deficits. They have also tested for structural shifts using Phillips and Perron's (1988) and Perron's (1989) tests. They concluded that the present value constraint (i.e. the IBC) holds for the long-run even in the presence of unusual events such as wars.

Although apparently the tests of stationarity of debt and cointegration between expenditures and revenues seem equivalent, the outcomes of these tests were different; for instance, Wilcox (1989) and Hakkio and Rush (1991) concluded that the deficits had become unsustainable in the second half of their samples. Similarly, Haug (1991) suggested that the deviation of fiscal policy from the IBC may create problems for the government in future. These tests were emphasising that the government was deviating from the IBC. The necessary and sufficient condition in Hamilton and Flavin (1986) was the existence of stationary debt series, whereas the necessary and sufficient condition for deficit sustainability in Trehan and Walsh (1991) was the existence of a stationary linear combination of the stock of debt and the net-of-interest deficit or, in other words, cointegration between government revenues and government expenditures.

Later studies suggested some flexible criteria for the sustainability of the IBC. For instance, Quintos (1995) extended the necessary and sufficient conditions for sustainability using cointegration tests. According to Quintos (1995), under the strict interpretation of deficit sustainability, cointegration between revenues and expenditures inclusive of debt payments is not a necessary but a sufficient condition. Under a weak interpretation of deficit sustainability, the necessary condition requires the debt to grow slower than the borrowing rate. She used a sequential Chow test for structural change that searches for the shifts endogenously and claimed that there are breaks in the data. These breaks indicate a shift in policy; however, under a weak interpretation of deficit sustainability, the deficit processes are still sustainable despite the shifts in policy.

Empirically, the strong condition requires the cointegrating vector to be (1, -1) for revenues and expenditures in (7). The strong condition of having cointegrating vector (1, -1) was used by Haug (1991), Smith and Zin (1991) and Trehan and Walsh (1988). The weak condition of sustainability allows the possibility that the deficit process can be integrated or even slightly explosive but still the deficit process will be sustainable provided that the growth rate of debt remains lower than the growth rate of

the economy. In contrast to Hakkio and Rush's (1991) strict interpretation of deficit sustainability that regards $0 \leq b \leq 1$ as a necessary condition, Quintos claims that $0 \leq b \leq 1$ is a necessary and sufficient condition for deficit sustainability and cointegration is only a sufficient condition. However, this weak condition is inconsistent with the government's ability to market its debt in the long run because spending more than earnings leads to a risk of default.

So far we have been emphasising that if $0 \leq b \leq 1$, sustainability might not be a problem at all, but in the special case where cointegration does not exist but $b > 1$, fiscal policy will be considered as sustainable. In this case the revenues respond to an increase in government expenditures by more than the increase in government expenditures.

2.1 Standard Tests of Unit Roots and Cointegration for Panel Data with Structural Breaks

Currently, panel tests of stationarity and cointegration with complementary tests of structural breaks are used for sustainability of fiscal policy. For instance, the massive deficit observed after 9/11 and the current financial crisis all over the world induced many economists to recheck the behaviour of government policies with respect to the IBC. Especially in the last decade, attention has been drawn to other countries including Latin American countries, the European Union and some of the developing countries. For instance, Afonso (2005) has examined the sustainability of the deficit process for the European Union using tests of unit roots and cointegration for panel data (i.e. using 'ad hoc' sustainability tests). The panel cointegration equation for expenditures and revenues becomes:

$$R_{it} = \mu_i + bG_{it}^r + \varepsilon_{it} \quad (7)^*$$

where R_{it} is government tax revenue and $G_{it}^r = G_{it} + r_{it}B_{i,t-1}$ is government expenditure inclusive of interest payments. The subscripts i and t represent the data varying across country and time respectively.

The European Union normally requires sustainable public policies including deficit policies. Therefore, some of the important studies have focused on the sustainability issue for the European Union. Afonso (2005) applied unit root and cointegration tests to the EU-15 countries for the period 1970-2003. The existence of structural shifts such as the introduction of the Euro and the efforts made by several

countries in the 1990s to update their public accounts in order to keep pace with the common currency were tested. The results from unit root and cointegration tests provided unpleasant implications, except for a few countries; most governments were expected to be in trouble. The unpleasant sustainability problem was due to a higher growth rate for expenditures than the growth rate of revenues. Afonso (2005) concluded that the higher growth rate was not the only factor causing sustainability problems and predicted that, in future, population growth may turn into a severe problem, especially the shift of population toward older societies. This shift on the one hand, decreases future revenues indirectly by a reduction in output and, on the other hand, increases public pension liabilities.

Rault and Afonso (2007) studied the sustainability of the European Union's fiscal policy in 15 countries. They applied panel cointegration methods allowing for multiple endogenous breaks or structural shifts. Their results are based on cointegration between expenditures and revenues and are consistent with sustainability if structural breaks are treated appropriately.

Westerlund and Prohl (2008) tested cointegration between government expenditures and revenues for eight rich OECD countries. Quarterly data were used covering the period 1977Q1 to 2005Q4. They claim that the usual tests of cointegration have low power for the null hypothesis of no cointegration against nearly cointegrated alternatives. Besides low power to reject the null hypothesis of no cointegration, some tests of panel cointegration require a strict condition of homogeneity among countries. They claim that the problem with the usual tests of panel cointegration is that the test is repeated for each country in the sample and every time using only the sample information for the particular country. Westerlund and Prohl (2008) claimed that existing tests are mostly biased, either fixing break points in advance or allowing only one break endogenously, such as Hakkio and Rush (1991) and Wilcox (1989) for the former and Haug (1995) and Quintos (1995) for the latter case. Therefore, they suggested tests with increased power that allow for multiple endogenously determined breakpoints. They used the Carrion-i-Silvestre et al. (2005) test of stationarity which is similar to Westerlund's (2006) cointegration test. These tests allow cross-country dependence and also allow for five structural breaks, which in their view are enough. Finally, they concluded that revenues and expenditures are non-stationary and cointegrated. Their results for the estimated structural breaks suggest strong structural instability.

Rubio et al. (2008) conducted tests of cointegration between expenditures and revenues similar to Westerlund (2006). Rubio et al. (2008) applied Bai and Perron's (1998; 2003) multiple structural change approach and allowed for five multiple structural breaks. They advocate use of Bai and Perron's test for its advantages such as flexibility in assumptions, calculation of confidence intervals for the break dates, the data and error terms are allowed to follow different distributions across segments, and the sequential method used in application can allow for the presence of serial correlation in the errors and heterogeneous variances across segments. The results of their approach are based on Quintos's (1995) strong and weak conditions of sustainability. Rubio et al. (2008) found evidence of weak sustainability of the deficits over the full sample and they found three structural breaks for the whole sample covering the period 1947Q1 to 2005Q3.

Most of the studies confirm weak sustainability of deficits if not the strong condition of deficit sustainability. However, the shift of results from sustainability toward weak sustainability has increased the suspicion about government solvency. Since the presence of structural breaks threatens the sustainability results, recent studies have emphasised the presence of structural shifts or breaks. The presence of structural breaks indicates shifts in fiscal policy that may not be consistent with the IBC. The number of studies considering the issue of structural breaks is increasing with new developments in the empirical literature. For instance, the early studies allowed for exogenous structural breaks and then the structural breaks were allowed to be endogenous but were fixed to one shift in regime. The later studies allowed multiple breaks in the sample and, recently, the breaks are allowed to be more flexible in nature. For instance, Martin (2000) allowed for both the intercept and slope to change endogenously and multiple times. Hence, the exogenous factors are captured by the intercept parameter whereas the endogenous factors are specified by the slope parameter. Martin (2000) applied a Bayesian inferential approach with results based on Markov Chain Monte Carlo (MCMC) posterior simulators using US quarterly data for the period 1947 to 1992. He concluded that government expenditures and revenues are cointegrated with three shifts in regime.

The presence of structural shifts was addressed by studies with more sophisticated models and econometric tools as the econometric techniques developed over time. Although the journey from simple unit root tests to tests with structural breaks and then multiple structural breaks is interesting and fruitful, the use of these tests with small samples may be problematical because of the reduction in the sample

size and may complicate the interpretation of results. Too many break points in the data contaminate the data. Moreover, attempting to find structural breaks in the data may lead to a series of unending structural breaks.

2.2 Model Based Sustainability

As we have seen, tests of stationarity and cointegration are widely used to determine whether some specific policies of governments or economies follow the IBC. Another school of thought, initiated by Bohn (1998), is of the view that these so-called tests of sustainability based on standard time-series tests make it difficult empirically to reject the null of a unit root in real debt and debt as a percentage of GDP. He argues that ‘ad hoc sustainability tests’ can only detect the unit root but it is unclear why the unit root exists.⁷ For instance, the decline in debt as a percentage of GDP-ratio could be due to luck, high economic growth, or policy design. According to Bohn, examining the response of the primary (non-interest) budget surplus to changes in the debt-GDP ratio, and in the presence of temporary government and output shocks, provides more information for policy makers. A positive response shows that the government is taking action, such as reducing non-interest outlays or raising revenues that neutralise the changes in debt. In Bohn’s view, this approach is more promising than unit root tests for the debt-GDP ratio. In criticising the misuse of standard time-series tests, he argues that the debt-GDP ratio is subject to various shocks, e.g. fluctuations in income growth, in interest rates, and shocks in government spending. These make the mean reversion of the debt-GDP ratio difficult to interpret. Bohn (1998) used US annual data for the period 1916-1995 and found significant evidence for a positive response of the primary surplus to the debt-GDP ratio. He emphasises that a regression equation of primary surpluses on debt would fail to find significant correlation between the two series because of not including war-time spending and cyclical fluctuations. The regression equation controlling for war-time spending and cyclical fluctuations was motivated by Barro’s (1979) tax smoothing model. Thus, a positive response of primary surpluses to debt/GDP in this extended equation implies that the government is satisfying the IBC.

Bohn (2005) is particularly critical of the tests of stationarity and cointegration for their low power of rejection of a unit root. Bohn identifies that the issue of sustainability deals with two important questions. Which fiscal policies are sustainable? And what can we say about the sustainability of particular policies

⁷ Henceforth following Bohn (2005) we use the term ‘ad hoc sustainability’ for the standard tests of unit root and cointegration to differentiate this from Bohn’s approach.

encountered in practice? Almost all the studies have emphasised the second question. He used US fiscal data from 1792-2003 and argued that the debt-GDP ratio has been held down by economic growth rather than by primary surpluses. The results support the sustainability of public policies but with the proviso that the “growth dividend” has historically covered the entire interest bill on the US debt. Most of the time, the US has had no need to run primary surpluses, whereas most of the sustainability studies, in contrast, claim that primary surpluses are necessary to keep the public debt from growing exponentially (Bohn, 2005).

Bohn’s basic argument is that the ad hoc sustainability tests have ignored the effect of war-time spending and cyclical effects. However, war-time spending or shocks have been considered in various studies such as Wilcox (1989), Haug (1991, 1995), Trehan and Walsh (1991), and Quintos (1995) in term of break points. Furthermore, Bohn (2005) tried to show the inconsistency among the results of Augmented Dickey-Fuller (ADF), Phillips-Perron (PP) and the KPSS (Kwiatkowski et al., 1992) test. The ADF and PP tests are compared according to their ability to deal with heteroskedasticity and autocorrelation. The PP test is robust with regard to heteroskedasticity but ignores autocorrelation beyond a finite lag window, whereas the ADF test includes an autoregressive correction but ignores heteroskedasticity. After reporting the various results produced by ADF, PP and KPSS tests, he concluded that the results about the deficits are contradictory. Since the time series were not covariance stationary the variances change over time; however, standard unit root tests have depicted them as stationary.

The IBC given (6) can also be derived alternatively using expectations. Let s_t be the primary surplus, b_t is the debt-GDP ratio and $E_t[.]$ represents conditional expectations. The lower-case represent the series as ratios of GDP.

$$b_{t-1} = \sum_{i=0}^{\infty} \frac{E_t[s_{t+i}]}{(1+r)^{i+1}} + \lim_{i \rightarrow \infty} \frac{E_t[b_{t+i}]}{(1+r)^{i+1}} \quad (8)$$

Hence, the transversality condition can be stated as:

$$\lim_{i \rightarrow \infty} \frac{E_t[b_{t+i}]}{(1+r)^{i+1}} = 0$$

According to Bohn the definition of ad hoc sustainability and derivation of the IBC contains a flaw by assuming an arbitrary interest rate r , which ignores an

important argument about why potential buyers of government bonds should care about the IBC. The sustainability literature assumes r to be the expected return on government bonds, which is a proxy for some historical average. The selection of r depends on the researcher's choice and, since we are dealing with an identity, any value of r should satisfy the equality. In addition, the ad hoc sustainability definition ignores practical politics because politicians may be unaware or aware about the extent of public debt. In the first case, the politicians are cautious about the public debt; therefore they would be willing to cut taxes and to increase spending when the debt decreases, and similarly increase taxes and decrease spending when the debt increases. Such responses to debt by the politicians would trigger an error-correction mechanism which might stabilise the debt or at least generate cointegration between debt and primary surpluses. However, in the second case, the politicians do not care about public debt and make exogenous decisions about taxes and non-interest spending. Therefore, each country's political process has distinct characteristics and ad hoc sustainability ignores this argument. In Bohn's view, the disturbing feature of ad hoc sustainability is the apparent disconnect from practical politics. The political debates are mostly about the bounds on debt/GDP and/or Deficit-GDP ratios, whereas much of the academic literature has focused on real fiscal series and treats non-stationary debt-GDP ratios as unproblematic.

Bohn (1998, 2005) argues that the question of which fiscal policies are sustainable remains unclear. The basic economic intuition is that an agent's (government's) ability to borrow is constrained by other agents' willingness to lend. Therefore, the question of which fiscal policies are sustainable should be posed in general equilibrium, a question of who the government's potential lenders are and what determines their behaviour. This is a more versatile approach because different assumptions about lenders lead to different conclusions about the set of sustainable policies.

The ad hoc sustainability tests are obtained by assuming that potential lenders are infinitely-lived optimizing agents and that financial markets are complete. Thus, such agents' asset accumulation necessarily satisfies the transversality condition. Complete markets imply that agents apply a common pricing kernel to value the financial assets; therefore the transversality conditions aggregate; while, the very agents in the presence of uncertainty may not behave in the same manner. Therefore, Bohn (1991, 1995) argues that the policies which are sustainable in a certain world may no longer be so with uncertainty. This is because, in contrast to ad hoc

sustainability tests, the discount factor is determined by the marginal rate of substitution between t and $t+1$, instead of the interest rate on government debt. Hence, with the marginal rate of substitution as the discount factor, the IBC can be written as:

$$B_t = -E_t \sum_{j=0}^{\infty} \frac{\beta^j u'(C_{t+j})}{u'(C_t)} (G_{t+j} - R_{t+j}) + \lim_{T \rightarrow \infty} E_t \frac{\beta^{T+1} u'(C_{t+T+1})}{u'(C_t)} B_{t+T+1} \quad (9)$$

where C_{t+j} is aggregate consumption, $u(\cdot)$ is the utility function of the representative agent, β_t is the rate of time preference, and the *primary deficit* ($G_{t+i} - R_{t+i}$) and C_{t+j} vary across different states of the world.

The counterpart transversality condition of MBS can be written as:

$$\lim_{T \rightarrow \infty} E_t \frac{\beta^{T+1} u'(C_{t+T+1})}{u'(C_t)} B_{t+T+1} = 0 \quad (10)$$

Again a sustainable fiscal policy must satisfy the transversality condition. This means that the government debt discounted by the agent's rate of time preference β^j should be zero at infinity. Equations (9) and (10) leave the IBC as:

$$B_t = -E_t \sum_{j=0}^{\infty} \frac{\beta^j u'(C_{t+j})}{u'(C_t)} (G_{t+i} - R_{t+i}) \quad (11)$$

Equation (11) is the required condition and it means that a government with a positive stock of debt necessarily runs a primary surplus in some following periods. It is therefore possible for a government with positive debt stock to have a primary deficit in expected value terms and still fiscal policy will be sustainable.

The IBC in (11) and the No Ponzi condition (the transversality condition) are consistent with optimizing bondholder behaviour. They differ from the ad hoc sustainability conditions of the IBC and No Ponzi condition.

The IBC and No Ponzi conditions are derived from the lender's perspective, by substituting the rate of time preference and consumption in the utility function as a discount factor, and highlight some important facts about the sustainability issue. First, the condition given in (10) may not operate in an economy if overlapping generations are assumed, for example, if lenders have finite planning horizons and do not impose transversality conditions.

These changes in the IBC motivate a search for robust sustainability conditions. The key insight is that robustness with respect to debt management

requires a feedback rule for the primary surplus, a rule that makes surpluses a function of initial debt. Bohn (2005) explains that to see this, suppose primary surpluses were unresponsive to initial debt and consider a slight variation in debt management. If the policy was sustainable before, a change in debt management that increases the return on debt in one state of nature and reduces the return in another state while obeying the Euler equation will raise initial debt in the high-return state. Without a policy response, the extra debt would not be supported by future surpluses, violating the No Ponzi condition.

Bohn (1991, 1998) proposes that the most simple feedback rule that ensures sustainability is when the primary-surplus/GDP ratio is an increasing linear function of the initial debt-GDP ratio. Avoiding the basic derivation in Bohn's early papers (1991, 1998), the Model Based Sustainability tests proposed in Bohn (2005) can be written as:

$$s_t = \rho b_{t-1} + \mu_t + \varepsilon_t \quad (12)$$

where s_t is the primary surplus-GDP ratio at time t , b_{t-1} is the debt-GDP ratio at $t-1$, and μ_t includes the temporary shocks to the economy (GDP) and government outlays (spending).

Model Based Sustainability (henceforth MBS) requires fiscal policies to be consistent with the general equilibrium condition which links the government and the private sector debt markets. The objective of the MBS approach is to find out whether the increase in public debt pushes the government's primary fiscal surplus to rise while controlling other determinants of the primary surplus. The other determinants include cyclical components of economic growth and temporary components of government spending. If the debt-GDP ratio and primary surplus-GDP ratio have a positive conditional correlation between them and the structure of shocks in the background is given, this implies that the fiscal authority is reacting to the positive changes in the debt-GDP ratio. Bohn proves that, in using a regression of the primary surplus against public debt, a measure of the cyclical behaviour of the economy, and transitory government spending, a positive coefficient on the debt variable ($0 < \rho < 1$) is sufficient to establish that fiscal policy is duly responding. The regression is of the form:

$$s_t = \rho b_{t-1} + \beta_0 + \beta_1 \tilde{g}_t + \beta_2 \tilde{y}_t + \varepsilon_t \quad (13)$$

where (\tilde{g}_t) represents the level of temporary government spending and (\tilde{y}_t) is the business cycle indicator, where (\tilde{y}_t) and (\tilde{g}_t) are the temporary fluctuations in government spending and output. Studies based on the MBS approach have usually used two alternative sets of measures of temporary fluctuations. The first method is to obtain the cyclical components of government spending and output by detrending the series using the Hodrick-Prescott filter. The second method derives the temporary fluctuations using the formulae given in Bohn (1998) based on Barro's (1986a, 1986b) tax-smoothing model.

The cyclical component of government spending and output by detrending the series using Hodrick-Prescott filter were used by Mendoza and Ostry (2008) and Ghatak and Fung (2007), they are:

$$GVAR_t = \left(\frac{g_t - g_t^T}{g_t^T} \right) \frac{g_t^T}{y_t}$$

$$YVAR_t = \left(\frac{y_t - y_t^T}{y_t^T} \right) \frac{g_t^T}{y_t}$$

The superscript T denotes the trend value of the corresponding variables. As discussed above the alternative method of measuring the temporary fluctuations is to detrend the data using a Hodrick-Prescott filter with the smoothing parameter set at 100 (Mendoza and Ostry; 2008). The resulting detrended series are labelled as the "output gap" and "government expenditures gap".

