August 2007

Testing the Keynesian Proposition of Twin Deficits in the Presence of Trade Liberalisation: Evidence from Sri Lanka

K. Chowdhury
University of Wollongong, khorshed@uow.edu.au

A. S. Saleh
University of Wollongong

University of Wollongong
Economics Working Paper Series 2007

http://www.uow.edu.au/commerce/econon/wpapers.html

Testing the Keynesian Proposition of Twin Deficits in the Presence of Trade Liberalisation: Evidence from Sri Lanka

Khorshed Chowdhury

and

Ali Salman Saleh

WP 07-09

August 2007

Testing the Keynesian Proposition of Twin Deficits in the Presence of Trade Liberalisation: Evidence from Sri Lanka

Khorshed Chowdhury
School of Economics
University of Wollongong
Northfields Avenue NSW 2522
Australia
Phone: +61 2 4221 4024
Fax: +61 2 4221 3725
Email: khorshed@uow.edu.au

and

Ali Salman Saleh
School of Economics
University of Wollongong
Northfields Avenue NSW 2522
Australia
Phone: +61 2 4221 5215
Fax: +61 2 4221 3725
Email: ali@uow.edu.au

Testing the Keynesian Proposition of Twin Deficits in the Presence of Trade Liberalisation: Evidence from Sri Lanka

Abstract

This paper examines the long-run and short-run relationships between the current account deficit, budget deficit, savings and investment gap and trade openness in Sri Lanka using the autoregressive distributive lagged (ARDL) approach. The time series properties of the variables, in the presence of endogenous structural breaks, was previously analysed using Perron's (1997) additive outlier (AO) and innovational outlier (IO) models. The empirical analysis supports the Keynesian view that a link exists between the current account, budget deficit and savings and investment gap. We found that trade openness has a positive effect on the current account deficit, but is statistically insignificant, and offer some strategies to stabilise the budget deficit and current account deficits in Sri Lanka.

JEL Classification: E60, E62, C22, F41.

Key words: twin deficit, structural change, unit roots, ARDL.

Testing the Keynesian Proposition of Twin Deficits in the Presence of Trade Liberalisation: Evidence from Sri Lanka

1. Introduction

An extensive theoretical and empirical literature has examined the relationship between current account deficits and other specified macroeconomic variables. The Keynesian school of thought argues that the budget deficit has a significant impact on the current account deficit. Studies by Fleming (1962), Mundell (1963), Volcker (1987), Kearney and Monadjemi (1990) and Smyth et al. (1995) argue that large government deficits increase trade deficits via different transmission mechanisms. According to the Mundell–Fleming model, an increase in the budget deficit will exert upward pressure on domestic interest rates, thereby causing capital inflows, and the exchange rate to appreciate, which in turn deteriorates the current account balance. The Keynesian approach argues that a rise in the budget deficit will increase domestic absorption via import expansion, causing a current account deficit.

Alternatively, the Ricardian equivalence hypothesis (REH) (Barro, 1989) argues that shifts between taxes and budget deficits do not affect the real interest rate, the quantity of investment or the current account balance. They argue that the effect of the present tax cut or increase in government expenditure do not alter the mix of current consumption and investment, because rational agents foresee that the present tax cut will become a tax burden in the future. In other words, the Ricardian equivalence hypothesis negates any link between the two deficits.

A vast empirical literature exists that tests the two paradigms, and Saleh and Harvie (2005) offer a comprehensive review of this research. Most empirical studies examine the "twin deficits" hypothesis for developed countries. However, empirical studies on developing countries are rare (Saleh *et al*., 2005), even though the relationship is much stronger in developing countries.

The following salient features emerge from the recent literature. The role played by financial variables (such as interest and exchange rates) is crucial in the nexus between the budget, savings, investment and the current account. Most earlier studies ignore the role of these two financial variables (interest rate and exchange rate) in the evolution of these deficits. Unlike the debt crises of the 1980s, which were driven by budget deficits, the 1994 Mexican and 1997–98 East Asian crises precipitated from overwhelming imbalances in current accounts.

The body of evidence has not yet yielded a consensus on the causal relationship between the two deficits. Neither does the evidence so far regarding the empirics provide a clear consensus on the debate. Researchers such as Ibrahim and Kumah (1996), Islam (1998), Vamvoukas (1999), Piersanti (2000), Leachman and Francis (2002), Fidrmuc (2003) and Saleh *et al.* (2005) found support for the conventional view that a worsening budget deficit stimulates an increase in current account deficit. A high correlation between the two deficits is also consistent in two other competing hypotheses: (1) the two variables are mutually dependent (see Kearney and Monadjemi, 1990) and (2) the causality runs from current account deficit to budget deficit, termed "current account targeting". Surprisingly, the contributions of the savings–investment imbalance and other macroeconomic variables relevant to the current account deficit are considered minor and often naïvely ignored. In contrast, the empirical evidence in Miller and Russek (1989), Rahman and Mishra (1992), Evans and Hasan (1994), Wheeler (1999) and Kaufmann *et al.* (2002) offer support for REH. The discussion provided above suggests that the twin deficits hypothesis is indeed an empirical issue.

