The Dynamics of Fiscal Sustainability

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Dedication

To

Mrs Thongbai Sangduan: My mother

I am very grateful to my mum for supporting me and helping me to achieve my dreams in life. A Big Thank you to her for always being there for me no matter what!!!
Abstract

The importance of achieving a sustainable fiscal budget deficit has received increasing attention from academics and policy-makers. A stable long-term relationship between government expenditures and revenues is a key requirement for macroeconomic stability and development. Thus, this dissertation addresses the issue of fiscal sustainability from an empirical perspective. We illustrate how different methodologies can be applied to the analysis of fiscal sustainability, some of which are novel in context of this literature. We first look at the application of an Indicator of Fiscal Sustainability, based on Blanchard (1990) and Croce and Juan-Ramon (2003), to a variety of countries. We then propose an efficient test for 'strong' fiscal sustainability, using the procedures of Horvath and Watson (1995) for inference when the cointegration vector is pre-specified. We show that regime shifts are pervasive in this context and suggest a Markov switching cointegration approach to test and model fiscal sustainability subject to regime changes. Finally, we model the dynamics of Thailand's discounted debt using the Markov switching framework developed by Davig (2005).
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1. INTRODUCTION

This study is aimed at understanding the dynamics of fiscal sustainability by using a variety of statistical and econometric techniques. There subsists a contradiction between the predictions of empirical models, which point to a significant degree of unsustainability across different countries, and the relative scarcity of episodes of full-scale defaults. Therefore, it is of great importance to reassess empirical methodologies dealing with the analysis of fiscal sustainability. Indeed, this work shows that once appropriate econometric methods are put to use, the paradoxical findings of earlier literature virtually disappear. The research focuses on developing countries, particularly Thailand. However, in order to illustrate the methodologies and its robustness, we also analyse countries from other regions and at different stages of development.

1.1 Background

Recently, fiscal sustainability has become a major concern in macroeconomics. In order to adopt an appropriate fiscal policy, it is important to have a clear understanding of the macroeconomic structure and the transmission mechanisms of an economy. The macroeconomic interactions of an economy determine how such economy responds to external shocks. The sustainability of the country indicates high economic credibility. If a government is aware of the dynamics of fiscal sustainability and how it responds to shocks, it will be better able to devise a suitable fiscal policy in order to maintain the economy’s growth and development potential. Fiscal sustainability requires the use of public finances to stabilize the economy during periods of external shocks without necessarily over-heating the economy or aggravating further macroeconomic distortions. The ability to sustain efficient government expenditure while prices are rising requires an effective coordination of fiscal and monetary policies with macroeconomic outcomes.
1. Introduction

Many researchers have examined how to measure fiscal sustainability. Popular amongst these methods are the Indicator of Fiscal Sustainability approach and the Intertemporal Budget Constraint approach. These methods are sector specific and have their limitations when the underlying assumptions are altered. The need to develop a robust and comprehensive measure of fiscal sustainability is an important research endeavor which this thesis intends to address, at least in part.

More specifically, we contribute to the literature in several distinct ways. First, we apply the Indicator of Fiscal Sustainability to a range of countries, thus providing the scope for international comparisons. More substantially, we propose the use of an efficient test for sustainability, that can be derived as a testable implication from the government’s Intertemporal Budget Constraint. It is based on the test procedure of Horvath and Watson (1995), developed for the case of testing under pre-specified cointegration vectors. This framework is more efficient than both the univariate approach and the standard cointegration tests, as it accounts for the likely correlation between innovations to revenues and expenditures and it incorporates the appropriate theoretical restriction on the cointegration vector. As a by-product of our long run analysis, we also analyse the dynamics of revenues and expenditures in a Granger causality framework. Using appropriate testing procedures to deal with $I(1)$ processes in VARs in levels, we were able to test four types of possible interactions: revenues causing expenditures (‘spend-and-tax’), expenditures predicting revenues (‘tax-and-spend’), revenues and expenditures being simultaneously determined (‘fiscal synchronization’) and no causality, implying unsustainability.

We then propose an alternative methodology to deal with potential changes in fiscal regimes. By employing a Markov switching specification of the long run relationship between revenues and expenditures, as in Hall, Psaradakis and Sola (1997), we are able to simultaneously: 1) test for cointegration using Gabriel’s et al. (2002) procedure; 2) assess the type of fiscal regime (whether ‘strongly’/‘weakly’ sustainable or unsustainable) that a country experienced at a given period and 3) analyse the timing of the transition between the estimated regime types.

Finally, we investigate sustainability of the discounted debt process resorting to a
1. Introduction

Markov switching sustainability test, applied to the case of Thailand, is an alternative framework of studying fiscal sustainability, based on the univariate properties of the debt process. It allows us to model discounted debt as following a two-state Markov switching process, in which the regimes correspond to periods of collapsing and expanding debt. We can expect to find long periods in which debt is repaid, corresponding to debt sustainability, alternating with shorter periods of rapidly expanding debt (due to political or economic crisis) which will appear to be locally unsustainable. Nevertheless, the presence of these regimes does not imply that the unconditional mean of the process is zero and therefore that discounted debt is globally sustainable.

This dissertation is structured as follows. Chapter 2 provides a review of the literature on the measurement of fiscal sustainability. We explore previous research on the Indicator of Fiscal Sustainability approach and set out the Intertemporal Budget Constraint, which form the theoretical framework for subsequent chapters.

Chapter 3 focuses on the implementation of the Indicator of Fiscal Sustainability to a set of countries, following Blanchard (1990) and Croce and Juan-Ramon (2003). The empirical results demonstrate how the indicator measures fiscal sustainability and its potential usefulness in signalling a crisis.

Then, in Chapter 4, we assess a variety of approaches that deal with the empirical implications of the Intertemporal Budget Constraints (IBC). These stem from the observed statistical properties of the time series involved in the study of the IBC. We explore the use of standard testing procedures, based on unit root and cointegration tests, and illustrate how an efficient test for strong sustainability can be employed.

In Chapter 5, we first show how regime changes seem to be pervasive in studies of fiscal sustainability. We then suggest an alternative method to test and model fiscal sustainability subject to regime changes. This is based on a Markov switching approach developed by Hall et al. (1997) and Gabriel, Psaradakis and Sola (2002). It allows the
researcher to simultaneously test for sustainability and model potential policy shifts.

In chapter 6 we focus on the implementation of the additional empirical implication of the IBC, based on the behaviour of a country's discounted debt. Thus, we test the stationarity of Thailand's discounted debt by employing the procedures developed by Davig (2005), which allows for possible departures from sustainability of a Markov switching type.

Lastly, a remainder chapter summarizes the main findings and addresses some of the limitations of our analysis, exploring potential guidelines for future research.
2. ASSESSING FISCAL SUSTAINABILITY: A SURVEY

This chapter surveys the literature on fiscal sustainability measurement. We focus on the three main themes covered in the present work, namely the Indicator of Fiscal Sustainability Approach (IFS), the implications of the Intertemporal Budget Constraint (IBC) and the Markov Switching Approach (MS).

2.1 The definition of Fiscal Sustainability

A formal definition of fiscal sustainability has not yet been agreed, although researchers agree that the concept of sustainability relates to a government's solvency or its ability to service debt repayment. A sound fiscal policy is at the core of the discussion and can be characterized as the balance between revenues and expenditures at a certain debt level. Burnside (2004) proposed a definition of fiscal sustainability as the government's ability to indefinitely maintain the same set of policies while remaining solvent. The key question is: what is government solvency? In the context of government solvency, fiscal sustainability requires that government's debt does not rise above the repayment threshold - such that the debt to GDP ratio does not hinder the government ability to service debt payment. Then the conclusion drawn from this point is that fiscal sustainability is the government's ability to service the debt, while performing the same set or current policies and maintain the debt ratio at a level during a certain period.

2.2 Indicators of Fiscal Sustainability

One of the various approaches which has been developed by many researchers to measure economy sustainability is the fiscal sustainability indicator. Its evolution started from Buiter (1985), Blanchard (1990) and has been followed by many scholars such as
Gramlich (1990), Chouraqi, Hagemann and Sartor (1990), and Croce and Juan-Ramon (2003). The advantage of the fiscal sustainability indicator approach is that the indicator is simple and can be comprehended, evaluated and compared in different countries and times. Moreover, it is not difficult to adjust and update.

To begin with, Buiter (1985) presented "a guide to public sector debt and deficits" in 1985. He reported four ways through which government can reduce the real value of their debt.

"First, at a given general price level and a given nominal price of bonds, they can run a budget surplus and repurchase existing debt. Secondly, they can attempt to reduce the real value of the outstanding stock of debt, at a given general price level, by pursuing or announcing policies that cause a drop in bond prices. Third, an inflationary policy can reduce the real value of the inherited stock of debt, even with a balanced budget and given nominal bond prices. Finally, a government can formally repudiate part or all of its debt." ¹

Buiter (1985)’s sustainability indicator relies on the difference between the primary surplus and the surplus that stabilizes net government wealth. The disadvantage of this indicator is that the approach to the measurement of government net wealth varies in different countries. This will lead to differences in the actual level of net wealth.

In another study, Blanchard (1990) proposed a CAB (Cyclically Adjusted Budget Balance) as an indicator of fiscal policy and suggested a new set of fiscal indicators. The CAB study focuses on how tax incentive factors in fiscal policy affects individual decision and aggregate demands. It found that the weak points of using the CAB are: 1.) there are many factors such as inflation or real interest rate, revenues, social insurance programmes and the changing composition of the population, for example, that make the future potentially change from the present; 2.) one assumption is that the economy will return to its mid-cycle position quite fast, otherwise this assessment may not work well. The proposed indicators in this study are the primary gap^ and the

¹ Buiter (1985, p 22).
² The primary surplus minus the debt to GNP ratio multiplied by the difference between the real
medium-term tax gap. He found that these indicators cannot be applied to the far future (as suggested by the application to Germany data), therefore a third indicator has been proposed, namely the long term tax gap. Gramlich (1990), Chouraqui et al. (1990) also examined the fiscal indicators approach. In addition, it is useful if details are taken into account such as the size/power of the economy or scale of economy or, for example, considering whether the data that we need to test is from a developed country or developing country or HIPC (Heavily Indebted Poor Countries), the structure of government expenditure, etc.

Rudin and Smith (1994) investigate sustainability measurements for Canada from 1937-1984 and the United States from 1890-1986. They proposed a simple sustainability indicator, presented in terms of the present-value budget balance. The measure of sustainability focused on the stock of net government liabilities and primary surpluses over some relevant period. It was called the U statistic: if the value of U is greater than one and keeps continuing, this would lead the government to insolvency or unsustainability and if the value of U is less than one, this case is considered as sustainable. The weak points of this study are the definition the government’s net debt and that this was applied to a developed country.

One variable which is debt in particular has received considerable attention. Indeed, the dynamics of debt was studied by Curtis (1997), who analysed the fiscal policy in Canada by using the data from 1980-1996. He examined the underlying causes of the persistent debt problem, following the Blanchard (1990) approach by using a set of indicators of fiscal policy sustainability called "tax gaps", setting the framework for the design and implementation of fiscal programs to control the debt ratio. The economy interest rate and the growth rate.

The average over the current and the next two years of spending and transfers as ratios to GDP plus the ratio of debt to GDP times the interest rate minus the growth rate minus the current tax rate

Unchanged benefit and retirement age policies would lead to an increase in the contribution rate as a percentage of taxable of close to 20 percent.

The average of the sum of government spending plus transfers, as ratio to GNP, over the next 50 years plus the debt-to-GNP ratio multiplied by the difference between the real interest rate and the growth rate, minus the current tax rate.

Rudin and Smith (1994) provided a detailed review of the definitions of scope of government.
is vulnerable to adverse shifts in monetary conditions and economic growth as the debt ratio is high. Burnside (2003) and Burnside and Meshcheryakova (2003) studied the cyclical adjustment of the budget surplus and proposed some tools for fiscal sustainability analysis.

Another aspect examined by Croce and Juan-Ramon (2003) was an assessment of fiscal sustainability using a cross-country comparison. They also focused on the debt ratio, following Buiter (1985) and Blanchard (1990). They proposed a recursive algorithm to set the indicator of fiscal sustainability. The proposed approach which is derived from the motion law of the debt-to-GDP ratio, which is subjected to a government reaction function that links convergence to the targeted debt ratio. They used quarterly data of 12 developed and developing countries to analyze this approach. They found evidence of causality between the fiscal policy stance and growth-adjusted real interest rates. An interesting point of this study is the use of quarterly data, which enables a more detailed picture of fiscal policy problems.

2.3 The Intertemporal Budget Constraint Approach: IBC

One of the centrepieces in analysing the fiscal sustainability is the Intertemporal Budget Constraint (or Present Value Budget Constraint). Many other approaches are based on or relate to this approach. Fiscal consolidation is a vital part of fiscal sustainability; not only can it improve public sector efficiency, but also stimulate economic growth. Nevertheless, if the government is not aware of how to manage expenditure, it will be unable to stimulate the economy, a collapse might occur instead.

The key components of fiscal consolidation are government’s expenditure and revenue. In the long run, an equilibrium relationship between expenditure and revenue is one of the main requirements for fiscal sustainability. Government’s expenditure and revenue is a sensitive area in policy-making: increases in revenue via taxes may cause negative effects on growth, for example. However, particularly in indebted countries, the government needs to run primary surplus to relieve the debt, which is one key fiscal policy issue. Thus, when should the government run a primary deficit or surplus? The
present value budget constraint approach of fiscal sustainability may provide a framework for answering these questions.

The IBC has been first applied to assess fiscal sustainability by Hamilton and Flavin (1986), by illustrating alternative measures of sustainability stance on the dynamic stability approach. It establishes that the government is subject to an IBC, which means that in the future, the government will run surpluses in order to compensate its prevailing deficit. They proposed an empirical framework based on unit root tests, assuming for simplicity a constant real interest rate. They conclude that the IBC has not been violated in the United States, hence fiscal policy is sustainable. Kremers (1988) argues, however, that it is difficult to accept the imbalance of the debt and deficit situation in the United States. Kremers showed that a bounded debt-GDP ratio is an essential and sufficient condition for fiscal policy to be sustained, and the condition is that there is an upper bound on the tax rate. And the results show that in order to satisfy the IBC condition, the interest rate should grow higher than the rate of debt.

When using econometric models, the results are not always consistent; the data is very sensitive, as suggested by Wilcox (1989). When he extended the data, the result changed. Wilcox (1989) followed Hamilton and Flavin's work and argued that the estimated process for the discounted debt series was stationary during the first half of the sample period (until 1974), but it is not stationary in the second sample period.

A number of academics employed different methods of analysing the data. In this respect, Hakkio and Rush (1991) also applied the IBC by using the concept of cointegration between government expenditure and revenue. They allow the interest rate can be fluctuated unlike Trehan and Walsh (1991). Moreover, they use several different sample periods to test for the deficits. In addition, they normalize the government spending and revenue by using GNP and population. Their findings show that if revenue is growing less than expenditure, this will cause deficits and a sustainability problem. Trehan and Walsh (1991) propose the tests of intertemporal budget balance in two ways. The first case is that if expected real rates are constant, the combination of the stock of debt and the net-of-interest deficit should be stationary which is necessary and sufficient for intertemporal budget balance. And the expected real rate should be positive, then
2. Assessing Fiscal Sustainability: a Survey

the stationarity of the inclusive-of-interest deficit is sufficient to satisfy intertemporal budget balance.

Researchers and economists have explored and employed various methodologies to capture the behaviour of economic factors, which affect the changing of the economy. The IBC can be considered as the base model for public sector sustainability measurement. Hence, in chapter 4, this approach will be employed for government expenditure and revenue data testing for fiscal sustainability.

2.4 Markov Switching Approach

This work will devote a great deal of attention to the effects of potential regime shifts in the relationship implied by the IBC. Indeed, it is relatively consensual to admit that a country’s fiscal policy is sometimes confronted with strains (that can arise from different sources: the business cycle, currency crises, etc.) which may lead to occasional departures from a sustainable path. An econometric approach that has gained widespread acceptance in modelling regime changes or sudden shifts is the Markov switching method proposed in the seminal paper of Hamilton (1989). This method was initially applied to investigate the dynamics of the business cycle, in which changes are driven by an unobserved discrete state variable generated by a homogeneous Markov process, see Hamilton and Raj (2002) for a survey. Several extensions and applications have been proposed, both in the field of Economics and Finance, including extensions of the ARCH family of models to account for time-varying volatility (see Hamilton and Susmel, 1994). Studies that have focused on developing countries include Eichengreen, Rose, and Wyplosz (1995), for example, who study the occurrence of crises by identifying which features of countries explain contagion effects, caused by trade linkages rather than macroeconomic fundamentals similarity. Jeanne and Masson (2000) focus on exchange rates and estimate devaluation probabilities, while Mouratidis and Spagnolo (2003) extend the work of Jeane and Masson (2000), which focus on EMS currency crises. They show that currency crises are caused either by fundamental or by self-fulfilling market expectations, driven by weak external uncertainty from both combinations.
Another strand of Markov switching models focus on exchange rate forecasting, such as Cerra and Saxena (2000) and Marsh (2000). These authors found that Markov-switching models provided better forecasts for exchange rates. Moreover, Bessec (2003) suggests a model that can explain not only past crises, but can also predict future financial crises. The investigation focuses on emerging markets especially during 1997-1998 Asian crises. He employs a Markov-switching model to analyze the role of contagion in the currency crises during the 1990s, by performing a systematic comparison and evaluation of three distinct causes of currency crises which are contagion, weak economic fundamentals and sunspot (unobservable shifts in agents’ beliefs).