Looking at time-series regressions like (13) naturally raises the question of the time-series properties of debt and the surplus. Bohn (2005) has identified some possibilities, such that, what are the assumptions about ε_t (the residual term in equation 13)? There can be two possibilities. First the debt and primary surplus are both non-stationary whereas μ_t is stationary in levels. A simple cointegrating regression of primary surplus (s_t) on debt (b_t) can be interpreted without modelling μ_t explicitly. Second, if both the primary surplus and debt are stationary in levels, the regression of the surplus on debt which ignores the omitted variables (\tilde{g}_t) and (\tilde{y}_t) will produce inconsistent estimates and the results will not be reliable. In supporting his argument, Bohn identifies a potential problem arising from omitting (\tilde{g}_t) and (\tilde{y}_t) because the standard Dickey-Fuller and Phillips-Perron unit root tests cannot reject a unit root in debt (b_t). For instance, Bohn (1998, p. 955-956) included \tilde{g}_t and \tilde{y}_t in the

unit root test model of debt/GDP. However, the critical values from the Dickey-Fuller distribution were inappropriate; Hansen (1995) has suggested alternative critical values for the unit root models with exogenous covariates. Therefore, much of the fiscal policy literature (Trehan and Walsh, 1991; Hakkio and Rush, 1991; Ahmed and Rodgers, 1995) treated the debt-GDP ratio and similarly real debt as non-stationary variables but strongly rejected the unit root in the primary surplus. The key problem with these unit root regressions is that they ignore the systematic components in μ_t . Bohn (2005) highlights the limitations of these standard unit root tests.

2.3 A Non-Linear Model

Bohn (1998) has also proposed a model for capturing the potential non-linearities in the relationship between the primary surplus and the debt-GDP ratio. This is important to answer questions like: Do governments respond more to primary deficits when the debt is high? Or does the surplus and debt relationship weaken at high levels of debts? In order to analyse these questions higher powers of debt (b_t) and functions of the form $\max(0, b_t - b^*)$ are added in equation (13) which pick the periods with debt levels higher than b^* , where $b^* = \bar{b}$ is the average debt level. But, Bohn (1998) emphasised that one obvious caveat about using such a test is that the high debt values picked by the max function create multi-collinearity with sample points with high debt picked by variables such as GVAR and YVAR. Therefore, the results should be interpreted with care.

Empirically, higher powers in the form of quadratic and cubic terms can be added. A positive coefficient on the quadratic term, for example, shows that the marginal response of the primary surplus to change in debt is increasing in the debt-GDP ratio. In other words, as the debt-GDP ratio increases, the government gets more cautious. The non-linear model can be written as

$$s_t = \rho b_t + \beta_0 + \beta_1 \tilde{g}_t + \beta_2 \tilde{y}_t + \beta_3 (b_t - \bar{b})^2 + \beta_4 (b_t - \bar{b})^3 + \varepsilon_t \quad (14)$$

where b_t is the debt-GDP ratio, and \bar{b} is the average debt level.

Bohn (2007) also pointed out the flaws in using stationarity and cointegration tests for assessing sustainability and argued that the sensitivity of sustainability is worth exploring in every aspect of economic or political policy and needs to be checked by more sophisticated models. Standard empirical strategies focus on testing if the debt series is difference-stationary or if revenues and spending are suitably

cointegrated. According to Bohn the rejection of stationarity and cointegration is interpreted as evidence against sustainability such as the interpretation in the following studies: Trehan and Walsh (1988, 1991) and Quintos (1995). Bohn did not agree with the necessary and sufficient condition in these studies and explains that although the mathematical derivations in these studies are correct, they place a restriction on the admissible alternatives, such that they rule out higher-order integration. For instance, Quintos's (1995) necessary and sufficient condition requires cointegration between revenues and spending. Cointegration exists between these series if both revenues and spending are integrated of order one and their linear combination is stationary. Bohn (2007) showed that there are broad classes of stochastic processes that violate the standard tests such as stationarity and cointegration but still satisfy the IBC. In supporting his argument, Bohn gave the example of the error-correction mechanism used by Trehan and Walsh (1991). He insisted that error-correction conditions yield sustainability without finite-order integrated debt series. Thus he proved, by example, that difference-stationarity of any order is not necessary for the IBC. Therefore, an implication for applied work is that the common practice of judging a policy to be unsustainable on the basis of unit root and cointegration tests is invalid.

2.4 Addition in MBS by Mendoza and Ostry (2008)

The MBS test was used by Mendoza and Ostry (2008) (Mendoza-Ostry henceforth) and Ghatak and Fung (2007). Similar to Bohn's series of papers, to support the argument about the misuse of interest on public debt in ad hoc sustainability tests, Mendoza-Ostry explain the Ljungqvist and Sargent (2004) model of complete markets, insurance and the distribution of wealth. Let an economy with output (y) and government spending (g) follow a well-behaved stochastic process such that the state ϕ_t at date t is given by $\phi_t = (y_t, g_t)$. The probability of moving from ϕ_t to ϕ_{t+1} follows a Markov transition density function $f(\phi_{t+1}, \phi_t)$, and the economy is characterised by complete asset markets. The equilibrium prices of these assets satisfy the standard optimal asset demand condition. The pricing kernel $Q_j(\phi_{t+j}/\phi_t)$ for j periods ahead is given as:

$$Q_j\left(\frac{\phi_{t+j}}{\phi_t}\right) = \frac{\beta^j u'(y(\phi_{t+j}) - g(\phi_{t+j}))}{u'(y(\phi_t) - g(\phi_t))} f^j(\phi_{t+j}, \phi_t) \quad (15)$$

where $u(\cdot)$ is the marginal utility of consumption, and consumption is given by the economy's resource constraint as the difference between output and government

spending, $c(\phi_{t+j}) = y(\phi_{t+j}) - g(\phi_{t+j})$. Likewise, the interest rate on risk-free public debt which matures j periods ahead, R_{jt} , satisfies the optimality condition:

$$[R_{jt}]^{-1} = \beta^j E_t \left[\frac{u'(y_{t+j} - g_{t+j})}{u'(y_t - g_t)} \right] \quad (16)$$

The government budget constraint at each date t is:

$$g(\phi_t) = \tau(\phi_t) + \int Q_1(\phi_{t+1}/\phi_t) b_t(\phi_{t+1}/\phi^t) d\phi_{t+1} - b_{t-1}(\phi_t) \quad (17)$$

where $\tau(\phi_t)$ is government revenues, $b_t(\phi_{t+1}/\phi^t)$ represents securities by which the government commits at date t to deliver an amount of goods at $t+1$ in state ϕ_{t+1} after a history of states ϕ^t . The model does not require strict assumptions about the maturity or structure of securities represented by $b_t(\phi_{t+1}/\phi^t)$. The government is free to issue bonds that may be tied to inflation, the exchange rate, foreign GDP and with multiple maturity periods. Similarly, one-period bonds can be issued but in this case $b_t(\phi_{t+1}/\phi^t) = b(\phi_t)$ for all ϕ_{t+1} . In addition, the model does not require assumptions on the residence status of holders of these assets; they can be domestic and/or foreigner. The prices of these assets are determined in complete markets.

Using equations (15) and (17), the government budget constraint can be derived easily as:

$$b_{t-1}(\phi_t) = \tau_t - g_t + \sum_{j=1}^{\infty} E_t \left[\frac{\beta^j u'(y_{t+j} - g_{t+j})}{u'(y_t - g_t)} (\tau_{t+j} - g_{t+j}) \right] \quad (18)$$

Using (15) and (17):

$$b_{t-1}(\phi_t) = \tau_t - g_t + \sum_{j=1}^{\infty} \left\{ R_{jt}^{-1} E_t [\tau_{t+j} - g_{t+j}] + cov_t \left[\frac{\beta^j u'(y_{t+j} - g_{t+j})}{u'(y_t - g_t)}, \tau_{t+j} - g_{t+j} \right] \right\} \quad (19)$$

As Mendoza and Ostry (2008) explain, ad hoc sustainability requires the initial debt to be equal to the expected present value of the primary surplus using the interest rate on public debt as the discounting factor. Therefore the covariance term on the right-hand side of the expression must be zero for the solvency condition. This condition is based on some anomalous assumptions and at least one of the following

assumptions must hold: (a) *there is no uncertainty*; (b) *private agents are risk neutral*; or (c) *future government surpluses are uncorrelated with the future marginal utilities of consumption*. But, in reality, the future is stochastic and lenders always try to hedge against risk; therefore assumptions (a) and (b) are unrealistic. Assumption (c) is sharply inconsistent with empirical studies on cyclical movements of fiscal variables in industrial and developing countries. Mendoza and Ostry list some of the studies examining these cyclical movement including Alesina and Tabellini (2005), Catao and Sutton (2002), Gavin and Perotti (1997), Kaminsky et al. (2004), and Talvi and Vegh (2005). These studies suggest procyclical behaviour of the primary surplus in industrial countries and range from acyclical to countercyclical in emerging countries. Fascinatingly, the countries with a countercyclical primary surplus or having a positive covariance between the marginal utility of consumption and the primary surplus can borrow more and are still able to meet the solvency condition.

2.4.1 Ponzi Game

A positive value of ρ in (13) is a sufficient condition, but not a necessary condition for solvency (Mendoza and Ostry, 2008). The positive response also rules out the Ponzi scheme because, if government is not responding to increases in debt, the marginal increase in debt between any two periods will be $(1-\rho)$ which implies a Ponzi scheme and similarly the j -periods-ahead Ponzi scheme debt will be $(1-\rho)^j$.

$$s_t = \rho b_{t-1} + \beta_0 + \beta_1 \tilde{g}_t + \beta_2 \tilde{y}_t + \varepsilon_t$$

Therefore, $0 < \rho < 1$ implies there is no Ponzi game whereas, if $\rho > 1$, $(1-\rho)^j$ will tend to ∞ which means the government would be accruing infinite assets instead of debt (Mendoza and Ostry, 2008). Hence if $0 < \rho < 1$ then:

$$E_t \left[q_{t+j+1}^t (\phi^{t+j+1}) b_{t+j} \left(\frac{\phi_{t+j+1}}{\phi_{t+j}} \right) \right] \approx (1-\rho)^j b_t \rightarrow 0 \text{ as } j \rightarrow \infty$$

where the discount factor is

$$q_{t+j+1}^t (\phi^{t+j+1}) = \frac{\beta^j u(y_{t+j} - g_{t+j})}{u(y_t - g_t)} f(\phi_{t+j}, \phi_{t+j-1}) f(\phi_{t+j-1}, \phi_{t+j-2}) \dots f(\phi_{t+j}, \phi_t)$$

If $\rho > 1$, the expected value will diverge to negative infinity as j grows. The government would be accumulating infinite assets (instead of debt).

2.4.2 Sustainable Debt Ratios

The MBS test also computes the sustainable debt ratio to which an economy converges in the long-run. Mendoza and Ostry (2008) explain that, if the other determinants of the primary surplus and the growth-adjusted real interest rate on public debt are stationary, with means $\bar{\mu}$ and \bar{r} respectively, then the linear response in (13) and the government budget constraint yield the following expected value in the long run for the public debt-GDP ratio, as derived by Mendoza-Ostry (2008):

$$E[b_t] = \frac{-\bar{u} + (1-\rho)cov(1+r_t, b_{t-1})}{\rho(1+\bar{r}) - \bar{r}} \quad (20)$$

Now if we assume that $\bar{u} < 0$ (which is true in general) and if $cov(1+r_t, b_{t-1}) \geq 0$, the mean debt ratio in (20) is a negative function of ρ . As a result, if everything else is constant, the higher ρ implies reduced average debt in the long run because the government is responding with a large primary surplus, instead of borrowing. Therefore a positive high value of ρ would indicate the sustainable solvency of government under optimal fiscal policies.

Mendoza and Ostry (2008) conducted the MBS test for a panel data of several countries for the period 1990-2005. The countries were placed in two groups of 34 emerging and 22 industrial countries. Their results show evidence of fiscal solvency in the form of a robust positive conditional response of the primary surplus to changes in public debt, in panels for emerging and industrial economies and in a combined panel. Mendoza and Ostry (2008) have applied the MBS approach including non-linearities in the relation, transitory effects of government purchases \tilde{g}_t , the business cycle \tilde{y}_t , effects of inflation and external deficits, as well as country fixed effects and country-specific autocorrelation of error terms. Moreover, the results strongly support the positive response of the primary surplus to changes in public debt for emerging countries and because of this stronger response, emerging countries converge to lower mean debt ratios. They claim that the empirical analysis of the MBS test is a useful tool for separating countries where fiscal solvency holds from those where it is in doubt.

Similarly, Ghatak and Fung (2007) conducted MBS tests for developing countries including Peru, the Philippines, South Africa, Thailand and Venezuela. Although the countries are all developing, the sample is heterogeneous, as the countries have been selected from Africa, Asia and Latin America. Ghatak and Fung applied the competing methodologies including tests of stationarity, cointegration and

Bohn's (1998) procedure on the IBC. They suggested using the Bohn (1998) approach for developing countries and advocate it because of the flexibility in assumptions regarding the interest rate. Moreover, Bohn's (1998) approach is more promising in asking only whether a government is exercising the necessary actions to comply with the IBC. Finally, they concluded that the bench-mark condition for the government's budget surplus is not binding in Peru, the Philippines, South Africa Thailand and Venezuela.

As discussed earlier, the aim of this study is to compare and analyse the models of sustainability. The following section describes the data and their sources. This section is followed by a short introduction to the tests that are used in the models of sustainability, such as tests of unit roots and cointegration. Finally, the models of sustainability are analysed in the following section.

Chapter 3 : Data

This thesis aims to examine the sustainability of fiscal policy for ten Asian countries using central government data. The data are collected from different sources including International Financial Statistics (IFS), World Development Indicators (WDI), International Monetary Fund (IMF), Asian Development Bank (ADB), and the Reserve Banks and Finance Ministries of respective countries. The data are all available publicly; sources will be detailed below. Although for some countries in our sample the data are available before 1993 and beyond 2007, to obtain a balanced panel we had to rely on the period 1993-2007, all data are annual. We have encountered only one missing value, that for interest payments in 2003 for Thailand. Thailand is an important member of the IMT-GT; therefore we could not exclude it from the sample. The missing value is approximated simply by taking the arithmetic mean of interest payments (as a percentage of debt) for the years 2001 and 2004.

Usually data for external debt are available for developing countries, including our sample, whereas data on public debt are hardly available for the complete period. Jaimovich and Panizza (2008)⁸ have collected data of central government debt for 89 countries, including some countries in our sample, such as Pakistan, Thailand, Bangladesh, Bhutan, Malaysia, Singapore, Nepal and Sri Lanka. The sources of data are almost the same, except that we have collected data from annual country reports published by the IMF. We have compared the data by drawing a line graph of the two

⁸ The Jaimovich-Panizza dataset is available at: http://www.iadb.org/res/pub_desc.cfm?pub_id=DBA-005 (accessed January 2010)

data sets from 1990 to 2005, where the data were available, and the comparison charts are given in Appendix 2. Our data are similar to Jaimovich and Panizza's data except for relatively minor differences in some of the series. This might be because of different sources. However as will be shown further, the qualitative conclusion from unit root test results are similar. Similarly Jeanne and Guscina (2006) have collected data for central government debt for 19 countries; however, their dataset does not include countries from Asia.

We have collected central government data for SAARC and IMT-GT countries. The SAARC comprises of Pakistan, India⁹, Bangladesh, Bhutan, Sri Lanka, Nepal and Afghanistan, while IMT-GT includes Indonesia, Malaysia, and Thailand. We have also included Singapore in the pool of all countries which is neither a member of SAARC nor IMT-GT. We had to exclude Nepal and Afghanistan from the SAARC group because of scarcity of data for some variables. However, Jaimovich and Panizza (2008) report data for Nepal; therefore we have included it in Jaimovich and Panizza's dataset, for the purpose of comparison.

Our aim was to test for cointegration between expenditures and revenues and also between debt and the primary surplus. Therefore, the analysis requires the data to be available for the same period. The primary source for central government debt and the primary surplus is the annual country reports published by the IMF. The reports are available at the IMF website from 1998. Each report contains five or more years' data for different series. Total central government debt is available only for a few years between 1993 and 2007 for some countries in these reports. Therefore, we have calculated total central government debt for the other years from annual central government debt given in Key Indicators of 2009 of the Asian Development Bank. The data for central government expenditures, revenues, and gross domestic product (GDP) are taken from the ADB, while the consumer price index (CPI) is available at IFS's website. The real variables were calculated using the consumer price index, such that each variable is divided by the CPI and multiplied by 100. The specific name, code and other details of the data sources are given in Appendix 1 to this chapter.

The mean of central government debt and primary surplus as a percentage of GDP from 1993 to 2007 for SAARC, IMT-GT and All-Countries are given in Figures 1 and 3. The mean central government debt in the Jaimovich-Panizza dataset is given

⁹ The data for India contain an outlier for the year 2007; therefore we have ignored this value when the unit root tests were applied to single countries. This is pointed out in the source of the data (Asian Development Bank, Key Indicators of Asia and Pacific 2009). As reported by the ADB, "India's debt-GDP ratio (after 2006) identifies a break in the analytical comparability of data or a change in magnitude".

in Figure 2. Central government debt was at a peak in 2001 for all the country groups (i.e. SAARC, IMT-GT and All Countries) as shown in Figure 1. The debt was above 71% of GDP for the pool of SAARC, 47% for the pool of IMT-GT and 66% for the mean of all countries (including Singapore). The data have an upward trend up until 2001 and decline slowly afterwards. Similarly, the increase in debt is shown in the Jaimovich-Panizza data set. Debt was above 70% of GDP in 2001 and started declining afterwards. It should be noted that we have selected only those countries from the Jaimovich-Panizza dataset that were present in our sample.¹⁰

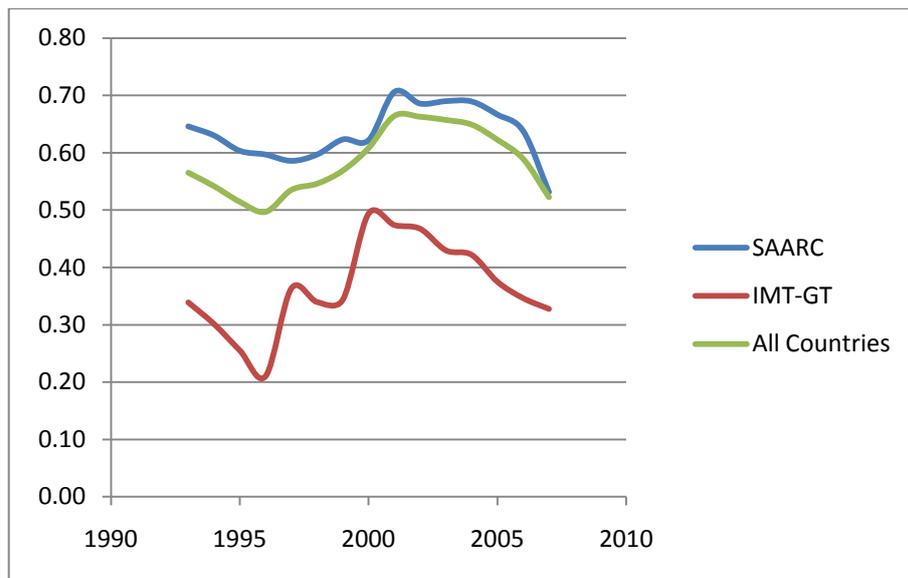


Figure 1: Mean Central Government Debt as a Percentage of GDP

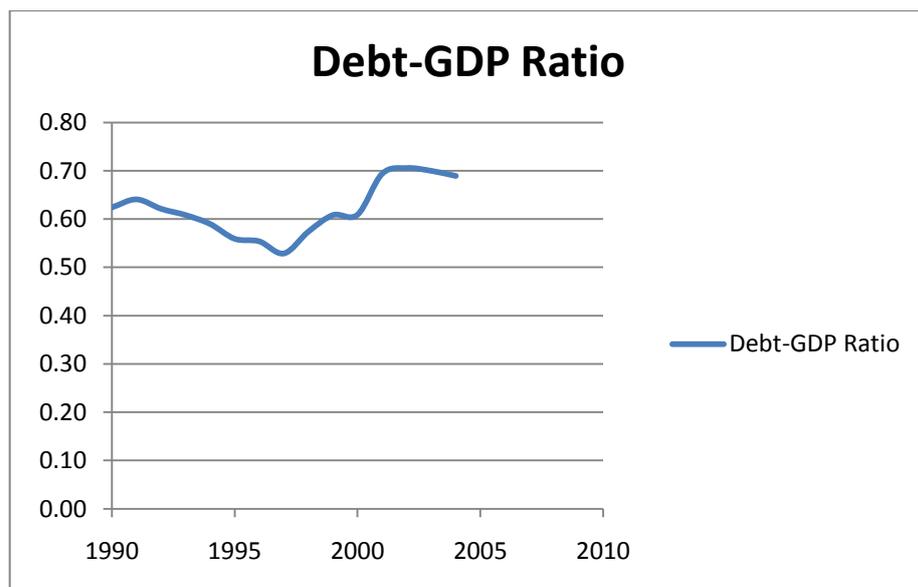


Figure 2: Jaimovich-Panizza Mean Debt as a Percentage of GDP

¹⁰ Countries selected from the Jaimovich-Panizza data set are Bangladesh, Bhutan, Malaysia, Pakistan, Singapore, Sri Lanka, and Thailand.