Our paper differs from the existing literature in two ways. This study uniquely examines the twin deficits in the presence of the savings and investment gap and trade openness for Sri Lanka. The study by Saleh *et al.* (2005) on Sri Lanka only concentrated on the relationship between the current account imbalance and the budget deficit. The authors of that paper would have liked to include the financial variables such as exchange and interest rates in the analytical framework, but the presence of strict regulation in the financial and foreign trade sectors in Sri Lanka precluded us from including these variables. Instead, a portmanteau variable of openness ([Exports + Imports]/GDP) was used as a surrogate to capture the impact of these variables on the current account. The degree of openness is also a reflection of the degree of trade liberalisation of an economy. Trade and financial reforms are recommended tools for boosting economic performance via efficiency gains, but their success cannot be guaranteed. Nonetheless, our maintained hypothesis is that trade openness, driven by reforms in the trade and financial sectors, can alleviate current account difficulties and promote economic growth. The East Asian “miracle”, and recently, China’s and India’s rapid growth, are examples of the effects of trade liberalisation on economic growth.

Sri Lanka is a very interesting case because the country has experienced both current account deficits and budget deficits since the 1960s. Sri Lanka’s budget was in deficit during the entire period of investigation (1970–2005). The data indicates that this deficit as a proportion of GDP increased significantly after 1977. This increase in budget deficit is attributable to many factors, such as decreased government revenue (due to a narrow tax base and the inefficiency of tax collection) and increased public expenditure, especially on food subsidies and defence. Saleh *et al.* (2005) offers an overview of Sri Lankan fiscal deficits.

The paper is organised as follows. Section 2 discusses the conceptual framework of the study. In Section 3 the time series properties of the variables are analysed using Perron’s (1997) additive outlier (AO) and innovational outlier (IO) models. This exercise tests the robustness of the traditional unit root tests in the presence of a structural break in the data. Appendix 1 reports a brief discussion of the methodology. The estimation methodology used is the autoregressive distributed lag (ARDL) developed by Pesaran and Shin (1999), which examines whether the current account and savings and investment gap, budget deficit and trade openness are cointegrated in the long run.

The ARDL framework used in this study has several advantages over conventional error correction methods. The estimates from the ARDL formulation are consistent, and are asymptotically normally distributed, irrespective of the underlying regressors being I(0) or I(1). The ARDL estimation and the bounds test are reliable for a small sample. Section 4 reports and analyses the short-run dynamics and adjustment toward long-run equilibrium. Finally, Section 5 offers some conclusions and policy implications.

2. The Conceptual Framework

The analytical framework is based on the national income identity. In an open economy, GDP (Y) is the sum of private consumption, C, private investment I, government expenditure, G, and net exports, (X-M), as in equation (1):

$$Y = C + I + G + (X - M) \tag{1}$$

Alternatively,

$$Y = C + S + T \tag{2}$$

Where S is savings and T is tax. Substituting equation (2) in equation (1) yields:

$$(X - M) = (S - I) + (T - G) \tag{3}$$

(X-M) is the current account balance; (S-I) is the savings and investment balance; (T-G) is the budget balance. Any current account imbalance is attributable to either a savings–investment imbalance and/or fiscal imbalance.

Some identify equation (3) as a mere identity, and its estimation as a trivial exercise. However, others consider equation (3) to be mis-specified to the extent that financial variables such as exchange and interest rates are omitted and their role ignored. They contend that a worsening of the budget deficit causes the domestic interest rate to increase, which results in net capital inflow, in turn leading to an appreciation of the domestic currency, and eventually worsening the current account balance via a decline in net exports.

In our view, the transmission mechanism is important, and it should be taken into account explicitly. We would have liked to include these financial variables in our analysis, but institutional realities in Sri Lanka preclude us from doing so. Despite the liberalisation in trade regime and financial market, and the relaxation of trade and exchange controls, many regulatory measures are in place in Sri Lanka. Therefore, we include a surrogate variable of openness ([X+M]/Y) in our specification to capture the combined effect of the exchange and interest rates. Hence, our augmented model is expressed in equation (4):

$$(X - M) = (S - I) + (T - G) + \{(X + M)/Y\} \tag{4}$$

Where (X+M)/Y measures trade openness. Equation (4) forms the basis of our ARDL model, which is estimated in the following section. The long-run model can be specified as:

$$CA_t = \alpha_0 + \alpha_1 SI_t + \alpha_2 BD_t + \alpha_3 OPEN_t + \varepsilon_t \tag{5}$$

Where ε_t is an error term.