However, we will specifically focus on the empirical implications of the IBC, which describes a present-value-type of relationship between debt levels and the forcing variable given by expected future budget deficits. This type of theoretical framework has also received attention from Markov switching practitioners. A common application is that of the stock price-dividend relationship in equilibrium asset pricing, as studied in Cecchetti, Lang and Mark (1990), Bonomo and Garcia (1994) and Driffill and Sola (1998), for example. The main idea is to allow the endowment stream in the present-value relationship (dividends in this case) to be subject to regime shifts of the Markov switching type and then model these effects in the context of the present-value model. These authors show that such a representation fits the data well and encompasses specifications that include non-linear intrinsic bubbles. A similar application of a Markov switching present-value relationship is studied in Hall, Psaradakis and Sola (1997), in which changes in the long-run consumption-income relationship is driven by shifts in permanent income. This then generates significant evidence in favour of time-varying cointegration where the long-run variables are allowed to shift stochastically between two different regimes.

Another closely related paper to our work is that of Raybaudi, Sola and Spagnolo (2004), in which current account deficits are allowed to follow a Markov process. Then, periods under which the current account accumulates at a non-stationary rate can be identified as periodically collapsing bubbles, employing modified unit root tests. Using data for 5 countries they found that the long run budget constraint is satisfied for Brazil,
Japan and UK, while Argentina and US's results are more controversial. Note however that their method is univariate and hence does not consider multivariate dynamics.

Thus, we suggest that a Markov switching present-value framework can be used to model potential shifts in the present-value-type relationship implied by the IBC. Although the approach in itself is not novel, it is the first application to the study of fiscal sustainability. There is, however, an alternative univariate Markov Switching approach suggested by Davig (2005). This author analyses the behavior of the US discounted debt by extending the works of Hamilton and Flavin (1986) and Wilcox (1989). Davig (2005) allows the discounted debt to follow two fiscal regimes, one in which is expanding in the first regime and a second regime in which it is collapsing. He concludes that the US discounted debt in the long run is sustainable even though the expanding regime is not sustainable. For the sake of completeness, we also explore this approach in Chapter 6, applying it to data on discounted debt in Thailand.
3. AN INDICATOR OF FISCAL SUSTAINABILITY (IFS)

The previous chapter provided the details of researchers's attempts in assessing fiscal sustainability by exploring an effective approach or indicators. Three prominent approaches that we mentioned are the Indicator Fiscal Sustainability approach, the Inter-temporal Budget Constraint approach and the Markov Switching approach.

The purpose of this chapter is to examine the effectiveness of the IFS approach in assessing fiscal sustainability and also the consistency of the indicator when applied to various regions. One of its advantages is its relative simplicity. The condition to assess fiscal sustainability is that the government budget constraint is satisfied. Not only debt repayment will be taken into consideration, but also government insolvency; therefore, the forward-looking approach which relates to the projection of government revenues and expenditures has to be compatible with the projection of GDP growth rates and real interest rates.

We focus our investigation on a set of 6 countries, extracting data from the IMF International Financial Statistics database, using quarterly data from 1975 to 2003. We examine countries from 5 regions: Europe (Finland and France), Latin America (Bahamas), Asia (Thailand), South Africa and US. There are two main reasons for choosing these countries for this empirical study: first, we wish to assess the robustness of the procedures for a variety of countries with different economic structures, varying degrees of economic development and from distinct geographic regions; second, we apply this method to some countries for which the IFS approach has not been used.
3. Data Definitions

In this research, the key variables, which we apply in our analysis, are all explained in this section. Most of variables are used in IFS approach such as Public Debt, Interest Rate, GDP Growth Rate and Primary Surplus, while in IBC approach we focus on Government Expenditure and Revenue. And Public Debt is also employed on Markov Switching approach. The detail of these variables are as follows:

3.1.1 Public Debt

The component of public debts is internal debt; owed by lenders within the country and external debt, owed by foreign lenders. Bonds and bank loans are also included in public debt. Every country tries to manage its debt by borrowing at the lowest possible cost over a medium-to long-term time frame, as it tries to avoid taking on high debt structures that can cause problems in the future. The role of public debt is vital in fiscal sustainability since the last decade; debt ratio is one of the indicators that can determine the country’s financial circumstance. There are various fields related to debt such as how to measure debt when it has been stated that it is at critical level; and how to manage debt as the stock of debt become more complicated, particularly in the countries that have been in debt crisis or are still in excessive debt level. In this chapter, debt is the one of the main variables and we will investigate its behaviour and the affect of debt on the financial situation. In the core part of the model, we will set the target of debt that the government need to achieve the solvency level. We employ domestic and foreign debts as public internal and external debts, correspondingly.

3.1.2 Interest Rate

Interest rate is an essential tool to stimulate economy activity; on the other hand, care is needed due to the threat of inflation. It is the key instrument of controlling inflation, as increase in interest rates can relieve the risk of inflation. Furthermore, the interest rate can effect investment, exchange rates and consumption. The interest rate, which plays an important role in this analysis, includes domestic and foreign interest rates. The data that we utilize are market rate and treasury bill rate as domestic interest rate
and foreign interest rate, respectively.

3.1.3 GDP Growth Rate

The GDP growth rate is one of the main variables in this analysis. Growth rate of GDP is potentially related to fiscal sustainability since fiscal management can improve the public sector by delivering public services and stimulate economic growth. The strong economic growth rate and the restraint of government expenditure can increase primary surplus, which will be one of the effective paths to reduce government debt. Hence, growth rate have a vital role not only in fiscal sustainability, but also in terms of credibility. We use Gross Domestic Product (with year price based) as real GDP and normalize to yield the GDP growth rate.

3.1.4 Government Expenditure

Expenditure or public spending is a key component for fiscal policy. The economy can be boosted or it can collapse if the government conducts the wrong policy via reducing, increasing or transferring spending. Different types of fiscal policy will have different effect on the structure of expenditure. The combination of government spending such as health, education and defence needs to be allocated the appropriate amounts. Reduction in government expenditure can ultimately alleviate the country’s debt. The data that we use for public spending is expenditure.

3.1.5 Government Revenue

When the government wants to increase expenditure, they may also need to raise the tax level, otherwise they may need to borrow the money from financial institutions (domestic or foreign) in order to meet their country’s needs. However, the performance of the government will be effective if they can create a policy that can serve demands without increase in resources. Tax plays a key role not only in fiscal policy, but also as a fiscal sustainability indicator, as tax is the main source of revenues. Revenues data
that we employ is exclusive grants receive.

3.1.6 Primary Surplus / Deficit

If the government wants to relieve public debt, the present value of future primary balances (generally primary surplus) should exceed the current public debt. The primary balance comprises of government revenue and expenditure, excluding grants and debt repayment. Hence, Primary surplus or primary deficit is one of the major tools of the government policy. Restraint in government expenditure or increased tax should be considered with the other factors within the structure of government budget such as rate of economic growth, interest rate and inflation rate. Primary balance is the most crucial factor in this approach, which we will examine in depth in the analytical section. We use deficit or surplus as public primary surplus.

3.2 Data Sources

We employ these approaches to examine the fiscal sustainability for various regions. Our sample includes quarterly data from 1975 to 2003 and annual data for some approaches extracted from the IMF database. The data that we will investigate in this chapter is required to have two main characters, which are: i) long period and ii) from the same source in order to obtain the same calculation criteria of the data set. Therefore, the country that we select to test will depend on the data availability. Nevertheless, not only will we consider the above mention characteristic of the data, but also the chosen country will be examined from both approaches (Indicator Fiscal Sustainability and Inter-temporal Budget Constraint). In this chapter, some of these variables such as GDP growth rate, interest rate and public debt will be utilised to test in the Fiscal Sustainability Indicator approach. The data of government expenditures, revenues and primary surplus will be mainly examined in chapter 4.
3.3 An Indicator of Fiscal Sustainability Approach

We follow Blanchard (1990) and Croce and Juan-Ramon (2003). This method will aim to build an indicators involving major factors of sustainability such as government expenditure and revenue, the interest rate, the GDP growth rate, and public debt (both domestic and foreign). Moreover, this method requires setting the assumptions and conditions which satisfy the intertemporal government budget constraint. As mentioned earlier, the debt ratio will play an important role in this study, as we will concentrate on the sustainability of the ratio of debt to GDP.

The main starting point of fiscal sustainability assessment is that the model must satisfy government budget constraint. Government budget constraint can be expressed as:

\[ (G_t - R_t) + iD_t = D_t - D_{t-1} \]  (3.1)

\[ PD_t + iD_t = D_t - D_{t-1} \]  (3.2)

\[ D_t = (1+i)D_{t-1} - PS_t \]  (3.3)

Given \( R_t \) is government revenue, \( G_t \) represents government expenditure, \( iD_{t-1} \) is interest payment on public debt, \( D_t \) and \( D_{t-1} \) are public debt at time \( t \) and public debt at time \( t-1 \) respectively. \( PD_t \) is primary deficit and \( PS_t \) represents primary surplus. And \( (G_t - R_t) = PD_t \) : if the government revenue is less than government expenditure, then the government runs a budget deficit (primary deficit), and \( PS_t = -PD_t \).

From the above equations, the government revenue less government spending and interest payment on public debt is equal to a change in the stock of public debt (both government domestic borrowings and foreign borrowings).

Based on previous research of Croce and Juan-Ramon (2003), we model as following.

\[ \Delta D = G - T + iD \]  (3.4)

\(^1\) The lowest debt rate will be set as a key condition in this approach
From the above equation, the change in government debt (denoted as $D$) is equal to the total budget deficit (if the government run budget deficit, $G > T$, therefore primary deficit $(PD) = -$ primary surplus $(PS)$ plus the debt payment for the next period (debt in this period times interest rate or we can write as:

$$D_t = D_{t-1} + iD - PS \quad (3.5)$$

(as primary deficit is equal to minus primary surplus: $PS_t = -PD_t$)

In order to get the condition of government solvency, we begin with equation (3.5). And consider with a full economy (with foreign currency and exchange rate), from equation (3.5), we obtain the government budget constraint in terms of domestic currency for period $t$:

$$PD_t + IP_t = (D_t^D - D_{t-1}^D) + E_t(D_t^F - D_{t-1}^F) \quad (3.6)$$

$$D_t^D + E_tD_t^F = (1 + i_t^D)D_{t-1}^D + E_t(1 + i_t^F)D_{t-1}^F - PS_t \quad (3.7)$$

$D_t^D$ and $D_t^F$ represent as domestic debt in domestic currency and external debt in foreign currency, respectively. $E_t$ express as the average exchange rate between the end of period $t - 1$ and $t$, hence $D_t^F = E_tD_t^F$. $i_t^D$ and $i_t^F$ are respectively the average interest rates on the domestic and external debt at time $t$, then the interest payment can be defined as $IP_t = i_tD_{t-1}^D + E_t i_tD_{t-1}^F$.

We divide the equation (3.7) by nominal GDP at time $t$ ($Y_t$), and denoting ,

domestic debt ratio: $d_t^D = \frac{D_t}{Y_t}$,

external debt ratio: $d_t^F = \frac{D_t}{Y_t} = \frac{E_tD_t^F}{Y_t}$,

primary surplus: $ps_t = \frac{PS_t}{Y_t} \cdot \frac{Y_t-1}{Y_t} = (1 + \pi_t)(1 + g_t)$,
is the change of the nominal gross domestic product in terms of the growth rate of the real gross domestic product \((g)\) and the inflation rate \((\pi)\); and

\[ e_t = \left(\frac{g_t}{E_t-1} - 1 \right) \text{ is the rate in the average nominal exchange rate.} \]

We will obtain the debt ratio equation as

\[ d_t = \frac{(1+r_t)}{(1+g_t)}d_{t-1} - ps_t \quad (3.8) \]

From the equation 3.8, the government is solvent and the debt ratio is stabilized if \(r_t < g_t\) as \(\lim_{t \to \infty} E(d_t) = 0\).

Or we can simplify as follows;

\[ d_t = (1+r_t)(1+g_t)^{-1}d_{t-1} - ps_t \quad (3.9) \]

\[ d_t = (1+r_t)(1+g_t)^{-1}d_{t-1} - (R_t - G_t)(1-r_t)^{-1} \quad (3.10) \]

In other words, two conditions are required as follows: \(r_t > g_t\) for all \(t\) as we need the debt ratio to be stabilized; furthermore, it is necessary that \(G_t - R_t \leq 0\) on average, the government needs to run a budget surplus. According to the sufficiency of these two conditions, running a budget surplus by either increasing tax or reduction in the expenditure can pay off the debt.

Then, denoting \(\beta_t = \frac{(1+r_t)}{(1+g_t)}\) is the spread between the real interest rate with regard to the total debt and the rate of growth of the real domestic product. We obtain:

\[ d_t = \beta_t d_{t-1} - ps_t \quad (3.11) \]

The meaning of this equation is that under the current policy and without shocks, debt ratio will rise continuously on the condition that the growth rate grows less than the
real interest rate while the government run budget surplus.\(^2\)

From the law of motion of the debt-to-GDP ratio, we can get debt ratio by other alternatives.

\[ d_t = \frac{1}{\beta_t} d_{t-1} - \frac{1}{\beta_t} ps_t \quad (3.12) \]

If \( d_t = d_t - 1 \)

Then \( d_t = \frac{1}{\beta_{t+1}} d_{t+1} - \frac{1}{\beta_{t+1}} ps_{t+1} \)

The condition for government solvency up to time \( N \) is

\[ d_t = \frac{1}{\beta_t} ps_{t+1} + \frac{1}{\beta_{t+1}} ps_{t+2} + \frac{1}{\beta_{t+1}} ps_{t+N} + \frac{1}{\beta_{t+N}} d_{t+1} \quad (3.13) \]

Beyond this, there are two conditions for solvency which are:
1) assuming the discount factor remains constant from time \( t \) to time \( t + N \), then as the government require the primary balance become positive; and
2) requiring \( d_{t+N} = d^* \) where \( 0 < d^* < d_t \) as we need the debt ratio to be reduced by the present value of expected primary surplus ratio.

Regarding specific assumptions, defining the variable and the government reaction function we will consider from equation (3.6).

\[ d_t = \beta_t d_{t-1} - ps_t \quad (3.14) \]

From this equation, we can set the targets for the government, which are

- Debt ratio target
  \[ d_t^* = \beta_t d_{t-1} - ps_t \quad (3.15) \]

- Primary surplus target
  \[ d_t = \beta_t d_{t-1} - ps_t^* \quad (3.16) \]

- Or even set the target of discount factor
  \[ d_t = \beta_t^* d_{t-1} - ps_t \quad (3.17) \]

\(^2\) (\( d_t \): the debt ratio; \( ps_t \): primary surplus ratio)
Following Croce and Juan-Ramon (2003), we will use the lowest value of the debt in the sample to be our debt target. The target that we will use can be obtained from setting a target equation.

\[ ps_t = (\beta^* - 1)d_t^* \]  
(3.18)

\[ ps_t^* \text{ and } \beta^* \text{ will be converge to } d^*, \text{ as we need to obtain the target debt ratio } (ps_t^* \text{ is primary surplus ratio, } \beta^* \text{ is discount factor and } d^* \text{ is the target debt ratio.}) \]

\[ ps_t = ps_t^* + \lambda_t(d_{t-1} - d^*) \]  
(3.19)

\[ d_t = (\beta_t - \lambda_t)(d_{t-1} - (\beta^* - \lambda_t - 1)d^*) \]  
(3.20)

From this equation, there are two main conditions, which are: \( d_{t-1} > d^* \) and \( |\beta_t - \lambda_t| < 1 \) as we want \( d_t \) converge to \( d^* \), then we obtain indicator fiscal sustainability as:

\[ IFS = (\beta_t - \lambda_t) = \left[ \frac{1 + r_t}{1 + g_t} - \frac{ps_t - ps_t^*}{d_{t-1} - d^*} \right] \]  
(3.21)

The indicator composes of two components which are \( \beta \) and \( \lambda \):

\( \beta \): the spread between the real interest rate with regards to the total debt and the rate of growth of the real domestic product.

\( \lambda \): the government surplus or deficit and the difference of the previous debt and the target debt.

A lead indicator is \( \beta \) which defines the spread between the observed real interest rate and the observed rate of growth (at time \( t \)). If the spread rises very high, this will cause the government indebtedness to increase. We will not consider when \( \beta \) is less than 1 as this will lead to inefficient capital over-accumulation (as \( r < g \)) in a steady state. \( \lambda \) reflects the ratio between two sets, the first one is the deviation of the observed primary
surplus ratio with respect to the primary ratio that keep the debt ratio at target level, and the second set is the deviation of the observed public debt ratio and the primary surplus ratios with respect to their target values. The value of $d^*$ can be obtained by considering the lowest value of the debt ratio during the testing period\(^3\). If $IFS < 1$: it means fiscal situation is sustainable and if $IFS \geq 1$: this case will give a signal of fiscal unsustainability.

\(^3\) see Enzo and Juan-Ramon (2003)
3.4 Empirical Results: Indicator of Fiscal Sustainability

3.5 European region

We observe two countries using quarterly data (France and Finland). The recognized crisis in Europe occurred during 1992-1993; which corresponds to the ERM (European Exchange Rate Mechanism) crisis. France was one of the members of the European Monetary System (EMS). However, Finland also faced the crisis; which will be a useful implication for this research. The weak fundamentals of the public sector might be one of the reasons of causing the crisis. Hence, we focus on the fiscal sustainability analysis. The tension within the ERM started to rise from July 1992, concentrating originally on the lira, then on sterling and finally on the other countries' currencies; the crisis seems to have accelerated due to interest rate reductions from the Bundesbank.