Apart from the apparently nonstationary behaviour before 1997 for the pool of IMT-GT, the primary surplus seems relatively stable for the rest of the years.

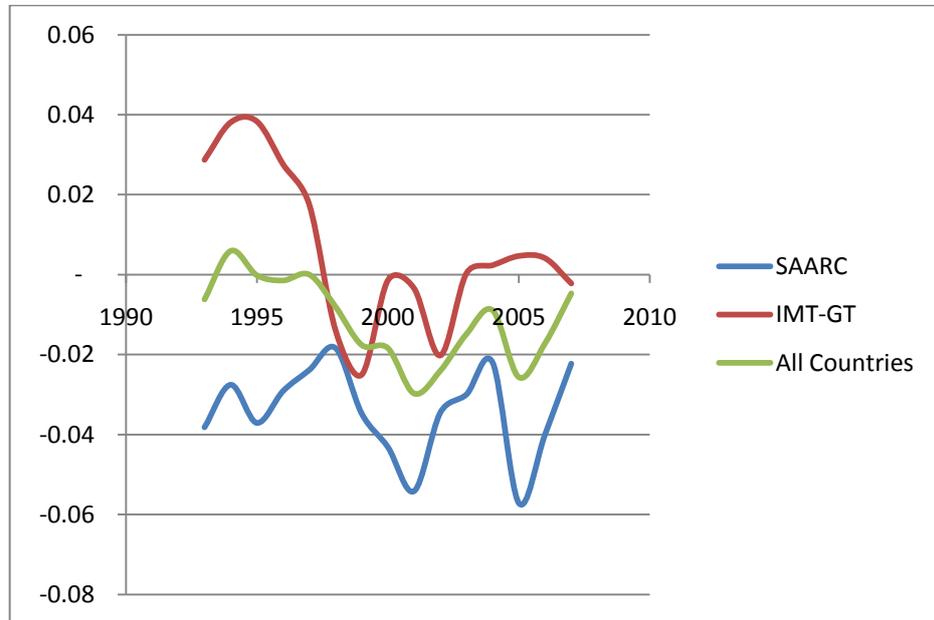


Figure 3: Mean of Primary Surplus as a Percentage of GDP

3.1 Comparisons of Higher and Lower Income Countries

Data for the mean of central government debt as a percentage of GDP for SAARC and IMT-GT countries are shown in Figure 1. As shown in the graph the mean debt as a percentage of GDP for lower income countries, i.e. SAARC, is 20% to 30% higher than that of the higher income countries. Figure 1 also highlights the Asian financial crisis of 1997-1998. The crisis hit the higher income countries much more harshly than the lower income countries, primarily because the crisis started in the so-called high income countries of Asia. For instance, the devaluation of the currency (Baht) in Thailand in 1996 set the scene for further economic disruption. Ruland (2000) has given a brief summary of what happened before the financial crisis of 1997-1998. By the end of 1998 the Thai currency had already lost 38% of its value. It was followed by the 40% devaluation in the Malaysian ringgit. The worst hit was the Indonesian currency which devalued by 81%. The vicious circle started and this wave affected exports, employment, output and economic growth. These failures lead to high borrowing as shown in Figure 1. However, the effects were less severe in lower income countries of Asia, such as those in SAARC. The Asian economies had

hardly started recovering from the financial crisis when another global incident, 9/11, occurred in 2001. Again higher income countries were affected more than lower income countries.

Chapter 4 : Results and Discussion

4.1 Unit Root Tests

This section discusses the time-series properties of the relevant variables and their significance for further analysis. The data cover the period 1993-2007 for a group of 10 Asian countries: Pakistan, India, Maldives, Bangladesh, Sri Lanka, Bhutan, Indonesia, Malaysia, Thailand and Singapore. The most important issue using time-series data is testing for the presence of a unit root, which makes the series nonstationary. Nonstationarity can arise due to deterministic or stochastic trends and in order to remove the trend each requires a different strategy.

There are a range of tests available for a unit root, each with a different set of problems and issues. In order to select an appropriate unit root test it would first be beneficial to introduce these tests. Econometricians have emphasised on the drawbacks of standard unit root tests such as low power and size distortion problems. Later tests were modified in different ways in order to overcome the low power and size distortion problems.

Once an appropriate test is selected for given time-series data, and then comes the issue of including appropriate deterministic components in the model. Furthermore, some selection criterion is needed to choose the optimal lag length of the autoregressive terms in the model.

Unit root testing in time series was initiated by Dickey and Fuller (1979). Let a time series have the following data generating process (DGP):

$$y_t = \alpha y_{t-1} + e_t, \quad t = 1, 2, \dots, \quad (21)$$

where y_t depends upon its autoregressive term and a white noise error term e_t . The series is stationary if $|\alpha| < 1$. We can apply the ordinary least square method for estimation of ' α ' and similarly the usual t-tests can be used to see whether α is significant or not. However, standard critical values of the t-distribution will not be appropriate if the given series is nonstationary such that $\alpha = 1$. The null hypothesis for nonstationary series is $H_0: \alpha = 1$ against the alternative hypothesis; $H_1: \alpha < 1$. In this

case, the critical values derived by Dickey and Fuller (1979, 1981) should be used. These critical values for Dickey and Fuller statistics were drawn from Monte Carlo simulations. Equation (21) can alternatively be tested for a unit root by defining $\gamma = \alpha - 1$. The standard equations for the Dickey-Fuller test, i.e., (21) can be rewritten in the form of (22) given below, where $\gamma = \alpha - 1$:

$$\Delta y_t = \gamma y_{t-1} + e_t, \quad t = 1, 2, \dots, \quad (22)$$

$$\Delta y_t = \alpha_0 + \gamma y_{t-1} + e_t, \quad t = 1, 2, \dots, \quad (23)$$

$$\Delta y_t = \alpha_0 + \gamma y_{t-1} + \alpha_1 t + e_t, \quad t = 1, 2, \dots, \quad (24)$$

The difference between the above three models is the presence of deterministic components. Equation (22) has no deterministic term, equation (23) contains only an intercept term, whereas equation (24) contains both an intercept and a time trend. The null hypothesis for the models would be $H_0: \gamma = 0$; hence, if $\gamma = 0$ the series contains a unit root.

Later on, several modifications were introduced in term of formulation of standard Dickey-Fuller models, such as Bhargava (1986) suggested a formulation derived by nesting the trend stationary process. Econometricians have conducted several modifications of Dickey and Fuller (1979, 1981) tests in order to have more power, lower size distortion and flexible assumptions about the error term. The error term was assumed to be white noise in the Dickey-Fuller test, whereas in reality it may not be white noise; therefore Dickey and Fuller extended their model by adding higher order autoregressive terms in the standard models and this is known as the Augmented Dickey Fuller (ADF) test. Hence equations (22), (23) and (24) are modified as:

$$\Delta y_t = \gamma y_{t-1} + \sum_{i=1}^p \alpha_i \Delta y_{t-i} + e_t, \quad t = 1, 2, \dots, \quad (25)$$

$$\Delta y_t = \alpha_0 + \gamma y_{t-1} + \sum_{i=1}^p \alpha_i \Delta y_{t-i} + e_t, \quad t = 1, 2, \dots, \quad (26)$$

$$\Delta y_t = \alpha_0 + \gamma y_{t-1} + \sum_{i=2}^p \alpha_i \Delta y_{t-i} + \alpha_1 t + e_t, \quad t = 1, 2, \dots, \quad (27)$$

The addition of higher order autoregressive terms is to ensure that the white noise assumption of the error term is satisfied, including serial correlation of errors. But the data may have error terms that are neither statistically independent nor have constant variance. Therefore, Phillips and Perron (1988) (henceforth Phillips-Perron) treated this problem and extended the Dickey-Fuller test by allowing for autocorrelation and heteroskedasticity in the error.

Dickey-Fuller (DF) and Phillips-Perron (PP) tests are standard tests for a unit root. The DF tests are based on parametric estimation techniques while the PP tests are based on nonparametric techniques. The two tests have played their role as a benchmark or starting point for the later tests both for time series data and panel data. The Augmented Dickey Fuller (ADF) tests and Phillips-Perron tests have dealt well with some specific issues of the error term such as autocorrelation and heteroskedasticity in error terms. But still these tests are lacking in dealing with the size distortion problem. Maddala and Kim (1998) are of the view that, although the ADF and PP tests are often used in research work, these tests are not of much help because of size distortion and low power problems. The severity of the power problem led econometricians to adopt stationarity (i.e., No Unit Root) as the null hypothesis, such as for the KPSS test suggested by Kwiatkowski et al. (1992). The KPSS test has been used as a complementary test with the ADF and PP. However, some econometricians have criticised the use of KPSS as a confirmatory test (Maddala and Kim, 1998).

Our aim is to find out whether individual series have a unit root or not. As discussed above, the Augmented Dickey Fuller, Phillips-Perron and KPSS tests may have problems in this regard; therefore we use some modified forms of ADF tests such as DF-GLS along with the ADF and PP. The modified forms perform better in terms of power and size distortion.

The DF-GLS test of a unit root is a modification of the Dickey-Fuller test proposed by Elliott, Rothenberg, and Stock (1996; henceforth ERS). The test performs well by improving the power when an unknown mean and trend is present in the series. Standard unit root tests suffer from low power when the coefficient of the AR(1) term is close to unity. Moreover, the power of these tests declines considerably as more deterministic terms are added in the model. However, ERS (1996, 1999) gains power by either demeaning or detrending when the alternative is close to a unit root (Patterson, 2010). The ERS test is applied in two steps. First, the series is detrended using a Generalised Least Square (GLS) method, assuming some specific value very

close to one for the AR(1) coefficient. Second, the detrended series is examined for a unit root using Dickey-Fuller's family of tests.

Following Maddala and Kim (1998), the DF-GLS test can be applied for the detrended series given below:

$$\Delta y_t^d = \alpha_0 y_{t-1}^d + \alpha_1 \Delta y_{t-1}^d + \dots + \alpha_p \Delta y_{t-p}^d + \varepsilon_t$$

where y_t^d is the locally detrended series y_t . The DF-GLS t-test is applied to the null hypothesis $H_0: \alpha_0 = 0$ in this case. The detrending of the series depends on whether the model contains an intercept only or also includes a linear trend. As the test is applied with intercept and linear trend in the model, therefore, the detrended series y_t^d can be given as (Maddala and Kim 1998):

$$y_t^d = y_t - \hat{\beta}_0 - \hat{\beta}_1 t$$

where $(\hat{\beta}_0, \hat{\beta}_1)$ are obtained by GLS, the detailed discussion can be found in Maddala and Kim (1998, p.114).

Although the modified tests have improved the size distortion and low power problems, ambiguous results are still possible. As discussed earlier in this section, that in some cases the ADF and PP tests may not point to the same conclusion. The former may accept the null hypothesis of a unit root while the latter may reject it, therefore, confirmatory tests like KPSS can be used to strengthen the result. In the present study, we have tried to use the modified form of ADF, i.e. DF-GLS that has more power than the ADF and PP tests of unit root. Therefore, we would mainly rely on the results of DF-GLS.

The following section presents the unit root test results for central government debt and the central government primary surplus for the application of the MBS test. As will be shown, the Debt-GDP ratio has a trend and is nonstationary in levels; therefore the results will be potentially statistically spurious if the data enter OLS regressions in levels. Unit root tests will be applied initially to individual series and then to panel data. In addition, the data are treated both in terms of GDP ratios and in real terms.

4.2 Unit Root and Cointegration Tests for Model Based Sustainability

As discussed earlier, the MBS approach defines sustainability if there is evidence for a significant response of the primary surplus to changes in debt. Mendoza and Ostry (2008) and Ghatak and Fung (2007) have used the general government data to assess the sustainability of fiscal policy, and used MBS tests for this purpose. But both studies assumed the debt data to be stationary in levels. A necessary and careful investigation requires the data to be checked for nonstationarity. Therefore, the data are analysed for their time-series properties before application of MBS.

All the tests used in this analysis are available in EViews 6. The results of the tests are presented in Tables 1 and 2. The Augmented Dickey-Fuller test results are presented in the first column, the DF-GLS results in column 2, and the Phillips-Perron results in column 3. The final verdict on whether there exists a unit root is given in column 4.

Before applying unit root tests the series were graphed in order to determine whether the series contain an intercept and/or linear trend. The line graph of the Debt-GDP ratio is shown in Figure 4. A linear trend is apparent in the Debt-GDP ratio of Pakistan and Singapore. For instance, in the case of Singapore the Debt-GDP ratio seems to be increasing over-time, while for Pakistan it decreases over-time. However, we tested the variables for all the countries both with only an intercept in the model and with an intercept and a linear trend in the levels.

The lag length is selected using the Akaike Information Criterion (AIC), (Akaike's 1973), for all the tests. As the span of the data series is very short, we have relied on a maximum of 3 lags in the model. The ADF and PP test results are given along with their p-values. The critical values for the DF-GLS test with trend are obtained from ERS (1996, Table I) and are given in the footnotes to Tables 1 and 2.

As shown in Table 1 central government debt to GDP ratio is nonstationary in levels for all the countries except for the following cases, i) Sri Lanka for both models with intercept and with intercept and linear trend, and ii) India, Malaysia, and Indonesia for the model with intercept only. As discussed earlier, we mainly rely on the results of DF-GLS for its high power as compared to ADF and PP. Therefore, even though the ADF or PP results differ from DF-GLS, but we have still decided according to DF-GLS such as, i) Bangladesh for the model with intercept only, ii) Sri Lanka for both the models with intercept and with intercept and linear trend, and iii) Malaysia for the model with intercept and linear trend.

As shown in the Table 2, the primary surplus-GDP ratio is nonstationary in levels for all the countries except Pakistan and Singapore for the model with intercept only and for Indonesia and Sri Lanka for the model with intercept and linear trend. Again, we have decided according to DF-GLS for cases in which either the ADF or PP contradict DF-GLS test of unit root. The primary surplus is nonstationary for most of the countries in the group with the results consistently implying a unit root in levels. The results for models with and without linear trend are more or less the same for both the debt and primary surplus as ratios of GDP.

As shown in Tables 1 and 2, debt-GDP and primary surplus-GDP are nonstationary in levels for all the countries except Sri Lanka. Therefore, the MBS test of sustainability can only be applied to Sri Lanka.

As discussed above, if debt and the primary surplus are used in levels, then the regression results would be meaningless unless the two series are tied in a long-run relationship, i.e., they are cointegrated. If the series are cointegrated the regression is meaningful and regarded as a long-run relationship. The preliminary step for testing cointegration is that the two variables, involved in a cointegrating equation should be integrated of the same order. For example the cointegration equation for the MBS is:

$$s_t = \alpha + \beta b_t + \varepsilon_t$$

where b_t is debt, s_t is the primary surplus, α is a constant term, and ε_t is the error term.

We assume that the primary-surplus-GDP ratio s_t and debt-GDP ratio b_t are I(1) time-series variables. For nonzero β , if the error term ε_t is nonstationary (unit root) then the regression equation is said to be spurious. However, if, for the above regression equation, the error terms are stationary then the primary-surplus-GDP ratio and the debt-GDP ratio are cointegrated. In other words, these variables are tied in a long-run relationship; for example, over a long period of time the change in debt-GDP ratio is responded to by the change in the primary-surplus-GDP ratio. Particularly, a positive response of the primary-surplus-GDP ratio to a debt-GDP ratio suggests that fiscal policy is sustainable. Meaningful results can be obtained from a valid cointegrating relationship; otherwise the results drawn from a spurious regression, as discussed above, can mislead the policy maker.

We have applied unit root tests to the first difference of the series that contain unit root in levels. Again as a precautionary step, the series are analysed through line graphs for specification of unit root tests. As shown in Figures 6 and 7, the series do

not seem to have either intercept or linear trend. The primary-surplus-GDP ratio and debt-GDP ratio have approximately zero means as shown in Figures 6 and 7. Unit root results for first differences suggest that all the series are stationary in first difference, as shown in Tables 3 and 4. Having confirmed the order of integration the series are examined for the presence of cointegration, using Engle-Granger test of cointegration.

Although the Engle-Granger method of cointegration testing is easy to implement, there are some limitations to this method. The residuals drawn in the first step from a cointegrating equation do not have the exact limiting distribution tabulated by Dickey and Fuller. In this case, other critical values are used; Engle and Granger (1987) recommended the tests abbreviated as CADF-tests with the critical values suggested by Engle and Granger. The critical values for these tests are slightly different from the critical values used in standard unit root tests. For instance, the critical values for the Engle-Granger cointegration test are given by Enders (2004, p.441) in Table C. We have applied the Engle-Granger method as a preliminary check on the equilibrium relationships (Banerjee et al., 1993). For more detailed analysis we have relied on the cointegration tests from panel data that will be presented in the following sections.

The Engle-Granger procedure requires two steps. First the regression equation of debt on the primary surplus is estimated and then the error term is tested for a unit root; the ADF unit root tests applied to the residual with only intercept in the model. The critical value for the Engle-Granger method is taken from Enders (2004, p.441) given in Table C. The presence of a unit root in the error term means the series are not cointegrated. As the null hypothesis is that of a unit root, the null hypothesis is therefore that of no cointegration. If the residual series is stationary in levels the null hypothesis is rejected, and the debt and primary surplus are regarded as cointegrated and have a long-run relationship.

The unit root test results applied to the error term of the cointegrating equation are reported in Table 5. As shown in Table 5, the error term is stationary for India, Maldives, and Singapore. As shown in Table 5, the test statistic value (i.e., -3.110) for Singapore is very close to the 10 % level of significance value (i.e., -3.130), therefore we have considered the residual for Singapore as stationary. Hence, the primary surplus-GDP and debt-GDP ratios for these countries can be regarded as cointegrated. However, for the remaining countries the error term is nonstationary; therefore cointegration does not exist. Table 6 presents the results for the orders of integration, the existence of cointegration, and the verdict on the applicability of MBS.

