MULTICOINTEGRATION AND SUSTAINABILITY OF FISCAL PRACTICES

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Using multicointegration methodology, we develop criteria for testing sustainability of fiscal budgeting processes across all states of nature. Criteria are derived from the optimal control literature where levels and rates of change of a system of variables are determinants of policy response. The appropriate policy response mechanisms are outlined and linked to the multicointegration methodology. We then test government spending and revenue systems of 15 industrialized countries for the presence of such mechanisms. We find that only Norway and the United Kingdom exhibit policy responses that are consistent with our criteria. (*JEL* H6, E62, C22)

I. INTRODUCTION

Governments are charged with the responsibility of crafting national budgets. Over time budgets tend to move between balance, surplus, and deficit. These fluctuations result from the fact that all too often a government makes financial decisions in one year that have implications for spending commitments and revenue streams a number of years down the road. Thus, responsible government budgeting involves examining the budget position over time, that is, engaging in intertemporal budgeting. Economists generally utilize two criteria to assess the intertemporal budget's sustainablity: does the government run persistent deficits? If so, what is the resulting level of debt?

Are these two criteria sufficient to make predictions regarding budget sustainability? Recent work by Bohn (1995, 1998) and Ball et al. (1998) suggests that budgets are far too complicated to be evaluated with respect to deficits and debt alone. These authors have shown that persistent deficits and accumulation of debt does not necessarily imply that the debt is unmanageable and, hence, fiscal processes unsustainable. The implication of their work is that the standard approach to testing whether government adheres to its intertemporal budget constraint, cointegration analysis, does not provide sufficient criteria for determining whether the fiscal process is truly sustainable.

Consequently, in this article we develop a more encompassing set of criteria under more realistic assumptions for determining whether a country exhibits a sustainable budgeting process. Our criteria for sustainability are based the multicointegration approach first presented by Granger and Lee (1989, 1990) and further developed in Engsted, Gonzalo and Haldrup (1997) and Haldrup (1998). The budgeting practices of 15 industrialized countries (Belgium, Canada, Denmark, Finland, France, Great Britain, Greece, Italy, the Netherlands, Norway, Portugal, Spain, Sweden, Switzerland and the United States) are evaluated in terms of the criteria. Our sample spans the modern era, 1960–98.

We extend the intertemporal budgeting literature by employing the multicointegration framework to develop the appropriate policy responses to deficits and debt accumulation and to test for their presence. The methodology assesses both the stock and flow relationships

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ABBREVIATIONS

ADF: Angmented Dickey-Fuller
ECM: Error-Correction Model
GDP: Gross Domestic Product

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that should characterize sustainable fiscal processes when the data are nonstationary. Cointegration between the spending-revenue flow relationship is the first component of our criteria. Cointegration between the flow of revenue (spending) and the stock of debt is the second. Jointly these conditions characterize multicointegration between government spending and revenue. In the multicointegration case, the system is characterized by a complex stock-flow equilibrium relationship that is not uncommon in intertemporal models of economic behavior. Such a relationship is typically associated with issues of optimal control where the levels and rates of change of the variables making up the system are determinants of the policy response. Multicointegration can ensure that a country's budgeting strategy is sustainable in "bad" states of nature, that is, when the rate of economic growth falls short of the real interest rate on sovereign debt.[1]

Bohn (1995) and Ball et al. (1998) point out that existing theoretical models that underpin traditional sustainability tests are too simple. Specifically, Bohn (1995) shows that the sustainability of imbalances in a stochastic setting involves satisfying an intertemporal budget constraint and a transversality condition that differs from that implicit in simple (deterministic) models. The transversality condition requires that the limit of the debt discounted at a rate that is a function of the probability distribution of future debt and the marginal rate of substitution between present and future consumption be zero. This correct discounting is critical in economies where the rate of growth has been higher than the real interest rate. Such an economy can sustain persistent deficits as high rates of economic growth lower the stochastic discount factor, thereby diminishing the debt burden. In such a setting, Ponzi schemes become Ponzi gambles, which are "undesirable for some generations in some realizations of history (when growth falls below the real interest rate), but desirable for all generations in most realizations of history" (Ball et al. 1998, p. 701). Therefore, we are developing criteria that assess whether the behavior that each country exhibits over the sample period is consistent with sustainable budgeting policies *regardless* of economic performance and ruling out default or inflation.

Results indicate that the budgeting practices of Norway, the United Kingdom, and the United States are consistent with multicointegration between government spending and revenues. However, the systems of coefficient estimates are significantly different for each of these three countries, leading to very different conclusions regarding the nature of policy response mechanisms and consequently fiscal sustainability. Results for Norway indicate that the country has on average experienced budget surpluses and has cut taxes in response to the accumulation of government savings. For the United Kingdom, the system of coefficient estimates suggests that the British government has maintained deficits on average but has moved to raise revenues in response to debt accumulation. In both of these countries the evidence is consistent with the presence of the appropriate policy response mechanisms. Hence their budgeting practices meet our sustainability criteria.

On the other hand, although the U.S. results indicate that the spending-revenue system is multicointegrated, the evidence indicates that spending has consistently exceeded revenues, yet the resulting debt accumulation has been accompanied by declines in government revenues (rather than increases). This finding is not consistent with the sustainability criteria developed here. Nor is the evidence regarding 11 of the remaining 12 countries. Although Danish, Finish, French, Spanish, and Swedish spending revenue systems are cointegrated, the evidence indicates that they have persistently run deficits and that they lack any systematic policy response to them. In the remaining seven countries there is no evidence of a long-run relationship between government spending and revenues. In every case except Switzerland spending has persistently exceeded revenues, suggesting that debt accumulation is the norm.

The remainder of the article is organized as follows. Section II reviews the literature on intertemporal budgeting and sustainability of deficits. Section III outlines the model

1. Multicointegration implies that in a bivariate I(1) system more than one cointegrating vector may exist such that the number of cointegrating vectors and the number of stochastic trends do not add up to the dimensions of the system as is the case with cointegrated I(1) models. This allows for a special case of polynomial cointegration that captures both flow and stock relations (see, e.g., Granger and Lee 1989 and Engsted and Haldrup 1999). The presence of such a relationship indicates that the bivariate system is bound together by two equilibrating forces rather than the more traditional single equilibrium relationship that characterizes conventionally cointegrated systems.

and derives the theoretical constructs to be tested. Section IV presents the multicointegration methodology. In section V the multicointegration results are presented and discussed. Section VI concludes.