Finland’s economy is similar to other countries in European region in that it mainly depends on manufacturing export, although it needs to import raw materials and basic products. The climate does not support developing agricultural products. The collapse followed the financial crisis of many countries. The combination of the pegged exchange rate, an overvalued currency coinciding with a high inflation rate resulting from the credit expansion and capital market deregulation in the latter half of the 1980s led Finland into the economic crisis in 1990s. This was a much more severe event than the crisis of the 1930's. Not only had the above-mentioned factors caused the crisis, but also the dismantling of trade with Soviet Union. The Soviet Union has been a major market for Finland. Figures 3.1 and 3.2 display the growth rate and primary surplus respectively, showing how the government budget dropped sharply from 1991 until 1994 and recovered from the end of 1997 onwards. The growth rate also fell dramatically in 1991. This circumstance corresponded to the ERM crisis, which thus forms a practical lesson for the analysis of fiscal sustainability.
Fig. 3.1: Growth Rate of Finland
Fig. 3.2: Primary Surplus of Finland
France joined the Euro currency in February, 2002. The French economy, compared with the other countries in the European area, was prominent in both industry and agriculture. A major burden of the economy was volatility high unemployment and economic growth which followed the recessions in the late 1990. The problems of the economy included the large stock of inefficient public sector enterprises and the increase of budget deficit. Other major burdens of French economy were high levels of taxation and a rising budget deficit. However, poverty and income inequality in France remained relatively low.
3.6 Asian Region

We study Thailand as the representative of the Asian region, where the Asian crisis was triggered from. After the crisis, Thailand recovered rather quickly by increasing consumption and encouraging export. The crisis started due to an increase of the inflows and the asset markets prices in the early 1990s, corresponding to a high growth period for East Asia. However, in 1997, the investors lost their confidence in securities, which caused major capital outflows. This problem affected neighbouring countries as well. The high debt that caused the crisis came mainly from the private sector and was guaranteed by the public sector. In the banking sector, the systemic of banking crises led to the liquidation of many commercial banks. The systemic crises was compounded by deteriorating capitalization of surviving bank, declining real estate valuation, and bearish trend in stock prices. The weaknesses of the financial sector was thus the major component of the crisis. Recently Thailand economy again faced difficult challenges, because of natural disasters (the 2005 tsunami) and the outbreak of SARS slowed the economy down. In general, the government policy reforms that follow the economic slow-down mitigated the further decline in output growth and worsening of the financial crisis.
3. An Indicator of Fiscal Sustainability (IFS)

Fig. 3.4: Growth Rate of US

3.7 US

US data are mostly employed in numerous studies, given the robustness and reliability of the data sets. The US economy is endowed with abundant natural resources and human capital. Since 1991, the US has sustained positive growth rate while maintaining low unemployment and inflation rates. In terms of government spending, there are conclusions on the sustainability of the US government spending, while some studies argued that the US deficit is appropriate for its growth and macroeconomic sustainability, others have seen the trends as detrimental to the economy.
Fig. 3.5: Primary Surplus of US
3.8 Latin America Region

The Latin America crisis occurred in 1994-5. The starting point emerged from the Mexican peso crisis.

![Graph of Growth Rate of Bahamas](image)

**Fig. 3.6: Growth Rate of Bahamas**

The Bahamas economy is dependent on tourism and offshore banking. Although the economy is market-oriented, the state still has an important role in the main areas, such as insurance, public utilities and tourism. Bahamas has no personal or corporate income taxes; hence the income tax structure is somewhat inelastic. The majority of the revenues comes from international trade or indirect tax from import, export and stamp duties. The figures shows that the Bahamas primary government budget has been in a deficit. This increased sharply in 1982 as the government focused on the tourism program. After the completion of construction projects, the growth rate rose dramatically in 1985. The slowdown in the US economy in 2001 has had an affect on
Fig. 3.7: Primary Surplus of Bahamas

Bahamas's economy as US are its main trading partner (visitor).
Fig. 3.8: Growth Rate of South Africa.
3. An Indicator of Fiscal Sustainability (IFS)

South Africa has one of the highest levels of income inequality, as the economy is relatively well-developed in the southern part, but undeveloped in the other areas. The economy is mainly based on the agricultural sector. Fixed exchange rates have been used in South Africa until the late 1960s, changing to floating exchange rates in 1979. South Africa faced a high debt ratio in 1985. The figure shows that the growth rate in South Africa increased steadily from 1994 until 1998 and declined significantly thereafter. In the mid 1990s, South Africa faced high debt which coincided with the budget balance. The primary surplus figure demonstrated that from 1990, budget deficit increased significantly, particularly in 1994. Nevertheless, from 1994 South Africa adopted a reforming agenda to secure its fiscal situation.

These are the overview of the countries that we will analyse for the fiscal sustain-
ability. Various factors that we need to use in this approach will be defined in the following section.

3.9.1 Debt ratio

The graphs below show the debt ratio in South Africa and US which will provide a preamble to investigate the indicator of fiscal sustainability.

![Debt ratio - South Africa](image)

**Fig. 3.10:** Debt ratio of South Africa.

As we can see from the case of South Africa, debt has increased to the highest point in 1978:2 at 40.55%; meanwhile in US, the peak debt point is over 50% in 1993:4 at 50.05%. On the contrary, the lowest point of debt in South Africa is 28.47% in 1981:4. In the United States, in 1975 the debt level is at 23.64% which is the lowest point of this data set. We consider the highest and lowest levels of debt so as to scrutinize the
fiscal unsustainability and set the target of debt respectively, which is the key point of this chapter. From these two countries, the characters of the graph are quite the same in the aspect of magnitude.

The debt ratio from these two countries have raised and the range is nearly the same, as well as the shape of the debt ratio. However, the economies of these two countries is totally different. Hence, the percentage of debt ratio could be viewed from different perspectives. We also investigate the countries from various regions, which are European, Asia, Latin American and South Africa as we demonstrate as follows.

Fig. 3.11: Debt ratio of US
Figure 3.12 are the graphs that we observe the debt ratio of 3 countries. The debt ratio of Finland starts to increase sharply in 1992, especially in 1993, until in 1998 it drops dramatically. France’s debt ratio has fluctuated during 1981-1984 and increased gradually from 1993, while Bahamas’s debt has fluctuated from 1976 and increased gradually to 26% in 1989, declining significantly to 17% in 1982. However, the level of debt ratio increased again from 1990 and reached the highest point at 35% in 1995. The debt ratio in these countries are the focus factor for the empirical countries in the test of the fiscal sustainability.
Fig. 3.12: Debt Ratio of Bahamas, Finland, France
3. An Indicator of Fiscal Sustainability (IFS)

3.9.2 IFS: Indicator of Fiscal Sustainability

From the indicator of fiscal sustainability equation

\[
IFS = (\beta_t - \lambda_t) = \left[ \frac{1 + \gamma_t - ps_t}{1 + g_t} \frac{ps_t - ps^*}{d_{t-1} - d^*} \right]
\]  \hspace{1cm} (3.22)

the result shows that \( \lambda \) will respond to various variables which are primary surplus, debt ratios, tax, exchange rate, expenditure deviation and shocks.

Result 1

These figures 3.13-3.18 demonstrate the indicators of both countries of South Africa and US, in South Africa, the result shows that the fiscal stance is entirely unsustainable, especially in 1982:2, the indicator became very high at 11.37. For the United States, it is clear that from 1976 to 1981, it is unsustainable.

Fig. 3.13: IFS of South Africa
If the government changes its policy or the interest rate, what is the effect on the indicator? We examine what happens after increasing and decreasing the value of $\beta_t$.

The results from the both countries are as shown in figures 3.15 - 3.16;
3. An Indicator of Fiscal Sustainability (IFS)

Fig. 3.15: IFS 1 of South Africa and US
3. An Indicator of Fiscal Sustainability (IFS)

Fig. 3.16: IFS 2 of South Africa and US
Result 2

IFS1 and IFS2 are the increasing and decreasing the value of $\beta^*_t$ respectively.

For South Africa, if we increase the value of $\beta^*_t$ from 1.10 to 1.15, the average value of $ps^*$ that expect to converge to the target debt ratio, will be from 2.936 to 4.2 of GDP given $d^*$ as 28 percent. On the other hand, if we decrease the value $\beta^*_t$ of from 1.10 to 1.05, the change of $ps^*$ value will be 1.4. In this respect, it also demonstrates that the model is quite consistent as when we deviate the value of $\beta^*_t$, as the IFS will change significantly as well. Our results show this trend vividly, for example in the case of the United State, when we raise up and minimize the value of $\beta^*_t$ from 1.10 to 1.15 and 1.02, given $d^*$ as 23 percent, the average values of $ps^*$ that expect to converge to the target debt ratio, will be from 21.276 to 2.3 and 0.46 of GDP respectively.

![IFS of Bahamas](image)

*Fig. 3.17: IFS of Bahamas*
3. An Indicator of Fiscal Sustainability (IFS)

From the figures 3.17 - 3.20, the figures demonstrate the other countries IFS from various regions. We find that fiscal policy is mostly unsustainable in the testing countries; however, in France, fiscal policy seems to be sustainable from the year 2002-1, and also from 2002-2 in Thailand the fiscal policy also is sustainable after they faced serious crisis in the year of 1996-1997. The obvious fiscal unsustainability country is Bahamas as the results show that the IFS are not only highly fluctuating, but also extremely high either in increasing or decreasing dimensions.
Fig. 3.19: IFS of France
Fig. 3.20: IFS of Thailand
3.10 Conclusion

In this chapter, we employed Croce and Juan-Ramon (2003)'s approach to a representative sample of countries. The approach emphasizes on setting the target of debt. We use this approach with various regions in order to explore the consistency of the approach. We found that IF5 presents positive results; it provides an explanation of the fiscal policy, even though the government requires to adjust the performance. One of the advantages of this indicator is that it is not difficult to obtain. The main disadvantage is that, in other regions apart from Europe, when we employ the lowest values in the sample as the target debt \((d^*)\) (following Croce and Juan-Ramon (2003)), the procedure causes countries to show unsustainability, particularly if episodes of unsustainability are recent.

We have seen some of the advantages of using an Indicator of Fiscal Sustainability, which bypass the need to test for stationarity of the series, for example. In the following chapters, however, we will focus on the tests that explicitly take into consideration the statistical properties of the data. We will base our analysis on the theoretical framework provided by the Intertemporal Budget Constraint Approach, which considers the joint behaviour of government expenditures and revenues.

\(^4\) For European countries, the target debt is set at 60 following the Stability Pact, see Croce and Juan-Ramon (2003).
3.11 Appendix

The government solvency equation calculation can be simplified by starting from the equation 3.7

\[ D_t^P + E_t D_t^F = (1 + i_t^P) D_{t-1}^P + E_t (1 + i_t^F) D_{t-1}^F - PS_t \]

\[ d_t^P + d_t^F = (1 + i_t^P) d_{t-1}^P \left[ \frac{Y_{t-1}}{Y_t} \right] + (1 + i_t^F) d_{t-1}^F \left[ \frac{Y_{t-1}}{Y_t} \right] \left[ \frac{E_{t-1}}{E_t} \right] - ps_t \]

We divide the first equation by nominal GDP at time \( t \) \((Y_t)\), and denoting

\[ d_{t-1}^P = \frac{D_{t-1}}{Y_{t-1}} \]

\[ d_t^P = \frac{D_t^P}{Y_t} = \frac{E_t D_t^F}{Y_t} \]

\[ ps_t = \frac{E_{t-1}}{Y_{t-1}} \]

\[ \frac{Y_{t-1}}{Y_t} = (1 + \pi_t)(1 + g_t) \] and

\[ e_t = \frac{E_t}{E_{t-1}} - 1 \]

are the change of the nominal gross domestic product in terms of the growth rate of the real gross domestic product \((g)\) and the inflation rate \((\pi)\); and the rate in the average nominal exchange rate respectively,

\[ d_t^P + d_t^F = \frac{(1 + i_t^P)}{(1 + \pi_t)(1 + g_t)} d_{t-1}^P + \frac{(1 + i_t^F)}{(1 + \pi_t)(1 + g_t)} d_{t-1}^F - ps_t \]

We denote that: \( r_t^P = \frac{(1 + i_t^P)}{(1 + \pi_t)} - 1 \)

\[ r_t^F = \frac{(1 + i_t^F)}{(1 + \pi_t)} - 1 \]

And \( r_t = r_t^P \frac{d_t^P}{d_{t-1}} + r_t^F \frac{d_t^F}{d_{t-1}} \)
or \( 1 + r_t = (1 + r_t^D) \frac{d^P_{t-1}}{d_{t-1}} + (1 + r_t^P) \frac{d^H_{t-1}}{d_{t-1}} \)

Hence, we obtain:

\[
d_t = \frac{(1+r_t^D)}{(1+g_t)} \frac{d^P_{t-1}}{d_{t-1}} + \frac{(1+r_t^P)}{(1+g_t)} \frac{d^H_{t-1}}{d_{t-1}} - ps_t
\]

We divide by \( \frac{d^H_{t-1}}{d_{t-1}} \), we get:

\[
d_t = \frac{(1+r_t^D)}{(1+g_t)} d^P_{t-1} + \frac{(1+r_t^P)}{(1+g_t)} d^H_{t-1} - ps_t
\]

Then simplifying, we obtain,

\[
d_t = \frac{(1+r_t^D)}{(1+g_t)} d^P_{t-1} - ps_t
\]

The next step, denoting \( \beta_t = \frac{(1+r_t^D)}{(1+g_t)} \) is the spread between the real interest rate with regard to the total debt and the rate of growth of the real domestic product. We obtain:

\[
d_t = \beta_t d^P_{t-1} - ps_t
\]

Hence,

\[
d_{t-1} = \frac{1}{\beta_t} d_{t-1} - \frac{1}{\beta_t} ps_t
\]

If \( d_t = d_{t-1} \)

\[
d_t = \frac{1}{\beta_t} d_{t+1} - \frac{1}{\beta_t} ps_{t+1}
\]

The condition for government solvency up to time \( N \), we can rewrite as:

\[
d_t = \frac{1}{\beta_t} ps_{t+1} + \frac{1}{\beta_{t+1}} ps_{t+2} + \frac{1}{\beta_{t+N}} ps_{t+1} + \frac{1}{\beta_{t+N}} d_{t+1} \tag{3.23}
\]

as government solvency equation.
4. AN EFFICIENT TEST FOR FISCAL SUSTAINABILITY

The purpose of this chapter is to empirically assess the sustainability of the fiscal regimes in six developed and developing economies, resorting to a variety of time series econometric techniques applied within the context of the intertemporal budget constraint (IBC) framework. We focus on the Bahamas, Finland, France, Thailand, South Africa and US. The purpose of choosing these countries is to provide an overview of fiscal sustainability over a range of economies with different degrees of development.

Following Hamilton and Flavin (1986) and as in the previous chapter, the IBC can be expressed as

\[ D_t = \sum_{n=0}^{\infty} \Pi_{k=1}^{n} (1 + \iota_{t+k})^{-1} (R_{t+n} - G_{t+n}) + \lim_{n \to \infty} \Pi_{k=1}^{n} (1 + \iota_{t+k})^{-1} D_{t+n} \]

where \( D_t \) : government debt in the present period

\( R_t \): Government Revenues

\( G_t \): Government primary expenditures

we know that the present value of government debt \( D_t \) is the combination of the expected present value of the future primary surpluses \( \sum_{n=0}^{\infty} \Pi_{k=1}^{n} (1 + \iota_{t+k})^{-1} (R_{t+n} - G_{t+n}) \) and \( \lim_{n \to \infty} \Pi_{k=1}^{n} (1 + \iota_{t+k})^{-1} D_{t+n} \), the expected present value of the government’s debt. If we assume that lenders rule out the possibility of a Ponzi game\(^1\), this implies that the asymptotic term converges to 0 and we thus have a ‘transversality condition’ ensuring sustainability.

---

\(^1\) That is, the government is not allowed to indefinitely pay its current interest payments merely by borrowing more. Otherwise, the rate of growth of debt could be equal to the (mean) real interest rate.
However, the above expression is not convenient for empirical work. Following the convention in the literature, one can rewrite (4.1) as

$$E_t - R_t = \sum_{n=0}^{\infty} \delta^{n-1} (\Delta R_{t+j} - \Delta G_{t+j}) + \lim \delta^{n+1} \Delta D_{t+j}$$  \hspace{1cm} (4.2)

by noting that $D_t$ can be expressed as $D_t = (1 + r)D_{t-1} + G_t - R_t$ and applying the difference operator to (4.1). $E_t$ is now government expenditures inclusive of interest payments with discount factor $\delta = (1 + r)^{-1}$. Given that the variables $E_t$ and $R_t$ usually appear to display non-stationary behaviour, this provides a statistical framework for testing sustainability. Indeed, deficit sustainability implies that revenues and expenditures must be cointegrated with cointegration vector $[1, -1]$, if each are $I(1)$ processes. In practice, this amounts to estimate the generic regression equation

$$R_t = a + bE_t + u_t$$  \hspace{1cm} (4.3)

and testing whether or not $b = 1$.