From the above discussion, the countries can be categorised into four groups regarding the applicability of the MBS tests, i) countries for which the debt-GDP ratio and primary-surplus-GDP ratio are stationary in levels, ii) the series are cointegrated, iii) the series are integrated of the same order but do not co-integrate, and iv) the series are integrated of different orders. Table 7 shows all the countries with their respective groups.

According to Table 7, MBS cannot be applied in levels except Sri Lanka. Hence, if tests for unit roots and cointegration are not considered, then the results from MBS may be misleading for all countries. However, if the series are examined for unit roots and cointegration, the MBS becomes applicable for three more countries in levels. But for countries such as Bangladesh, Bhutan, Pakistan and Thailand, cointegration does not exist; therefore the series cannot be used in levels unless they are transformed to stationary series. Finally, for the countries with different orders of integration, such as Indonesia and Malaysia, the MBS is also not applicable.

Although the presence of cointegration in three countries allows for the MBS in levels but the presence of cointegration implies sustainability of fiscal policy as suggested by Trehan and Walsh (1988), and Haug (1991; 1995). Therefore the MBS is not necessarily required to evaluate sustainability.

The accuracy of unit root tests in a very small sample, as in our case, is an obvious concern. By applying unit root and cointegration tests at the individual-country level, we do not intend to conclude in favour or against the MBS method. Our aim is to compare our results at the individual level to using pooled data. The next section will analyse stationarity and cointegration issues for comparable panel data.

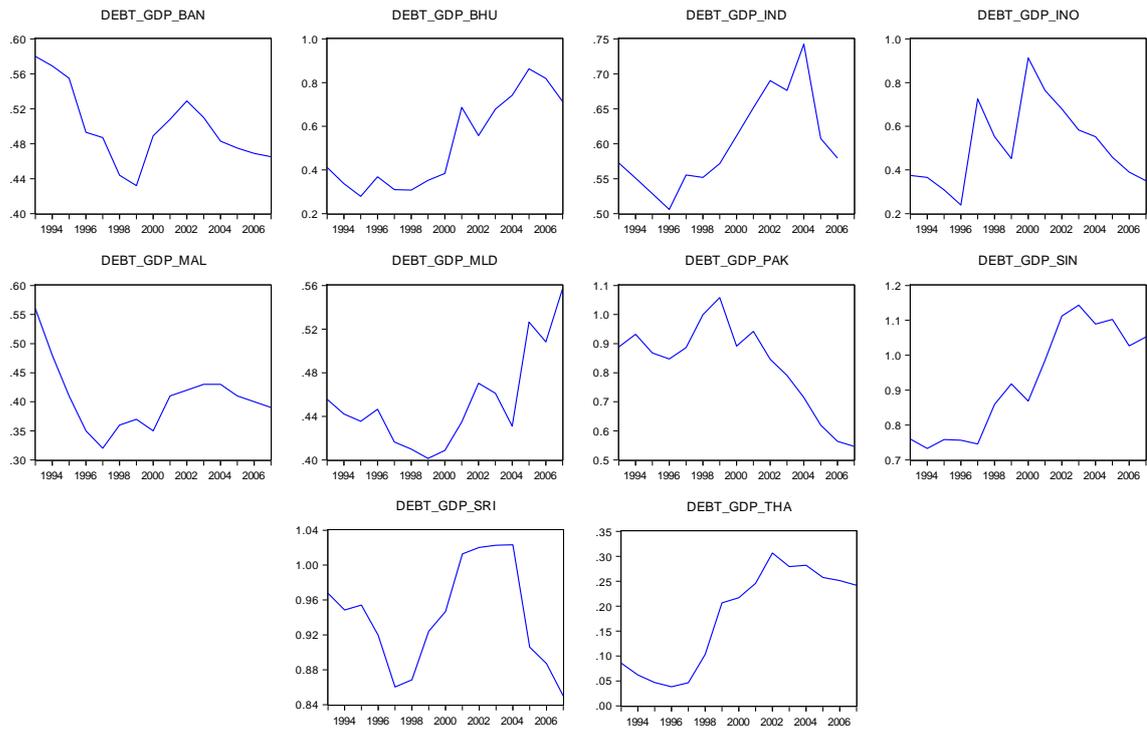


Figure 4: Debt-GDP Ratio in Levels

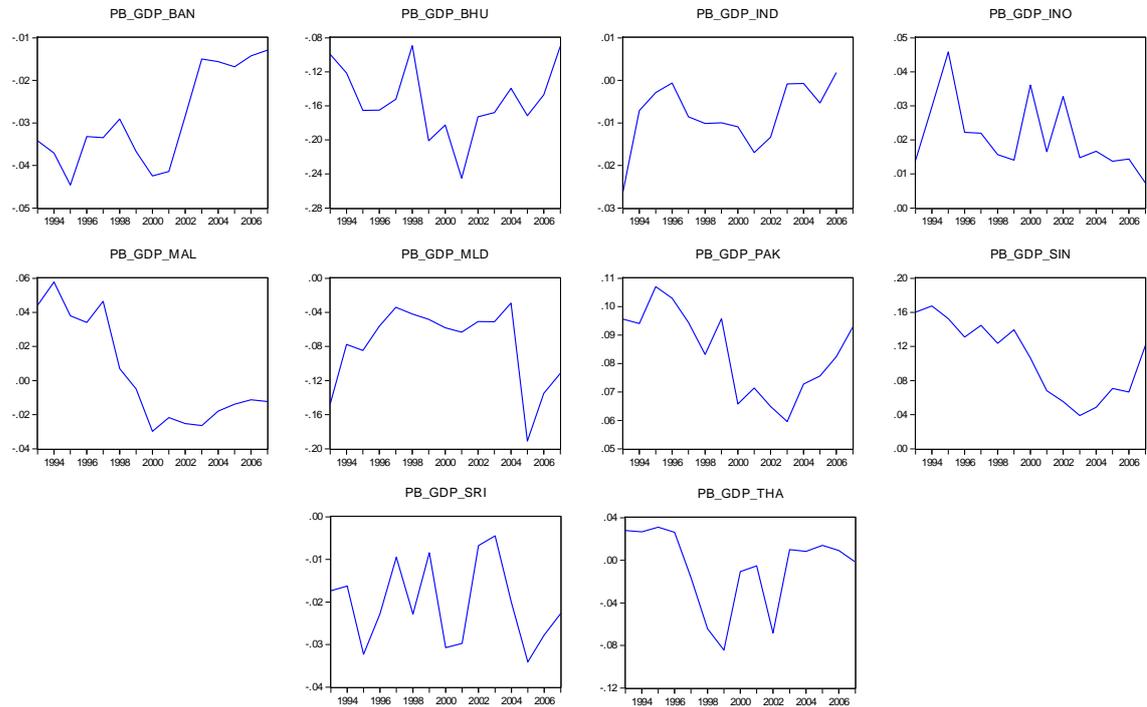


Figure 5: Primary-Surplus-GDP Ratio in Levels

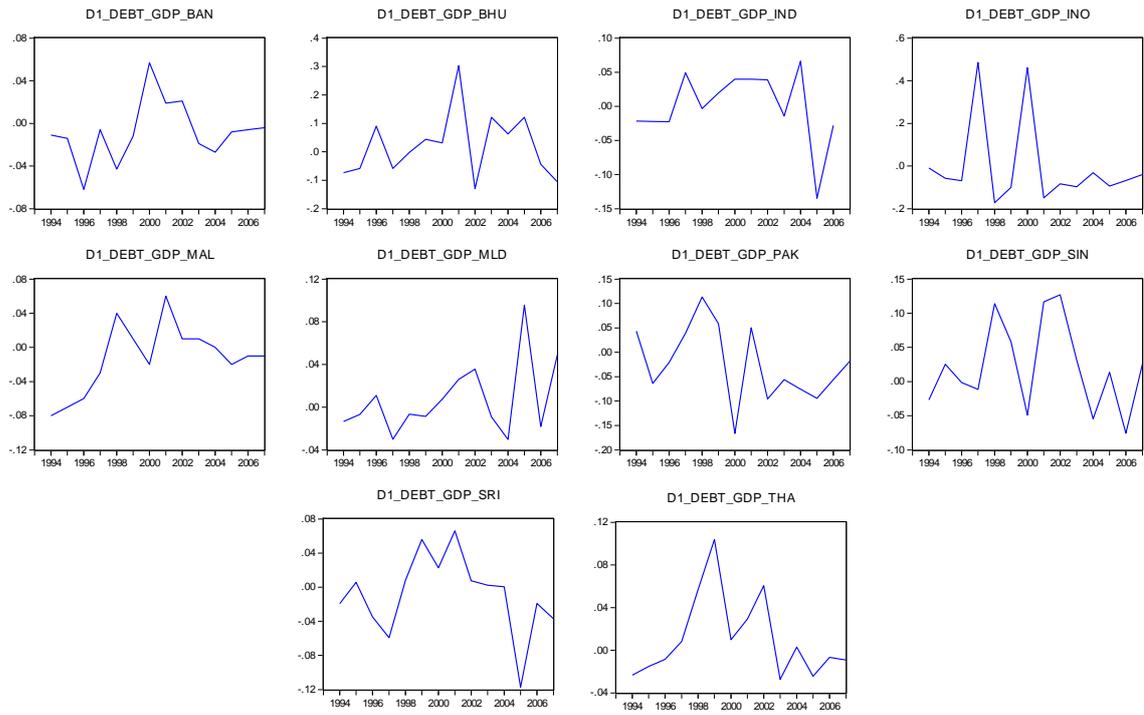


Figure 6: First Differences of the Debt-GDP Ratio

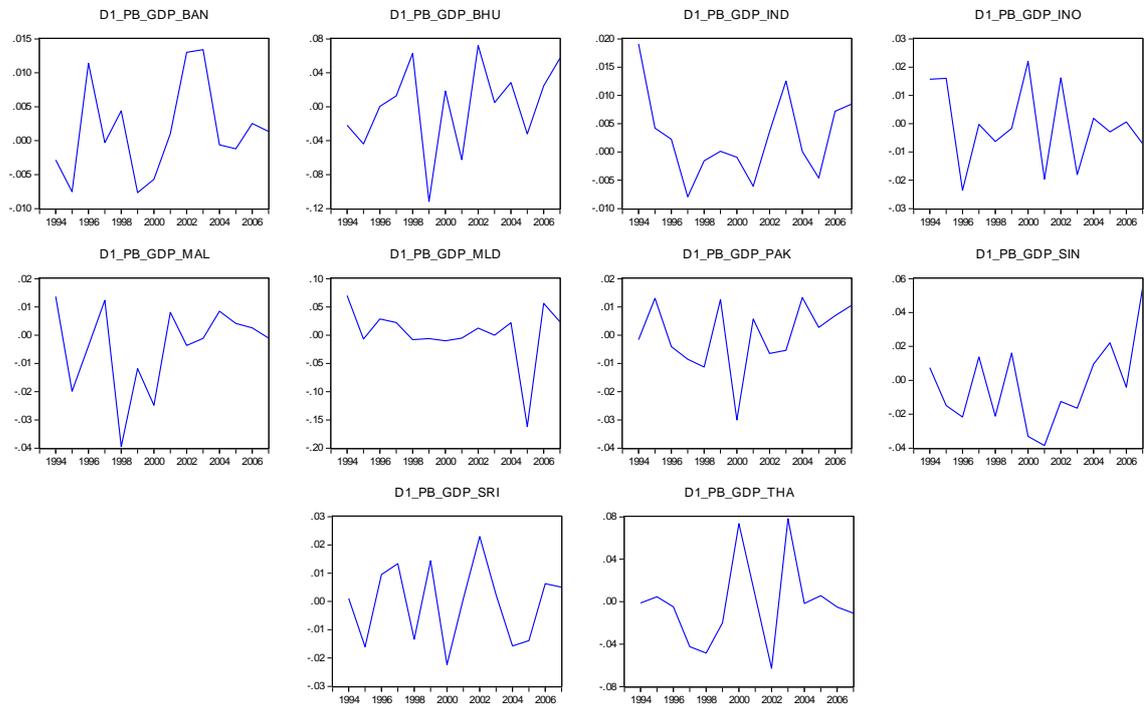


Figure 7: First Differences of Primary-Surplus-GDP Ratio

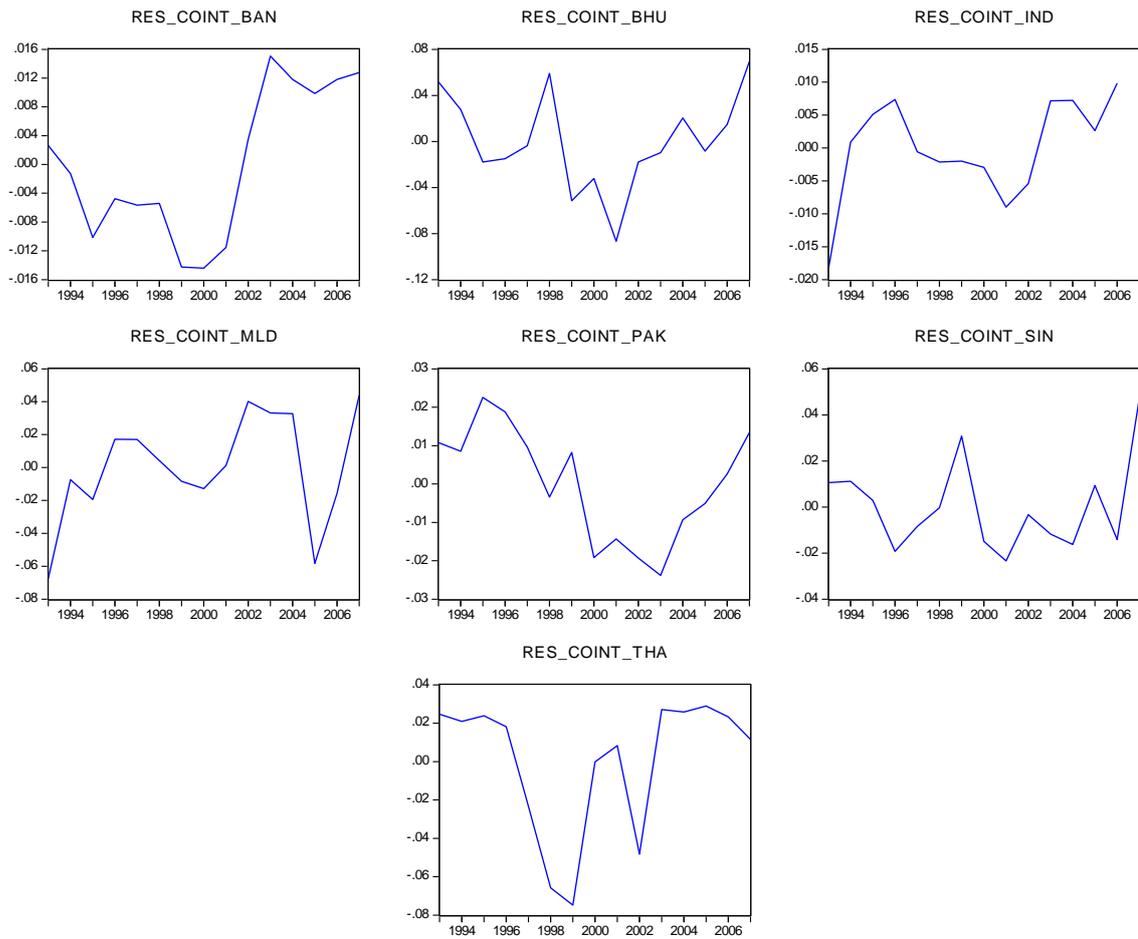


Figure 8: Residuals of Engle-Granger Cointegration Tests

Table 1: Debt-GDP Ratio in Levels

Country		ADF	PP	DF-GLS	Verdict
Bangladesh	Intercept	-3.940 (0.013)	-1.999 (0.283)	-2.196	Inconclusive
	Trend	-2.921 (0.195)	-1.720 (0.687)	-2.947	
Bhutan	Intercept	-0.826 (0.780)	-0.718 (0.811)	-0.883	I(1)
	Trend	-2.835 (0.210)	-2.820 (0.214)	-2.870	I(1)
India	Intercept	-2.273 (0.195)	-1.352 (0.572)	-2.367	I(0)
	Trend	-0.746 (0.937)	-1.519 (0.768)	-1.825	I(1)
Pakistan	Intercept	0.043 (0.948)	0.043 (0.948)	-0.203	I(1)
	Trend	-1.310 (0.841)	-1.294 (0.845)	-1.508	I(1)
Sri Lanka	Intercept	-3.585 (0.026)	-1.485 (0.511)	-3.831	I(0)
	Trend	-3.726 (0.066)	-1.369 (0.823)	-3.647	I(0)
Maldives	Intercept	-0.425 (0.880)	-0.010 (0.942)	-0.695	I(1)
	Trend	-1.590 (0.744)	-1.590 (0.744)	-1.992	I(1)
Indonesia	Intercept	-2.149 (0.231)	-2.065 (0.259)	-2.179	I(0)
	Trend	-0.365 (0.974)	-1.768 (0.665)	-2.176	I(1)
Malaysia	Intercept	-3.007 (0.065)	-3.305 (0.035)	-2.527	I(0)
	Trend	-2.174 (0.456)	-3.528 (0.075)	-3.237	I(1)
Thailand	Intercept	-0.833 (0.778)	-0.914 (0.752)	-1.343	I(1)
	Trend	-1.868 (0.605)	-1.508 (0.776)	-3.092	I(1)
Singapore	Intercept	-0.929 (0.747)	-0.929 (0.747)	-0.867	I(1)
	Trend	-1.927 (0.574)	-1.927 (0.574)	-1.771	I(1)

Parenteses contain p-values, DF-GLS: When intercept is included the critical values for 1%, 5%, and 10% are -2.755, -1.971, and -1.604 respectively, -2.792, -1.978, and -1.602 for India (as it has fewer values than others in the group). DF-GLS: when intercept and linear trend are included the critical values for 1%, 5% and 10% are -3.770, -3.190 and -2.890.

Note: all the critical values for DF-GLS have been taken from EViews 6.0.

Table 2: Primary-Surplus-GDP Ratio in Levels

Country		ADF	PP	DF-GLS	Verdict
Bangladesh	Intercept	-0.699 (0.816)	-0.848 (0.773)	-1.255	I(1)
	Trend	-2.549 (0.304)	-2.183 (0.462)	-2.711	I(1)
Bhutan	Intercept	-2.746 (0.091)	-2.709 (0.097)	-2.567	I(0)
	Trend	-2.325 (0.396)	-2.223 (0.443)	-2.743	I(1)
India	Intercept	-3.288 (0.038)	-3.225 (0.042)	-2.863	I(0)
	Trend	-3.067 (0.153)	-3.055 (0.156)	-3.041	I(1)
Pakistan	Intercept	-2.626 (0.117)	-1.464 (0.521)	-2.369	I(0)
	Trend	-0.447 (0.971)	-1.122 (0.887)	-2.274	I(1)
Sri Lanka	Intercept	-3.950 (0.015)	-3.955 (0.011)	-3.630	I(0)
	Trend	-3.337 (0.112)	-4.044 (0.033)	-3.779	I(0)
Maldives	Intercept	-2.699 (0.099)	-2.713 (0.096)	-2.537	I(0)
	Trend	-3.079 (0.148)	-3.185 (0.127)	-3.141	I(1)
Indonesia	Intercept	-3.024 (0.057)	-3.042 (0.055)	-3.021	I(0)
	Trend	-2.902 (0.200)	-4.482 (0.017)	-4.722	I(0)
Malaysia	Intercept	-1.306 (0.596)	-1.306 (0.596)	-1.184	I(1)
	Trend	-1.170 (0.876)	-1.124 (0.886)	-1.425	I(1)
Thailand	Intercept	-1.382 (0.560)	-1.388 (0.557)	-1.293	I(1)
	Trend	-2.123 (0.480)	-0.159 (0.986)	-2.725	I(1)
Singapore	Intercept	-2.244 (0.201)	-2.158 (0.228)	-2.253	I(0)
	Trend	-2.090 (0.507)	-1.910 (0.597)	-2.265	I(1)

Parenteses contain p-values, DF-GLS: When intercept is included the critical values for 1%, 5%, and 10% are -2.755, -1.971, and -1.604 respectively, -2.792, -1.978, and -1.602 for India (as it has fewer than others in the group). DF-GLS: when intercept and linear trend are included the critical values for 1%, 5% and 10% are -3.770, -3.190 and -2.890. Note: all the critical values for DF-GLS have been taken from EViews 6.0.