II. BACKGROUND

Many researchers have explored the issue of solvency and Ponzi financing in a deterministic setting. Hamilton and Flavin (1986) were among the first to adopt the intertemporal budget constraint approach to empirically investigate the issue. They examine the 1962–84 period for the United States concluding that the data support a binding constraint. Wilcox (1987) and Kremers (1989) extend the work in this area, contradicting the Hamilton and Flavin conclusion.

Using the cointegration approach, studies by Trehan and Walsh (1988, 1990), Smith and Zin (1988), Hakkio and Rush (1991), Haug (1991), Ahmed and Rogers (1995), and Leachman (1996) produce conflicting evidence surrounding the issue of government's use of Ponzi financing. Trehan and Walsh and Haug find evidence supporting intertemporal fiscal balance for the United States Hakkio and Rush and Leachman do not. Smith and Zin explore the intertemporal fiscal balance of Canada, producing evidence that supports a sustainable fiscal path over the long run. Finally, the work of Ahmed and Rogers inspects the fiscal balance of both the United States and the United Kingdom. The authors conclude that the evidence is consistent with both countries obeying their intertemporal budget constraints.

With the exception of Ahmed and Rogers (1995), all of the models that underpin the work are derived in a deterministic setting, generally under the assumption that economies are dynamically efficient and the rate of growth is less than the safe interest rate.[2] More realistically the environment is stochastic and uncertainty is present. In such a setting, sustainability of fiscal deficits is more complex. Bohn (1995) develops the theoretical considerations for this scenario, and Ahmed and Rogers demonstrate that under certain conditions cointegration remains a sufficient condition. Ball et al. (1998) further explore the issue of sustainability. They produce evidence for the United Staes indicating that the probability of a bad outcome, defined as rates of growth below the real interest rate, is between 10% and 20%. Bohn (1998) outlines and tests for a corrective mechanism in the budgeting process that enables an economy to sustain imbalances given bad outcomes. He finds that the United States exhibits such a budgeting strategy.

Von Hagen and Harden (1994), Milesi-Ferretti and Razin (1995, 1996), and Uctum and Wickens (1996) also explore the sustainability issue. These studies look at the fiscal processes of an array of countries and factors that influence a country's ability to sustain persistent imbalances. Milesi-Ferretti and Razin focus on factors that influence sustainability (through the promotion of growth) and directly affect the willingness to pay for debt in a number of developing countries. Von Hagen and Harden and Uctum and Wickens inspect the sustainability of the actual fiscal practices in the United States and various European countries. Von Hagen and Harden conclude that France, Germany, the United Kingdom, Luxembourg, and the Netherlands exhibit fiscal practices that are "close" to sustainable for the entire sample period (1970–84). Denmark, Belgium, and Ireland start the sample period with unsustainable processes but improve their performance in the 1980s. Italy, Greece, Spain, and Portugal exhibit unsustainable practices. The empirical evidence produced by Uctum and Wickens indicates that the fiscal stance of Denmark, the Netherlands, and Ireland is sustainable, whereas the fiscal processes exhibited by the United States, Spain, Italy, Belgium, and Portugal are not.

III. THE MODEL

In this section we build on the work of Bohn (1995, 1998), Ahmed and Rogers (1995), and Granger and Lee (1990) to develop a set of criteria by which government budgeting processes can be considered sustainable in all states of nature. We first assume that for all t there exists a unique nonnegative process $\{M_t^{t+s}\}_{s=0}^{\infty}$. This process, called the stochastic discount factor, is defined so that $M_t^t = 1$ almost surely and if $\{X_{t+s}\}_{s=0}^{\infty}$ is a sequence

2. See Ball et al. (1998) and Bohn (1999) for conditions in which persistent deficits can be welfare improving in dynamically efficient economies.

of random payoffs beginning in period t, then its value in units of period t consumption is $E_t \sum_{\nu=1}^{\infty} [M_t^{t+\nu} X_{t+\nu}]$ (see, e.g., Duffie 1996 for discussion).

To derive the relationships relevant to this article, we begin with the government's budget constraint. It is expressed as

$$(1) \qquad G_t + (1 + i_{t-1}) B_{t-1} = R_t + B_t,$$

where G = government spending, which includes purchases of goods and services as well as transfers; i = a stationary safe rate of interest; B = government bonds of one period maturity; and R = total government revenue, comprised primarily of taxes.

Substituting forward for B_t in equation (1) and rearranging, we obtain the following present value relationship:

$$(2) \qquad (1 + i_{t-1}) B_{t-1} = E_t \sum_{\nu=0}^{\infty} M_t^{t+\nu} \times [R_{t+\nu} - G_{t+\nu}] + \lim_{\nu \to \infty} E_t [M_t^{t+\nu} B_{t+\nu}].$$

Equation (2) simply says that the current value of government debt is equal to the expected present value of all future primary surpluses, plus a limiting term representing the asymptotic expected present value of the government's debt. We can ensure that the limiting term on the right-hand side of (2) is nonnegative by assuming that the government does not allow individuals to engage in Ponzi schemes against it. Furthermore, if the government is satisfying its budget constraint intertemporally, it cannot asymptotically leave a debt with positive expected present value. Hence the time t expected paths of spending and revenues are sustainable if the limiting term on the right-hand side of (2) is equal to zero.

In a deterministic setting and/or one characterized by risk neutrality, the stochastic discount factor is constant and equal to $1/(1 + i)$, and the condition for sustainability reduces to $\lim_{\nu \to \infty} [B_{t+\nu}/(1 + i)^{t+\nu}] = 0$. Assuming this environment and nonstationary data, the restriction has been empirically interpreted as requiring a cointegrating or long-run equilibrium relationship between spending and revenues with a coefficient of cointegration less than or equal to one. The reasoning behind such tests is typically based on ruling out a deterministic bubble in government debt. However, in a stochastic environment, Bohn (1995) has demonstrated that even if government debt is riskless and pays a constant rate of return i, $\lim_{\nu \to \infty} [B_{t+\nu}/(1 + i)^{t+\nu}] = 0$ does not necessarily imply that $\lim_{\nu \to \infty} E_t [M_t^{t+\nu} B_{t+\nu}] = 0$. The problem here is that the correct discount factor is a function of state contingent claim prices that can become arbitrarily large in bad (low GNP) states. Even if government debt grows at a rate smaller (larger) than i, the risk of a sharp decrease (increase) in GNP can still cause the limiting term to be infinite (zero).