However, as pointed out by Quintos (1995), this not a necessary but a sufficient condition for a stringent interpretation of fiscal sustainability. In fact, a necessary condition imposes that debt should grow slower than the borrowing rate. Thus, following the typology of Quintos (1995) and Martin (2000), we may have four possible scenarios for sustainability:

- 'Strong' sustainability, if and only if the $I(1)$ processes $R_t$ and $E_t$ are cointegrated and $b = 1$: this means that the IBC holds and simultaneously the undiscounted debt $D_t$ is also $I(1)$).

- 'Weak' sustainability in the case where $R_t$ and $E_t$ are cointegrated but $0 < b < 1$: this is corresponding to the case of a smaller than 1 long-run elasticity of revenue relative to expenditure and therefore may be an incentive for debt default.

- Unsustainability, when $b < 0$, implying that deficits are being accumulated at a rate greater than the growth rate in the economy and the IBC is therefore violated\(^2\).

\(^2\) The case $b > 1$ implies indefinitely growing surpluses and therefore is not consistent with fiscal sustainability per se.
Thus, the usual procedure in the literature is to apply conventional unit root tests to $D_t$ (Hamilton and Flavin, 1986, Trehan and Walsh, 1988 and 1991, for example) or cointegration tests such as the two-step Engle-Granger procedure applied to (4.3) (Haug, 1991, Hakkio and Rush, 1991, Ahmed and Rogers, 1995). We depart from, and thus contribute to, the literature by using efficient tests of the 'strong' sustainability hypothesis. Indeed, we employ the cointegration test developed by Horvath and Watson (1995) for the case when the cointegration vector is pre-specified, as is the case with 'strong' sustainability, with cointegration vector $[1, -1]$.

The common practice in empirical applications is to proceed in two stages: first, test/estimate cointegration assuming the cointegration vector is unknown and, if cointegration is found, as a second step proceed with estimation with cointegration maintained both under the null and the alternative, with a 'restricted' cointegration vector arising from the first step. However, as pointed out by Horvath and Watson (1995), in this situation the usual tests are inefficient in small samples. These authors derived a testing procedure for the case when the cointegration vector is known, which allows for substantial gains in power when compared to standard procedures that do not impose a cointegration vector. Its computation is also reasonably easy, as it is based on a Wald test of the error correction term in a Vector Error Correction Model (VECM).

In the bivariate case, the 'strong' sustainability case implies that a direct test can be obtained by testing the stationarity of $D_t$ itself. However, Horvath and Watson (1995) also show that a multivariate cointegration approach can lead to efficiency gains over the univariate unit root tests if the error terms of $E_t$ and $R_t$ are correlated, as it is likely to be the case, as shocks affecting the expenditure and the revenue sides are likely to be highly correlated.

Therefore, there seems to be a compelling case for the use of this procedure. The caveat of this test is, naturally, that its relative power will suffer if the variables are cointegrated with a cointegrating vector different from the pre-specified one, namely the case of 'weak' sustainability. We argue, however, that given the implications of the latter, the 'strong' hypothesis should be the benchmark case when assessing fiscal sustainability.
A separate issue that we consider is to ascertain the causal direction between expenditures and revenues. This may help in identifying which element, if any, of the budget constraint can lead to control over the other and thus assist policy-making by identifying the source of potential government fiscal imbalances. For that purpose, we employ modified causality tests developed by Toda and Yamamoto (1995) that allow for the presence of non-stationary variables in an estimated VAR.

This chapter is structured as follows. The next section analyses the fiscal regimes of 6 countries using conventional unit root and cointegration methodologies. We then describe the testing procedure of Horvath and Watson (1995) and contrast the previous results with those obtained with the efficient tests of Horvath and Watson (1995). Section 4.3 presents the results for causality tests and a discussion concludes this chapter.

4.1 Empirical analysis

4.1.1 Univariate tests of fiscal sustainability

As discussed above, one can adopt two strategies to test for fiscal sustainability. One is to note that 'strong' sustainability implies a cointegration vector of [1, -1], which means that the long run equilibrium relationship between expenditures and revenues can be tested based on a univariate test for the primary surplus/deficit \( PS_t = G_t - R_t \). Testing whether or not this series is stationary allow us to draw conclusions on sustainability of the 'strong' type. An alternative, and perhaps more flexible, approach is to estimate a standard cointegration regression like (4.3) and test whether \( b = 1 \) or, instead, \( 0 < b < 1 \). In this section, we follow the first route.

Figure 4.1 displays the series of primary surplus for the six countries under consideration. Visual inspection suggests that the series do not exhibit a trending pattern, rather fluctuating around a mean, although with periods of substantial deviation from this 'mean' behaviour. To formally assess the properties of this series, one should resort to unit root tests.
In Table 4.1 we present results for the Augmented Dickey-Fuller, Phillips-Perron and the Elliot-Rothenberg-Stock unit root tests, both on the levels and in first-differences of the $PS_t$ series (with a constant term included) computed using the software EViews (lag lengths and bandwidths automatically selected based on the Schwarz Information Criterion).

According to these results, we find that the series for primary surplus in the Bahamas and France display a clear stationary and, hence, sustainable behaviour. The picture is less clear for the USA, given that the Phillips-Perron test does not reject the null of a unit root. On the other hand, Finland, South Africa and Thailand appear to be on an unsustainable path, given that all tests fail to reject the null of non-stationarity. However, as argued above, there may be efficiency gains in resorting to a multivariate testing framework, using the joint dynamics of expenditures and revenues. We next explore cointegration tests involving these two variables, after assessing their individual statistical properties.
4. An Efficient Test for Fiscal Sustainability

Fig. 4.1: Primary Surplus
4. An Efficient Test for Fiscal Sustainability

<table>
<thead>
<tr>
<th>Level</th>
<th>Countries</th>
<th>ADF</th>
<th>PP</th>
<th>ERS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Primary Surplus</td>
<td>Bahamas</td>
<td>-4.8722*</td>
<td>-4.982*</td>
<td>2.725</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(0.0006)</td>
<td>(0.0004)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Finland</td>
<td>-1.806</td>
<td>-2.925</td>
<td>12.928</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(0.696)</td>
<td>(0.156)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>France</td>
<td>-7.812*</td>
<td>-8.320*</td>
<td>1.710</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(0.000)</td>
<td>(0.000)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>South Africa</td>
<td>-1.594</td>
<td>-2.402</td>
<td>14.522</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(0.789)</td>
<td>(0.376)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Thailand</td>
<td>-1.713</td>
<td>-3.355***</td>
<td>15.594</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(0.739)</td>
<td>(0.063)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>US</td>
<td>-2.957</td>
<td>-1.501</td>
<td>0.083</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(0.149)</td>
<td>(0.824)</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>First Difference</th>
<th>Countries</th>
<th>ADF</th>
<th>PP</th>
<th>ERS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Primary Surplus</td>
<td>Bahamas</td>
<td>-10.608*</td>
<td>-15.013*</td>
<td>0.226*</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(0.000)</td>
<td>(0.000)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Finland</td>
<td>-11.242*</td>
<td>-16.210*</td>
<td>0.259*</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(0.000)</td>
<td>(0.000)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>France</td>
<td>-9.251*</td>
<td>-74.647*</td>
<td>0.946*</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(0.000)</td>
<td>(0.00001)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>South Africa</td>
<td>-5.514*</td>
<td>-10.104*</td>
<td>2.489**</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(0.000)</td>
<td>(0.000)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Thailand</td>
<td>-12.044*</td>
<td>-16.147*</td>
<td>0.267*</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(0.000)</td>
<td>(0.000)</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>(0.118)</td>
<td>(0.000)</td>
<td></td>
</tr>
</tbody>
</table>

*: Test at 1% significance level

**: Test at 5% significance level

***: Test at 10% significance level

Tab. 4.1: Unit Root Tests of Primary Surplus
4. An Efficient Test for Fiscal Sustainability

4.1.2 Unit Root and Standard Cointegration Tests

As mentioned earlier, the series of government expenditures and revenues appear to be non-stationary, as shown in Figure 4.2.

This is largely confirmed by unit root tests on each series. Again, we employ the Augmented Dickey-Fuller, Phillips-Perron and the Elliot-Rothenberg-Stock unit root tests, both on the levels and in first-differences of the variables, the results being presented in Table 4.2. Given that the variables display a clear trending pattern, a deterministic trend is also included. The unit root tests reveal, as expected, that the series can be classified as being $I(1)$. Indeed, the tests on the levels are not rejected, while the results for the first-differenced series indicate stationarity. This is true for all testing procedures. This means that cointegration is the appropriate framework to assess the sustainability of these fiscal regimes. Thus, we now estimate the cointegration regression (4.3) and test whether $b = 1$ or $0 < b < 1$. We employ a residual-based approach to testing cointegration, i.e., we first estimate (4.3) and then ascertain whether the estimated equilibrium errors are stationary or not. There is no efficiency losses in pursuing a single-equation route when compared to the multi-equation method of Johansen (1988), as we are studying a bivariate relationship with potentially a single cointegration vector. Thus, we consider the standard OLS estimator of $b$, as well as the dynamic OLS (DOLS) estimator of Stock and Watson (1991), which augments the cointegrating regression with $p$ lags and leads of the differenced explanatory variable, in order to correct for second-order biases usually associated with the simple OLS estimator (see Maddala and Kim, 1998 for a survey). Hence, we also estimate $b$ via the regression

$$R_t = a + b E_t + \sum_{j=-p}^{p} \Delta E_{t-j} + u_t,$$

determining $p$ by testing down the significance of the extra leads and lags, starting from $p = 4$. 
4. An Efficient Test for Fiscal Sustainability

![Graphs of Expenditure and Revenue](image)

**Fig. 4.2: Expenditure and Revenue**
### Table 4.2: Unit Root Tests of Expenditures and Revenues

<table>
<thead>
<tr>
<th>Countries</th>
<th>Level Expenditures</th>
<th>Revenues</th>
<th>First Difference Expenditures</th>
<th>Revenues</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>ADF</td>
<td>PP</td>
<td>ERS</td>
<td>ADF</td>
</tr>
<tr>
<td></td>
<td>(0.145)</td>
<td>(0.000)</td>
<td>(0.298)</td>
<td>(0.000)</td>
</tr>
<tr>
<td></td>
<td>(0.0037)</td>
<td>(0.0157)</td>
<td>(0.109)</td>
<td>(0.0178)</td>
</tr>
<tr>
<td></td>
<td>(0.374)</td>
<td>(0.374)</td>
<td>(0.551)</td>
<td>(0.102)</td>
</tr>
<tr>
<td></td>
<td>(0.000)</td>
<td>(0.000)</td>
<td>(0.166)</td>
<td>(0.0052)</td>
</tr>
<tr>
<td>Thailand</td>
<td>-2.246</td>
<td>-3.044</td>
<td>11.720</td>
<td>-2.671</td>
</tr>
<tr>
<td></td>
<td>(0.459)</td>
<td>(0.125)</td>
<td>(0.251)</td>
<td>(0.598)</td>
</tr>
<tr>
<td></td>
<td>(0.967)</td>
<td>(0.001)</td>
<td>(0.324)</td>
<td>(0.0721)</td>
</tr>
</tbody>
</table>

* : Test at 1% significance level

** : Test at 5% significance level

*** : Test at 10% significance level
We observe from Table 4.3 that, in general, the OLS estimates tend to further away from 1 that the corresponding DOLS estimates. Considering the estimates alone, this would imply that the Bahamas, Finland and France would be classified as 'weakly' sustainable, with the remaining countries to be considered 'strongly' sustainable. If one looks at the DOLS results, however, all countries display estimates very close to the 'strong' sustainability benchmark, with the exception of Finland, with $b = 0.824$.

Note that this analysis is conditional on the existence of cointegration between expenditures and revenues. Looking at the residual-based tests, with OLS residuals one would be lead to conclude that, according to the AEG test, Thailand, Finland and the USA would fail to meet the sustainabilty criteria, given that the statistic fails to reject the null of no cointegration. Interestingly, however, the Phillips-Ouliaris test indicates that only the US would not be sustainable.

If we consider instead tests based on the DOLS estimator, the AEG would point to unsustainability for all countries with the exception of France. The Phillips-Ouliaris
test, on the other hand, would add South Africa and the Bahamas to the latter. Therefore, a contradiction seems to emerge: by employing a theoretically more appealing estimator, it appears that the case for sustainability is weakened, although the point estimates suggest that the cointegration is indeed \([1, -1]\). Next, we employ the efficient test of Horvath and Watson (1995) to try to disentangle this issue.

4.2 Testing for cointegration when the cointegration vector is specified

The setup for the derivation of the test is similar to the reduced rank procedure based on a Gaussian VAR

\[
Y_t = d_t + X_t \\
X_t = \sum_{i=1}^{p} \Pi_i X_{t-i} + \varepsilon_t
\]

where \(Y_t\) and \(X_t\) are \(n \times 1\) variables, \(d_t\) is a deterministic term (possibly including time trends) and \(\varepsilon_t\) is normally distributed with covariance matrix \(\Sigma_\varepsilon\). As usual, we can rewrite the above system in vector error-correcting form as

\[
\Delta X_t = \Pi X_{t-1} + \sum_{i=1}^{p-1} \Phi_i \Delta X_{t-i} + \varepsilon_t
\] \hspace{1cm} (4.4)

where \(\Pi = -I_n + \sum_{i=1}^{p} \Pi_i\).

As in Johansen (1988), a test for \(r = \text{rank}(\Pi)\) can be developed for the hypotheses

\[
H_0 : \text{rank}(\Pi) = r = \tau_c \\
H_0 : \text{rank}(\Pi) = r = \tau_c + \tau_a, \quad \tau_a > 0.
\]

We follow the notation of Horvath and Watson (1995), so that the alternative hypothesis contains \(\tau_a\), the number of additional cointegrating vectors that are present under the alternative. We can partition the ranks according to the number of (un)known cointegration vectors, that is, \(\tau_c = \tau_{ck} + \tau_{au}\) and \(\tau_a = \tau_{ak} + \tau_{au}\), with the subscripts \(k\) and \(u\) indicating 'known' and 'unknown', respectively.
In order to derive the test statistic, we need to factor the matrix Π as Π = δα', so that δ and α are n × r matrices of full column rank and the columns of α give the cointegration vectors. As above, these matrices can be partitioned into α = (α₀αₖ) and δ = (δ₀δₖ) and, to reflect the knowledge of the cointegration vector, αₖ = (αₖ₁αₖ₂) and δₖ = (δₖ₁δₖ₂), so that the rₖ columns of αₖ give the additional known cointegration vectors under the alternative Hₙ. This implies that ΠXₜ₋₁ = δ₀(α₀'Xₜ₋₁) + δₖ(αₖ'Xₜ₋₁).

In our case, given that we have a bivariate relationship, we will be testing H₀ vs Hₙ in the case where r₀ = 0 (i.e., no cointegration) and rₖ = rₖ = 1, since we have a single, pre-specified cointegration vector given by [1, −1]. Thus, the model can be rewritten as (ignoring dₜ for notational convenience)

\[ ΔY_t = δ_{a₀}(α_{a₀}'Y_{t-1}) + βZ_t + ε_t, \]

where \( β = (Φ₁Φ₂...Φ_p⁻¹) \) and \( Z_t = (ΔY'_{t-1}ΔY'_{t-2}...ΔY'_{t-p+1}) \). Let \( Y = [Y \_2...Y \_T]' \), \( ΔY = Y - Y \_1 \), \( Z = [Z \_1...Z \_T] \), \( ε = [ε \_1...ε \_T] \) and \( MZ = [I - Z(Z'Z)^{-1}Z'] \). The Wald statistic for H₀ against Hₙ is

\[ W = [vec(ΔY'M \_2Y \_1α \_αₖ)]'(α \_a₀'Y \_1M \_2Y \_1α \_αₖ)^{-1} Ω^{-1} vec(ΔY'M \_2Y \_1α \_αₖ) \] (4.5)

where \( Ω^{-1} \) is the OLS (MLE), given the Gaussianity assumption) estimator of \( Σ (Ω = T^{-1}ε'ε) \) and \( (ΔY'M \_2Y \_1α \_αₖ)(α \_a₀'Y \_1M \_2Y \_1α \_αₖ)^{-1} \) is the OLS (MLE) estimator of δₖ.

The authors show that the above statistic has a complicated asymptotic distribution that depends on Wiener processes. Critical values were obtained by simulation and tabulated by the authors. In our empirical application, we allow for a constant term in the VECM, to reflect the fact that the variables contain trends. Thus, critical values for our case can be found when n – rₖ = 2, rₖ = rₖ = 0, rₖ = 1 and for Case 2, with critical values 13.73, 10.18 and 8.30, for the 1%, 5% and 10% significance levels, respectively (see Table 1 of Horvath and Watson, 1995, pp. 996-998).
4.2.1 Empirical results

In this section, we test the rank of matrix II in (4.4) using the Wald statistic (4.5) described in earlier section. In the case at hand, the null hypothesis if \( H_0 : r = 0 \), that is, no cointegration, against \( H_1 : r = 1 \), with cointegration vector \([1, -1]\). This entails estimating the VAR in vector-error correction form. We establish the number of lags to be included by considering the AIC and SIC methods.