Table 3: Debt-GDP Ratio at First Difference

Country	ADF	DF-GLS	PP	Verdict
Bangladesh	-2.570 (0.015)	-2.721	-2.570 (0.015)	Stationary
Bhutan	-4.224 (0.000)	-4.290	-4.225 (0.001)	Stationary
India	-3.633 (0.002)	-3.592	-3.633 (0.002)	Stationary
Pakistan	-3.149 (0.004)	-3.510	-3.153 (0.004)	Stationary
Maldives	-4.496 (0.000)	-4.855	-4.483 (0.000)	Stationary
Indonesia	-1.623 (0.096)	-1.606	-5.344 (0.000)	Stationary
Thailand	-2.312 (0.025)	-2.467	-2.312 (0.025)	Stationary
Singapore	-2.955 (0.007)	-3.303	-2.937 (0.007)	Stationary

Parentheses contain p-values, DF-GLS critical values for 1%, 5%, and 10% are -2.755, -1.970, and -1.604 respectively without intercept and trend. Note: The critical values for DF-GLS test statistics have been taken from the MacKinnon simulations, as calculated by EViews.

Table 4: Primary-Surplus-GDP Ratio at First Difference

Country	ADF	DF-GLS	PP	Verdict
Bangladesh	-2.918 (0.007)	-3.209	-2.918 (0.007)	Stationary
Bhutan	-5.114 (0.000)	-5.114	-5.210 (0.000)	Stationary
India	-3.061 (0.006)	-3.164	-5.388 (0.000)	Stationary
Pakistan	-4.693 (0.000)	-4.682	-4.665 (0.000)	Stationary
Maldives	-5.151 (0.000)	-4.684	-6.073 (0.000)	Stationary
Malaysia	-3.749 (0.001)	-4.032	-3.747 (0.001)	Stationary
Thailand	-4.064 (0.001)	-4.077	-5.155 (0.000)	Stationary
Singapore	-2.538 (0.016)	-2.472	-2.697 (0.011)	Stationary

Parentheses contain p-values, DF-GLS critical values for 1%, 5%, and 10% are -2.755, -1.970, and -1.604 respectively without intercept and trend. Note: The critical values for DF-GLS test statistics have been taken from the MacKinnon simulations, as calculated by EViews.

Table 5: Engle-Granger Cointegration Test Result

Country	ADF	Verdict
Bangladesh	-1.313	Unit Root
Bhutan	-2.590	Unit Root
India	-3.288	Stationary
Pakistan	-2.786	Unit Root
Maldives	-4.117	Stationary
Thailand	-2.137	Unit Root
Singapore	-3.110	Stationary

The calculated test statistics value of ADF unit root test is compared with critical values for the Engle-Granger Cointegration tests, given in Enders (2004, p.441), Table C. The critical value for two variables at 10 % level of significance is -3.130.

Table 6: Applicability of MBS Test

Countries	Order of Integration		Cointegration* (Engle-Granger)	Verdict
	Debt-GDP	primary surplus-GDP		
Bangladesh	I(1)	I(1)	No Cointegration	Not Applicable
Bhutan	I(1)	I(1)	No Cointegration	Not Applicable
India	I(1)	I(1)	Cointegration Exists	Applicable
Pakistan	I(1)	I(1)	No Cointegration	Not Applicable
Sri Lanka	I(0)	I(0)	Stationary in Level	Not Applicable
Maldives	I(1)	I(1)	Cointegration Exists	Applicable
Indonesia	I(1)	I(0)	No Cointegration	Not Applicable
Malaysia	I(1)	I(1)	No Cointegration	Not Applicable
Thailand	I(1)	I(1)	No Cointegration	Not Applicable
Singapore	I(1)	I(1)	Cointegration Exists	Applicable

Table 7: Preliminary Results for the Existence of Cointegration

Countries	Stationary in Levels	Cointegration Exists	No Cointegration	Integrated of Different Order
Sri Lanka	√			
Singapore		√		
India		√		
Maldives		√		
Bangladesh			√	
Bhutan			√	
Pakistan			√	
Thailand			√	
Indonesia				√
Malaysia				√

4.3 Panel Unit Root Tests

The unit root tests for single series have been modified to increase the power of the tests for large samples. However, the issue of power becomes even more important for small samples. An alternative way of increasing the power of the test is to merge the data both across time and space, using a panel data approach. The survey papers by Banerjee (1999) and Breitung and Pesaran (2008) provide an extensive overview of the evolution of panel unit root and cointegration tests.

The power of unit root tests increases when the data are stacked together, due to an increase in information. Panel unit root testing has become widely used in Purchasing Power Parity (PPP). The Augmented Dickey Fuller test applied to the series for individual countries does not reject the null hypothesis of a unit root in the real exchange rate. However, panel unit root tests applied to a group of industrialised countries reject the unit root in the real exchange rate, (Coakley and Fuertes, 1997; Choi, 2001).

Panel unit root tests however have their own problems. One has to keep in view the characteristics of the data while selecting an appropriate test. Breitung and Pesaran (2008) have listed these problems. First, the stacking of data across time and space introduces an unobserved heterogeneity in the data. For instance, in our data, although the countries are from one region, that is Asia, and belong to specific groups like SAARC and IMT-GT, the countries are still different from each other in terms of institutions, human capital, trade volumes, political stability and economic development; therefore it is necessary to allow for some degree of difference among countries. Second, the unit root tests and cointegration tests for panel data are difficult

to interpret when the null hypothesis is rejected. For instance, the null hypothesis of a unit root test is nonstationarity; the rejection of the null hypothesis does not mean that all the series in the panel are stationary, depending on which test is used. It can only be claimed that a significant fraction of the cross section data are stationary. Finally, some tests, for example ADF, when applied to panel data produce some biases unlike in the case when they are applied to univariate data (Breitung and Pesaran, 2008).

As the data vary across time (T) as well as across cross-section units (N), another subscript is needed to show the cross-section variation in the series. Following Breitung and Pesaran (2008), let the time series be $\{y_{i0}, \dots, y_{iT}\}$, where i denotes the cross-sectional unit (country); then the simple first order autoregressive, AR(1), process can be written as;

$$y_{it} = (1 + \alpha_i)\mu_i + \alpha_i y_{i,t-1} + \varepsilon_{it} \quad \text{AR(1)}$$

for given initial values, y_{i0} , and with errors ε_{it} that are identically, independently distributed (i.i.d.) across i and t with $E(\varepsilon_{it}) = 0$, $E(\varepsilon_{it}^2) = \sigma_i^2 < \infty$ and $E(\varepsilon_{it}^4) = 0 < \infty$. The above model is also known as a simple dynamic linear heterogeneous panel data model, where μ_i helps in introducing heterogeneity in the model (Pesaran, 2005). The first order autoregressive model can alternatively be written as a Dickey-Fuller (DF) regression:

$$\Delta y_{it} = (1 + \alpha_i)\mu_i + \gamma_i y_{i,t-1} + \varepsilon_{it}$$

where Δ is the difference operator, and $\gamma_i = \alpha_i - 1$. The null hypothesis can be written as

$$H_0: \gamma_1 = \dots = \gamma_N = 0$$

whereas the alternative hypothesis could be

$$H_{1a}: \gamma_1 = \dots = \gamma_N \equiv \gamma \text{ and } \gamma < 0$$

or

$$H_{1b}: \gamma_1 < 0, \dots, \gamma_{N_0} < 0, N_0 \leq N$$

Our discussion is based on the above two alternative hypotheses. Under H_{1a} , the autoregressive parameters are assumed to be identical for all cross section units.

This is known as a homogenous alternative (Breitung and Pesaran 2008). For this purpose the Levin, Lin and Chu (2002) (LLC henceforth) test of a unit root has been applied to panel data. Breitung and Pesaran (2008, p. 5) have commented on the modification of panel unit root tests based on H_{1a} and H_{1b} as “The panel unit root statistics motivated by the first alternative, H_{1a} , pools the observations across the different cross section units before forming the “pooled” statistic, whilst the tests developed against the heterogeneous alternatives, H_{1b} , operates directly on the test statistics for the individual cross section unit using (standardised) simple averages of the underlying individual statistics or their suitable transformations such as rejection probabilities.”

The LLC model allows for fixed effects, time trends and common time effects. It is an extension of a univariate DF test. The LLC uses the pooled cross-section time-series data to test the null hypothesis that each individual time series contains a unit root, against the alternative hypothesis that each time series is stationary. Therefore, γ is assumed the same for all cross-sectional units.

LLC test is criticised for its drawback, that is, if the null hypothesis of a unit root is rejected in one of the series in a pool, it may be enough to reject the unit root for the whole panel (Karlsson and Lothgren, 2000). In other words, ignoring heterogeneity across countries in a panel may depict the whole panel as stationary, even though there may be a significant portion of nonstationary series in the panel. Following the discussion in Im, Pesaran, and Shin (2003), the LLC testing framework of three models can be written as:

$$\Delta y_{it} = \gamma y_{i,t-1} + u_{it}$$

$$\Delta y_{it} = \gamma y_{i,t-1} + \alpha_{1i} + u_{it}$$

$$\Delta y_{it} = \gamma y_{i,t-1} + \alpha_{1i} + \alpha_{2i}t + u_{it}$$

where the error process (u_{it}) is distributed independently across individuals and follows a stationary invertible ARMA process for each individual.

Unlike the LLC test, the Im, Pesaran, and Shin (2003, IPS henceforth) test of a unit root considers the H_{1b} alternative hypothesis. The IPS test allows the parameter γ_i to vary across cross section units. Therefore the alternative hypothesis H_{1b} is known as a heterogeneous alternative. Im, Pesaran, and Shin (2003) consider a stochastic

process, y_{it} which is generated by a first-order autoregressive process or simple dynamic linear heterogeneous panel data model as discussed at the beginning of this section, repeating the AR(1) model as:

$$y_{it} = (1 + \alpha_i)\mu_i + \alpha_i y_{i,t-1} + \varepsilon_{it}$$

Moreover, the IPS test allows for correlation in the residual terms and heterogeneity of the dynamics and error variances, across groups. As IPS combines the outcomes of unit root tests from the cross section units, it therefore needs a balanced panel. In practice, for unbalanced panel data, more simulations are required for appropriate critical values (Maddala and Wu, 1999). Fortunately, our sample consists of a balanced panel; therefore, we do not need to work out simulations for critical values.

We have also applied Fisher PP test that calculates two test statistics i.e. ADF- χ^2 and PP- χ^2 . The Fisher ADF and PP tests the null hypothesis of a unit root against the heterogeneous alternative H_{lb} . The test has been applied with an intercept and linear trend. The Fisher PP test is based on Fisher's (1932) tests results which combine the p -values from individual unit root tests. As discussed by Maddala and Wu (1999) and Choi (2001), let ζ_i be the p -value from any individual unit root test for cross-section i , then under the null of a unit root for all N cross-sections, the following asymptotic result holds:

$$-2 \sum_{i=1}^N \log(\zeta_i) \rightarrow \chi_{2N}^2$$

In addition, Choi demonstrates that:

$$Z = \frac{1}{\sqrt{N}} \sum_{i=1}^N \varphi^{-1}(\zeta_i) \rightarrow N(0, 1)$$

where φ^{-1} is the inverse of the standard normal cumulative distribution function (Choi, 2001; Hlouskova and Wagner, 2005).

Although we have used a battery of panel unit root tests, such as, LLC, Fisher ADF and PP, and IPS, but we mainly rely on Fisher ADF and PP, and IPS tests of unit root rather than LLC test only. Particularly if Fisher ADF and PP, and IPS suggest that the series is nonstationary in level. This is because LLC has a drawback of rejecting the null hypothesis of unit root for the whole panel even though there may be a significant portion of nonstationary series in the panel (Karlsson and Lothgren, 2000).

As it will be shown in the results the LLC rejects the null hypothesis of unit root for some series while all the other tests do not reject the null hypothesis based on available evidences. Interestingly, the LLC rejects the null hypothesis only for the model with intercept and linear trend.

4.4 Panel Unit Roots Tests Result MBS

Model Based Sustainability requires a significant response of the primary surplus to changes in debt for fiscal sustainability. In order to use the regression equation suggested by Bohn (2005), the time-series processes generating the primary surplus and debt need to be examined for unit roots and cointegration. The next section presents the panel unit root tests results applied to the primary surplus and debt as percentages of GDP.

4.4.1 All Countries

The panel unit root results for the group of all countries are shown in Table 8. All the tests are applied to models with and without linear trend. The Table contains the results for the central government debt-GDP ratio, the primary surplus-GDP ratio, real debt and real primary surplus. The primary surplus-GDP ratio, in a model without a linear trend, is stationary in levels as confirmed by all three tests, using 10 % level of significance in all the cases. But, it becomes nonstationary upon adding the linear trend in the model. The two tests by Fisher and IPS simultaneously do not reject the null of a unit root while only the LLC test rejects the null of a unit root. As discussed in the commentary on the LLC test, this test has a tendency towards rejection of the null hypothesis. Therefore, based on the results of the Fisher and IPS tests for a unit root, the primary surplus-GDP ratio is regarded as nonstationary for the model including an intercept and a linear trend.

Similarly, the results are shown for the central government debt-GDP ratio. All the tests consistently suggest that the debt-GDP ratio is nonstationary whether the linear trend is omitted or added. However, the series becomes stationary in first differences, i.e. $I(1)$, the results are not reported in order to save space. The three panel unit root tests were also applied to the real primary surplus and real debt. Again the unit root tests suggest the presence of a unit root in levels and the series become stationary in first differences.

As discussed in the data section, Jaimovich and Panizza (2008) have collected debt-GDP data for 89 countries. We have selected the countries that are in our sample and applied panel unit root tests. The data include the following countries, Pakistan,

Thailand, Bangladesh, Bhutan, Malaysia, Singapore, Nepal and Sri Lanka. The results of panel unit root tests for the Jaimovich-Panizza data are shown in Table 9. The LLC and IPC reject the null hypothesis at the 10 % level of significance. Similarly, the Fisher test statistic $PP-\chi^2$ rejects the null at the 10 % level of significance. Hence, the debt-GDP ratio in the Jaimovich-Panizza data set is stationary in levels for the model without a linear trend. But, for the model with a linear trend, all the tests consistently do not reject the null hypothesis of a unit root except for LLC. Hence, the Jaimovich-Panizza debt-GDP ratio is nonstationary due to the presence of a unit root for the model with a linear trend. The presence of a unit root in the Jaimovich-Panizza dataset strengthens our argument for considering central government debt as a nonstationary variable due to the presence of a unit root.

4.4.2 SAARC Countries

The panel unit root tests were applied to the SAARC countries data as shown in Table 10. The primary-surplus-GDP ratio is stationary in levels for the model without a trend as suggested by all the tests being significant. However, the series is nonstationary due to unit root when a linear trend is included in the model. The primary surplus-GDP ratio becomes stationary in first differences. Similarly, the other three series, i.e. central government debt-GDP ratio, real primary surplus, and real debt are examined for a unit root. All the tests decisively suggest that all the above three series are nonstationary in levels due to the presence of a unit root but becomes stationary when first differenced, the results are not reported in order to save space.

4.4.2 IMT-GT Countries

Finally, the panel tests were applied to the group of IMT-GT series containing Indonesia, Malaysia, and Thailand. The primary-surplus-GDP ratio, debt-GDP ratio and real debt are clearly nonstationary, regardless of the addition or omission of a linear trend. The results can be seen in Table 11. However, in contrast to the results of other two groups (i.e. all-countries and SAARC countries) the real primary surplus is stationary for a model without a trend in levels. All the series become stationary in first differences, i.e. $I(1)$.

As shown by the panel unit root tests results, the series are nonstationary in levels, due to a unit root. Enders (2004) has listed four implications for nonstationary variables:

1. If all the variables are stationary in levels then the ordinary least square (OLS) regression is appropriate.

2. If the time-series variables are integrated of different orders then the regression results using such variables are meaningless.
3. If the series are integrated of the same order but the error term contains a stochastic trend, the regression is spurious. The results from such spurious regression are useless because the errors are permanent.
4. Finally, if the series are integrated of the same order and the error term is stationary in levels these series are said to be cointegrated.

Examining the time-series variables for a unit root has become common practice and any further analysis, e.g. MBS based on simple OLS regression, would produce potentially misleading results without practicing the unit root tests first. Any policy action based on these results may lead to severe problems. For instance, in the presence of a unit root or absence of cointegration between the series, if the MBS (based on OLS regression) results suggest that fiscal policy is sustainable and if it is not sustainable in reality, it may unnecessarily induce the governments to carry on with the same policy. Likewise, if the MBS results suggest non-sustainable fiscal policy, while it is sustainable, the government may stop using fiscal policy even in critical situations.

In the next section the series are examined for cointegration. This is related to Enders' (2004) points 3 and 4; hence, the next step is to examine the series for any long-run relationship, i.e. cointegration. Although the presence of cointegration allows the MBS to be applied in levels, the presence of cointegration (or a long-run relationship) also confirms the sustainability of fiscal policy. Hence, in this case, there is no need for further evaluation of fiscal policy such as MBS tests of sustainability. This is discussed in the following sections.

Table 8: Panel Unit Root Test for MBS (Pool of All Countries)

Series		LLC	Fisher		IPS	Verdict
			ADF- χ^2	PP- χ^2		
Primary-Surplus-GDP ratio	Intercept	-2.639	36.709	37.506	-2.394	Stationary
	Only	(0.004)	(0.013)	(0.010)	(0.008)	I(0)
	Intercept and Trend	-1.295 (0.098)	24.196 (0.234)	27.547 (0.121)	-0.281 (0.390)	Unit Root I(1)
Debt-GDP ratio	Intercept	-0.795	25.353	16.179	-0.641	Unit Root
	Only	(0.213)	(0.188)	(0.705)	(0.261)	I(1)
	Intercept and Trend	-1.407 (0.080)	18.337 (0.565)	12.723 (0.899)	0.001 (0.501)	Unit Root I(1)
Real primary surplus	Intercept	-0.240	26.750	24.777	-0.187	Unit Root
	Only	(0.405)	(0.142)	(0.210)	(0.426)	I(1)
	Intercept and Trend	-0.991 (0.161)	20.417 (0.432)	18.255 (0.571)	0.709 (0.761)	Unit Root I(1)
Real Debt	Intercept	2.430	19.308	6.136	3.149	Unit Root
	Only	(0.993)	(0.502)	(0.999)	(0.999)	I(1)
	Intercept and Trend	0.077 (0.531)	13.851 (0.838)	9.626 (0.975)	1.383 (0.917)	Unit Root I(1)

Parenteses contain the p-values, LLC: Levin, Lin and Chu unit root test, PP- χ^2 : Fisher Chi-Square test, PP-Z: Fisher Choi Z-statistics. IPS: Im, Pesaran and Shin.