3. Data Sources and Unit Root Test

This study uses annual data from 1970 to 2005 from various sources. The data for savings and investment were extracted from the World Bank *World Tables*; openness data was obtained from the Pe*nn World Table Version 6.2* (Heston *et al.*, 2006); and data for budget deficits and current account balances from the Central Bank of Sri Lanka *Annual Reports*. All variables were measured as a proportion of GDP.

Equation (4) is analysed by the cointegration test. Before conducting this, it is essential to check each time series for stationarity. If a time series is non-stationary, the traditional regression analysis will produce spurious results. Therefore, the unit root test is conducted first. Hence it is imperative to review some of the recently developed models and tests for unit roots which we use in this paper. Appendix 1 gives a succinct review.

To ascertain the order of integration, we apply the traditional augmented Dickey-Fuller (ADF) and Phillips-Perron (PP) unit root test. These tests suggest that all variables in the model are non-stationary (refer to Tables 1 and 2).

One of this study's main concerns is to evaluate the implication of a structural break[1] on the time series properties of the variables. Because ADF and PP tests suffer from power deficiencies in the presence of structural breaks, we apply the most comprehensive models of Perron (1997). Perron (1997) includes both t (time trend) and DT_b (time at which structural change occurs) in his innovational outlier (IO1 and IO2) and additive outlier (AO) models. The distinction between the two is worth noting: the IO2 model represents the change that is *gradual*; whereas the AO model represents the change that is *rapid*.

We apply both AO and IO2 models to the data and report the results in Tables 1 and 2. Of the two models, the innovational outlier (IO2) model is preferred (reported in Tables 1 and 2), because this model captures the *gradual* change in the variables, rather than picking up an abrupt change. Also, the endogenously determined break dates are more plausible, given the events occurring in the Sri Lankan economy.

The IO2 model finds additional evidence of no unit root (that is, stationary), which is contrary to the results given by ADF and PP unit root tests. This vindicates the assertion that the ADF and PP tests suffer from power deficiencies when there is a structural break in the data. These tests fail to reject the null hypothesis of a unit root.

In Tables 1 and 2 the unit root hypotheses are rejected at the five per cent level of significance for all variables (CA, SI, BD and open). The estimated break date corresponds to 1978 for CAB, SI and BD; while the break date for openness occurs in 1998. These break dates are plausible. The United National Party (UNP) government came to power in July 1977. The new government immediately initiated many far-reaching economic and financial policy changes[2]. These changes provided new directions in the Sri Lankan economy. The new policy reforms very quickly impacted on all variables except for openness.

The structural break for openness occurred in 1998, which also seems plausible. For the past three decades structural adjustment and economic reform has been the foundation of Sri Lankan economic policy, but the implementation of these policies has been slow and patchy. However, tax and trade reforms[3] effected improvements during 1997 and 1998, and the privatisation program is now the most flourishing area of structural reform. The Asian financial crisis of 1997 also left a mark on Sri Lanka's openness.

[Insert Table 1 about here]

[Insert Table 2 about here]

4. Empirical Findings

The error correction specification of the ARDL model pertaining to equation (5) is given in equation (6), and can be expressed as:

$$\begin{aligned}\Delta CA_t &= \alpha_0 + \delta_1 CA_{t-1} + \delta_2 SA_{t-1} + \delta_3 BD_{t-1} + \delta_4 OPEN_{t-1} + \\ &+ \sum_{i=1}^{p} b_i \Delta CA_{t-i} + \sum_{i=0}^{q} c_i \Delta SI_{t-i} + \sum_{i=0}^{r} d_i \Delta BD_{t-i} + \sum_{i=0}^{s} e_i \Delta OPEN_{t-i} + u_t\end{aligned} \quad (6)$$

By incorporating the structural break in 1978 for CA, a dummy variable is included in equation (6) to give equation (7):

$$\begin{aligned}\Delta CA_t &= \alpha_0 + \delta_1 CA_{t-1} + \delta_2 SA_{t-1} + \delta_3 BD_{t-1} + \delta_4 OPEN_{t-1} + \delta_5 DU_{CA} \\ &+ \sum_{i=1}^{p} b_i \Delta CA_{t-i} + \sum_{i=0}^{q} c_i \Delta SI_{t-i} + \sum_{i=0}^{r} d_i \Delta BD_{t-i} + \sum_{i=0}^{s} e_i \Delta OPEN_{t-i} + u_t\end{aligned} \quad (7)$$

Where the dummy variable DU takes on a value of zero prior to 1978 and unity thereafter. The parameter δ_i, i = 1, 2, 3, 4, 5 are the long-run multipliers. The parameters b_i, c_i, d_i, e_i are the short-run multipliers. u_t represents the residual. The model above is ARDL (p, q, r, s), where p, q, r and s represent the lag length.