Fortunately, Ahmed and Rogers (1995) show that under relatively general conditions, tests of cointegration are still appropriate. They demonstrate that under certain conditions on the stochastic discount factor and the risk premia on government revenue and spending, $\lim_{\nu \to \infty} E_t [M_t^{t+\nu} B_{t+\nu}] = 0$ holds if and only if the system $(R_t, G_t, i_{t-1} B_{t-1})$ is cointegrated with the cointegrating vector $(1, -1, -1)$ (see Ahmed and Rogers 1995 for a full discussion). Moreover, these authors point out that cointegration, hence stationarity of the deficit, does not necessarily imply that the national debt must eventually be paid off to be sustainable. Sustainability as it is defined here is an asymptotic property: Even if revenue and spending tend to drift together in the long run, deficits and surpluses may grow arbitrarily large over short time horizons. For example, Ball et al. (1998) characterize budget deficits as Ponzi gambles in which the government "bets" that aggregate income will grow fast enough to make the debt-income ratio fall systematically over time. An important result is that the larger the debt-income ratio grows, the less certain a Ponzi gamble is to succeed and the more likely it is that state contingent claims prices, hence the correct discount factor, rise.

Therefore, we develop further criteria for sustainability. Let $G_t^* = G_t + i_{t-1} B_{t-1}$. In other words, G^* is government expenditures including interest payments.[3] Suppose that the vector process (G_t^*, R_t) is cointegrated. Specifically, let G_t^* and R_t be I(1) and assume there exists a real constant A, the coefficient of cointegration or cointergrating scalar, such that $z_t = G_t^* - A$

3. Note that if (R_t, G_t, z_t) are CI(1, 1) with cointegrating vector $(-1, \gamma_1, \gamma_2)$, then $(R_t, \gamma_1 G_t + \gamma_2 z_t)$ will be CI(1, 1) with cointegrating vector $(-1, 1)$. For consistency with the data we make this simple change of variables here.

$R_t \sim I(0)$. The variable z_t then is a measure of short-run deviations from the equilibrium (cointegrating) relationship. In this system z_t represents the current period budget deficit (surplus). The accumulation of z_t, $\sum_{s=0}^{t} z_{t-s} = D_t$ is an I(1) process that represents government debt (savings). Granger and Lee (1989, 1990) define (G_t^*, R_t) to be multicointegrated if $h_t = (D_t - \lambda R_t) \sim I(0)$. Note, if G_t^* and R_t are multicointegrated, D_t and G_t^* will also be cointegrated.

The simplest criteria for intertemporal balance require that G_t^* and R_t be cointegrated with cointegrating vector $(-1, 1)$. This implies that G_t^* and R_t are I(1) processes with the following representations

$$\Delta G_{t-1}^* = a_{G^*} + v_{G^*,t-1}, \tag{3}$$

$$\Delta R_{t-1} = a_R + v_{R,t-1}, \tag{4}$$

where Δ is the first difference operator and

$$v_{G^*,t} = \Delta W_t + v_{G^*1,t}, \tag{5}$$

$$v_{R,t} = \Delta W_t + v_{R1,t}. \tag{6}$$

In equations (5) and (6) W_t is I(1) and $v_{*1,t}$ are I(−1) processes, $Z^* = R, G^*$. This is the standard common factor representation for cointegrated series. In this case, one can think of W_t as a state variable that summarizes time t economic conditions, and (5) and (6) can be interpreted as the government's policy response rules. Sustainability occurs when the government's spending and tax revenues depend on information that can be summarized by the same I(1) information variable. Changes in government spending and revenues will then both depend linearly on changes in W_t.

Similarly, R_t and G_t^* will be multicointegrated if v_R and v_{G^*} can be represented as

$$v_{G^*,t} = \Delta W_t + \alpha_2 \Delta^2 W_t + v_{G^*2,t}, \tag{7}$$

$$v_{R,t} = \Delta W_t + \alpha_1 \Delta^2 W_t + v_{R2,t}, \tag{8}$$

where $\Delta^2 W_t = W_t + W_{t-2} - 2W_{t-1}$, and $v_{Z^*2,t}$ are I(−2) processes, and α_1, α_2 satisfy $\alpha_1 - \alpha_2 \neq 0$. In this case, R_t and D_t will be cointegrated with cointegrating vector $(1, -[\alpha_1 - \alpha_2]^{-1})$. Equations (7) and (8) can be thought of as more sophisticated policy response mechanisms in which the government considers both the change and the rate of change in economic conditions in formulating its fiscal policy. This strengthens the equilibrium relationship in a subtle but powerful way asymptotically, both the levels and the rates of change of the two series are tied together.

With this more sophisticated policy response in place, taxes are increased and/or spending is decreased when the cumulative deficit becomes too large and/or the rate of increase is accelerating. This can be considered similar to the production example in Granger and Lee's (1990) paper. Here the government faces quadratic adjustment costs for spending and revenues as well as a cost of large deficits.

To be concrete, consider the following optimal taxation problem. Suppose that the government has determined its optimal spending decision (including interest payments) as a sequence of policy functions $\{G_{t-j}^*(I_{t-j})\}_{j=0}^{\infty}$ where I_{t-j} is the time t information set. By manipulating tax rates, the government controls its time t revenues R_t to minimize

$$L_t = E_t \sum_{j=0}^{\infty} \xi^j [(R_{t-j} - G_{t-j}^*(I_{t-j}))^2 + \varphi_1 (D_{t-j} - \kappa G_{t-j}^*(I_{t-j}))^2 + \varphi_2 (R_{t-j} - R_{t-j-1})^2]. \tag{9}$$

In this example the government balances three costs in its budgeting decision: the cost of issuing debt in the current period, a cost that occurs when the cumulative deficit (or surplus) becomes large relative to the current size of government, and finally the cost of manipulating tax rates to change revenues from period to period. Drawing on the results of Lee (1992), the solution is a sequence of revenues $(R_{t-j})_{t-j}^{\infty}$ that make the process (R_t, G_t^*) multicointegrated.

This example is one of many ways in which multicointegration can arise in our system of variables. In more general models, the criteria can be interpreted as requiring that the government's policy response functions for revenues and spending follow the error-correction models (ECMs) in equations (7) and (8). If government is to satisfy its budget constraint intertemporally, its revenues and spending decisions must depend on some common stochastic trend. If the government is taking potential costs of a large cumulative deficit into account, its revenue and spending decisions

will also depend on the rate of change in the common trend. For example, when the primary deficit is accelerating, the government takes preventative action (raising taxes and/or lowering spending) to prevent the cumulative deficit from becoming too large in future periods.