Table 9: Panel Unit Root Test for Jaimovich-Panizza Data Set

Series	LLC	Fisher		IPS	Verdict	
		ADF- χ^2	PP- χ^2			
Jaimovich & Panizza	Intercept	-2.329	28.196	25.810	-1.440	Unit Root
	Only	(0.010)	(0.030)	(0.057)	(0.075)	I(0)
(2008) Debt-GDP* ratio	Intercept and	-2.962	17.279	12.242	0.094	Unit Root
	Trend	(0.002)	(0.368)	(0.727)	(0.537)	I(1)

Parentheses contain the p-values, LLC: Levin, Lin and Chu unit root test, PP- χ^2 : Fisher Chi-Square test, PP-Z: Fisher Choi Z-statistics. IPS: Im, Pesaran and Shin, *Jaimovich-Panizza Data Set is for the following countries: Pakistan, Thailand, Bangladesh, Bhutan, Malaysia, Singapore, Nepal and Sri Lanka.

Table 10: Panel Unit Root Test in Levels for Pool of SAARC

Series	LLC	Fisher		IPS	Verdict	
		ADF- χ^2	PP- χ^2			
Primary-Surplus-GDP ratio	Intercept	-2.278	25.571	26.546	-2.285	Stationary
	Only	(0.011)	(0.012)	(0.009)	(0.011)	I(0)
	Intercept and	-1.178	14.346	18.050	-0.630	Unit Root
	Trend	(0.119)	(0.279)	(0.114)	(0.264)	I(1)
Debt-GDP ratio	Intercept	-0.916	17.134	5.628	-0.578	Unit Root
	Only	(0.180)	(0.145)	(0.934)	(0.282)	I(1)
	Intercept and	-1.520	12.855	5.677	-0.432	Unit Root
	Trend	(0.064)	(0.380)	(0.931)	(0.333)	I(1)
Real primary surplus	Intercept	1.073	9.406	8.777	1.306	Unit Root
	Only	(0.858)	(0.668)	(0.722)	(0.904)	I(1)
	Intercept and	-0.747	10.514	8.156	0.632	Unit Root
	Trend	(0.228)	(0.571)	(0.773)	(0.736)	(1)
Real Debt	Intercept	1.175	16.238	3.528	1.673	Unit Root
	Only	(0.880)	(0.181)	(0.991)	(0.953)	I(1)
	Intercept and	2.224	7.865	3.560	1.504	Unit Root
	Trend	(0.987)	(0.796)	(0.990)	(0.934)	I(1)

Parentheses contain the p-values, LLC: Levin, Lin and Chu unit root test, PP- χ^2 : Fisher Chi-Square test, PP-Z: Fisher Choi Z-statistics. IPS: Im, Pesaran and Shin.

Table 11: Panel Unit Root Test in Levels for Pool of IMT-GT

Series	LLC	Fisher		IPS	Verdict	
		ADF- χ^2	PP- χ^2			
Primary-Surplus-GDP ratio	Intercept	-1.495	9.979	9.791	-1.206	Unit Root
	Only	(0.067)	(0.125)	(0.134)	(0.114)	I(1)
	Intercept and Trend	-1.437	9.818	9.469	-0.747	Unit Root
		(0.075)	(0.133)	(0.149)	(0.228)	I(1)
Debt-GDP ratio	Intercept	-0.474	7.636	9.980	-0.669	Unit Root
	Only	(0.318)	(0.266)	(0.125)	(0.252)	I(1)
	Intercept and Trend	-0.671	4.926	6.490	0.286	Unit Root
		(0.251)	(0.553)	(0.371)	(0.613)	I(1)
Real primary surplus	Intercept	-1.484	15.260	15.051	-2.025	Stationary
	Only	(0.069)	(0.018)	(0.020)	(0.021)	I(0)
	Intercept and Trend	-1.780	9.886	10.047	-0.929	Unit Root
		(0.038)	(0.130)	(0.123)	(0.176)	I(1)
Real Debt	Intercept	0.593	3.069	2.608	1.273	Unit Root
	Only	(0.724)	(0.800)	(0.856)	(0.898)	I(1)
	Intercept and Trend	-1.985	5.846	6.061	-0.361	Unit Root
		(0.024)	(0.441)	(0.416)	(0.359)	I(1)

Parentheses contain the p-values, LLC: Levin, Lin and Chu unit root test, PP- χ^2 : Fisher Chi-Square test, PP-Z: Fisher Choi Z-statistics. IPS: Im, Pesaran and Shin.

4.5 Panel Cointegration Tests

As the central government primary surplus and debt as a percentage of GDP are I(1) in most of the cases, we therefore check for cointegration. As discussed earlier, researchers have a little more faith in panel unit root and cointegration tests than simple time-series tests due to the increased power of the tests, although the panel cointegration tests come with their own problems and issues. These problems are common for panel unit root tests and panel cointegration tests; some of these were discussed earlier in the commentary on panel unit root tests.

Breitung and Pesaran (2008) have reviewed the panel cointegration tests including Pedroni (2004), Kao (1999) and Johansen (1995). The Pedroni (2004) and Kao (1999) tests of panel cointegration are based on residual based, whereas the Johansen (1995) is a multivariate test of panel cointegration that is based on VAR representation of variables. They claim that the residual based tests of cointegration have been emphasised usually more, as compared to the tests based on VAR. As we are interested in the cointegration relationship between only two series, i.e., primary-

surplus-GDP and Debt-GDP; therefore the tests based on multiple variables such as Johansen (1995) would not be appropriate.

As shown in Table 6, the cointegration exists for some individual countries, such as, India Maldives and Singapore; therefore the residual based tests are more appropriate as suggested by Breitung and Pesaran (2008). We have chosen to apply Pedroni (2004) test of cointegration for the following reasons. First, unlike Kao (1999) the Pedroni (2004) test has the ability to test the null hypothesis in heterogeneous framework. Moreover the Pedroni (2004) test of cointegration is applicable to a model with linear trend whereas the Kao (1999) test can only be applied to a model without linear trend.

We applied the Pedroni (1999, 2004) test of cointegration to series with the same order of integration. These tests are extensions of the Engle-Granger test of cointegration based on residuals. Pedroni's (1999, 2004) test allows both the short-run dynamics and long-run slope coefficients to be heterogeneous across individual members of the panel. Pedroni (2004) has derived the limiting distributions and these are free from nuisance parameters. Wagner (2008) and Wagner and Hlouskova (2010) have recently evaluated the performance of panel cointegration methods. They compared a battery of cointegration tests in a large-scale simulation study including the tests developed by Pedroni (1999, 2004), Westerlund (2005), Larsson et al. (2001) and Breitung (2005). They concluded that, amongst the single-equation tests, where the null hypothesis was that of no cointegration, the Pedroni test of cointegration performed best, whereas all other tests were partly severely undersized and had low power. Furthermore, among the seven panel cointegration test statistics of Pedroni, the group ADF and panel ADF are best for small samples as shown by Pedroni in his simulation results. Therefore, keeping in mind the small sample, we would have more faith in the results of Pedroni's panel ADF and group ADF compared to other test statistics.

The Pedroni test is an extension of the Engle and Granger (1987) two-step test of cointegration. In the first step the cointegration equation is estimated separately for each member of the panel. In the second step, the residuals are tested for a unit root. If the null hypothesis of a unit root is rejected, then cointegration exists but the cointegration vector may be different for each cross section. The Pedroni tests use the following system:

$$y_{it} = \alpha_i + x_{it}\beta_i + u_{it} \quad i = 1, 2, 3 \dots N,$$

$$t = 1, 2, 3 \dots T$$

$$x_{it} = x_{it-1} + \varepsilon_{it}$$

where α_i are individual constant terms, β_i is the slope parameter, u_{it} are stationary disturbance terms and y_{it} and x_{it} are integrated of order one for all i .

The error terms in the second step can be pooled in two ways, either in the panel (within) or between (group) dimensions of the panel, which leads to seven test statistics. Pedroni proposed these seven test statistics, out of which 4 are for the panel and 3 are for the groups. In the case of within or panel statistics the first order autoregressive parameter is restricted to be the same for all the cross sections i.e. $\beta_i = \beta < 1 \forall i$. Hence, if the null hypothesis of a unit root in the error terms is rejected, the series are cointegrated for all the cross sections. On the other hand, in the group (between) statistics the autoregressive parameter is allowed to vary across the cross sections; in this case the slope parameter is β_i , with subscript i . The group statistic for a group is the average of all the individual statistics drawn from individual cross sections. The rejection of a null hypothesis of a unit root in the error term indicates that cointegration does exist at least for one member of the panel. Hence the group statistics consider the heterogeneity among the cross sections. The homogenous and heterogeneous null and alternative hypotheses can be written as:

Homogenous:	$H_0: \beta_i = 1,$	$H_1: \beta_i = \beta < 1 \forall i$
Heterogeneous:	$H_0: \beta_i = 1,$	$H_1: \beta_i \leq 1 \forall i$

The next section presents the results of Pedroni's panel cointegration tests for the group of all-countries, SAARC and IMT-GT.

4.5.1 Cointegration Results for All Countries

The panel cointegration test results applied to time-series processes both as percentages of GDP and in real terms are shown in Tables 12, 13, and 14. Table 12 shows the panel cointegration results for a panel of all countries. As shown in Table 8 the primary-surplus-GDP ratio and the debt-GDP ratio are integrated of the same order only for unit root models with fixed effects (intercept) and a linear trend. Therefore, the Pedroni test of cointegration is applied to variables as percentages of GDP with a linear trend in the model. Similarly, the panel cointegration tests are applied to the real

variables with and without linear trend after having confirmed the same order of integration.

The second column of Table 12 shows Pedroni's seven test statistics for GDP ratios with an intercept and a linear trend. The two panel statistics, panel-v and panel-rho do not reject the null of no cointegration, whereas panel-PP does not reject the null of no cointegration at the 5% level of significance and finally panel-ADF rejects the null hypothesis. Similarly, for group statistics only, group-rho does not reject the null of no cointegration while the other two, i.e. group-PP and group-ADF, reject the null of no cointegration.

For small samples the researcher is advised to be careful when imposing cointegration or no cointegration. For instance, Gutierrez (2003, p.109) states that for small-T panels there is a risk of modelling the whole panel as a non-cointegrated relationship, because of the low power of the tests even when a large number of cointegrated relationships exist. Moreover, the difference in the results of Pedroni's seven test statistics may lead one to different conclusions. However, the simulation results drawn in Pedroni (2004)¹¹ suggest that group-ADF or panel-ADF is more appropriate when the sample is small. Hence according to the test results of the group-ADF and panel-ADF tests, cointegration exists for the primary surplus and debt as percentages of GDP when an intercept and a linear trend are included in the model. We can also claim that cointegration exists for the real variables both for intercept only model and for the model with intercept and a linear trend.

The existence of cointegration between primary surplus-GDP and debt-GDP ratios suggests that fiscal policy is sustainable as some of the studies suggested, such as, Chalk and Hemming (2000) and Trehan and Walsh (1988). The existence of cointegration however allows the MBS to be applied in levels due to the existence of a long-run relationship. But, at the same time, it also implies that fiscal policy is sustainable. Therefore, there is no need for further evaluation of sustainability of fiscal policy using MBS tests of sustainability. However, we apply the MBS test of sustainability in order to see what the results imply regarding sustainability.

Studies based on the MBS, such as, Mendoza and Ostry (2008) and Ghatak and Fung (2007) have used the primary surplus-GDP and debt-GDP ratio. Therefore, we intend to apply MBS to the group of all-countries to a model without a linear trend and to a model with a linear trend. It is also known from Table 8 that cointegration

¹¹ I am thankful to Peter Pedroni for his comments on the panel cointegration results.

exists only for the model with a linear trend. Therefore, the results drawn from an OLS regression (MBS) for the model without linear trend would be meaningless.

We have applied MBS to both models with trend and without a trend; the results are presented in section 4.5.5.

4.5.2 Cointegration Results for SAARC Countries

The panel of SAARC countries consists of lower income countries. The cointegration results for SAARC countries are shown in Table 13. Again, the results of the Pedroni test statistics of cointegration are shown both for GDP ratios and real variables. The panel unit root test results shown in Table 9 show that the primary surplus and debt both as percentages of GDP and in real terms are integrated of order one except the primary surplus for the model with an intercept only. Therefore, the cointegration test can be applied to all other cases. The panel cointegration test are applied to the following three cases: i) primary surplus and debt as GDP ratios for a model with intercept and trend, ii) real primary surplus and real debt with intercept only and iii) real primary surplus and real debt with intercept and trend. Again, as discussed earlier the test results for panel ADF and group ADF suggest that cointegration exists between primary surplus and debt as percentages of GDP and also for the real variables.

4.5.3 Cointegration Results for IMT-GT Countries

Table 14 shows the panel cointegration tests results for IMT-GT, the group of higher income countries of Asia. The Pedroni test of cointegration does not reject the null of no cointegration for the variables as percentages of GDP; however the results for real variables suggest cointegration exists. Hence the MBS is not applicable for the variables as percentages of GDP.

In the next section, the results of MBS are presented for all countries. As discussed earlier, cointegration exists for the variables as percentages of GDP when the model includes an intercept and a linear trend. However, the different order of integration between primary surplus-GDP ratio and debt-GDP ratio, with an intercept only, confirms that the MBS cannot be applied in levels. Knowing the results of cointegration testing would help us in evaluating the results of MBS if applied to a model with an intercept only and a model with intercept and trend. The results are shown in Tables 15 and 16.

Table 12: Panel Cointegration Tests for All-Countries

Pedroni (Engle Granger) test of Panel Cointegration			
Pools	GDP Ratios	Real Variables	
	Intercept and Trend	Intercept Only	Intercept and Trend
Panel-v	0.139 (0.445)	1.311 (0.095)*	-1.555 (0.940)
Panel-rho	0.943 (0.827)	-5.061 (0.000)*	-2.769 (0.003)*
Panel-PP	-1.640 (0.051)*	-6.700 (0.000)*	-8.078 (0.000)*
Panel-ADF	-2.500 (0.006)*	-7.083 (0.000)*	-5.568 (0.000)*
Group-rho	1.838 (0.967)	0.864 (0.806)	1.619 (0.947)
Group-PP	-3.212 (0.001)*	-0.553 (0.290)	-1.938 (0.026)*
Group-ADF	-4.645 (0.000)*	-1.992 (0.023)*	-2.545 (0.005)*

Parentheses contain the p-values, Linear Trend in the data while there is no trend in the cointegrating equation, *shows the rejection of null of no cointegration at 10% or less than 10% level of significance.

Table 13: Panel Cointegration Tests for SAARC Countries

Pedroni (Engle Granger) test of Panel Cointegration			
Pools	GDP Ratios	Real Variables	
	Intercept and Trend	No Trend	Intercept and Trend
Panel-v	0.443 (0.329)	1.758 (0.039)*	0.500 (0.309)
Panel-rho	0.543 (0.707)	-0.764 (0.222)	-1.012 (0.156)
Panel-PP	-1.633 (0.050)*	-1.161 (0.123)	-2.062 (0.020)*
Panel-ADF	-2.970 (0.001)*	-1.353 (0.088)*	-2.058 (0.020)*
Group-rho	1.557 (0.940)	1.084 (0.861)	1.317 (0.906)
Group-PP	-2.973 (0.001)*	-0.078 (0.469)	-1.932 (0.027)*
Group-ADF	-4.480 (0.000)*	-1.365 (0.086)*	-2.450 (0.007)*

Parentheses contain the p-values, Linear Trend in the data while there is no trend in the cointegrating equation, *shows the rejection of null of no cointegration at 10% or less than 10% level of significance.

Table 14: Panel Cointegration Tests for IMT-GT Countries

Pools	Pedroni (Engle Granger) test of Panel Cointegration		
	GDP Ratios		Real Variables
	Intercept Only	Intercept and Trend	Intercept and Trend
Panel-v	0.276 (0.391)	-0.639 (0.739)	-0.993 (0.840)
Panel-rho	0.039 (0.516)	0.750 (0.773)	-1.702 (0.044)*
Panel-PP	-0.403 (0.343)	-0.099 (0.460)	-4.881 (0.000)*
Panel-ADF	-0.422 (0.336)	0.065 (0.526)	-3.387 (0.000)*
Group-rho	0.387 (0.651)	0.908 (0.818)	0.540 (0.705)
Group-PP	-0.292 (0.385)	-0.680 (0.248)	-1.436 (0.075)*
Group-ADF	-0.284 (0.388)	-1.099 (0.136)	-1.147 (0.126)

Parentheses contain the p-values, Linear Trend in the data while there is no trend in the cointegrating equation, * shows the rejection of null of no cointegration at 10% or less than 10% level of significance.

4.5.5 MBS Results

We started our analysis of the MBS by examining whether unit roots exist in the time-series processes of the series for individual countries. The results showed that MBS cannot be applied in levels for all the countries except Sri Lanka in sample. The series that were integrated of the same order, i.e. $I(1)$, were then tested for the existence of cointegration and it exists only for three countries in the panel; those are India, Maldives and Singapore. In the second section of our analysis, we applied panel unit root tests to the group of all-countries, SAARC, and IMT-GT. Again the series were nonstationary due to unit roots in levels. Once again we examined the panel data of three groups for cointegration using the Pedroni test of panel cointegration.

The MBS test of sustainability is applied to primary surplus-GDP and debt-GDP ratios of all-countries both Model-I (without a linear trend) and Model-II (with a linear trend). The results are shown in Tables 15 and 16. Column I of Tables 15 and 16 shows the results of the MBS test when the model includes GVAR, YVAR, and the first-order autoregressive term $AR(1)$. Column II shows the results without the autoregressive term $AR(1)$, while column III shows the results with only the autoregressive term $AR(1)$. In order to adjust for heteroskedasticity, White cross-section standard errors are used and they are shown in the square brackets.

The results shown for the model without a linear trend are shown in Table 15. It shows that the coefficient of debt in all the columns is negative and insignificant except for the model with only GVAR and YVAR, i.e. Column II. The coefficients of GVAR and YVAR are negative as predicted by Barro's tax smoothing model and are statistically significant. The R^2 values are above 85% for all the models. The

coefficient of debt is important for sustainability. But the negative value for the coefficient is meaningless. Because, the coefficient of debt-GDP is greater than 0 but less than 1, it means that government is reacting to increases in debt by increasing the primary surplus, or the fiscal policy is sustainable. Whereas if the coefficient is greater than 1 the government is said to be accumulating infinite assets; see for example Mendoza and Ostry (2008). However, there is no explanation given for the negative coefficient. The negative coefficient mathematically implies that the government is not even responding to increases in the debt-GDP ratio, by increasing the primary-surplus-GDP ratio; rather it is decreasing the primary-surplus-GDP ratio over time.

The results for the model with a linear trend are given in Table 16 and they are similar to the results of Table 15. The only difference is that Table 16 includes a linear trend in the model but the coefficient of debt and other explanatory variables are same qualitatively and in terms of statistical significance. This explains that the addition of a linear trend in the model does not make any important difference.

Examining the response of government towards changes in debt is by no means a worthless approach but the analysis of time-series variables in the presence of I(1) variables does not allow such analysis. A detailed discussion of the applicability of the MBS and a comparison between MBS and standard tests of unit roots and cointegration will be presented in section 4.6.

Table 15: MBS Panel Regression All Countries Without Linear Trend

Variables	Dependent Variable: Primary-Surplus-GDP Ratio		
	GDP Ratios (All countries)		
	I	II	III
Debt-GDP Ratio	-0.031 [0.024] (0.206)	-0.043 [0.017] (0.013)	-0.049 [0.033] (0.140)
Expenditures Gap (GVAR)	-5.85E-07 [1.70E-07] (0.001)	-2.60E-07 [9.06E-08] (0.005)	
Output Gap (YVAR)	-0.639 [0.296] (0.033)	-0.351 [0.132] (0.009)	
Country AR(1) Coeffs.	0.508 [0.086] (0.000)		0.480 [0.084] (0.000)
Adj. R ²	0.905	0.864	0.893
No. Of Observations	139	149	139

Parentheses contain p-values, square brackets contains the White cross-section standard errors Output and government expenditures gaps are percent deviations from Hodrick-Prescott trends.