To select the appropriate model in equation (7), several specifications with different lags were tested for statistical significance and for consistency with the cointegration method. Model specifications that were neither statistically significant nor cointegrated were discarded. The specification used here is the unrestricted intercept with no trend (see Case III in Pesaran *et al.*, 2001: 296).

We estimated the augmented model given in equation (7) and found the optimal model to be ARDL$\left[1,1,0,0\right]$. We chose the optimal specification based on the AIC model selection criterion[4]. Appendix 2, Table A2.1 shows the estimated ARDL model for the current account balance and the relevant macroeconomic variables.

Estimation of Long-run Coefficients

We investigated the long-run relationship between the budget deficits and specified macroeconomic variables by the using the "bounds test" (given in Table 3). Based on this test, the computed *F*-statistic is 4.13, which is above the upper critical bound (UCB*)* at the 10 per cent significance level. Hence, a long-run relationship exists between current account deficits and the relevant macroeconomic variables.

[Insert Table 3 about here]

Table 4 gives the estimated long-run coefficients for the ARDL model. In the long run a one per cent increase in the savings and investment gap will lead to a 0.67 increase in current account deficit; while a one per cent increase in the budget deficit will lead to a 0.20 increase in the current account deficit. The empirical result shows that the budget deficit and savings–investment balance have a statistically significant effect on current account deficit. Of the two, the savings–investment balance has a more dominant effect on the current account balance.

[Insert Table 4 about here]

This finding sharply contradicts that of Saleh *et al.* (2005), where the computed elasticity of the budget deficit on the current account was 0.63 per cent. This high elasticity value is due to the mis-specification of the model, where the savings–investment balance was omitted, thereby invoking an erroneous assumption that savings equals investment. Econometrically, the coefficient estimated by Saleh *et al.* (2005) is not only biased, but also inconsistent, if the budget deficit and savings–investment are correlated. The variance of the estimated coefficient is also positively biased, and the standard tests of significance concerning the coefficient are not valid. On average, the estimated coefficient will overestimate[5] the true coefficient, which explains the high coefficient estimate of Saleh *et al.* (2005).

The dummy variable has a positive effect, but is statistically insignificant. The effect of trade openness on the current account is positive, implying that a one per cent increase in trade openness leads to a 0.013 per cent increase in the current account deficit. The coefficient is very small and statistically insignificant. Despite the reforms of 1977, the degree of trade liberalisation was weak, and both nominal and effective rates of protection rose (Weiss and Jayanthakumaran, 1995: 67). The removal of import licensing saw a significant surge in imports, while exports also increased, but dramatically. Weis and Jayanthakumaran (1995) found no long-run relationship between trade liberalisation and productivity growth. The reform measures in Sri Lanka did not affect the overall openness of the economy, and hence we find a statistically insignificant result which is positive (implying that openness increased current account deficit). A J-curve effect is unremarkable in the short run for any economy.

Appendix 2, Table A2.1 reports various diagnostic analyses for serial correlation, heteroscedasticity, normality of residuals and other tests. These indicate that the specified model passes all the diagnostic tests. There is no evidence of autocorrelation, and the model passes the test of normality. Furthermore, Figure A2.1 in Appendix 2 indicates the stability of both long-run and short-run coefficients because the residuals lie within the upper and lower bounds of the critical values.

Short-run Dynamics

Table 5 gives the short-run dynamics and the long-run equilibrium for the estimated ARDL model. The short-run adjustment process is measured by the error correction term (ECM). The ECM indicates how quickly variables adjust and return to equilibrium, and the coefficient of ECM should carry a negative sign and be statistically significant. Table 5 shows that the estimated coefficient for ECM is -0.66 for the specified model, and is highly significant. This indicates that the deviation from the long-term current account equilibrium path is corrected by nearly 66 per cent over the following year. In other words, the adjustment process is very high. The statistical significance of the ECM further confirms the presence of long-run equilibrium between the current account deficit and the relevant macroeconomic data.

[Insert Table 5 about here]

5. Summary and Conclusion

This paper adds new insights to the literature on the "twin deficit" phenomenon, especially regarding Sri Lanka. Previous studies by Saleh *et al.* (2005) found that budget deficits contributed overwhelmingly to current account imbalances. However, this model is grossly mis-specified, because the analysis excludes other relevant variables, such as the savings–investment balance. This paper differs from previous studies on the twin deficit phenomena by its inclusion of trade openness in the analysis. Trade openness is an all-inclusive surrogate that captures various trade and financial reforms[6].

This study tests the time series properties of the variables in the presence of structural breaks, because traditional unit root tests (ADF and PP) suffer from power deficiency. This study also applies a flexible, robust econometric framework — ARDL modelling — to estimate long and short-term relationships among variables.