<table>
<thead>
<tr>
<th>Countries</th>
<th>Bahamas</th>
<th>Finland</th>
<th>France</th>
<th>South Africa</th>
<th>Thailand</th>
<th>US</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wald test</td>
<td>30.4159**</td>
<td>5.5532</td>
<td>29.181**</td>
<td>14.270**</td>
<td>14.602**</td>
<td>46.194**</td>
</tr>
</tbody>
</table>

** : statistically significant at 1% level

Table 4.4: Wald Tests

Table 4.4 presents the results of the test. It is interesting to notice that the null hypothesis of no cointegration is rejected quite comfortably, at the 1% significance level, for all countries, with the exception of Finland. Thus, apart from this country, the results suggest that all countries pursue a strongly sustainable fiscal policy. This conclusion is line with what one could realistic expect, although the result for Finland, a developed economy, is at first sight, surprising. We argue that this may have to do with the substantial distortions that temporary, although persistent, deviations from a sustainable path may have on statistical tests based on a linear specification. Thus, in the next chapter, we explore a more flexible approach that explicitly models the possibility of deviations from a 'strongly' sustainable regime. However, for completeness, the next section considers causality tests among government expenditures and revenues.
4.3 Testing for causality

Having established in the previous section, through the use of efficient sustainability tests, that there is evidence a long run equilibrium relationship, another interesting question is whether one can ascertain which side of the budget equation leads the dynamics of the fiscal regimes. Governments may decide to spend and then tax in order to restore the balance ('spend and tax' hypothesis), in which case we would expect changes in revenues to be predicted by past variations in expenditures (Barro, 1979). Conversely, governments may prefer to raise funds to finance future expenditures or cut taxes to limit spending ('tax and spend' hypothesis) and thus one expects that growth in revenues predicts changes in expenditure (Friedman, 1978). Alternatively, expenditures and revenues may vary simultaneously, reflecting the fact that fiscal authorities plan both sides of the budget equation, according to the classical view of public finance (Musgrave, 1966), which we refer to as the 'fiscal synchronization' hypothesis. Finally, if revenues and expenditures are planned separately, reflecting institutional arrangements that effectively separate allocation and taxation, then neither variable can predict the other (Hoover and Sheffrin, 1992) and this would be consistent with no cointegration and, hence, unsustainability.

Thus, understanding the joint dynamics of revenues and expenditures may provide clues on how governments might respond to fiscal imbalances, given that tests of the above hypotheses provide estimates of the reactions to past imbalances. The statistical framework that is appropriate in this case is that of Granger-causality testing. However, the series involved are non-stationary. We know from the works of Toda and Yamamoto (1995) and Yamada and Toda (1998) that causality testing in the presence of unit roots may lead to correct inferences if the standard procedures are applied. Therefore, we rely on the modified causality test of Toda and Yamamoto (1995) to carry out our tests. This implies determining the order $p$ of the VAR, where the order of the VAR may be selected with a usual lag selection procedure. Then, a $p + d_{\text{max}}$ order VAR should be estimated, where $d_{\text{max}}$ is the maximum order of integration of the variables. The usual tests can then be applied, that is, this procedure essentially corrects for the degrees of freedom by adding $d_{\text{max}}$. In our case, we have established that $d_{\text{max}} = 1$. 
Consider a \((p + 1)\)-order bivariate VAR involving revenues and expenditures:

\[
\begin{bmatrix}
R_t \\
E_t
\end{bmatrix} = \begin{bmatrix}
\alpha_1 \\
\alpha_2
\end{bmatrix} + \begin{bmatrix}
\beta_{11}^1 & \beta_{12}^1 \\
\beta_{21}^1 & \beta_{22}^1
\end{bmatrix} \begin{bmatrix}
R_{t-1} \\
E_{t-1}
\end{bmatrix} + \ldots + \begin{bmatrix}
\beta_{11}^{p+1} & \beta_{12}^{p+1} \\
\beta_{21}^{p+1} & \beta_{22}^{p+1}
\end{bmatrix} \begin{bmatrix}
R_{t-(p+1)} \\
E_{t-(p+1)}
\end{bmatrix} + \begin{bmatrix}
\epsilon_{1t} \\
\epsilon_{2t}
\end{bmatrix}
\]

where \(\epsilon_t = (\epsilon_{1t}, \epsilon_{2t})\) is assumed to be i.i.d. with covariance matrix \(\Sigma_\epsilon\). A test of the hypothesis that revenues do not Granger cause expenditures is equivalent to testing \(H_0: \beta_{12}^1 = \ldots = \beta_{12}^p = 0\), where the \(p + 1\) matrix is left unrestricted, acting as a long run correction mechanism. Note that this implies long-run causal inference, as the variables appear in levels. Similarly, expenditures will cause revenues if the hypothesis \(H_0: \beta_{21}^1 = \ldots = \beta_{21}^p = 0\) is rejected. This can be tested with a classical test statistic for the joint nullity of these coefficients.

The results of the above tests are presented in Table 4.5, test at statistically significant at 5% level. The order of the VARs was selected using the SIC procedure.

<table>
<thead>
<tr>
<th>Countries</th>
<th>Null hypothesis</th>
<th>Statistic</th>
<th>Conclusion</th>
<th>Type of hypothesis</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bahamas</td>
<td>E does not cause R</td>
<td>7.9702</td>
<td>do not reject</td>
<td>No causation (Unsustainability)</td>
</tr>
<tr>
<td></td>
<td>R does not cause E</td>
<td>7.2131</td>
<td>do not reject</td>
<td></td>
</tr>
<tr>
<td>Finland</td>
<td>E does not cause R</td>
<td>0.6114</td>
<td>do not reject</td>
<td>No causation (Unsustainability)</td>
</tr>
<tr>
<td></td>
<td>R does not cause E</td>
<td>1.3989</td>
<td>do not reject</td>
<td></td>
</tr>
<tr>
<td>France</td>
<td>E does not cause R</td>
<td>12.4602</td>
<td>reject the null</td>
<td>Spend and tax</td>
</tr>
<tr>
<td></td>
<td>R does not cause E</td>
<td>7.5496</td>
<td>do not reject</td>
<td></td>
</tr>
<tr>
<td>South Africa</td>
<td>E does not cause R</td>
<td>10.7801</td>
<td>reject the null</td>
<td>Spend and tax</td>
</tr>
<tr>
<td></td>
<td>R does not cause E</td>
<td>10.1476</td>
<td>do not reject</td>
<td></td>
</tr>
<tr>
<td>Thailand</td>
<td>E does not cause R</td>
<td>12.3110</td>
<td>reject the null</td>
<td>Synchronization</td>
</tr>
<tr>
<td></td>
<td>R does not cause E</td>
<td>36.2308</td>
<td>reject the null</td>
<td></td>
</tr>
<tr>
<td>US</td>
<td>E does not cause R</td>
<td>19.7284</td>
<td>reject the null</td>
<td>Spend and tax</td>
</tr>
<tr>
<td></td>
<td>R does not cause E</td>
<td>39.9453</td>
<td>do not reject</td>
<td></td>
</tr>
</tbody>
</table>

Tab. 4.5: Granger Causality Tests
We can observe that for the Bahamas and Finland, the statistic fails to reject the null of no causation in both directions. This seems to be consistent with the results obtained in previous sections for the case of Finland, since several tests point to a sustainability problem and lack of cointegration between revenues and expenditures. However, the result is surprising for the Bahamas.

On the other hand, the null hypothesis that revenues do not Granger-cause expenditures is rejected for France. This implies that these countries' governments pursue a 'spend-and-tax' fiscal policy or, in other words, that these countries fiscal authorities are able to raise revenues required to finance planned expenditures and, ultimately, are able to maintain their budgets under control. As for Thailand, the test rejects the null of no causality in both directions. Thus, the empirical evidence suggests that variations in expenditures occur at the same time as changes in revenues, i.e., this supports the hypothesis of fiscal synchronization for these countries.
4.4 Conclusion

This chapter reviewed the empirical implications of a government's Intertemporal Budget Constraint. We have seen that, in the presence of non-stationary variables, fiscal sustainability implies that government expenditures and revenues must be cointegrated. It is possible to distinguish distinct forms of sustainability, namely 'strong' and 'weak' sustainability, depending on the long run coefficient of the cointegration vector. In order to empirically assess fiscal sustainability, one can: i) resort to univariate tests on the statistical properties of the series of primary surplus, which implies a test of the 'strong' sustainable case, or ii) a multivariate test of the joint long run relationship between expenditures and revenues.

We propose a multivariate efficient test of the 'strong' hypothesis based on the test procedure of Horvath and Watson (1995), developed for the case of testing under pre-specified cointegration vectors. This framework is more efficient than both the univariate approach and the standard cointegration tests, as it accounts for the likely correlation between innovations to revenues and expenditures and it incorporates the appropriate theoretical restriction on the cointegration vector.

We show that the results of the conventional methodologies tend to penalize the sustainability hypothesis, even when the estimated $b$ is close to 1. Indeed, in many instances unsustainability was found for 3 countries. This could be explained by the fact that the inefficiency of conventional tests may lead to loss of power of unit root and cointegration tests. This implies that the null hypothesis of cointegration is rejected less often than it should. When the Horvath-Watson (1995) test is employed, the empirical support for the 'strong' sustainability hypothesis is quite convincing, with the null of no cointegration being rejected at the 1% significance level for all countries, with the exception of Finland.

Furthermore, we analysed the dynamics of revenues and expenditures in a causality framework. Using appropriate testing procedures to deal with I(1) processes in VARs in levels, we were able to test four types of possible interactions: revenues causing expenditures ('tax-and-spend'), expenditures predicting revenues ('spend-and-tax'),
4. An Efficient Test for Fiscal Sustainability

revenues and expenditures being simultaneously determined ("fiscal synchronization") and no causality, implying unsustainability.

In this chapter, the results of causality show that Bahamas and Finland have fiscal unsustainability which is coincide with the results of Bahamas from chapter 3. While the results from cointegration test indicate only Finland that fiscal policy is unsustainable.

Thus, we have shown how employing a diversity of time series tests can help to better characterize the dynamics of fiscal policy and the interactions between the variables of interest. Nevertheless, there are some issues that point to interesting directions for further study. The case of Finland is paradigmatic, as it seems odd that a rich and developed country, with no history of debt default, is signalled to be unsustainable. A possible explanation for this is that periods of persistent and considerable deviation from a sustainable regime, though limited in time, change the correlation structure of the series and hence affect conventional tests, which are based on a linear structure. Therefore, in the next chapters, we explore a methodology that allow us to model departures from a sustainable regime and thus offers the appropriate statistical framework to deal with potential regime shifts and non-linearities.
5. ASSESSING FISCAL SUSTAINABILITY SUBJECT TO REGIME CHANGES

5.1 Introduction

In the previous chapter, we looked at efficient tests for the ‘strong’ sustainability hypothesis in a collection of six developed and developing countries. We observed that given the statistical properties of the variables involved, cointegration is the appropriate framework to conduct the analysis, as we are interested in the possible existence of long run equilibrium relationships among government expenditures and revenues. However, researchers have been concerned with the effects that structural changes may have on the analysis of econometric models. Indeed, failure to detect and account for parameter shifts is a serious form of misspecification, therefore affecting inference and leading to poor forecasting performances (see Clements and Hendry, 1999, for example). This is especially relevant for cointegration analysis, since it normally involves long time spans of data, which, consequently, are likely to display structural breaks.

In the context of the analysis of fiscal sustainability, the possibility of breaks affecting the results of empirical tests has been recognized early on, namely by Wilcox (1989) and Hakkio and Rush (1991). These authors split their sample (of US data) at exogenously chosen break dates, but this may be problematic, as subsequent tests may have their power affected if the chosen date does not correspond to the true one. The situation when there is no a priori information requires a particular type of analysis, so the adopted solution has been to endogeneize the break point selection in the testing problem, maintaining the inference valid. Thus, Haug (1995), using the tests proposed by Hansen (1992), and Quintos (1995), allowing for changes in the cointegration rank, use procedures to endogenously select the break point in the sample (arriving at different conclusions regarding the existence of structural breaks, however).
In this chapter, we pursue a different route. We initially test whether or not the long run relationships studied in the previous chapter have been subject to structural breaks. We do so by employing the tests proposed by Gregory and Hansen (1996) and extending them to the case of a cointegrating relationship without constant term. Based on the results from these procedures, we then apply the method proposed by Gabriel, Psaradakis and Sola (2002) to investigate cointegration subject to possible changes in regime. This is based on the assumption that cointegration regimes are governed by an unobserved Markov chain process. Testing for cointegration may be carried out by means of standard residual-based tests, using the standardized residuals obtained from Markov switching estimation.

This approach offers a number of advantages. First, one can resort to the usual asymptotic critical values for residual-based tests, as the finite-sample distributions of the standardized residuals appear to be well approximated by the usual asymptotic distributions. Secondly, the above mentioned works either consider a single, deterministic break or assume that the break points are known when cointegration is being tested. A Markov switching approach is instead more flexible, as it allows for an unspecified number of breaks, of unknown location. Moreover, information on the timing of the breaks is a natural by-product of estimation. Thirdly, one can also assume changes in the variance of the long run relationship. Furthermore, testing for cointegration arises naturally from the estimation step, since only standard cointegration testing procedures are used. Specifying long run relationships in this way encompasses a number of empirically plausible and economically relevant models, including the case of a single permanent regime change, as discussed below.

The chapter is structured as follows. The next section discusses the application of the cointegration tests of Gregory and Hansen (1996). Then, we use the Markov switching approach outlined above to test for fiscal sustainability. A final section concludes.

\(^1\) I thank my supervisor for additional help with this issue.
5.2 Testing for fiscal sustainability allowing for regime shifts

5.2.1 Gregory-Hansen Tests

Gregory and Hansen (1996), building upon Zivot and Andrews (1992), generalized the standard cointegration tests by considering an alternative hypothesis in which the cointegration vector may suffer a regime shift at an unknown timing. They analyzed models that accommodate under the alternative hypothesis of cointegration the possibility of changes in parameters, namely a level shift model (C),

\[ R_t = \mu_1 + \mu_2 D_t + \beta' E_t + u_t, \quad t = 1, \ldots, T, \]  

(5.1)
a model with a level shift plus trend (C/T),

\[ R_t = \mu_1 + \mu_2 D_t + \alpha t + \beta' E_t + u_t, \]  

(5.2)
a “regime shift” model (C/S) where both the constant and slope parameters change,

\[ R_t = \mu_1 + \mu_2 D_t + \beta_1' E_t + \beta_2 E_t D_t + u_t, \]  

(5.3)
as well as a regime shift model where a trend shift is added (C/S/T)

\[ R_t = \mu_1 + \mu_2 D_t + \alpha_1 t + \alpha_2 t D_t + \beta_1' E_t + \beta_2 E_t D_t + u_t. \]  

(5.4)

The vector \((R_t, E_t)\) is assumed to be of \(I(1)\) variables of dimension \(k\), \(u_t\) should be a stationary disturbance and \(D_t\) is a dummy variable of the type

\[ D_t = \begin{cases} 0, & \text{if } t > [Tr] \\ 1, & \text{if } t \leq [Tr] \end{cases}. \]  

(5.5)

Here, \(\tau \in J\) denotes the unknown relative timing of the break point and \([.]\) denotes the integer part operator. The trimming region defined by \(J\) may be any compact set of \((0, 1)\), but following earlier literature, Gregory and Hansen (1996) propose \(J = (0.15, 0.85)\).

As with the previous tests, these are residual-based cointegration tests that evaluate if the error term is \(I(1)\) under the null of no cointegration. In this framework, however, since the change point or its occurrence are unknown, the testing procedures involve
computing the usual statistics for all possible break points $\tau \in J$ and then selecting the smallest value obtained, since it will potentially present greater evidence against the null hypothesis of no cointegration. Therefore, one should observe the values of

\[ GH-Z_{\alpha} = \inf_{\tau \in J} Z_{\alpha}, \]  
\[ GH-Z_{t} = \inf_{\tau \in J} Z_{t}, \]  
\[ GH-ADF = \inf_{\tau \in J} ADF. \]  

(5.6) \hspace{1cm} (5.7) \hspace{1cm} (5.8)

Nevertheless, as pointed out by the authors, these tests possess power against other alternatives, namely "stable" cointegration. Hence, a rejection of the null hypothesis does not necessarily imply changes in the cointegration vector, since an invariant relationship might be the cause of the rejection. Also, note that the smallest value of the statistic, if it leads to a rejection, can provide an idea of where a shift might have occurred.

These test statistics have non-standard limiting distributions with no closed form and, therefore, critical values were obtained by resorting to simulation methods. In this chapter, we examine types of structural breaks that were not previously tabulated by Gregory and Hansen (1996), which are the change in slope with stable intercept,

\[ R_t = \mu + \beta_1 E_t + \beta_2 E_t D_t + u_t, \]  

(S)

as well as a model with change in slope and no constant term,

\[ R_t = \beta_1 E_t + \beta_2 E_t D_t + u_t. \]  

(S_{nc})

This is of interest for the empirical analysis of fiscal sustainability, as there can be cases where fiscal regimes shift between 'strong' and 'weak' sustainability, as in (S). Furthermore, we also consider the theory-consistent case of no intercept, as the IBC implicitly assumes zero-deficits. The justification for the use of an intercept term in empirical studies is mainly computational, as it ensures that residuals have zero-mean.

\footnote{This procedure should not, however, be understood as a formal way of estimating breakpoints, as its properties are not well known.}
For proper comparison, and following Gregory and Hansen (1996, p. 110), we obtained critical values for these types of shifts, with a single regressor, using the same response surface: with 10000 replications for sample dimensions \( T = 50, 100, 150, 200, 250 \) and 300, critical values at the \( p \) percent level are obtained and then the regression

\[
C(p, T) = \psi_0 + \psi_1 T^{-1} + \text{error},
\]

is run. The critical values at the 5% significance level for the (S) model are \(-4.685\) (GH-ADF and GH-Zt tests) and \(-39.172\) (GH-Za test). For the (Snec) model, the critical values are \(-4.192\) for the GH-ADF and GH-Zt tests, and \(-30.322\) for the GH-Za test, respectively. The critical values for (5.3), to be used below, are \(-4.95\) and \(-47.04\).