The relationships outlined reflect the policy response that results from an optimal control mechanism where adjustment costs are quadratic. In conjunction with restrictions on parameter estimates outlined next they define our sustainability criteria.

IV. METHODOLOGY

To assess a country's fiscal performance in terms of our criteria, the multicointegration framework first presented in Granger and Lee (1989, 1990) and further developed by Engsted et al. (1997) and Haldrup (1998) is employed. Where multicointegration is rejected, traditional Engle and Granger (1987) cointegration tests are executed. The cointegration and multicointegration methodologies are based on the single-equation approach pioneered by Engle and Granger. Work by Zhou (2001) and Gonzalo and Lee (1998) has shown that single-equation test statistics are generally more robust.

Consider two series x_t and y_t. Typically, it is assumed that they are stationary, in which case they are integrated of order zero. In many macroeconomic time series, however, it is more commonly the case that series are I(1). In the previous section we have outlined the conditions under which (the generic variables) $x_t \sim$ I(1) and $y_t \sim$ I(1) are found to be (multi) cointegrated.

Multicointegration is a very special form of I(2) cointegration. Engle and Yoo (1991) and Johansen (1995) among others have explored the more general properties of I(2) systems, but until quite recently the multicointegration property and methodology has not been well developed. Lee (1992), Engsted and Johansen (1997), and Engsted et al. (1997) point out that the presence of multicointegration invalidates traditional methods of testing for cointegration. Therefore, Engsted et al. have developed a single-equation procedure for testing multicointegration that exhibits quite favorable statistical properties. It is an extension of the Engle and Granger (1987) two-step procedure to the case of I(2) variables. We employ this approach.[4] It exploits the fact that multicointegration implies a particular form of I(2) cointegration. In so doing it simultaneously tests both levels of cointegration and produces test statistics with distributions that are well known.

The initial step requires estimation of the following regression:

$$(10) \quad Y_t = K_0 X_t + K_1 \Delta X_t + \delta_0 + \delta_1 td + e_t,$$

where $Y_t = \sum_{i=1}^{t} y_i \sim I(2)$, $X_t = \sum_{i=1}^{t} x_i \sim I(2)$, td = trend, and ΔX_t could be replaced by ΔY_t. This is followed by tests of e_t for the order of cointegration. In that a number of cointegration possibilities exist, a variety of hypotheses may be relevant for testing. However, in most practical situations I(2) variables will cointegrate to the I(1) level at least. Therefore, we test the null hypothesis that the I(2) variables cointegrate to I(1) level, but no further cointegration occurs such that e_t is I(1). The distributions of the test statistics depend on the number of I(1) and I(2) regressors, m_1 and m_2, respectively. Additionally, deterministic components included in (10) will affect the distributions. Critical values for various combination of m_1 and m_2 are presented in Haldrup (1994) for the case with a constant and in Engsted et al. (1997) for trend and quadratic trend cases.[5]

In equation (10) the Y_t, X_t variables are I(2) by construction, whereas ΔX_t is I(1). In terms of our system of variables, Y represents accumulated spending, X is the accumulated revenue series and ΔX is government revenues. In the presence of multicointegration, K_0 is a super-super-consistent estimate of the first coefficient of cointegration converging to the true value at a rate of $O_p(T^{-2})$. K_1 is a super-consistent estimate of the second stock-flow

4. We have also estimated a modified version of the Engle-Granger two-step procedure to assess the (multi)-cointegration property. Those results, accompanied by an explanation of the procedural modifications, are available on request.

5. Should we be unable to accept multicointegration, we sequentially test for conventional cointegration; that is, we test the validity of the null hypothesis. Where we are unable to accept the hypothesis of I(1) cointegration in conventional tests, the null hypothesis in the tests for multicointegration is obviously misspecified. Test statistics assuming a null of no cointegration such the $e_t \sim$ I(2) may be constructed in principle but are not currently available. See Haldrup (1998) for further discussion.

cointegrating relationship exhibiting $O_p(T^{-1})$ convergence.

Because the environment is stochastic, sustainable budgeting does not impose any a priori restrictions on the magnitude of K_0. It can be greater than, equal to, or less than one. If it is less than one, on average revenues outpace spending, leading to the accumulation of surpluses. If it is equal to one, on average the budget is in balance. If K_0 is greater than one, on average spending outpaces revenues and the government may be engaged in a Ponzi gamble requiring tax increases and/or spending cuts in bad states of nature.

Given $K_0 > 1$ ($K_0 < 1$), our sustainability criteria requires that government revenues and the present value of debt be positively (negatively) related, that is, $K_1 > 0$ ($K_1 < 0$). The positive (negative) nature of the relationship ensures that revenues rise (fall) to accommodate rising levels of debt (savings). These conditions ensure that neither the government nor the private sector engage in a Ponzi scheme or gamble.

Granger and Lee (1989) have shown that for a bivariate multicointegrated system ECMs can be represented by

$$\Delta x_t = \gamma_1 z_{t-1} + \gamma_2 h_{t-1} + \text{lagged } (\Delta x_t, \Delta y_t) + e_t^x \quad (11)$$

$$\Delta y_t = \gamma_1 z_{t-1} + \gamma_2 h_{t-1} + \text{lagged } (\Delta x_t, \Delta y_t) + e_t^y. \quad (12)$$

The changes in x_t and y_t are related to the lagged cointegration errors with the necessary condition that at least one component of each pair of γ_1 and γ_2 is nonzero. Inclusion of the second error correction term, h_{t-n}, enables the system to be more robust to disturbances. The evidence produced by the ECM provides information concerning the nature of the short-run dynamics necessary for achieving the long-run equilibrium. For a more complete discussion and technical derivation see Johansen (1992, 1995), Paruolo and Rahbek (1996), and Engsted and Haldrup (1999).