Table 16: MBS Panel Regression All Countries With Linear Trend

Variables	Dependent Variable: Primary Surplus-GDP Ratio		
	GDP Ratios (All countries)		
	I	II	III
Debt-GDP Ratio	-0.022 [0.026] (0.393)	-0.035 [0.017] (0.039)	-0.043 [0.030] (0.158)
Expenditures Gap (GVAR)	-4.25E-07 [2.31E-07] (0.068)	-1.40E-07 [1.02E-07] (0.173)	--
Output Gap (YVAR)	-0.673 [0.309] (0.031)	-0.305 [0.139] (0.030)	--
Country AR(1) Coeffs.	0.501 [0.086] (0.260)		0.454 [0.099] (0.000)
Linear Trend	0.501 [0.086] (0.000)	-0.001 [0.0004] (0.020)	-0.001 [0.001] (0.315)
Adj. R ²	0.905	0.865	0.893
No. Of Observations	139	149	139

Parentheses contain p-values, square brackets contains the White cross-section standard errors Output and government expenditures gaps are percent deviations from Hodrick-Prescott trends.

4.6 Summary of MBS and Ad Hoc Sustainability Test Results

Ad hoc sustainability tests are based on the standard tests of stationarity and cointegration. The former requires the discounted debt to be stationary, while the latter requires cointegration between surpluses and debt. Some other tests of cointegration require cointegration between expenditures (either with interest payments or net of interest payments) and revenues; similarly some require cointegration between net of interest expenditures, revenues and interest payments in levels or as a percentage of GDP. In contrast, MBS requires a significant response of the primary surplus to changes in debt. The MBS models suggested by Bohn, tries to control for temporary shocks by including temporary government expenditure shocks and output shocks in the MBS model. These shocks are derived in terms of trends from government expenditures and output. Mendoza and Ostry (2008) have discussed how to derive these shocks from government expenditures and output (GDP).

The applicability and interpretation of ad hoc sustainability tests are simple. For instance, the presence of a unit root in discounted debt or the first difference of debt indicates that the government is not following the IBC. Similarly, if surpluses (or

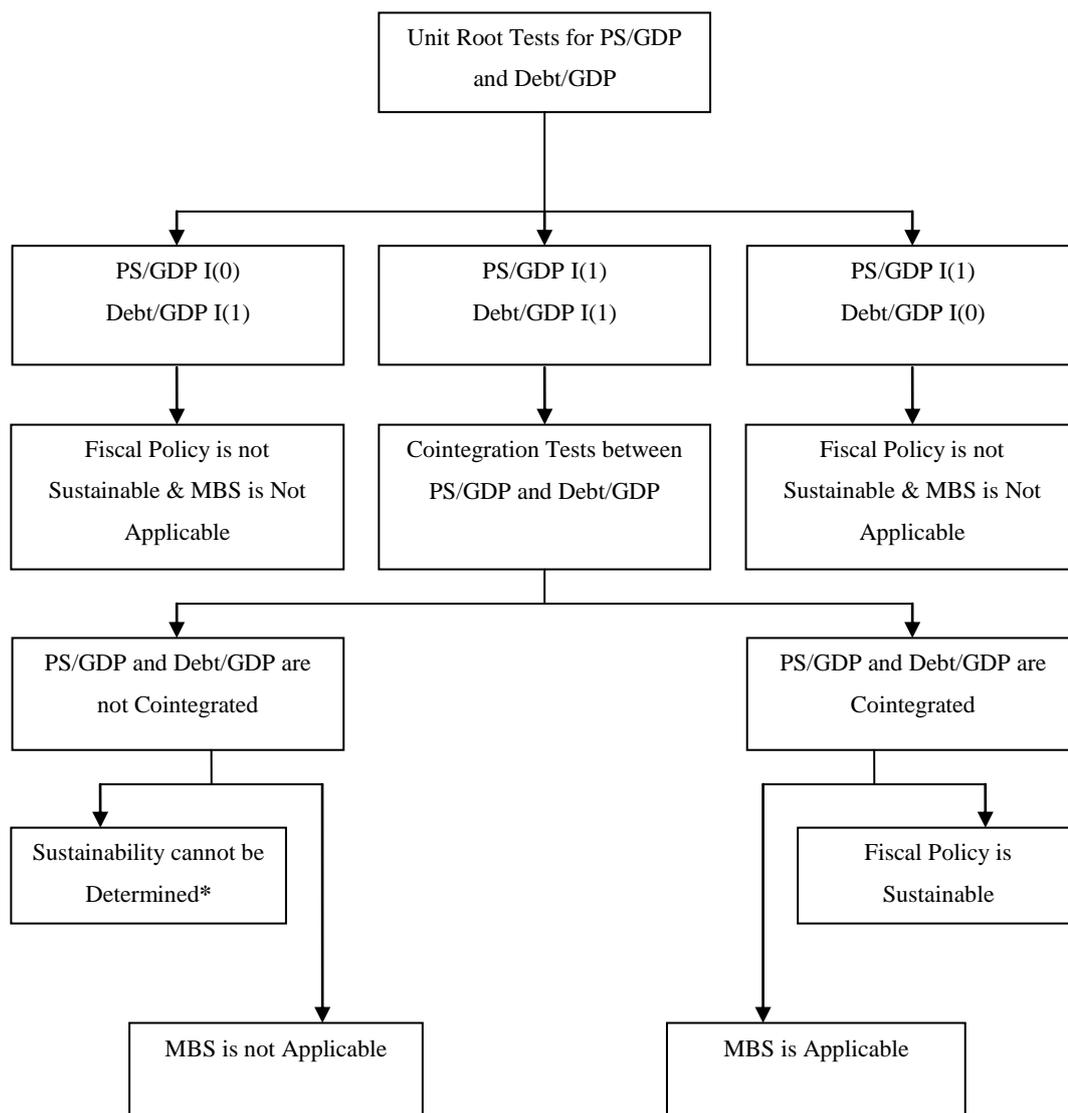
primary surpluses) and debt are not cointegrated then fiscal policy is not regarded as sustainable. In addition, the ad hoc sustainability tests do not violate the time-series properties. On the other hand, the MBS test regresses primary surplus on debt. A significant response of government via its primary surplus to changes in debt is sufficient for sustainability of fiscal policy. The coefficient of debt should lie between 0 and 1. A value greater than 1 means government is playing a Ponzi scheme; however any value below 0 cannot be interpreted either against or in favour of sustainability. Although the addition of temporary shock variables is considered as necessary in the model, estimated coefficients on these variables are often insignificant (i.e. the null hypothesis is accepted). The summary of testing procedure of ad-hoc and MBS tests of sustainability is given in Figure 9.

The majority of researchers have used standard tests of unit roots and cointegration for the purpose of fiscal sustainability. We have reproduced the Table of empirical evidence from Afonso (2004) and added some new studies to it; the Table is given in the Appendix. The studies based on MBS tests are given in the top rows of Table 17. The MBS test was used by Bohn (1998; 2005), Greiner et al (2006), Ghatak and Fung (2007), and Mendoza and Ostry (2008), while all the other studies given in Table 17 used the so called tests of ad-hoc sustainability.

An important point of concern about MBS is that its applicability is conditional on the existence of stationarity or cointegration as discussed so far. Hamilton and Flavin (1986) proposed that a discounted debt or surplus can be tested for a unit root. If it is stationary, fiscal policy is regarded as sustainable; otherwise fiscal policy cannot be regarded as sustainable. Similarly, various studies have applied the tests of cointegration between primary surplus/deficit and debt. For instance, Trehan and Walsh (1991) applied their cointegration test to US debt and primary deficit over the period 1964-1984. This is the same period as used by Hamilton and Flavin (1986). Haug (1995) applied cointegration tests to surplus and debt. Similarly, various studies have checked debt and surplus for stationarity as shown in Table 17.

Hence, based on our results and the above discussion, we have concluded that the applicability of MBS is conditional on the existence of either stationarity or cointegration of the series. Moreover, the sustainability of fiscal policy can be determined by the existence of stationarity or cointegration, as for instance, by Chalk and Hemming (2000) and Trehan and Walsh (1988); therefore MBS does not contribute to the verdict about sustainability.

Figure 9: Sustainability of Fiscal Policy through Tests of Cointegration and Model Based Sustainability (MBS)



*According to Bohn (2007), if the primary surplus-GDP and Debt-GDP ratios are not cointegrated then the sustainability cannot be determined because the existence of cointegration is not a necessary condition for sustainability.

Chapter 5 : Conclusion

In this thesis, we have explored the issue of sustainability of fiscal policy for ten Asian Countries. The data are collected from different sources but all the sources are publicly accessible. The sustainability of fiscal policy was addressed by using two well-known methods for checking sustainability: ad hoc sustainability tests (i.e. standard tests of unit roots and cointegration) and MBS tests. Panel unit root and cointegration tests have been used for this purpose.

The applicability of the MBS approach was examined for primary surplus-GDP and debt-GDP ratios. We have analysed the applicability of MBS both for variables in real terms and as percentages of GDP. Debt is nonstationary decisively at individual-country level, whereas the primary surplus is either inconclusive or stationary. The difference in orders of integration rules out the existence of a cointegration relationship. However, cointegration exists in the case of India, Maldives and Singapore for which the MBS can be applied in levels.

The data were then examined for stationarity and cointegration using panel unit root and cointegration tests on three groups, i.e. all-countries, SAARC and IMT-GT. The panel unit root tests again suggested the series are nonstationary due to unit roots in level. The panel cointegration tests were then applied to pairs of series (i.e. primary surplus and debt) with the same order of integration. Cointegration exists only for primary surplus-GDP and debt-GDP ratios when a linear trend is included in the cointegrating equation, while, for the model with a linear trend, cointegration does not exist. The MBS test of sustainability was then applied to both models of primary-surplus-GDP and debt-GDP ratios of all countries. The results of MBS test are similar and do not change after addition of a linear trend in the model.

The results show that MBS is conditional on the existence of stationarity or cointegration between the series. The sustainability of fiscal policy can be determined by the existence of stationarity or cointegration, as for instance in the studies by Chalk and Hemming (2000) and Trehan and Walsh (1988); therefore MBS either adds relatively little value or is a potentially unreliable approach to assessing the sustainability of fiscal policy.

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Appendices

Appendix 1: Data Source

Pakistan, India, Bhutan, Bangladesh, Sri Lanka, Maldives, Indonesia, Malaysia, Thailand, Singapore

Pakistan

Gross Domestic Product: GDP by industrial origin at current factor cost, Source: Key Indicators of Asia and the Pacific 2009, available at the Asian Development Bank (ADB) website.¹²

Federal Government Revenues: Source: Annual Economic Surveys of Pakistan, Ministry of Finance website.¹³

Federal Government Expenditures: Source: Annual Economic Surveys of Pakistan, Ministry of Finance website.

Consumer Price Index (CPI): Source: International Financial Statistics, Code: 56464ZF.

Federal Government Debt: Source: Source: International Monetary Fund Country Reports (IMF-CR henceforth) available at IMF website.¹⁴

Central Government Interest Payments: Source: Annual Economic Surveys of Pakistan, Ministry of Finance website.

India

Gross Domestic Product: Source: Key Indicators of Asia and the Pacific 2009, Section: National Accounts

Central Government Expenditures: Source: Key Indicators of Asia and the Pacific 2009, Section: Government Finance

Central Government Revenues: Source: Key Indicators of Asia and the Pacific 2009, Section: Government Finance

Consumer Price Index: Source: International Financial Statistics, Code: 53464ZF.

Central Government Interest Payments: Source: International Financial Statistics, Code: 534c24BA.

¹² <http://www.adb.org/statistics> (October 2009)

¹³ <http://www.finance.gov.pk> (October 2009)

¹⁴ <http://www.imf.org/external/pubind.htm> (October 2009)

Central Government Debt: Source: International Financial Statistics, Code: 534c63BA.

Sri Lanka

Gross Domestic Product: Source: Key Indicators of Asia and the Pacific 2009, Section: National Accounts

Central Government Expenditures: Source: Key Indicators of Asia and the Pacific 2009, Section: Government Finance

Central Government Revenues: Source: Key Indicators of Asia and the Pacific 2009, Section: Government Finance

Consumer Price Index: Source: International Financial Statistics, Code: 52464ZF.

Central Government Interest Payments: Source: International Financial Statistics, Code: 524c24BA.

Central Government Debt: Source: International Financial Statistics, Code: 524c63BA.

Maldives

Gross Domestic Product: Source: Key Indicators of Asia and the Pacific 2009, Section: National Accounts

Central Government Expenditures: Source: Key Indicators of Asia and the Pacific 2009, Section: Government Finance

Central Government Revenues: Source: Key Indicators of Asia and the Pacific 2009, Section: Government Finance

Consumer Price Index: Source: World Development Indicators 2007,¹⁵ Code: FP.CPI.TOTL, International Financial Statistics, Code: 55664ZF.

Central Government Interest Payments: Source: International Financial Statistics: Code: 556c24BA.

Central Government Debt: Source: International Financial Statistics: Code: 556c63BA.

Bhutan

Gross Domestic Product: Source: Key Indicators of Asia and the Pacific 2009, Section: National Accounts

¹⁵ World Development Indicators CD-ROM 2007

Central Government Expenditures: Source: Key Indicators of Asia and the Pacific 2009, Section: Government Finance

Central Government Revenues: Source: Key Indicators of Asia and the Pacific 2009, Section: Government Finance

Consumer Price Index: Source: International Financial Statistics, Code: 51464ZF.

Central Government Interest Payments: Source: World Development Indicators 2007, Code: GC.XPN.INTP.CN

Central Government Debt: Source: World Development Indicators 2007, Code: GC.DOD.TOTL.CN

Bangladesh

Gross Domestic Product: Source: Key Indicators of Asia and the Pacific 2009, Section: National Accounts

Central Government Expenditures: Source: International Monetary Fund Country Reports No. 98/131, 02/114, 05/241, and 08/334.

Central Government Revenues: Source: International Monetary Fund Country Reports No. 98/131, 02/114, 05/241, and 08/334.

Central Government Debt: Source: International Monetary Fund Country Reports No. 98/131, 02/114, 05/241, and 08/334.

Central Government Interest Payments: Source: International Monetary Fund Country Reports No. 98/131, 02/114, 05/241, and 08/334.

Consumer Price Index: Source: International Financial Statistics, Code: 51364ZF.

Malaysia

Gross Domestic Product: Source: Key Indicators of Asia and the Pacific 2009, Section: National Accounts

Central Government Expenditures: Source: Key Indicators of Asia and the Pacific 2009, Section: Government Finance

Central Government Revenues: Source: Key Indicators of Asia and the Pacific 2009, Section: Government Finance

Consumer Price Index: Source: International Financial Statistics, Code: 54864ZF.

Central Government Interest Payments: Source: World Development Indicators 2007, Code: GC.XPN.INTP.CN

Central Government Debt: Source: International Financial Statistics, Code: 548c63CG, Source: Key Indicators of Asia and the Pacific 2009.

Indonesia

Gross Domestic Product: Source: Key Indicators of Asia and the Pacific 2009, Section: National Accounts

Central Government Expenditures: Source: Key Indicators of Asia and the Pacific 2009, Section: Government Finance

Central Government Revenues: Source: Key Indicators of Asia and the Pacific 2009, Section: Government Finance

Consumer Price Index: Source: Source: International Financial Statistics, Code: 53664ZF.

Central Government Debt: Source: World Development Indicators 2007, Code: GC.DOD.TOTL.CN,

Central Government Interest Payments: Source: World Development Indicators 2007, Code: GC.XPN.INTP.CN, Source: International Financial Statistics, Code: 536c24BA.

Thailand

Gross Domestic Product: Source: Key Indicators of Asia and the Pacific 2009, Section: National Accounts

Central Government Expenditures: Source: Key Indicators of Asia and the Pacific 2009, Section: Government Finance

Central Government Revenues: Source: Key Indicators of Asia and the Pacific 2009, Section: Government Finance

Central Government Debt: Source: International Financial Statistics: Code: 578c63CG.

Consumer Price Index: Source: International Financial Statistics: Code: 57864ZF.

Central Government Interest Payments: International Monetary Fund Country Reports No: 98/199, 01/155, 02/195, 03/388, and 09/261

Singapore

Gross Domestic Product: Source: Key Indicators of Asia and the Pacific 2009, Section: National Accounts, Source: World Development Indicators 2007, Code: NY.GDP.MKTP.KN

Central Government Expenditures: Source: Key Indicators of Asia and the Pacific 2009, Section: Government Finance, World Development Indicators 2007, Code: GC.XPN.TOTL.CN

Central Government Revenues: Source: Key Indicators of Asia and the Pacific 2009, Section: Government Finance, World Development Indicators 2007, Code: GC.REV.XGRT.CN

Consumer Price Index: Source: International Financial Statistics: Code: 57664ZF.