5.2.2 Empirical Results

We apply the tests discussed above to the cointegrating equation between expenditures and revenues for the six countries analysed before. We focus our attention on tests of variants (5.3), (S) and (Snec), as these are the most relevant for our application. There is no theoretical reason to expect the cointegrating relationship to have a deterministic trend and the parameter of interest in our case is \( \psi \). The results Gregory-Hansen tests are shown in Table 5.1.

Overall, we find that the null of no cointegration is rejected by the majority of tests, for the three model variants and across the six countries. We notice that the GH-ADF test rejects the null less often, while the Z-type tests almost always reject the null. The variant (Snec) is not rejected for Thailand, while in the case of Finland, only the GH-Zt is able to reject. Otherwise, for every country, model variants (5.3) and (S) have their nulls rejected by at least two test statistics. The general conclusion seems to point to the existence of a long-run equilibrium between government expenditures and revenues, but one that appears to have been subject to regime shifts.

In the table, we also report the dates corresponding to the smallest value attained by each statistic. As mentioned above, we can use this as an informal way of dating potential regime shifts. It is interesting to note that for several statistics, the minimum appears around the Asian crisis of 1997-1998, with the first quarter of 1998 the most often identified date. These results seem to be consistent with the stylized fact observed
5. Assessing fiscal sustainability subject to regime changes

<table>
<thead>
<tr>
<th>C/S</th>
<th>C/S</th>
<th>Bahamas</th>
<th>Finland</th>
<th>France</th>
<th>South Africa</th>
<th>Thailand</th>
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<td></td>
<td>[93 : 1]</td>
<td>[96 : 3]</td>
<td>[98 : 1]</td>
</tr>
</tbody>
</table>

* means rejection of the null hypothesis of no cointegration

Break date in square brackets

Tab. 5.1: Gregory-Hansen Tests

in many countries, which have experienced fiscal difficulties following the Asian turmoil. This seems to be the case for France, Finland, South Africa and Thailand. In the case of the Bahamas, breaks are also informally identified in the early 90s, while for the US, 1995 appears to signal a shift in the fiscal regime. This coincides with the start of the surplus years of the Clinton Administration.

Thus, it seems appropriate to try to model fiscal sustainability as potentially being subject to shifts. However, the tests of this section assume that shifts occur in a de-
terministic fashion, which is not very realistic. Also, the timing of the shifts may not be accurate, as the above procedures will signal the largest break in the series. For the sample period considered, it is likely that more than one break as occurred, as it contain years of fiscal difficulties, which at same point appear to have been resolved. Thus, the Gregory-Hansen tests, while being very informative in terms of inference, do not offer a convenient framework to model long run relationships subject to regime changes. A possible way of allowing for stochastic shifts is to use a Markov switching approach, as explained in the next section.

5.3 Fiscal sustainability under Markov Switching regime changes

Markov switching models have been extensively (and successfully) used to characterize and account for regime changes that typically occur in economic and financial time series, such as GDP, stock prices, interest rates, inflation rates, or exchange rates, for example (see Kim and Nelson, 1999 for a survey). Given their flexibility, it would be natural to extend their use to model changes in long run relationships. Hall, Psaradakis and Sola (1997) and Krolzig (1997), for example, illustrate the usefulness of such a specification by analysing the Japanese consumption function and co-movements in international business cycles, respectively. The Markov switching cointegration approach is also related, from a methodological point of view, with the work of Hansen (2000), as this author generalizes Johansen's cointegrated VAR model by allowing for structural breaks.

Here, we attempt to use a more general type of cointegration, where the cointegrating vector is allowed to undergo occasional changes, which may be the result of sudden changes in policy, economic conditions, technology or institutions. In order to describe the long run relationship between revenue and expenditures, we will use the following model

$$R_t = (\alpha_1 + \alpha_2 s_t) + (\beta_1 + \beta_2 s_t)E_t + (\omega_1 + \omega_2 s_t)u_t$$  \hspace{1cm} (5.9)

where $s_t$ is the discrete-valued latent random variable indicating the regime operative at time $t$ and $u_t$ is a stationary and ergodic random disturbance with mean 0 and unit variance. The variable $s_t$ is assumed to follow a homogeneous first-order Markov
5. Assessing fiscal sustainability subject to regime changes

The chain with state space \( \{1, 2\} \) and transition probabilities \( p = \Pr(s_t = 2|s_{t-1} = 2) \), \( q = \Pr(s_t = 1|s_{t-1} = 1) \). Accordingly, the cointegrating vector will have two regimes defined by \( s_t \), \( \{(\alpha_1, \beta_1), (\alpha_2, \beta_2)\} \), while \( \omega_s = \{\omega_1, \omega_2\} \), so that we allow the variance of the long run relationship to change stochastically as well, thus capturing potential low and high volatility regimes. Note that this is a generalization of the (5.3) model of Gregory and Hansen (1996) discussed above, in that we allow the shifts to be stochastic as opposed to deterministic. In addition, they can occur more than once and the variance is allowed to change. In fact, the Gregory-Hansen model corresponds to the case where one of the regimes is 'absorbing', that is, the staying probability of one of the regimes is 1.

One can test for cointegration simply by resorting to the standard residual-based procedures, but using instead the standardized residuals obtained from the estimation of the Markov switching cointegrating model. These residuals are computed as

\[
e_t = \{R_t - \left[(\alpha_1 + \beta_1 E_t) \Pr(s_t = 1|I_t) + (\alpha_2 + \beta_2 E_t) \Pr(s_t = 2|I_t)\right]\}/\sigma_t, \tag{5.10}
\]

where \( \Pr(s_t = i|I_t) \), \( i = 1, 2 \), are the filter probabilities from the Markov switching estimation and \( \sigma_t \) is the residuals conditional standard deviation. If more than one shift has occurred, the usual residuals will reflect this by appearing to be non-stationary and thus cointegration may not be detected. By allowing for an unspecified number of regime changes in the estimation step, the standardized residuals will be free of unusual observations due to breaks, and therefore will replicate the stationary behaviour of the true errors.

We start by analysing the (non)stationarity of the standardized residuals. Figures 5.2-5.7 plot the standardized residuals computed as in (5.10), contrasted with the residuals obtained from a simple linear regression. We can see that the former appear to be a lot more stable and, hence, stationary. This is confirmed by residual-based cointegration tests that are essentially the extension of unit root tests to a cointegration framework. We focus on ADF-type and Phillips-Perron-type tests, which are also known as Augmented-Engle-Granger (AEG) and Phillips-Ouliaris (PO) cointegration tests. Gabriel et al. (2002) show that the asymptotic distributions of these tests provide a good approximation when standardized Markov switching residuals are used. The
critical values obtained by McKinnon (1991) for these tests are $-3.9001$, $-3.3377$ and $-3.0462$ for 1%, 5% and 10% significance levels, respectively.

Table 5.2 reports the results of the AEG and PO tests for each country. As before, the lag length for the AEG test was automatically selected based on the SIC procedure, while the bandwidth for the Phillips-Ouliaris test is also data-dependent, based on a Bartlett kernel (results do not change if other intermediate procedures are used instead). We can see that the null hypothesis of cointegration is always comfortably rejected at the 1% significance level for all countries. Comparing with the results of

<table>
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<th>PO</th>
</tr>
</thead>
<tbody>
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<td>(0.0000)</td>
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</table>

* means rejection of the null hypothesis of no cointegration

Table 5.2: AEG and PO: standard residual-based cointegration Tests

the previous chapter, we have seen that standard residual-based cointegration tests, in particular the AEG test, point to unsustainability in the case of Finland, Thailand and the USA. This conclusion is now overturned by the Markov switching-based tests. Indeed, it seems that when we account for regime changes, fiscal sustainability receives
stronger empirical support. Inspecting the OLS residuals obtained in the previous chapter, we can observe that these three countries experienced periods of persistent, but temporally circumscribed, deviation from their average time series path (deficits in the case of the first two countries, surpluses in the case of the latter). Given that a linear approach will not model these deviations, the OLS residuals will appear to be non-stationary. The Markov switching approach discussed here allow us more flexibility in incorporating the regime changes and thus reflecting them in the inference step.
Fig. 5.1: Filtered probabilities
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<th>Country</th>
<th>$\alpha_1$</th>
<th>$\alpha_2$</th>
<th>$\beta_1$</th>
<th>$\beta_2$</th>
<th>$\omega_1$</th>
<th>$\omega_2$</th>
<th>$p$</th>
<th>$q$</th>
<th>AIC</th>
<th>SIC</th>
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<tr>
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<td>-0.0554</td>
<td>1.4099</td>
<td>0.9785</td>
<td>-0.8890</td>
<td>0.1517</td>
<td>-0.0252</td>
<td>0.9337</td>
<td>0.9781</td>
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<td>-16.01</td>
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<td>(0.1867)</td>
<td>(0.0401)</td>
<td>(0.1081)</td>
<td>(0.0202)</td>
<td>(0.0429)</td>
<td>(0.0490)</td>
<td>(0.0237)</td>
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<tr>
<td>Finland</td>
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<td>1.0365</td>
<td>-0.3110</td>
<td>4.6671</td>
<td>0.9717</td>
<td>0.9122</td>
<td>0.9790</td>
<td>-109.85</td>
<td>-96.04</td>
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<td></td>
<td>(1.2913)</td>
<td>(2.4950)</td>
<td>(0.0247)</td>
<td>(0.0333)</td>
<td>(0.4002)</td>
<td>(0.5574)</td>
<td>(0.0468)</td>
<td>(0.0134)</td>
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<tr>
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<td>0.8997</td>
<td>0.9644</td>
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<td>0.0388</td>
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<td>(0.0271)</td>
<td>(0.1146)</td>
<td>(0.0464)</td>
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<td>South Africa</td>
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<td>0.9010</td>
<td>-0.1963</td>
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<td>(78.0121)</td>
<td>(8.02577)</td>
<td>(0.1325)</td>
<td>(0.1540)</td>
<td>(3.4916)</td>
<td>(4.6211)</td>
<td>(0.0200)</td>
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<td>Thailand</td>
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<td>-711.3915</td>
<td>0.6915</td>
<td>0.2002</td>
<td>238.8339</td>
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<td>0.9745</td>
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<td>(122.9582)</td>
<td>(123.9996)</td>
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<td>(0.0769)</td>
<td>(25.2317)</td>
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<td>US</td>
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<td>(0.0225)</td>
<td>(0.0339)</td>
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<td></td>
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</tbody>
</table>

*: statistically significant at 5% level

Tab. 5.3: Cointegration Test: Markov Switching model
Another advantage of this framework is that one can interpret changes in the cointegration vector as shifts in fiscal regimes. Table 5.3 displays the estimates arising from estimation of (5.9). We also compute in the last two columns the difference between the AIC and BIC for the Markov switching and the simple linear model, so that a negative number favours the non-linear specification, which is the case for all countries. Also, the estimated regimes appear to be quite persistent, with estimated probabilities well above 0.9. We also note that, with the exception of Thailand and South Africa, the variance appears to be the same across regimes.
Taking each country in turn, we observe that for the Bahamas regime 1 corresponds to a period of 'strong' sustainability, as the estimate of $\beta$ is not significantly different from 1. However, in state 2, the fiscal regime appears to be unsustainable, as $\beta$ becomes close (statistically speaking) to 1. Looking at Figure 5.1, which displays the filtered probabilities of regime 1, we can see that periods of instability have occurred in 1984-86 (with a glitch in 1981) and in 1988-1995, after which sustainability seems to have been resumed. The economy of the Bahamas is capital intensive, in which state ownership plays a significant role in the economy and it depends mainly on Tourism. Hence, from 1981 onwards, the large increase in the fiscal deficit can be attributed to governmen-
5. Assessing fiscal sustainability subject to regime changes

tal policies to boost the economy, namely by promoting the construction hotels and a casino project.

France

![Graph showing France standardized residuals](image)

The same pattern is present in the case of France, in which $\beta$ drops considerably from 0.9664 to a value statistically close to, or below, 0. The period of fiscal unsustainability coincides with the 'Euroscletic', low growth and high unemployment years of the 90s, which lead to increased pressure on government spending.
Finland

In the case of Finland, again regime 1 corresponds to 'strong' sustainability (with $\beta = 1.0365$), while regime 2 sees a shift to a 'weakly' sustainable regime, since the $\beta$ becomes lower, but different (and positive) from 1. The filtered probabilities in Figure 5.1 identify the shift to regime 2 around 1991, which then lasts until 1998. This corresponds to a recessionary period following the collapse and dismantling of trade with the Soviet Union, accompanied by an increase in interest rates in Europe, which drove the currency up (under a pegged exchange rate) and later on to a banking crisis. The economy started to recover from the recession in late 1993 as the government focused on capital-intensive export industries and the deficits started to gradually decline after
the government initiated a fiscal consolidation programme in 1995.

South Africa

![South Africa standardized residuals](image)

**Fig. 5.5: South Africa standardized residuals**

A similar pattern of switches between 'strong' and 'weak' sustainability is apparent for South Africa. For Thailand, the increase in volatility of the fiscal regime since 1988 (see previous chapter) drives the procedure to identify transitions which seem to coincide with switches in the variance rather than in the strength of fiscal sustainability. This seems to suggest that a better way to model the dynamics of Thailand’s fiscal regime would be to specify the variance as following a distinct Markov chain. One could then separate the effects of changes in the ‘mean’ from changes in volatility.
Fig. 5.6: Thailand standardized residuals
5. Assessing fiscal sustainability subject to regime changes

The same effect seems to be present in the case of the US, although to a lesser extent. Both countries seem to be well within the 'weak' sustainability case, but the filtered probabilities correctly identify for the US case the troublesome periods of the 70s and early 90s already identified in the literature (Hakkio and Rush, 1991 and Quintos, 1995), corresponding to a tighter monetary policy and the Reagan administration tax cut policy. This was followed by a period of smaller deficits in the late 80s and then the accumulation of surpluses during the late Clinton years. Again, a clearer picture would probably emerge if one considers a model with two Markov chains. However, this is beyond the scope of the present work, which aims at illustrating the usefulness of this
5. Assessing fiscal sustainability subject to regime changes

Markov switching approach.

5.4 Conclusion

There is ample evidence in the literature that policy changes or sudden shifts in economic conditions may have a substantial impact on the dynamics of fiscal deficits. In statistical terms, if these changes are left unaccounted for, then a policy that is sustainable overall might appear to be unsustainable. Indeed, if one uses conventional residual-based procedures, structural breaks induce an increase in the residuals autocorrelation which may induce an near-unit root type of behaviour.

By employing cointegration tests specifically designed to take potential regime shifts into account, we have shown that structural breaks seems to be pervasive in tests of fiscal sustainability. However, given that economies may experience periods of limited duration of fiscal stress, modelling this by only estimating breakpoints as in Haug (1995) and Quintos (1995) seems to carry little information other than potential timings of changes. Therefore, we propose an alternative methodology to deal with potential changes in fiscal regimes. By employing a Markov switching specification of the long run relationship between revenues and expenditures, as in Hall et al. (1997), we are able to simultaneously: 1) test for cointegration using Gabriel’s et al. (2002) procedure; 2) assess the type of fiscal regime (whether ‘strongly’/’weakly’ sustainable or unsustainable) that a country experienced at a given period and 3) analyse the timing of the transition between the estimated regime types.

An alternative to the results presented here would be model the primary surplus/deficit series as a Markov switching process. In principle, similar conclusions would emerge in the case of economies that switch between sustainability and unsustainability. However, it should be noticed that this approach imposes the cointegrating vector [1, -1] throughout and therefore does not allow to distinguish the cases where switches occur between ‘strong’ and ‘weak’ sustainability, as the formulation proposed here does.
The results in this chapter is illustrated different from the results in chapter 4 in that in this chapter, Markov switching indicates the unsustainable periods clearly in each regime. 'Strong' or 'Weak' sustainability provides the evidence of each country's unsustainable period.

We notice, however, that there is scope for further refinements. As mentioned before, further insight may be gained if one allows the variance of the long run relationship to follow an independent Markov chain. This means that the model can be rewritten as a four-state Markov switching model (see Hall et al. 1997 for an example) and then test the hypothesis of whether changes in the variance and in the mean follow the same unobserved latent process.

Having established the usefulness of modelling potential shifts via a Markov switching approach, in the next chapter we turn our attention to modelling the dynamics of discounted debt for the case of Thailand. Again, we stress the point that, although countries may experience occasional periods of fiscal imbalance, tests for fiscal sustainability should take into account the 'global' dynamic properties of the variables. Thus, we illustrate these issues by looking at the case of Thailand, now from a perspective of the univariate dynamics of the discounted debt series.
6. DISCOUNTED DEBT USING A MARKOV SWITCHING APPROACH

In chapter 3, we have employed the Indicator of Fiscal Sustainability approach to assess the sustainability of fiscal policy. Then, in chapter 4 we focused on the equilibrium dynamics of government revenues and expenditures as expressed by the Intertemporal budget constraint.

In this chapter, we focus on the time series path of debt, investigating the sustainability of discounted debt. Indeed, as pointed out by Hamilton and Flavin (1986), a simple present-value condition on government debt does not lead to full debt repayment if the rate of increase in the level of debt is smaller than the rate at which the debt is discounted. The constraint will be satisfied if the interest component of the deficit remains constant or decreasing, which will mean that the discounted value of future debt will converge to zero.