V. MULTI/COINTEGRATION RESULTS

The data utilized in this study are drawn exclusively from Organisation for Economic Co-operation and Development Economic Outlook series. They are annual observations in real domestic currency units from 1960 through 1998 roughly because 1960 "seemed to be a watershed, and the growth in public spending after that year was quite dramatic" (Tanzi and Schuknecht 1997, p. 165). The government spending series is composed of expenditures across all levels of government. Similarly, the tax revenue series is an aggregate of government receipts from income tax, social security tax or its equivalents, corporate tax, and indirect taxes at the various government levels. These series represent consolidated government revenues and expenditures, thereby producing a general or consolidated deficit and debt series.[6]

The series have been adjusted to produce two measures of spending and revenues. In general all reported test statistics reflect estimations undertaken using real values/gross domestic product (GDP). The issues raised by Bohn (1995, 1998) and Ball et al. (1998) are framed in terms of this measure. However, for Norway, the Netherlands, and the United Kingdom real values per capita are employed because the systems comprised of real spending/GDP and real revenue/GDP do not meet the I(1) criteria (see later discussion). Real values per capita are real values deflated by population. McCallum (1984) and Easterly (2000) note that this measure may be pertinent because population growth may lead economic growth and help to service debt. Graphs of the system(s) of the spending and revenue variables from each country are available from the authors on request.

In Table 1 the augmented Dickey-Fuller (ADF) statistics are presented. They are accompanied by the average growth rate for each country over the sample period.[7] The

6. For the Netherlands the data sample spans 1970–98. The sample period for Norway is 1962–98, for France and the United Kingdom it is 1963–98, and for Spain it is 1964–1998. For the remaining 10 countries the sample period is 1960–98. Base years vary across countries. France and Switzerland have 1980 as the base year; Canada, Denmark, and Spain use 1986; Greece uses 1988; the base year for Belgium, Finland, Italy, the Netherlands, Norway, Portugal and the United Kingdom is 1990; Sweden and the United States employ 1991 and 1992, respectively. Due to the limitations of the data, interest payments are not separately deflated in the expenditure series.

7. It is important to note that in our sample of countries growth rates were zero or negative for all countries except Norway between 1974 and 1975, in the early 1980s, and again in the early 1990s. This finding is consistent with the Ball et al. (1998) finding that the probability of rates of growth falling below real interest rates is between 10% and 20%.

TABLE 1
ADF Statistics

		Real per Capita Spending	Real per Capita Revenues	Spending GDP	Revenue GDP	Ave. Growth Rates (%)
Belgium	ADF(1)*	1.3028	1.0974	1.6140	2.2947	3.1
	ADF(1)	0.9251	0.6265	0.7971	0.8013	
Canada	ADF(1)*	1.5453	1.5052	1.4128	1.7333	3.9
	ADF(1)	0.6813	1.0615	1.7707	1.7719	
Denmark	ADF(1)*	0.9385	0.8688	1.6586	2.4610	2.8
	ADF(1)	1.2502	2.8375	0.4286	1.0937	
Finland	ADF(1)*	0.6135	0.0518	1.2018	0.7429	3.3
	ADF(1)	2.1060	3.1411	3.6038	3.6810	
France	ADF(1)*	1.4550	1.6635	1.0793	0.8583	3.2
	ADF(1)	1.0460	0.3059	1.9600	1.7063	
Greece	ADF(1)*	0.6089	0.9230	1.1940	0.5457	4.8
	ADF(1)	1.4714	2.5266	1.7349	3.0250	
Italy	ADF(1)*	1.2095	0.8990	1.4434	0.3895	3.4
	ADF(1)	0.9312	1.7331	1.5133	1.7023	
Netherlands	ADF(1)*	2.9685	2.8608	12.5520	19.7231	2.8
	ADF(1)	0.8452	1.9950	10.5591	17.8589	
Norway	ADF(1)*	0.5894	1.7686	2.3364	11.2812	4.2
	ADF(1)	2.3266	6.4706	1.3290	13.1079	
Portugal	ADF(1)*	0.6857	1.7231	0.6486	0.1554	4.7
	ADF(1)	2.8145	3.6390	2.6004	3.8896	
Spain	ADF(1)*	0.7057	0.3474	1.2705	1.2895	4.2
	ADF(1)	2.0775	1.7440	1.1962	0.2082	
Sweden	ADF(1)*	1.9378	1.5746	1.8281	2.3468	2.5
	ADF(1)	0.4574	1.9608	0.7958	1.4844	
Switzerland	ADF(1)*	0.6491	0.8736	0.7889	0.4479	2.3
	ADF(1)	2.4298	1.5401	2.9670	2.1961	
United Kingdom	ADF(1)*	1.3368	1.1354	2.4260	3.7368	2.4
	ADF(1)	2.0224	3.6743	2.0990	3.4477	
United States	ADF(1)*	0.8089	0.3487	2.3650	1.5609	3.2
	ADF(1)	2.7028	3.5110	4.2600	2.9040	

Notes: Nontrended $\gamma = 0$ 0.05 critical value is approximately −2.98; trended $\gamma = 0$ 0.05 critical value is approximately −3.59. * indicates no trend.

ADF statistics test for the presence of a unit root with and without a trend and allowing for a drift in each series. The two measures of government spending and revenues generally exhibit unit roots with a trend for all countries.[8] However, for Finland the real/GDP series are nontrended. Similarly, in Portugal revenue/GDP is nontrended, while spending/GDP is nontrended, for the United States In Norway and the United Kingdom revenue/GDP is I(0), whereas both real/GDP series are stationary in the Netherlands.

Next we accumulate the appropriate series to produce new series that are I(2) by construction. This is followed by tests for multicointegration between government spending and receipts. Results of multicointegration tests and, where appropriate, the corresponding ECMs are presented in Tables 2 and 3.

Inspection of Tables 2 and 3 indicates that multicointegration is present in the fiscal systems of Norway, the United Kingdom and the United States. However, the results indicate that the nature of each country's fiscal budgeting process is quite different. First consider Norway. The estimated values of K_0 and K_1

8. For Finland the real/GDP series are nontrended. Similarly, in Portugal revenue/GDP is nontrended whereas spending/GDP is nontrended for the United States.