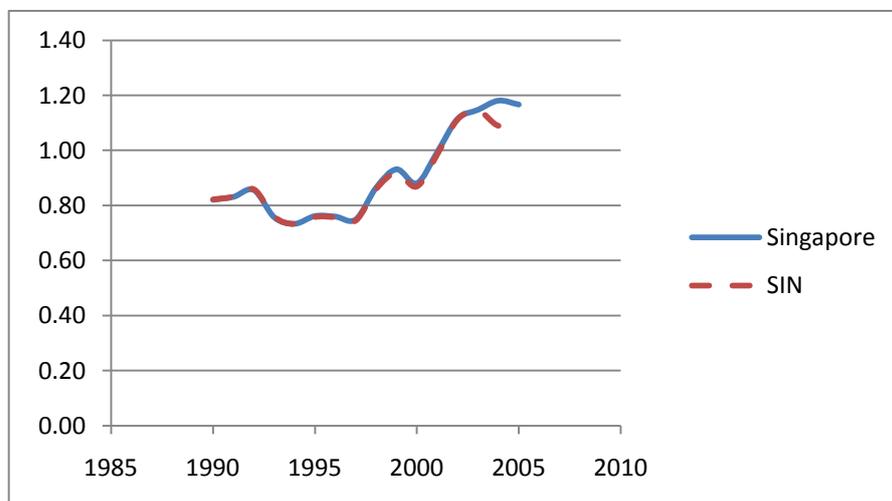
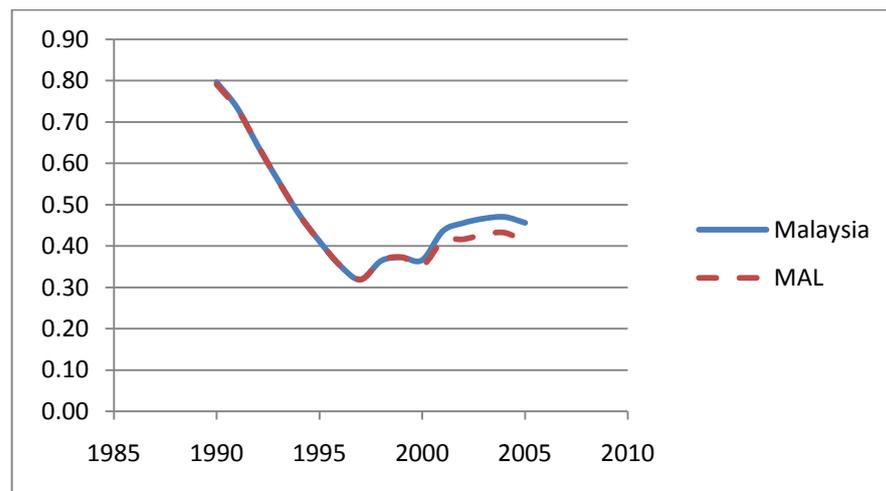
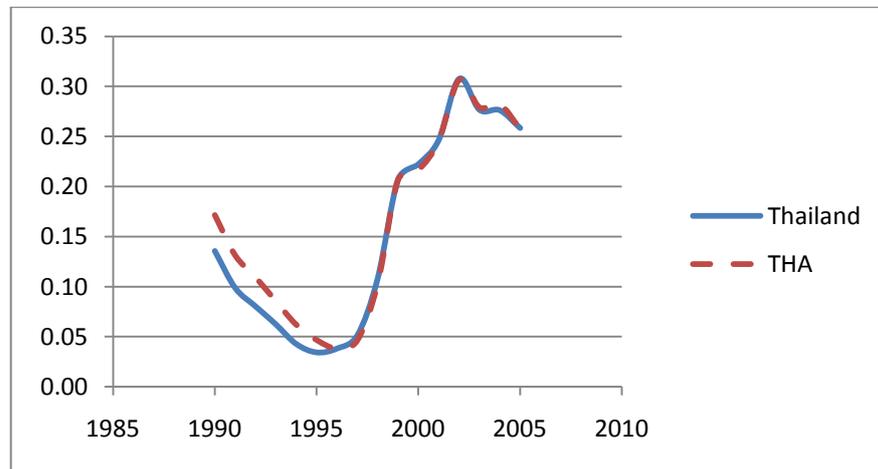
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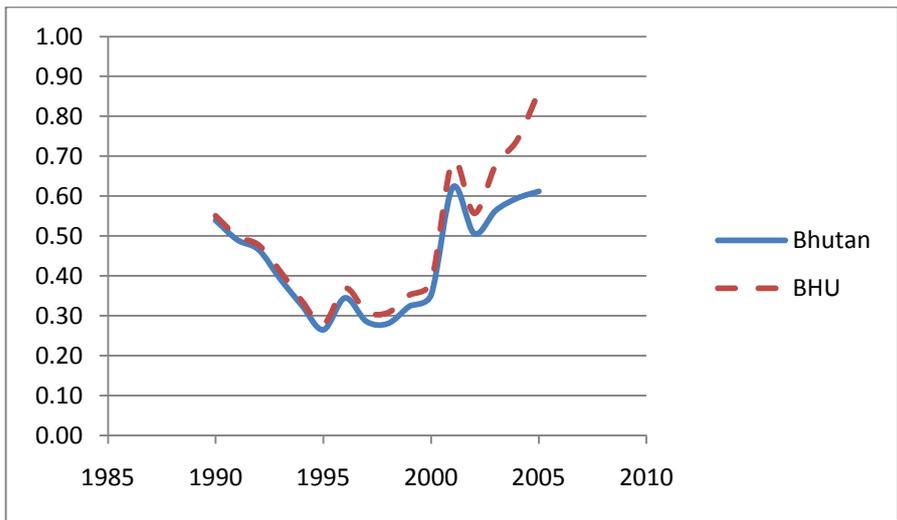
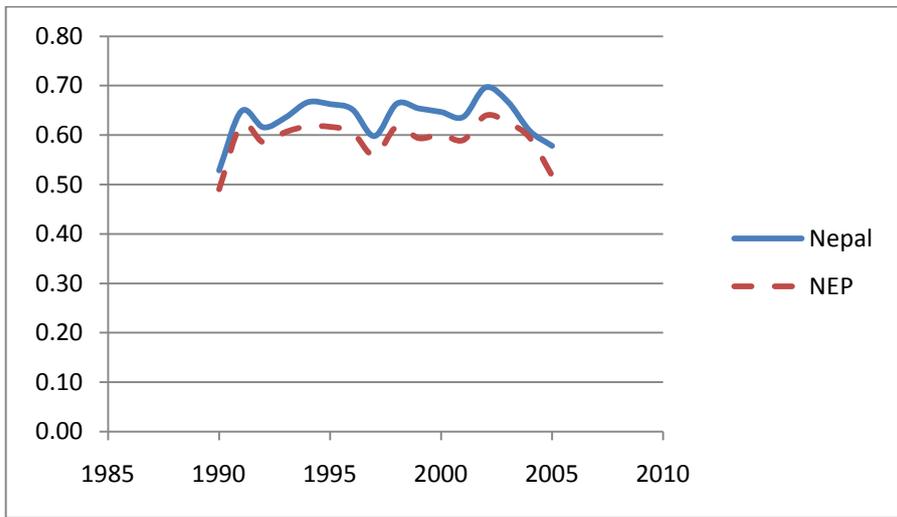
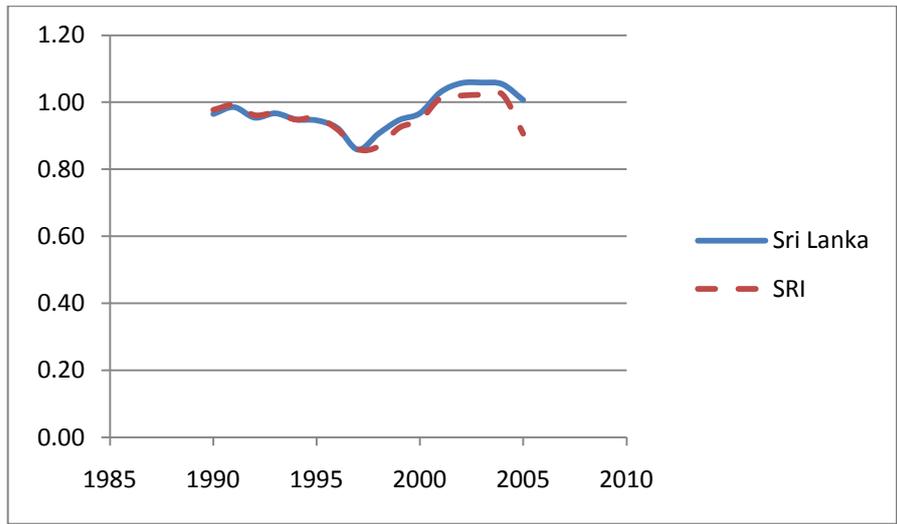
Central Government Debt: Source: Key Indicators of Asia and the Pacific 2009, Section: National Accounts, Source: World Development Indicators 2007, Code: GC.DOD.TOTL.CN

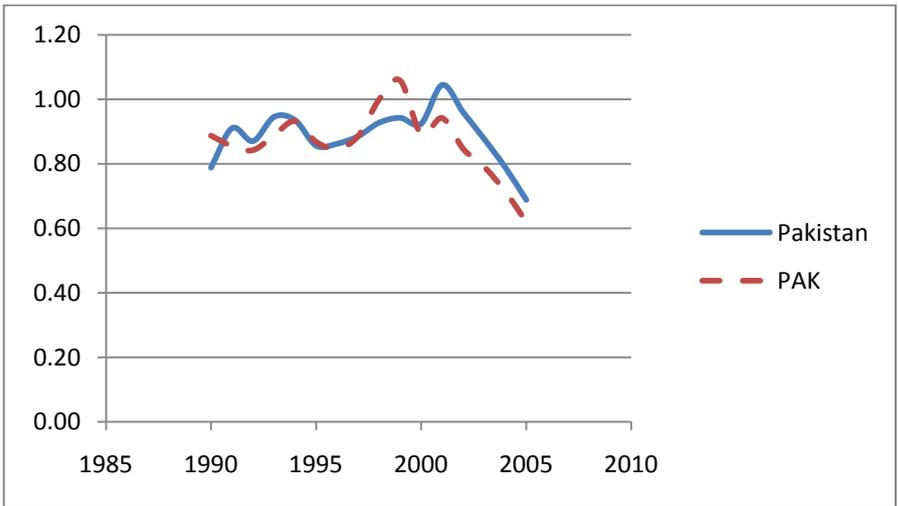
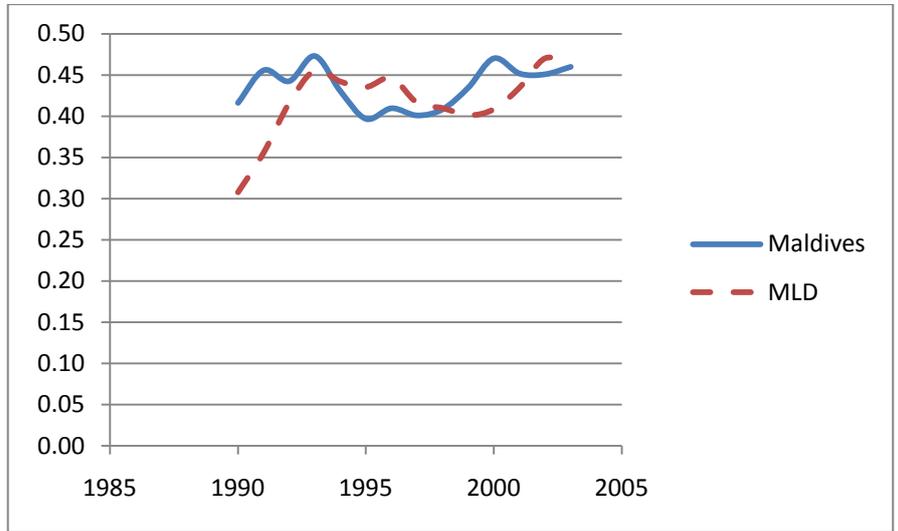
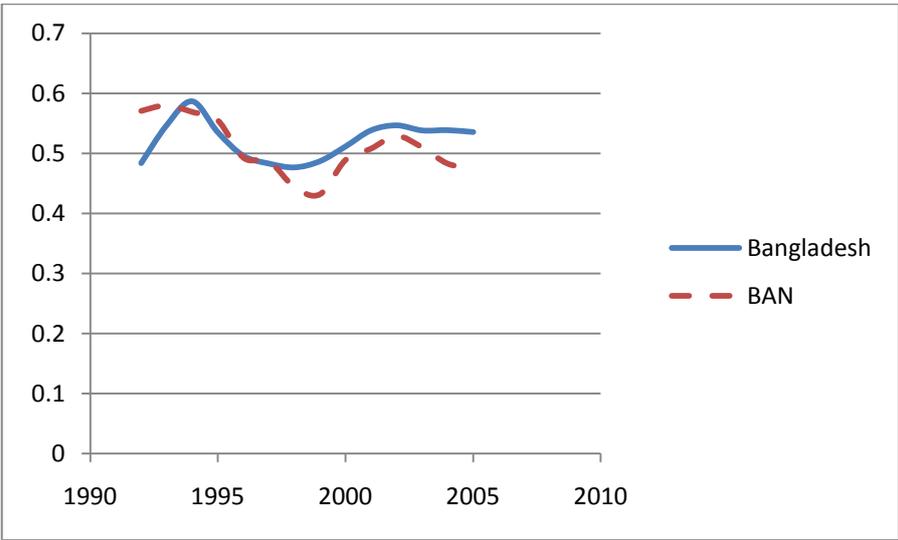
Appendix 2: Comparison of Debt-GDP Data with the Jaimovich-Panizza Data Set

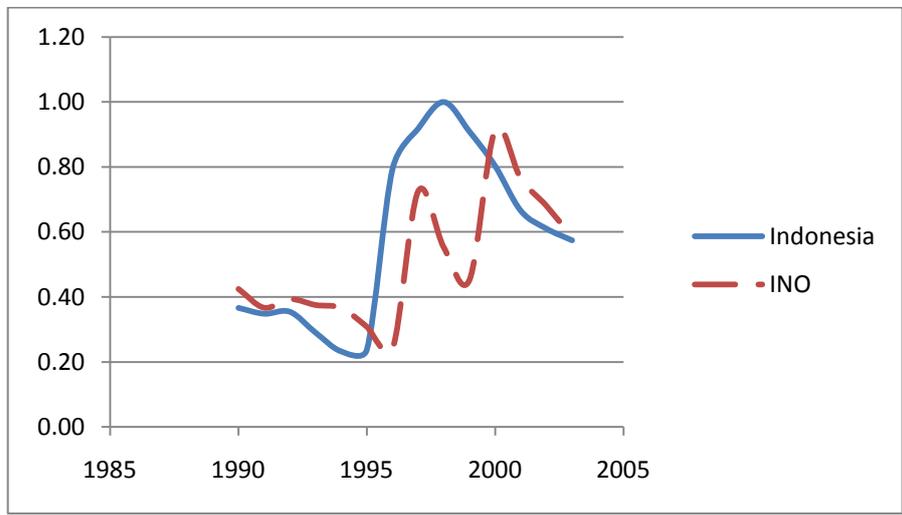
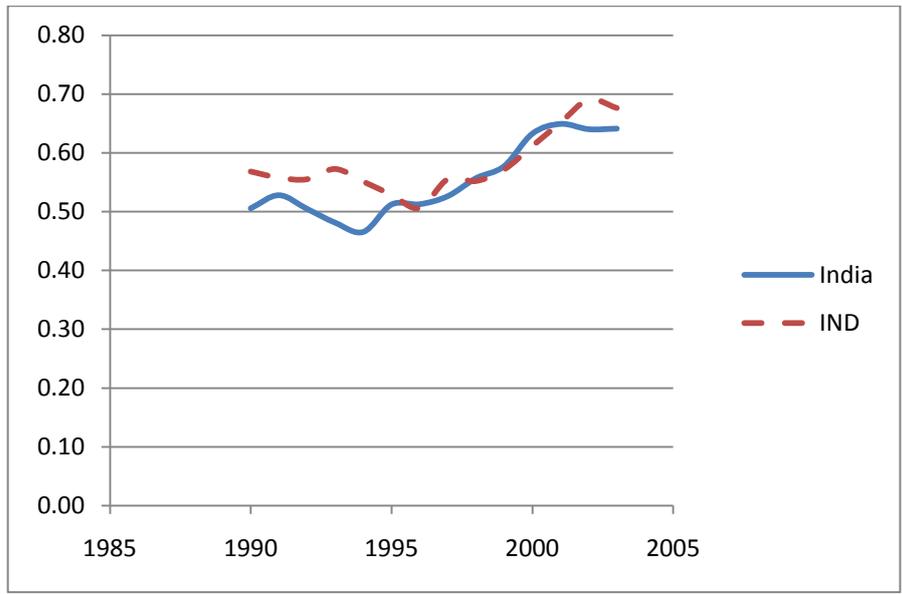
Debt-GDP Ratio

— Solid Line: Jaimovich-Panizza Data Set
 - - Dashed Line: Our Data Set









Appendix 3: Empirical Evidence

Table 17: Empirical Evidence for Fiscal Policy Sustainability

Author and Date*	Data Frequency	Period and Country	Test Performed	Sustainability
Bohn (1991)	Annual	1800-1988 (US)	Taxes and Spending, Stationarity and relationships	Spending cuts have covered almost 65% of deficit due to taxes and 70% due to high spending
Bohn (1998)	Annual	1916-1995 (US)	MBS	Yes
Bohn (2005)	Annual	1792-2003	MBS	Yes, but 'growth dividend has covered the deficit.
Greiner, Koeller and Semmler (2006)	Annual	1960-2003 (Germany, France, Italy, Portugal and US)	MBS	Yes
Mendoza and Ostry (2008)	Annual Panel Data	(1990-2005) 34 Emerging and 22 Industrial countries	MBS	Yes
Ghatak and Fung (2007)	Annual	1970-2000 Five Latin American countries	MBS, Stationarity and cointegration	No for Stationarity and Cointegration, Inconclusive for MBS
Hamilton and Flavin (1986)	Annual	1962-1984 (US)	Stationarity Tests (Deficit and Public Debt)	Yes
Trehan and Walsh (1988)	Annual	1890-1983 (US)	Stationarity tests (deficit)	Yes
Kremers (1988)	Annual	1920-1985 (US)	Stationarity tests (public debt)	Yes until 1981, no afterwards
Elliot and Kearney (1988)	Annual	1953/54-1986/87 (Australia)	Public revenues and expenditures cointegration	Yes
Wilcox (1989)	Annual	1960-1984 (US)	Stationarity test (public debt)	No
MacDonald and Speight (1990)	Annual	1961-1986 (UK)	Stationarity tests (public debt); deficit and debt cointegration	Inconclusive
Hakkio and Rush (1991)	Quarterly	1950:II-1988:IV (US)	Public revenues and expenditures cointegration	No
Smith and Zin (1991)	Monthly	1946:1-1984:12 (Canada)	Stationarity tests (deficit and public debt), cointegration	No

*Taken from Afonso (2004). However, the Table is updated by adding recent studies.

Table 17 (Continued)

Author and Date	Data Frequency	Period and Country	Test Performed	Sustainability
Trehan and Walsh (1991)	Annual	1960-1984 (US)	Stationarity tests (deficit and public debt)	Yes
MacDonald (1992)	Monthly	1951:1-1984:12 (US)	Stationarity tests (public debt); deficit and debt cointegration	No
Baglioni and Cherubini (1993)	Monthly	1979:1-1991:5 (Italy)	Stationarity tests (deficit and public debt)	No
Tanner and Liu (1994)	Annual	1950-1989 (US)	Public revenues and expenditures cointegration	Yes, with a break in 1982
Liu and Tanner (1995)	Quarterly	?-1991:IV (US)	Public revenues and expenditures cointegration	Yes, with a break in 1982
Caporale (1995)	Semi-annual and annual	1960-1991 (EU countries)	Stationarity tests (deficit and public debt)	No for Italy Greece, Denmark and Germany
Quintos (1995)	Quarterly	1947:II-1992:III (US)	Public revenues and expenditures cointegration	Yes
Haug (1991)	Quarterly	1960:I-1987:IV (US)	Deficits and Surpluses stationarity and cointegration	Yes
Haug (1995)	Quarterly	1950:I-1990:IV (US)	Public revenue and expenditures cointegration	Yes
Ahmed and Rogers (1995)	Annual	1692-1992 (US), 1792-1992 (UK)	Public revenues and expenditures cointegration	Yes
Vanhorebeek and van Rompuy (1995)	Annual	1970-1994 (8 EU countries) 1870-1993 (Belgium)	Stationarity tests (deficit and public debt)	Yes for Germany and France
Owoye (1995)	Annual	1961-1990 (G7 countries)	Causality between taxes and spending	Bi-directional in five G7 countries
Payne (1997)	Annual	1949-1994 (G7 countries)	Public revenues and expenditures cointegration	Yes for Germany

Table 17 (Continued)

Author and Date	Data Frequency	Period and Country	Test Performed	Sustainability
Artis and Marcelino (1998)	Annual	1963-1994 (EU countries)	Stationarity tests (Public debt)	Yes, for Austria, Netherlands, UK
Makrydakis (1999)	Annual	1958-1995 Greece	Stationarity tests (public debt)	No
Papadopoulos and Sidiropoulos (1999)	Annual	1961-1995 (4 European countries)	Public revenues and expenditures cointegration	Yes for Greece and Spain
Greiner and Semmler (1999)	Annual	1955-1994 Germany	Stationarity tests (public debt)	No
Olekalns (2000)	Annual and Quarterly	1900/01-1994/95, 1978:3-1997:4 (Australia)	Public revenues and expenditures cointegration	No
Fève and Hélin (2000)	Semi-Annual	(G-7 countries)	Stationarity Tests (public debt)	Yes for Denmark, Netherlands, Ireland, and France
Uctum and Wickens (2000)	Annual	1947-1992 (US)	Public revenues and expenditures cointegration	Yes, with break in the 70s and 80s
Getzner, Glatzer and Neck (2001)	Annual	1960-1999 (Austria)	Stationarity tests (central public debt)	Yes, for 1960-1974; No, for 1975-1999
Bravo and Silvestre (2002)	Annual	1970-1997 (EU countries)	Public revenues and expenditures cointegration	Yes, for Germany, Austria Finland, UK, Netherlands