Our empirical results support the Keynesian view that a strong, positive link exists between the current account deficit, savings–investment balance and budget deficit in Sri Lanka during 1970–2005. A one per cent increase in the savings and investment gap will lead to a 0.67 increase in current account deficit, while a one per cent increase in budget deficit will increase the current account deficit by 0.20 per cent. Considering the effect of trade openness on the current account, a one per cent increase in trade openness leads to a 0.013 per cent increase in the current account deficit, but the result is not statistically significant. The structural break dummy variable has a positive effect, but is also statistically insignificant.

These findings suggest that reducing the budget deficit and/or reducing the savings and investment gap in Sri Lanka may assist in improving the current account deficit. However, this requires drastic trade and financial sector reforms in order to bring efficiency to the markets. The trade and financial sector reforms initiated in 1977 were incrementally implemented in phases, and these reform measures only had a salutary effect on the Sri Lankan economy. In order to increase external competitiveness, policies must be put in place to produce increased exports and assist the country to benefit from trade liberalisation policies in the area of specialisation.

This paper offers findings that could be vital for small open economies such as Sri Lanka, which need to be aware of the relationships between key macroeconomic variables in the country in order to employ appropriate policies to avoid any crises in the external balance.

Table 1: Unit Root Tests in the Absence and Presence of a Structural Break

Current Account Balance (CA) and Savings and Investment Balance (SI)

CA					**SI**				
Test	**k**	**TB**	**Tα=1**	**Result**	**Test**	**k**	**TB**	**Tα=1**	**Result**
ADF	3	NC	-2.709	NS	ADF	3	NC	-2.503	NS
PP	1	NC	-3.016	NS	PP	1	NC	-2.429	NS
IO2	3	1978	-6.809	S	IO2	8	1978	-6.814	S
AO	0	1981	-4.198	NS	AO	1	1982	-4.387	NS

S = stationary

NS = non-stationary

NC = not calculated

The critical values for IO2 for 70 observations are -6.32 and -5.59 and at 1% and 5% respectively.

The critical values for AO for 100 observations are -5.45 and -4.83 at 1% and 5% respectively.

The critical values for ADF (lag length 3) are -3.558 and -4.273 at 1% and 5% respectively.

The critical values for PP are -4.244 and -3.544 (lag length 1) at 1% and 5% respectively.

Table 2: Unit Root Tests in the Absence and Presence of a Structural Break

Budget Deficit (BD) and Openness (OPEN)

BD					**Open**				
Test	**k**	**TB**	**Tα=1**	**Result**	**Test**	**k**	**TB**	**Tα=1**	**Result**
ADF	4	NC	-2.978	NS	ADF	0	NC	-1.985	NS
PP	1	NC	-2.903	NS	PP	1	NC	-2.189	NS
IO2	8	1978	-6.073	S	IO2	7	1998	-5.616	S
AO	3	1979	-4.110	NS	AO	5	1973	-3.659	NS

S = stationary

NS = non-stationary

NS = not calculated

The critical values for IO2 for 70 observations are -6.32 and -5.59 at 1% and 5% respectively.

The critical values for AO for 100 observations are -5.45 and -4.83 at 1% and 5% respectively.

The critical values for ADF (lag length 4) are -4.285 and -3.563 at 1% and 5% respectively.

The critical values for ADF (lag length 0) are -4.244 and -3.544 at 1% and 5% respectively.

The critical values for PP are -4.244 and -3.544 (lag length 1) at 1% and 5% respectively.

Table 3: Bounds Test for Cointegration Analysis in Sri Lanka

Computed *F*-Statistics (F_{Bounds})	4.13	
Critical Bounds (10%)	LCB: 2.72	UCB: 3.77
Critical Bounds (5%)	LCB: 3.23	UCB: 4.35

Note: Critical Bounds are from Pesaran *et al.* (2001:300) Case III.

Table 4: Estimated Long-run Coefficients for Equation 7: ARDL (1, 1, 0, 0)

Dependent Variable: *CA*

Variables	Coefficient	P-value
SI	0.671*	0.000
BD	0.204**	0.043
OPEN	0.013	0.638
DU_{CA}	1.398	0.104
INERCEP	1.696	0.373

Note: Akaike information criterion (AIC) was used to select the optimum number of lag in the ARDL model; *, **, *** denote significant at the 1%, 5% and 10% respectively.

Table 5: Error Correction for the Selected ARDL Model: ARDL (1, 1, 0, 0)

Dependent Variable: ΔCA

Variables	Coefficient	P-value
ΔSI	0.752*	0.000
ΔBD	0.134**	0.030
$\Delta OPEN$	0.009	0.640
ΔDU_{CA}	0.919	0.122
$\Delta INTERCEPT$	1.114	0.371
ECM_{t-1}	**-0.657***	**0.000**
R-squared	0.963	
AIC	-40.599	
Durbin–Watson	1.667	
F(5,27)	134.709	0.000

Note: Akaike information criterion (AIC) was used to select the optimum number of lag in the ARDL model; *, **, *** denote significant at the 1%, 5% and 10% respectively.