TABLE 2
Multicointegration Tests

	K_0	K_1	Con	Trd	ADF	DW
Belgium: real/GDP	1.5919	5.3799	1.8813	0.2532	3.0865	0.5003
Canada real/GDP	1.6148	1.1284	0.4436	0.2147	2.2111	0.1760
Denmark real/GDP	1.1759	1.2633	0.4408	0.1036	3.9332	0.2080
Finland real/GDP	1.3353	2.2193	0.7282	0.1740	3.7313	0.3005
France real/GDP	1.4315	0.0000	0.1622	0.2118	3.6471	0.2331
Greece real/GDP	2.3904	1.2673	0.4134	0.3867	2.8789	0.2313
Italy real/GDP	2.1484	12.7868	3.4824	0.6004	3.1759	0.7228
Netherlands real per capita	1.1844	0.6284	0.0311	0.0026	1.1101	0.2497
Norway real per capita	0.9572	1.507	0.0649	0.0014	4.2879	0.3747
Portugal real/GDP	1.2024	1.4386	0.2424	0.0703	1.6427	0.3156
Spain real/GDP	1.1915	0.3217	0.0704	0.0655	3.8808	0.2772
Sweden real/GDP	1.4118	2.7138	1.0663	0.2332	3.7852	0.3070
Switzerland real/GDP	1.0336	0.6599	0.1636	0.0987	3.6984	0.1675
United Kingdom real per capita	1.2764	0.3082	0.0027	0.0009	5.4799	0.2786
United States real/GDP	1.5536	1.2474	0.3395	0.1530	4.5851	0.4486

Notes: Based on the equation: $Y = K_0 X + K_1 \Delta X + \delta_0 + \delta_1$ trend, where Y = spending ~ I(2) and X = revenues ~ I(2). Critical values for the ADF statistic of the residuals are drawn from Engsted et al. (1997). For $n = 25$, $\gamma = 0.05$ value is −4.71, and $\gamma = 0.10$ value is −4.30. For $n = 50$, $\gamma = 0.05$ value is −4.42 and $\gamma = 0.10$ value is −4.08.

are 0.96 and −1.51, respectively. The fact that $K_0 < 1$ indicates that revenues have outpaced spending over the sample period. The negative value on K_1 indicates that revenues have fallen as surpluses have mounted. The results are consistent with sustainability and the conjecture that the Norwegian government has not allowed the private sector to run a Ponzi scheme against it.

Next consider the United Kingdom. The estimated value of K_0 is 1.28, indicating that on average spending has exceeded revenues.

TABLE 3
Multicointegration Error Correction Models

	α	γ_1	γ_2	B_1	B_2	r^2
Norway						
ΔS	0.0015**	−0.2326**	−0.1322	0.3566**	−0.0538	0.13
	(2.5408)	(−2.4218)	(−1.0401)	(2.1327)	(−0.3222)	
ΔR	0.0024**	−0.1528	−0.0503	0.3563*	0.3032	0.04
	(3.2825)	(−1.2670)	(−0.3148)	(−1.6971)	(1.4468)	
United Kingdom						
ΔS	0.0030**	−0.4735	−1.2849**	2.2347**	−2.1266**	0.081
	(32.8759)	(−1.3119)	(−10.6964)	(2.2705)	(−3.1926)	
ΔR	0.0001**	−0.0335	−0.0474**	0.2350	−0.2286*	0.23
	(3.9041)	(−0.4852)	(−2.0634)	(1.2497)	(−1.7466)	
United States						
ΔS	0.0010	−0.6038**	−0.0975	0.4899**	−0.0000	0.40
	(0.7786)	(−4.8370)	(−0.5702)	(3.3698)	(−1.1421)	
ΔR	123084.1	−8611962	−6782881	2231811	−0.1270	0.08
	(1.2362)	(−0.8722)	(−0.5015)	(−0.1941)	(−0.6932)	

Notes: Estimated models are based on the equations: $\Delta \text{Spending} = \gamma + \gamma_1 EC1_{t-1} + \gamma_2 EC2_{t-1} + B_1 \Delta \text{Spending}_{t-1} + B_2 \Delta \text{Revenues}_{t-1}$, $\Delta \text{Revenues} = \gamma + \gamma_1 EC1_{t-1} + \gamma_2 EC2_{t-1} + B_1 \Delta \text{Spending}_{t-1} + B_2 \Delta \text{Revenues}_{t-1}$, where EC1 is the residual from the first cointegrating relationship (spending and revenues) and EC2 is the residual from the second cointegrating relationship (revenues and debt). t-statistics in parentheses. * indicates $\gamma = 0.10$ significance level. ** indicates $\gamma = 0.05$ significance level.

TABLE 4
Engle-Granger Cointegration Tests

	α	A	DW	ADF Residual
Belgium spending	0.3103	1.6674	0.2904	2.0232
Canada spending	0.1334	1.3794	0.3860	2.5949
Denmark spending	0.0891	1.1275	0.3906	3.1446
Finland spending	0.1751	1.3130	0.5672	3.1635
France spending	0.2157	1.4332	0.9870	3.4246
Greece spending	0.2180	1.7856	0.4201	1.7423
Italy spending	0.0272	1.1859	0.2314	1.1637
Netherlands spending (real per capita)	0.0032	1.2087	0.9265	2.1074
Portugal spending	0.0451	1.1409	0.7253	2.6961
Spain spending	0.0642	1.1934	0.7031	3.7754
Sweden spending	0.2356	1.3917	0.3066	3.6040
Switzerland spending	0.0968	1.0423	0.4302	2.3658

Notes: Based on the equations: Spending $= \gamma_0 + A$ Revenues. Due to the small sample size, the critical values for the ADF statistic are drawn from Engle and Yoo (1987). For $\alpha = 0.05$, the critical value is -3.29; for $\alpha = 0.10$, the critical value is -2.90.

Consistent with our sustainability criteria, K_1 has an estimated value of 0.31. The positive K_1 value indicates that revenues have been raised as debt has mounted. Thus the British fiscal system is also sustainable. However, in this case the evidence indicates that the government has not run a Ponzi scheme against the private sector or engaged in a Ponzi gamble.

The fiscal system of the United States is the last multicointegrated system. Estimated values of K_0 and K_1 from equation (10) are 1.55 and -1.25, respectively. The fact that the estimated value of K_0 is greater than one indicates that on average spending has been greater than revenues, causing deficits to be the norm. The negative value on K_1 implies that revenues have fallen as debt has risen. Therefore, although the fiscal system is multicointegrated, it does not satisfy our sustainability criteria. Instead the evidence suggests that the U.S. policy response is inappropriate given the budget situation. The implication is that the U.S. government has undertaken a Ponzi scheme or engaged in a Ponzi gamble.

Evidence produced in the ECMs of the three multicointegrated systems suggests that spending is more responsive. In the ECMs where estimates of γ_1 are significant they are all negative and in the equations normalized on spending. This suggests that changes in spending decline in response to divergences from the flow equilibrium. The magnitude of γ_1 estimates is generally small, indicating rather slow speeds of adjustment. Estimates of γ_2 are only significant in the U.K. ECM. They indicate that spending rises rapidly and revenues fall quite slowly when there are deviations from the debt-revenue long-run relationship.