In order to study the sustainability of discounted debt, we need to bear in mind that fiscal policy is often subject to abrupt changes, motivated by political or economic reasons. This may lead to periods of sustained rise in the value of discounted debt. As we have seen in the previous chapters, this may have important implications for the statistical analysis of debt dynamics. Indeed, the presence of short-lived periods of expanding debt will alter the persistence (by increasing it) of the time series, thus resulting in apparent global unsustainability. Therefore, it is crucial to take this episodes into account and focus on the unconditional expected value of the process. We follow Davig (2005) in resorting to a Markov switching sustainability test, applied to Thai-
land’s discounted debt.

This framework allows us to model discounted debt as following a two-state Markov switching process, in which the regimes correspond to periods of collapsing and expanding debt. We expect to find long periods in which debt is repaid, corresponding to debt sustainability, alternating with shorter periods of rapidly expanding debt (due to political or economic crisis) which will appear to be locally unsustainable. Nevertheless, the presence of these regimes does not imply that the unconditional mean of the process is zero and therefore that discounted debt is globally sustainable.

We apply this method to Thailand. This is an interesting exercise because the 1997 Asian crisis seems to have originated from Thailand. Hence, the first section will provide a review of Thailand’s economy and public debt’s structure. We then show how to construct a series for discounted debt for Thailand, as in Wilcox (1989). This is followed by the empirical analysis based on the Markov Switching framework and a concluding section.

6.1 The Economy of Thailand

Thailand\(^1\) has historically been a "tiger" economy, with high rates of annual growth from the late 1970’s to 1996, with periodic slowdowns mirroring the world and regional economies. After having enjoyed a real compound annual growth rate of 9.6 percent between 1986 and 1996, Thailand suffered a sharp economic downturn with the combination of currency and financial crises in 1997, as a result of the unsuccessful defence of the currency and a weak banking system. After the 1997-8 currency crisis, Thailand became impoverished once again, and it was not until 2001 that the baht and the economy regained momentum.

\(^1\) In what follows, we draw extensively from reports of the Bank of Thailand and Library of Congress-Federal Research Division.
The contraction was sharper than anticipated, with a decline in real GDP of 0.4 and 0.8 percent in 1997 and 1998 respectively. A number of external and domestic factors contributed to this outlook. Reduced export values below previous estimates delayed the recovery in private capital flows. Also, both domestic consumption and investment demand were weaker than expected. Thailand faced four major macroeconomic problems:

1. Net international reserves were depleted, because of the unsuccessful defence of the Thai baht.
2. There were systemic problems in the financial sector.
3. The real sector faced a serious liquidity shortage.
4. Regional economic turmoil was a significant constraint in the country’s ability to resolve its economic difficulties.

Therefore, the government has taken a systematic, but flexible, approach in addressing these problems and strictly adhered to the economic program agreed with the International Monetary Fund. To date, Thailand has made steady progress in resolving the above problems. The Thai government has adopted an expansionary fiscal policy for the fiscal year 1998/1999 to stimulate domestic demand and employment and to finance economic and financial restructuring. The overall public sector deficit for fiscal year 1998/1999 was increased to 5 percent of GDP, compared to about 3 percent of the previous fiscal year. Note that these deficit targets do not include the fiscal cost of financial restructuring. In order to achieve the numerical targets, the government has implemented various revenue and expenditure measures including tax refunds due to exporters and corporations, temporary postponement of both the payment of corporate income tax and the remittance of state enterprises' profits, and removing tax disincentives to corporate debt restructuring.

Furthermore, the government resorted to foreign financing, at a level of about 1% of GDP, to support specific spending projects directed towards a social safety net and
related labor-intensive investment projects. The government also continued to accelerate the payment of budgetary and no budgetary expenditures. The exchange rate has reached 37.00/USD (GDP dollars 7.3 trillions baht) as of October 26, 2006, for a nominal GDP at market rates of approximately US dollars 200 billions. However, due to rapid appreciation in 2007, nominal GDP hovers around dollars 230 billions, slightly smaller than that of the Guangdong province in China. This keeps Thailand as the 2nd largest economy in Southeast Asia, after Indonesia, a position it has held for many years. Despite this, Thailand ranks midway in the wealth spread in Southeast Asia as its 4th richest nation per capita, after Singapore, Brunei, and Malaysia. It is also an anchor economy for the neighbouring least developed countries of Laos, Burma, and Cambodia.

Thailand is a lower middle income developing nation, heavily export-dependent. Its major industries are tourism, textiles and garments, agricultural processing, beverages, tobacco, cement, light manufacturing such as jewelry and electric appliances, computers and parts, integrated circuits, furniture, plastics, automobiles and automotive parts; it is the world’s second-largest tungsten producer and third-largest tin producer and the major agricultural products are rice, cassava (tapioca), rubber, corn, sugarcane, coconuts, soybeans.

Thailand’s recovery from the 1997-98 Asian financial crisis relied on exports, largely on external demand. Thailand has a strong automotive export industry along with electronic goods manufacturing which has helped to strengthen the baht. Agriculture has always provided traditional income generation, but has declined in relative terms in recent years, as overall exports increased. Tourism has been on the rise as well, but not without negative consequences. With the instability surrounding the recent coup, however, the GDP growth of Thailand has decreased from a peak under the previous administration, as locals as well as foreign companies hold investment back due to the political uncertainty. Foreign investor sentiment was further tempered by a 30% reserve requirement on capital inflows instituted in December 2006, and discussion of amending Thailand’s rules governing foreign-owned businesses.
The Thaksin government took office in February 2001 with the intention of stimulating domestic demand and reducing Thailand’s reliance on foreign trade and investment. Since then, the Thaksin administration embraced a dual track economic policy that combines domestic stimulus with Thailand’s traditional promotion of open markets and foreign investment. Weak export demand held 2001 GDP growth to 1.9%. In 2002/03/04, however, domestic stimulus and export revival fuelled a better performance, with real GDP growth at 5.3%, 7.1% and 6.3% respectively. However, in 2005, under rising oil prices and inflation, severe droughts and floods, the Southern Thailand Insurgency reaching a high, uncertainty of the future of Thaksin’s government and the tourism aftershocks of the Indian Ocean Earthquake Tsunami on December 26th 2004, economic growth slumped to 4.5%. In 2006 the economy sped up slightly under strong export growth; however the military coup d’etat on September 19th 2006 caused economic growth to stagnate into 2007 once again. Economic growth in 2007 was due almost entirely to robust export performance - despite the pressure of an appreciating currency. Exports have performed at record levels, rising nearly 17% in 2006 and 12% in 2007. Export-oriented manufacturing - in particular automobile production - and farm output are driving these gains.
6.2 The Public Debt of Thailand

Rattakul(2002) provides a recent review on this issue. Public debt in Thailand is composed of three parts: government debt, non financial public enterprise debt(NFPE) and Financial Institutions Development Fund debt (FIDF). Domestic and external borrowings are the components of the Government debt, the borrowings used to finance government expenditure and the financial restructuring cost (Tier 1, Tier 2 and FIDF I and II). Tier 1 and Tier 2 bonds are bonds issued by the government to recapitalise distressed financial institutions, by receiving preferred stocks and subordinated debentures. The NFPE debt comprises government-guaranteed and non-government-guaranteed debt. The FIDF debt included with FIDF II and non-government-guaranteed liabilities. Table 6.1 shows the structure of public debt between 1996 and 2003 (July) by the public Debt Management Office (PDMO), Bank of Thailand. Before the crisis in 1996, the government debt was 4.3 % of GDP. However, in 2003 government debt declined from 1,690 in 2002 to 1,622 billions corresponding to 27.52% of GDP. The recovery of the exchange rate made the debt in term of US dollars decrease to 8.86 million of US dollars.

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<td>1690</td>
<td>1622</td>
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<td>901</td>
<td>860</td>
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<tr>
<td>% of GDP</td>
<td>10.5</td>
<td>11.3</td>
<td>18.6</td>
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<td>781</td>
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<tr>
<td>% of GDP</td>
<td>4.3</td>
<td>18.7</td>
<td>15.9</td>
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<td>608</td>
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<td>2901</td>
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<tr>
<td>% of GDP</td>
<td>14.8</td>
<td>35.0</td>
<td>57.3</td>
<td>54.3</td>
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In billions of Baht

Tab. 6.1: Structure of Public Debt
Likewise, the NFPE debt increased from 10.5% of GDP in 1996 to 16.8% of GDP in 2002. In 2003, it slightly decreased to 14.7% of GDP. In 1996, there was no FIDF debt yet. It was set up in 1997 which was highest at 18.7% of GDP. After 1997, it declined substantially to 6.3% of GDP in 2002. Nevertheless, it inclined a bit to 7.2% of GDP in 2003. This is due to the recovery of financial sector.

Public debt increased from 14.8% of GDP in 1996 to 57.3% of GDP in 2000, afterward declined to 49.4% of GDP in 2003. The debt comprises of Domestic and External borrowings. The distinctive aspect was the ratio between domestic and external; in 1996 domestic borrowings became lower than external; after 1997, domestic borrowings became higher than external borrowings and the ratio domestic/external debt continued increasing in the year to 2003.


Before the crisis in 1997, the fiscal position of Thailand was a surplus, and the percentage of public debt to GDP was as low as 14% in 1996. In 1997, due to the crisis, the government absorbed substantial financial sector losses, by incurring in an expansionary fiscal policy. This led to a large increase in public debt to a peak at 58% of GDP in 2000/01. Subsequently, it gradually decreased to 49% at the end of July in 2003, while the government cash deficit became better than planned in 2001/02, due to the economic recovery and fiscal consolidation.

At the present level of public debt, the fiscal position remains stronger than planned. The government has improved fiscal flexibility by improving the efficiency of both revenues and expenditures. The government has increased revenue by raising tax collections and expanding the tax base. In 2001/02, the tax elasticity to GDP stood at 2.2 compared with 1.5 in 2000/01, reflecting substantially more efficient tax collection. The corporatisation of state-owned enterprises will further enhance efficiency and bring higher returns to the government. On the expenditure side, the government has improved the efficiency of allocation and effectiveness of spending, by implementing
Thailand's public debt

% of GDP

1985 1987 1989 1991 1993 1995 1997 1999 2001 2002 (Dec)

Source: Public Debt Management Office (PDMO).

Fig. 6.1: The Public Debt of Thailand
the zero-based budgeting. The Bank of Thailand assessed the public debt sustainability from 2002/03 (From October 2002 to September 2003) onwards, incorporating the FIDF debt resolution. The general conclusions indicate that Thai public debt remains sustainable even under relatively unfavourable circumstances. Nevertheless, there are some other factors that could affect the debt towards a more or less sustainable level. The government has set as targets to maintain a debt ratio of less than 60% GDP, accomplish budget balance within five years, and drive the debt service ratio to lower than 16%.

Nevertheless, as discussed previously, in order to assess fiscal sustainability, one should also consider the evolution of discounted debt. The next section discusses this issue.

6.3 Discounted Debt

As discussed in previous chapters, in a dynamically efficient economy government debt is subject to a present-value borrowing constraint, in which the current market value of the debt should equal the discounted sum of expected future surpluses. Hamilton and Flavin (1986) analyse whether or not US government debt is subject to this present-value borrowing constraint by employing unit root tests, finding that the constraint is satisfied. Wilcox (1989) extended their work by allowing for stochastic real interest rates, unlike Hamilton and Flavin’s (1986) assumption of a fixed interest rate. This author also accounts for structural breaks in the process, by splitting the sample in different periods and thus reverting Hamilton and Flavin’s (1986) results. Subsequently, Trehan and Walsh (1991) relax the assumption that expenditures and revenues are difference-stationary, but maintain a constant expected real rate of the interest. They test for cointegration based on the behaviour of the interest-inclusive deficit. They then assess under which conditions cointegration holds when interest rates are allowed to be stochastic. They demonstrate that if the expected real rate of interest is more than zero, and the inclusive-of-interest deficit is stationary, then the intertemporal budget balance is held.
6. Discounted Debt Using A Markov Switching Approach

More recently, Davig (2005) tests the present-value constraint using a Markov Switching approach, using an updated data series on US discounted debt. This method has several advantages, as it separates local unsustainability from global sustainability of the debt process. Thus, if periods of expanding debt do not last for long, the debt process will remain sustainable, that is, the unconditional mean of the Markov-switching stochastic process underlying discounted debt is zero. The next section discusses definitions and the construction of a discounted debt series.

6.3.1 Discounted Debt data for Thailand

As discussed in previous chapters, in a dynamically efficient economy government debt is subject to a present-value borrowing constraint (also designated as an intertemporal budget constraint as in the previous chapters), in which the current market value of the debt should equal the discounted sum of expected future surpluses. Hamilton and Flavin (1986) analyse whether or not US government debt is subject to this present-value borrowing constraint by employing unit root tests, finding that the constraint is satisfied. Wilcox (1989) extended their work by allowing for stochastic real interest rates, unlike Hamilton and Flavin's (1986) assumption of a fixed interest rate. This author also accounts for structural breaks in the process, by splitting the sample in different periods and thus reverting Hamilton and Flavin's (1986) results. Subsequently, Trehan and Walsh (1991) relax the assumption that expenditures and revenues are difference-stationary, but maintain a constant expected real rate of the interest. These authors test for cointegration based on the behaviour of the interest-inclusive deficit. They then assess under which conditions cointegration holds when interest rates are allowed to be stochastic. Trehan and Walsh (1991) demonstrate that if the expected real rate of interest is more than zero, and the inclusive-of-interest deficit is stationary, then the intertemporal budget balance is held.

More recently, Davig (2005) tests the present-value constraint using a Markov Switching approach, using an updated data series on US discounted debt. This method has several advantages, as it separates local unsustainability from global sustainability of the debt process. Thus, if periods of expanding debt do not last for long, the debt process will remain sustainable, that is, the unconditional mean of the Markov-switching
stochastic process underlying discounted debt is zero.

The next section discusses definitions and the construction of a discounted debt series.

### 6.3.2 Discounted Debt data for Thailand

We restate the fundamental government budget constraint (already discussed in chapter 4)

\[ D_t = (1 + i)D_{t-1} - PS_t \]  

\( D_t \): government debt in the present period  
\( D_{t-1} \): government debt in the previous period  
\( PS_t \): the difference of government expenditures and revenues  
\( i \): the interest rate for the debt

Assuming that seigniorage is negligible,

\[ D_{t-1} = \frac{D_t}{1 + i_t} + \frac{R_t - G_t}{1 + i_t} \]  

(6.2)

Iterating equation (6.2) \( n \) periods forward yields the government intertemporal budget constraint;

\[ D_t = \sum_{k=1}^{\infty} \prod_{n=0}^{k} (1 + i_{t+k})^{-1} (R_{t+n} - G_{t+n}) + \lim_{n \to \infty} \prod_{k=1}^{n} (1 + i_{t+k})^{-1} D_{t+n} \]  

(6.3)

This equation demonstrates that \( D_t \), the present value of government debt is the combination of the expected present value of the future primary surpluses \( \sum_{n=0}^{\infty} \prod_{k=1}^{n} (1 + i_{t+k})^{-1} (R_{t+n} - G_{t+n}) \) and \( \lim_{n \to \infty} \prod_{k=1}^{n} (1 + i_{t+k})^{-1} D_{t+n} \) the expected present value of the government's debt in a limiting term.

The term \( \lim_{n \to \infty} \prod_{k=1}^{n} (1 + i_{t+k})^{-1} D_{t+n} \) can be interpreted as a solvency condition, so that in the future, the present value government's debt converges to zero.

Next, we construct a series for discounted debt using time-varying interest rates, following Hamilton and Flavin (1986) and Wilcox (1989). Indebtedness should be

\footnote{Hamilton and Flavin (1986) test this constraint assuming a constant real interest rate, while Wilcox (1989) allows the interest rate to vary.}
defined as net of holding of gold, so that the relevant interest rate is defined as the holding-period return on the stock of government debt net of the real value of gold. This adjustment takes into account the well documented evidence that governments often run down their stocks of gold in the wake of fiscal crises.

Another important point to consider when testing sustainability in developing countries through the present-value constraint is the role of seigniorage, as it can be used as a source for financing fiscal deficits. Thus, in order to account for money creation, government surplus should be defined for the consolidated public sector (i.e., government and central bank) and therefore the relevant expression should be

\[ S_t = R_t - G_t + \pi_t M_t, \]  

where \( \pi_t \) denotes the inflation rate and \( M_t \) represents real monetary base. In the case of Thailand, seigniorage does not appear to represent a significant source of deficit financing, as it is relatively stationary and does not seem to have increased during the more turbulent periods after 1997, as can be seen in Figure 6.2.

Thailand public debt's data has been extracted from the IMF database, in annual terms. The data consists of domestic and foreign debts, as well as the domestic (lending) interest rate, US treasury bill rates (used as the foreign interest rate), world gold prices, the Consumer Price Index and the Primary Surplus. The sample period of the data is 1975 to 2003.

In order to obtain the discounted debt series, the following steps have been taken:

1. calculate the rate of return of gold by forming the ratio of the world gold price and the CPI,

2. yield the real rate return of gold by subtracting from the foreign interest rate by the rate of return of gold from the previous step,

3. the discount factor can be obtained by beginning with the accumulation of government debt, following Wilcox (1989) and Davig (2005)'s works;

\[ d_t = (1 + \tau_t) d_{t-1} - p s_t \]  

(6.5)
Fig. 6.2: The Seigniorage of Thailand
where \( d_t \) is the government, \( r_t \) is the real interest rate in the previous period and \( ps_t \) is the primary surplus.