Appendix 1

A Review of Unit Root Tests with Endogenous Structural Breaks

Traditional tests for unit roots (such as the Dickey-Fuller, augmented Dickey-Fuller and Phillips-Perron tests) have low power in the presence of structural breaks.

Perron (1989) demonstrated that, in the presence of a structural break in a time series, many perceived non-stationary series were in fact stationary. Perron (1989) re-examined data from Nelson and Plosser (1982) and found that 11 of the 14 important US macroeconomic variables were stationary when known exogenous structural breaks are included[7]. Perron (1989) allows for a one time structural change occurring at a time T_B ($1 < T_B < T$), where T is the number of observations.

The following models were developed by Perron (1989) for three different cases. Notations used in equations A1 to A16 are the same as in the papers quoted.

Null hypothesis:

Model (A) $y_t = \mu + dD(TB)_t + y_{t-1} + e_t$ (A 1)

Model (B) $y_t = \mu_1 + y_{t-1} + (\mu_2 - \mu_1)DU_t + e_t$ (A 2)

Model (C) $y_t = \mu_1 + y_{t-1} + dD(TB)_t + (\mu_2 - \mu_1)DU_t + e_t$ (A 3)

where $D(TB)_t = 1$ if $t = T_B + 1$, 0 otherwise, and $DU_t = 1$ if $t > T_B$, 0 otherwise.

Alternative hypothesis:

Model (A) $y_t = \mu_1 + \beta t + (\mu_2 - \mu_1)DU_t + e_t$ (A 4)

Model (B) $y_t = \mu + \beta_1 t + (\beta_2 - \beta_1)DT_t^* + e_t$ (A 5)

Model (C) $y_t = \mu_1 + \beta_1 t + (\mu_2 - \mu_1)DU_t + (\beta_2 - \beta_1)DT_t + e_t$ (A 6)

where DT_t^* = t – $T_{B…}$, if t > T_B, and 0 otherwise.

Model A permits an exogenous change in the level of the series; whereas Model B permits an exogenous change in the rate of growth. Model C allows change in both. Perron's (1989) models include one known structural break. These models cannot be applied where such breaks are unknown. Therefore, this procedure is criticised for assuming known break dates, which raises the problem of pre-testing and data mining regarding the choice of the break date (Maddala and Kim, 2003). Further, the choice of the break date can be viewed as being correlated with the data.

Unit Root Tests in the Presence of a Single Endogenous Structural Break

Despite the limitations of Perron's (1989) models, they form the foundation of subsequent studies discussed hereafter. Zivot and Andrews (1992), Perron and Vogelsang (1992) and Perron (1997), among others, developed unit root test methods that include one endogenously determined structural break. Here we review these models briefly; detailed discussions are found in the cited works.

The Zivot and Andrews (1992) models are as follows:

Model with Intercept

$$y_t = \hat{\mu}^A + \hat{\theta}^A DU_t(\hat{\lambda}) + \hat{\beta}^A t + \hat{\alpha}^A y_{t-1} + \sum_{j=1}^{k} \hat{c}_j^A \Delta y_{t-j} + \hat{e}_t \qquad \text{(A 7)}$$

Model with Trend

$$y_t = \hat{\mu}^B + \hat{\beta}^B t + \hat{\gamma}^B DT_t^*(\hat{\lambda}) + \hat{\alpha}^B y_{t-1} + \sum_{j=i}^{k} \hat{c}_j^B \Delta y_{t-j} + \hat{e}_t \qquad \text{(A 8)}$$

Model with Both Intercept and Trend

$$y_t = \hat{\mu}^C + \hat{\theta}^C DU_t(\hat{\lambda}) + \hat{\beta}^C t + \hat{\gamma}^C DT_t^*(\hat{\lambda}) + \hat{\alpha}^C y_{t-1} + \sum_{j=1}^{k} \hat{c}_j^C \Delta y_{t-j} + \hat{e}_t \qquad \text{(A 9)}$$

Where $DU_t(\lambda)$ = 1 if t > $T\lambda$, 0 otherwise; $DT_t^*(\lambda) = t - T\lambda$ if $t > T\lambda$, 0 otherwise.

The above models are based on Perron's (1989) models. However, these modified models do not include DT_b.

On the other hand, Perron and Vogelsang (1992) include DT_b, but exclude *t* in their models. The Perron and Vogelsang (1992) models are given below:

Innovational outlier model (IOM)

$$y_t = \mu + \delta DU_t + \theta D(T_b)_t + \alpha y_{t-1} + \sum_{i=1}^{k} c_i \Delta y_{t-i} + e_t \qquad \text{(A 10)}$$

Additive outlier model (AOM) — two steps

$$y_t = \mu + \delta DU_t + \widetilde{y}_t \tag{A 11}$$

and

$$\widetilde{y}_t = \sum_{i=0}^{k} w_i D(T_b)_{t-i} + \alpha \widetilde{y}_{t-1} + \sum_{i=1}^{k} c_i \Delta \widetilde{y}_{t-i} + e_t \tag{A 12}$$

$\widetilde{y}$ in the above equations represents a detrended series y.