Having rejected multicointegration for the remaining 12 countries, we next test for conventional cointegration between government spending and revenues. Results of these tests accompanied by the corresponding ECMs of the cointegrated systems are reported in Tables 4 and 5. Results indicate that cointegration is present between the fiscal variables in Denmark, Finland, France, Spain, and Sweden. In every system the estimated value of A is greater than one. These results indicate that although spending and revenues share a long-run equilibrium relationship, that relationship is characterized by persistently higher spending relative to revenues.

Not unlike the multicointegrated systems, evidence produced by the ECMs of these countries suggests that spending tends to adjust to divergences from the equilibrium relationship. This conclusion is based on negative and significant values of γ_1 in the Danish, Finish, Spanish, and Swedish equations normalized on spending (and insignificance of γ_1 values in the corresponding equations normalized on revenues). These findings are consistent with Barro's (1979) tax-smoothing argument. On the other hand, the French ECM results indicate that revenues rise in response to deviations from the spending-revenue equilibrium. The French

TABLE 5
Error Correction Models

	α	γ_1	B_1	B_2	r^2
Denmark					
ΔS	0.0050* (1.7394)	0.1529** (1.9811)	0.5133** (3.2009)	0.1311 (0.8260)	0.22
ΔR	0.0074** (2.1803)	0.1093 (1.1932)	0.0594 (0.3121)	0.2291 (1.2152)	0.02
Finland					
ΔS	0.0040 (1.3783)	0.2912** (3.0515)	0.5793** (4.0767)	0.0829 (0.4154)	0.41
ΔR	0.0068** (2.3149)	0.0106 (0.1083)	0.0146 (0.0997)	0.0259 (0.1263)	0.69
France					
ΔS	0.0025 (1.1997)	0.2655 (1.4692)	0.4406** (2.0720)	0.0536 (0.1943)	0.11
ΔR	0.0021 (1.5165)	0.2302* (1.9196)	0.1455 (1.0288)	0.2054 (1.1221)	0.21
Spain					
ΔS	0.0037* (1.7162)	0.3114** (2.0713)	0.4933** (2.5296)	0.0716 (0.2984)	0.23
ΔR	0.0059** (2.6761)	0.0196 (0.1274)	0.1220 (0.6122)	0.1388 (0.5664)	0.08
Sweden					
ΔS	0.0062* (1.9639)	0.1777* (2.8709)	0.4959** (3.3959)	0.2973 (1.6022)	0.32
ΔR	0.0056* (1.8680)	0.0486 (0.8268)	0.1434 (1.0336)	0.3915** (2.2198)	0.06

Notes: Based on $\Delta S_t = \alpha + \gamma_1 EC1_{t-1} + B_1 \Delta S_{t-1} + B_2 \Delta R_{t-1}$, $\Delta R_t = \alpha + \gamma_1 EC1_{t-1} + B_1 \Delta S_{t-1} + B_2 \Delta R_{t-1}$, where EC1 is the residual from the cointegrating relationship. *t*-statistics in parentheses. * indicates $\alpha = 0.10$ significance level; ** indicates $\alpha = 0.05$ significance level.

estimate of γ_1 is insignificant in the spending equation, while the γ_1 value is positive and significant in the equation normalized on revenue. For all countries the coefficient estimates of γ_1 are relatively small, indicating slow speeds of adjustment.

In the remaining seven countries no evidence of multicointegration or cointegration is present. In Belgium, Canada, Greece, Italy, the Netherlands, and Portugal deficits and debt accumulation have been the norm. However, revenues have exceeded spending in every period in Switzerland, suggesting that surpluses and the accumulation of government savings characterizes the Swiss fiscal system.

VI. CONCLUSION

In this article we develop a richer set of criteria under the more realistic assumption that the discount factor is variable through time for assessing the sustainability of fiscal budgeting practices. We draw on the work of Granger and Lee (1989, 1990), Bohn (1995), Ahmed and Rogers (1995), Engsted et al. (1997), Ball et al. (1998) and Haldrup (1998) to derive a more general test for sustainability of the fiscal budgeting process across all states of nature. We show that multicointegration of government spending and revenue is an appropriate test for the sustainability of the fiscal process in a stochastic environment. The multicointegration condition implies that both the levels and rates of change of the series are tied together over the long run. In the context of our model, they are linked through a sophisticated policy response mechanism that is derived from the optimal control literature.

We then apply our sustainability criteria to the fiscal systems of 15 industrialized countries. Results confirm that intertemporal budgeting strategies vary from country to country. Norway, the United Kindgom, and the United States are the three countries that exhibit multicointegration of their systems of fiscal variables. However, the implications for the nature of the budgeting strategy in each country are quite different. Results of multicointegration tests for Norway and the United Kingdom suggest that these governments have adopted different approaches to fiscal budgeting. Norway experiencing surpluses and the United Kingdom experiencing deficits. However, both governments' budgeting processes indicate that their fiscal system is characterized by policy responses that are consistent with budgeting sustainability across all states of nature. In the United States on the other hand, the evidence supports the notion that the government has consistently run deficits and has not increased revenues to accommodate rising debt

levels. These findings are inconsistent with the sustainability criteria presented here, suggesting that the United States has engaged in a deliberate attempt to execute a Ponzi scheme or a Ponzi gamble.

In the remaining countries the evidence indicates that deficits and debt accumulation have been the norm for all countries except Switzerland. Although the fiscal systems of Denmark, Finland, France, Spain, and Sweden are cointegrated, they exhibit budgeting practices that are consistent with debt accumulation yet inconsistent with criteria that would enable them to sustain such debt regardless of economic conditions. Therefore, with the exception of Switzerland, the remaining 11 countries either completely lack policy response mechanisms to systematic deficits and debt accumulation or exhibit policy responses that are inadequate for addressing the issue. The evidence is consistent with the conjecture that they, like the United States, have deliberately undertaken a Ponzi gamble attempting to exploit low rates of interest relative to growth or have engaged in a Ponzi scheme. The Swiss evidence suggests that the private sector may be running a Ponzi scheme against the government.

REFERENCES

Ahmed, S., and J. H. Rogers. "Government Budget Deficits and Trade Deficits, Are Present Value Constraints Satisfied in Long-Term Data?" *Journal of Monetary Economics*, 36,1995, 329–50.

Ball, L., D. W. Elmendorf, and N. G. Mankiw. "The Deficit Gamble." *Journal of Money, Credit and Banking*, 30, 1998, 699–720.

Barro, R. M. "On the Determination of Public Debt." *Journal of Political Economy*, 87, 1979, 940–47.