Let \( k_t \) be the real discount variable from period \( t \) back to the starting period; hence we obtain;

\[
k_t = \prod_{j=0}^{t-1} (1 + r_t)^{-1}; k_0 = 1 \tag{6.6}
\]

4. From the above equation, discounted debt and the discount factor for primary surplus are normalized by multiplying the equation (6.1) through by \( k_t \);

\[
k_t d_t = k_{t-1} d_{t-1} - k_t ps_t \tag{6.7}
\]

Rewriting the above equation with \( DD_t \) is discounted debt and \( PS_t \) is discounted primary surplus, we therefore obtain;

\[
DD_t = DD_{t-1} - PS_t \tag{6.8}
\]

5. The total discounted value of the debt is computed by summarizing both domestic and foreign discounted debts.

Figure 6.3 displays the series obtained for Thailand. As can be observed, the series displays a relatively smooth path until 1997, with a subsequent steep increase, coinciding with the Asian crisis. As discussed in previous chapters, sudden jumps or regime changes can affect inference on the sustainability of the debt process. Next, we study stationarity and test for potential breaks in the discounted debt series.
Fig. 6.3: Thailand Discounted Debt
6.4 Preliminary Statistical Analysis

The standard test for sustainability is to test for unit roots in the debt process. As shown in figure 6.1, the series remains fairly stable for the first part of the sample, but displays a significant positive trend after 1997/1998. From a theoretical point of view, a test of a unit root in the debt series should not contain a trend, but one could argue that, from a purely statistical perspective, a trend should be included. Given this, we present results both for the case of no trend and with a trend included.

Table 6.2 displays the results of unit root and stationarity tests (automated lag length selection criteria are used for all tests). It is possible to observe that the evidence is overwhelmingly in favour of a unit root being present in the series. Hence, one would conclude that debt is not sustainable.

However, visual inspection and prior knowledge lead us to believe that a break may have occurred around the period of the Asian crisis. One possibility is to use the Chow test at an exogenously chosen break date, but this test may have its performance affected if the date is mistakenly chosen. Instead, we prefer the break point to be endogenously determined by the data. Thus, we resort to the tests for unknown breakpoints developed by Andrews (1993) and Andrews and Ploberger (1996), based on a seminal paper by Quandt (1960). The idea is to test for a break at every possible sample point (using a Chow test $F_T$, for example) and then analyse a function of this sequence of tests. A natural choice is to analyse the largest value in this sequence

$$Q = \sup_{\lambda \in J} F_T (\lambda),$$

where $F_T (\lambda)$ represents the Chow statistic computed over a support $J = (\lambda_0, \lambda_1) \subset (0, 1)$ indicating the fraction of the sample corresponding to a particular observation. Uniformly most powerful alternatives have been suggested by Andrews and Ploberger (1994), which entail averaging the sequence

$$mean-F_T (\lambda) = \frac{1}{1 + \lambda_1 - \lambda_0} \sum_{\lambda = \lambda_0}^{\lambda_1} F_T (\lambda)$$

or, alternatively, an exponential 'mean'

$$Exp-F_T (\lambda) = \log \left[ \frac{1}{1 + \lambda_1 - \lambda_0} \sum_{\lambda = \lambda_0}^{\lambda_1} \exp \left( \frac{1}{2} F_T (\lambda) \right) \right].$$
### Tab. 6.2: Unit root Test for Thailand's Discounted Debt

<table>
<thead>
<tr>
<th>Unit root tests</th>
<th>I-level</th>
<th>first different</th>
</tr>
</thead>
<tbody>
<tr>
<td>Augmented Dickey Fuller</td>
<td>-3.4908*</td>
<td>-4.7206***</td>
</tr>
<tr>
<td></td>
<td>(0.0623)</td>
<td>(0.0070)</td>
</tr>
<tr>
<td>Dickey-Fuller GLS (ERS)</td>
<td>-3.7501**</td>
<td>-4.6553***</td>
</tr>
<tr>
<td></td>
<td>(0.0010)</td>
<td>(0.0001)</td>
</tr>
<tr>
<td>Phillips-Perron</td>
<td>-3.1128</td>
<td>-5.5004***</td>
</tr>
<tr>
<td></td>
<td>(0.0021)</td>
<td>(0.0009)</td>
</tr>
<tr>
<td>Elliott-Rothenberg-Stock Point-Optimal</td>
<td>8.5236</td>
<td>5620.745</td>
</tr>
<tr>
<td>Ng-Perron - MZa</td>
<td>-12.0847</td>
<td>-12.2657</td>
</tr>
<tr>
<td>Ng-Perron - MZt</td>
<td>-2.1812</td>
<td>-2.1348</td>
</tr>
<tr>
<td>Ng-Perron - MSB</td>
<td>0.1805*</td>
<td>0.1741*</td>
</tr>
<tr>
<td>Ng-Perron - MPT</td>
<td>8.9017</td>
<td>9.0965</td>
</tr>
<tr>
<td>Kwiatkowski-Phillips-Schmidt-Shin</td>
<td>0.1303*</td>
<td>0.2545</td>
</tr>
</tbody>
</table>

*** statistically significant at 1% level  

** statistically significant at 5% level  

* statistically significant at 10% level
Andrews (1993) shows that the Chow test can have any of the classical forms (LR, LM or Wald). However, these tests require the support to be 'trimmed', since they are not defined for the entire sample. The recommended default is to use $J = (\lambda_0, \lambda_1) = (0.15, 0.85)$, that is, one excludes the first and the last 15% of observations.

<table>
<thead>
<tr>
<th></th>
<th>Sup F-statistic (1998)</th>
<th>Exp F-statistic</th>
<th>Ave F-statistic</th>
</tr>
</thead>
<tbody>
<tr>
<td>LR and Wald Tests</td>
<td>17.59176</td>
<td>6.019436</td>
<td>3.462131</td>
</tr>
<tr>
<td></td>
<td>(0.0035)</td>
<td>(0.0032)</td>
<td>(0.1229)</td>
</tr>
</tbody>
</table>

$H_0$: no breakpoints within trimmed data.

Tab. 6.3: Stability Test for Discounted Debt time series

Table 6.3 presents the results of the tests applied to an AR(1) process fitted to the discounted debt series. The null hypothesis of constant coefficients is comfortably rejected by the sup $F_T$ and $Exp-F_T$ versions, with extremely low p-values (calculated using Hansen’s (1997) procedure), and is close to being rejected at the 10% significance level by the mean-$F_T$ statistic. As expected, the break date picked up by the sup $F_T$ test is 1998, which coincides with the full effect of the Asian crisis.

Thus, given that the series displays a structural break, this fact has to be taken into account when assessing global sustainability of the debt process. A useful solution is to model debt as a Markov switching series, following Davig (2005). This is done in the next section.

---

3 Additional lagged terms were not significant.
6.5 Discounted Debt Using a Markov-Switching Approach

This section tests the present-value constraint by employing a Markov Switching approach. We admit the possibility of alternating states where discounted debt is collapsing and expanding. Global sustainability results if the unconditional mean of the process is zero. Indeed, even if the process is at an expansionary stage, a fiscal policy can still be sustainable. This can be determined by testing the persistence of the regimes.

We model discounted debt as a two-state Markov Switching process:

\[ D_t = \gamma(s_t) + \rho D_{t-1} + \epsilon_t \]  

(6.12)

where \( \{\epsilon_t\} \) is a stationary random sequence with mean zero and unit variance, while \( s_t \) is a discrete-valued independent random process, uncorrelated with \( \epsilon_{t-i} \) for all \( i \). This variable indicates the unobserved regime operative at time \( t \) for \( D_t \), forming a homogeneous first-order Markov chain with state space \( \{1, 2\} \) and transition probabilities \( p_{11} = \Pr(s_t = 1|s_{t-1} = 1) \), \( p_{22} = \Pr(s_t = 2|s_{t-1} = 2) \) with a transition matrix

\[
\Pi = \begin{pmatrix}
p_{11} & p_{12} \\
p_{21} & p_{22}
\end{pmatrix}
\]

Table 6.4 presents maximum likelihood estimates of equation 6.16 obtained with a numerical optimization procedure using the BFGS algorithm, along with corresponding asymptotic standard errors. Regime 1 is represented by \( \gamma(1) \), indicating a low level of debt, whereas \( \gamma(2) \) corresponds to the expanding regime. Note, however, that the estimated value of the unconditional mean is not significantly different from zero. This corresponds to the pre-crisis period and conditional on staying in this regime, the present-value constraint is satisfied. The value of \( \gamma(2) \), on the other hand, is significantly different from zero, implying that the present-value constraint is violated in this regime, so that fiscal policy is locally unsustainable. Conditional upon staying in this regime, discounted debt would become explosive.

\footnote{Given the sample size, the possibility of more than two regimes was not tested.}
Figure 6.4 plots the corresponding smoothed probabilities for regime 2. As expected, the switching appears to occur in 1998, coinciding with the currency crisis period. In order to assess whether the switch from regime 1 to regime 2 implies long run fiscal unsustainability, one needs to test global stationarity of the process. Theorem 1 in Davig (2005) contains an expression of the present-value constraints in a Markov switching framework and can be summarized as follows:

- If $\rho < 1$, then the unconditional mean of $D_t$ converges to zero if

  $$\Lambda(I_2 - \rho \Pi)^{-1}\Gamma = 0$$

  where $\Gamma = [\gamma(1) \gamma(2)]^\prime$, $\Lambda = [\lambda(1) \lambda(2)]$ and $\lambda(i) = \Pr(s_t = i), i = 1, 2$, while $I_2$ indicates a $2 \times 2$ identity matrix (see Davig, p. 838).

The $1 \times 2$ vector $\Lambda(I_2 - \rho \Pi)^{-1}\Gamma$ gives the weights placed on $\gamma(1)$ and $\gamma(2)$ for the test on whether the process converges to zero. Testing this condition determines whether the unconditional mean of discounted debt is zero. The procedure implies setting $\lambda(1)$ and $\lambda(2)$ equal to the ergodic probabilities

$$\lambda(i) = \frac{1 - p_{ij}}{(1 - p_{ii}) + (1 - p_{jj})}$$

for $i = 1, 2$ and $j = 1, 2$.

This nonlinear restriction is tested with a likelihood ratio test, that is, by comparing the likelihoods of the restricted and unrestricted models. The test is asymptotically $\chi^2(1)$. The constrained likelihood is $-324.5942$, so that the likelihood ratio yields $2(-324.5942 - 319.5450) = 10.0983$, so that the null is rejected at the standard significance levels. This implies that the unconditional mean of the process is significantly different from zero. Therefore, we find that the present-value constraint on Thailand’s discounted debt is not satisfied, implying a globally unsustainable fiscal policy.

<table>
<thead>
<tr>
<th></th>
<th>$\gamma(1)$</th>
<th>$\gamma(2)$</th>
<th>$\rho$</th>
<th>$p_{11}$</th>
<th>$p_{22}$</th>
<th>$\ln L$</th>
</tr>
</thead>
<tbody>
<tr>
<td>MS - AR (1)</td>
<td>23971.624</td>
<td>264962.26**</td>
<td>0.891</td>
<td>0.9668</td>
<td>0.9271</td>
<td>324.5942</td>
</tr>
<tr>
<td></td>
<td>(24439.88)</td>
<td>(68486.83)</td>
<td>(0.089)</td>
<td>(0.1607)</td>
<td>(0.5873)</td>
<td></td>
</tr>
</tbody>
</table>

Tab. 6.4: Discounted Debt via Markov Switching Approach
Fig. 6.4: The Discounted Debt of Thailand via a Markov Switching approach
6. Discounted Debt Using A Markov Switching Approach

6.6 Conclusion

This chapter applies the methodology proposed by Davig (2005) to test sustainability of fiscal policy. Based on a Markov switching framework, it tests whether or not the discounted debt is globally unsustainable, accounting for the possibility of changes in regime, where fiscal policy may oscillate between calm and explosive periods. We show that a significant shift in policy occurred around the Asian financial crisis of 1997-1998, which is confirmed by tests of structural breaks and Markov switching transition probabilities. A test for global sustainability of Thailand’s discounted debt reveals that fiscal policy appears to be unsustainable.

This finding does not seem to be in accordance with the results stemming from the analysis of the previous chapters. One possible explanation, which is a potential methodological lesson, is that by focusing on the univariate dynamics of the discounted debt process, one is missing the added efficiency that a multivariate approach could bring. Thus, a future topic for research would be to carry out a multivariate Markov switching analysis of the joint dynamics of government revenues and expenditures, together with discounted debt.

Naturally, the result of this chapter is highly influenced by the for the sample period considered here. Given that data on official debt is subject to considerable revisions, it was not possible to include data on more recent years. If, as preliminary reports suggest, debt has declined recently, it may well be the case that results on an extended dataset would revert our conclusions. Nevertheless, the purpose of this study is to illustrate the usefulness of the approach devised by Davig (2005), which has clear methodological advantages. By considering the possibility of different regimes, it allows for a more accurate statistical description and inference on fiscal sustainability. On the other hand, this approach can be used as a tool to signal sustainability issues. As new data become available, the debtor’s position can be re-evaluated, even if sudden changes in policy occur.
7. CONCLUDING REMARKS

The purpose of this thesis, as mentioned in the introduction, was twofold. On one hand, we attempted to make use of distinct methods from which inferences regarding sustainability of the fiscal stance could be drawn. On the other hand, we looked for potential explanations for the fact that several studies point to widespread fiscal unsustainability, when in reality default episodes are uncommon.

We first applied a simple approach, that of the Indicator of Fiscal Sustainability. We have seen that its main advantage is simplicity, both of calculation and interpretation. Its purpose, however, is to summarize the information stemming from the variables of interest, rather than testing empirical implications of theoretical models of fiscal sustainability. Albeit it lacks the formal rigor of statistical methods, it can be very helpful in identifying periods of unsustainability.

We then concentrated on the main theoretical framework to understand debt dynamics, the Intertemporal Budget Constraint. From this condition, we are able to define a typology of distinct cases and derive testable implications. We have seen that the appropriate statistical framework in which to conduct empirical analysis is cointegration. We also noted that an efficient test of ‘strong’ sustainability has so far been ignored in the literature. Thus, we illustrated the implementation of such a test, based on the procedures derived by Horvath and Watson (1995) for cointegration analysis when the cointegration vector is pre-specified. Once such a method is put in practice, contradictions between results from standard procedures and conventional wisdom and stylized facts seem to vanish.

However, we also point to a potential caveat with cointegration analysis of fiscal sustainability. Given that it deals with long run, it is likely that typical samples will
contain periods in which substantial and persistent deviations from a sustainable path may have taken place. We show, by means of cointegration tests robust to structural breaks that appears to be the case with the countries under scrutiny. To tackle this, we suggest the application of two approaches. In chapter 5, we propose using a Markov switching cointegration approach, which allow us to test for cointegration and model debt dynamics when the relationship may be subject to regime changes. This is novel in this literature. Using this method, we show that the results strongly favour the sustainability hypothesis. It also allow us to identify the periods in which governments have faced difficulties and may have switched to a non-sustainable or a weakly sustainable path.

A second approach is to directly model the dynamics of discounted debt, based once again on a testable implication of the Intertemporal Budget Constraint. As mentioned above, the purpose is model instances in which fiscal policy is subject to abrupt changes, motivated by political or economic reasons. This may lead to periods of sustained rise in the value of discounted debt and may have important implications for the statistical analysis of debt dynamics, as it can result in apparent global unsustainability. We followed Davig (2005) in resorting to a Markov switching sustainability test, applied to Thailand's discounted debt. We found long periods corresponding to debt sustainability, alternating with shorter periods of rapidly expanding debt which are locally unsustainable. We apply Davig's (2005) test for a null restriction on the unconditional mean of the process is zero and found that evidence of unsustainability for Thailand.

Interestingly, we can observe that there is an overall agreement between the more informal approach offered by the IFS and the Markov switching models that account for occasional departures of sustainability. Indeed, the IFS is able to identify periods of unsustainability, but these in general are short-lived and do not tend to last. This is the broad conclusion that we can retain from the application of Markov switching models. Indeed, we found that once these episodes are accounted for, evidence favours the case for global fiscal sustainability.

Overall, we believe the main goals of this dissertation were achieved, that is, to provide an illustration of the usefulness of several methodologies to assess fiscal sus-
tainability. Some of these approaches were applied in this work for the first time in the context of fiscal sustainability studies. Nevertheless, this work suffers from several limitations and insufficiencies. Time constraints did not allow the pursuit of a more thorough analysis of both the joint and the univariate dynamics of the variables of interest, through richer specifications in the context of Markov switching models. An interesting possibility would be to model the apparent surge in volatility that accompanies periods of fiscal difficulties. For that purpose, one could model the variance as following a distinct independent Markov chain. Another interesting perspective would be to model the transition probabilities to be dependent on explanatory variables and, thus, time-varying. A natural extension would then be to evaluate how good these richer non-linear models are in terms of predicting crises.

Nevertheless, we find that the results presented here can provide useful guidelines for future work. One example is the development of Dynamic Stochastic General Equilibrium (DSGE) models, which have been successfully used to model and assess monetary policy. The next generation of DSGE will seek to model the fiscal side of the economy and therefore will have to take into account the particularities of debt dynamics. We hope we have contributed, though in a very limited fashion, to bring new results to the fore and hence provide clues for the next challenges in this topic.
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