Perron (1997) includes both t (time trend) and DT_b (time at which structural change occurs) in his innovational outlier (IO1 and IO2) and additive outlier (AO) models.

The innovational outlier model allowing one time change in intercept only (IO1):

$$y_t = \mu + \theta DU_t + \beta t + \delta D(T_b)_t + \alpha y_{t-1} + \sum_{i=1}^{k} c_i \Delta y_{t-i} + e_t \tag{A 13}$$

The innovational outlier model allowing one time change in both intercept and slope (IO2):

$$y_t = \mu + \theta DU_t + \beta t + \gamma DT_t + \delta D(T_b)_t + \alpha y_{t-1} + \sum_{i=1}^{k} c_i \Delta y_{t-i} + e_t \tag{A 14}$$

The additive outlier model allowing one time change in slope (AO):

$$y_t = \mu + \beta t + \delta DT_t^* + \widetilde{y}_t \tag{A 15}$$

where $DT_t^* = 1(t > T_b)(t — T_b)$

$$\tilde{y}_t = \alpha \tilde{y}_{t-1} \sum_{i=1}^{k} c_i \Delta \tilde{y}_{t-i} + e_t \tag{A 16}$$

The innovational outlier models represent the change that is *gradual*; whereas the additive outlier model represents the change that is *rapid*. All models considered above report their asymptotic critical values.

More recently, additional test methods are proposed for unit root test allowing for multiple structural breaks in the data series (Lumsdaine and Papell 1997; Bai and Perron 2003), which we do not discuss here.

Regarding the power of tests, the Perron and Vogelsang (1992) model is robust. The testing power of the models of Perron (1997) and Zivot and Andrews (1992) are almost the same. On the other hand, Perron's (1997) model is more comprehensive than Zivot and Andrews' (1992) model, because the former includes both *t* and DT_b; while the latter includes *t* only.

Appendix 2

Table A2.1 Autoregressive Distributed Lag Estimates (ARDL) for equation (6): ARDL (1, 1, 0, 0, 0) selected based on Akaike Information Criterion

Dependent variable is CA				
Regressors	Coefficient	Standard Error	T-Ratio	Probability
CA_{t-1}	0.343	0.149	2.307	0.029
SI	0.752	0.053	14.208	0.000
SI_{t-1}	-0.311	0.115	-2.696	0.012
BD	0.134	0.059	2.295	0.030
$OPEN$	0.009	0.019	0.473	0.640
DU_{CA}	0.919	0.576	1.596	0.123
Intercept	1.114	1.224	0.910	0.371
R-squared 0.967 R-bar-squared 0.959				
S.E. of regression 0.755 F-statistic: F (6, 26) 126.652 [0.000]				
Mean of dependent variable -4.537 S.D. of dependent variable 3.739				
Residual sum of squares 14.804 Equation log-likelihood -33.599				
Akaike information criterion -40.599 Schwarz–Bayesian criterion -45.836				
DW-statistic 1.667 Durbin's h-statistic 1.843 [0.065]				

Diagnostic Tests		
Test Statistics	**LM Version**	**F Version**
A: Serial Correlation	CHSQ (1) = 1.715 [0.190]	F (1, 25) = 1.370 [0.253]
B: Functional Form	CHSQ (1) = 3.108 [0.078]	F (1, 25) = 2.599 [0.119]
C: Normality	CHSQ (2) = 2.407 [0.300]	Not applicable
D: Heteroscedasticity	CHSQ (1) = 1.347 [0.246]	F (1, 31) = 1.319 [0.260]

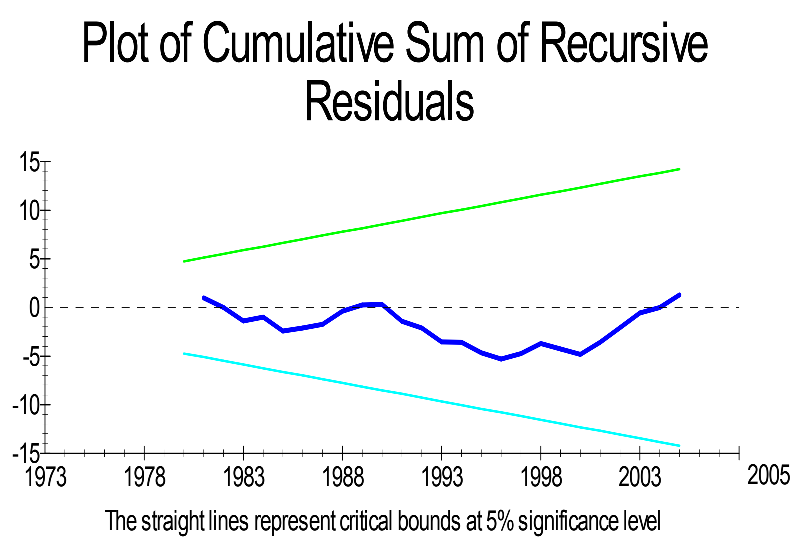
A: Lagrange multiplier test of residual serial correlation