Bohn, H. "The Sustainability of Budget Deficits in a Stochastic Economy." *Journal of Money, Credit and Banking*, 27, 1995, 257–71.

———. "The Behavior of U.S. Public Debt and Deficits." *Quarterly Journal of Economics*, 113, 1998, 949–63.

———. "Fiscal Policy and the Mehra-Prescott Puzzle: On Welfare Implications of Budget Deficits When Real Interest Rates Are Low." *Journal of Money, Credit and Banking* 31, 1999, 1–13.

Duffie, J. D. *Dynamic Asset Pricing Theory*. Princeton, N.J.: Princeton University Press, 1996.

Easterly, W. "Growth Implosions, Debt Implosions and My Aunt Marilyn: Do Growth Slowdowns Cause Debt Crises?" World Bank Working Paper, 2000.

Engle, R. F. "Forecasting and Testing Cointegrated Systems." *Journal of Econometrics*, 35, 1987, 143–59.

Engle, R. F., and C. W. J. Granger. "Cointegration and Error Correction: Representation, Estimation and Testing." *Econometrica*, 55, 1987, 251–71.

Engle, R. F., and Byung S. Yoo. "Cointegration of Economic Times Series: A Survey with New Results," in *Long Run Economic Relations: Readings in Cointegration*, edited by C. W. J. Granger and R. F. Engle. Oxford: Oxford University Press, 1991, pp. 237–66.

Engsted, T., and N. Haldrup. "Multicointegration in Stock-Flow Models." *Oxford Bulletin of Economics and Statistics*, 61, 1999, 237–54.

Engstal, T., and S. Johansen., "Granger's Representation Theorem and Multicointegration." European University Institute Working Paper Eco. No. 97/15, 1997.

Engsted, T., J. Gonzalo, and N. Haldrup."Testing for Multicointegration." *Economic Letters*, 56, 1997, 259–66.

Gonzalo, J. and T. H. Lee, "Pitfalls in Testing for Long Run Relationships." *Journal of Econometrics*, 86, 1998, 129–54.

Granger, C. W. J. "Investigation of Reproduction, Sales and Inventory Relationships Using Multicointegration and Non-Symmetric Error Correction Models." *Journal of Applied Econometrics*, 4, 1989, 145–59.

Granger, C. W. J., and T. H. Lee. "Multicointegration," in *Advances in Econometrics: Cointegration, Spurious Regression and Unit Roots*, edited by G. F. Rhodes, Jr. and T. B. Fomlsy. New York: JAI Press, 1990, pp. 71–84.

Hakkio, C., and M. Rush. "Is the Budget Deficit Too Big?" *Economic Inquiry*, 29,1991, 429–45.

Haldrup, N. "An Econometric Analysis of I(2) Variables." *Journal of Econometric Surveys*, 12, 1998, 595–650.

———. "The Asymptotics of Single-Equation Cointegration Regressions with I(1) and I(2) Variables." *Journal of Econometrics*, 63, 1994, 153–81.

Hamilton, J. D., and M. A. Flavin. "On the Limitations of Government Borrowi-ng: A Framework for Empirical Testing." *American Economic Review*, 76, 1986, 808–16.

Haug, A. A. "Cointegration and Government Borrowing Constraints: Evidence for the United States." *Journal of Business Statistics*, 9, 1991, 97–101.

Johansen, S. "Statistical Analysis of Cointegration Vectors." *Journal of Economic Dynamics and Control*, 12, 1988, 231–54.

———. "Maximum Likelihood Estimation and Inference on Cointegration—with Applications to the Demand for Money." *Oxford Bulletin of Economics and Statistics*, 52, 1990, 169–210.

———. "A Representation of Vector Autoregressive Processes Integrated of Order 2." *Econometric Theory*, 8, 1992, 188–202.

———. "A Statistical Analysis of Cointegration for I(2) Variables." *Econometric Theory*, 11, 1995, 25–59.

———. "A Likelihood Analysis of the I(2) Model." *Scandanavian Journal of Statistics*, 1997, 433–462.

Johansen, S., and K. Juselius. "Testing Structural Hypothesis in a Multivariate Cointegration Analysis of the PPP and UIP for the UK." *Journal of Econometrics*, 53, 1992, 211–44.

Kremers, J. "US Federal Indebtedness and the Conduct of Fiscal Policy." *Journal of Monetary Economics*, 23, 1989, 219–38.

Leachman, L., "New Evidence on the Ricardian Equivalence Theorem: A Multi-Coinegration Approach." *Applied Economics*, 28, 1996, 1–10.

Lee, T.-H. "Stock-Flow Relations in Housing Construction." *Oxford Bulletin of Economics and Statistics*, 54, 1992, 419–30.

McCallum, B. T. "Are Bond Financed Deficits Inflationary? A Ricardian Analysis." *Journal of Political Economy*, February 1984, 123–35.

Milesi-Ferritti, G. M., and A. Razin. "Current Account Sustainability." Mimeo, IMF, December 1995.

. "Sustainability of Persistent Current Account Deficits." NBER Working Paper No. 5467, February 1996.

Paruolo, P., and A. Rahbek. "Weak Exogeneity in I(2) Systems." European University Institute Working Paper, 1996.

Smith, G. W., and S. Zin. "Testing a Government's Present-Value Borrowing Constraint." Unpublished manuscript, Queens University, 1988.

Tanzi, V., and L. Schunecht. "Reconsidering the Fiscal Role of Government: The International Perspective." *American Economic Review Papers and Proceedings*, 87, 1997, 164–68.

Trehan, B., and C. E. Walsh. "Testing Intertemporal Budget Constraints: Theory and Applications to US Federal Budget and Current Account Deficits." Federal Reserve Banks of San Francisco, Unpublished manuscript, 1990.

Uctum, M., and M. Wickens. "Debt and Deficit Ceilings, and Sustainability of Fiscal Policies: An Intertemporal Analysis." Federal Reserve Bank, Bank of New York Research Paper No. 9615, June 1996.

Von Hagen, J., and I. J. Harden. "National Budget Process and Fiscal Performance." *European Economy Reports and Studies*, 3, 1994, 311–418.

Wilcox, D. W. "The Sustainability of Government Deficits: Implications of the Present Value-Borrowing Constraint." Board of Governors of the Federal Reserve System Working Paper No. 77: 9, 1987.

Zhou, S. "The Power of Cointegration Tests Versus Data Frequency and Time Spans." *Southern Economic Journal*, 67, 2001, 906–21.