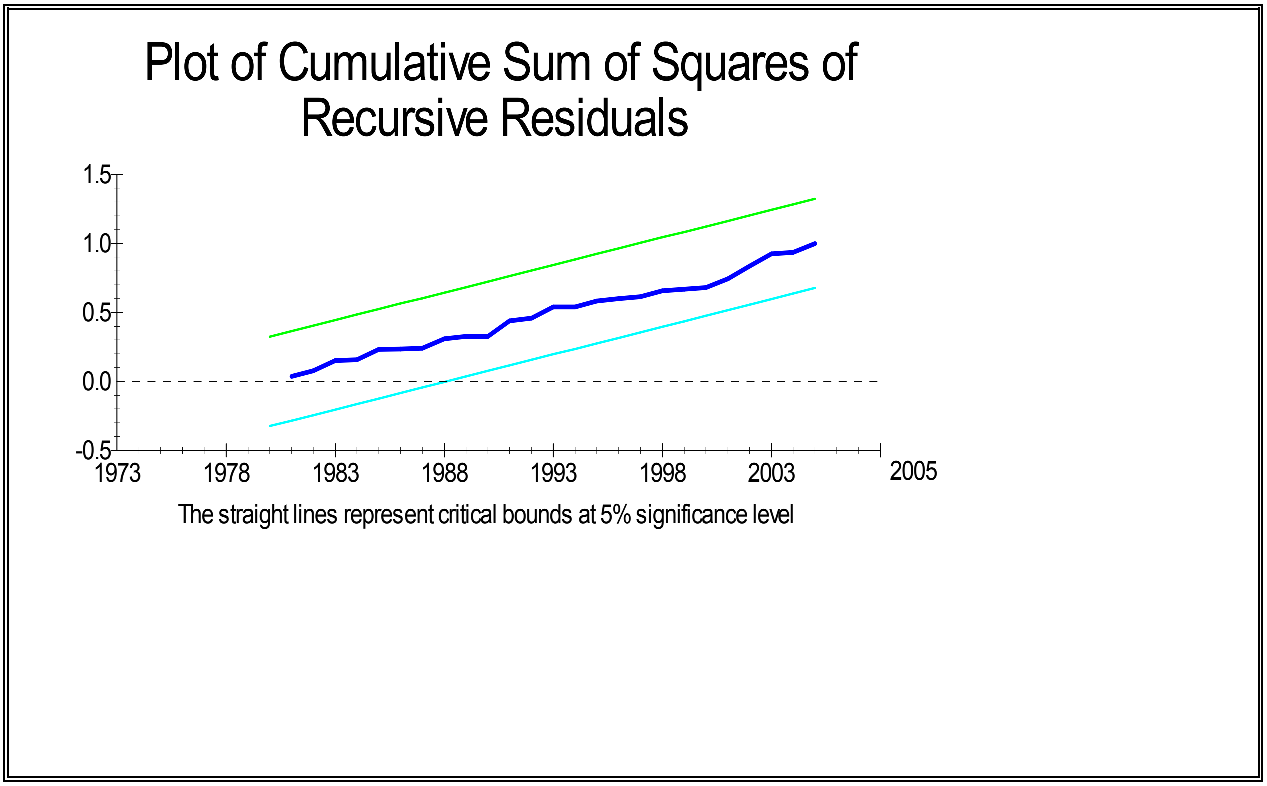
B: Ramsey's RESET test using the square of the fitted values

C: Based on a test of skewness and kurtosis of residuals

D: Based on the regression of squared residuals on squared fitted values

Figure A2.1 CUSUM and CUSUMQ Statistics for the Coefficient Stability for the Specified Model




Plot of Cumulative Sum of Squares of
Recursive Residuals
1.5
1.0
0.5
0.0
-0.5
1973
1978
1983
1988
1993
1998
2003
2005
The straight lines represent critical bounds at 5% significance level

References

Athukorala, P. and Rajapatirana S. (1993), "Domestic Financial Market and the Trade Liberalisation Outcome: Evidence from Sri Lanka", W*orld Development*, 21(7), 1191–1203.

Bai J. and Perron P. (2003), "Computation and Analysis of Multiple Structural Change Models", *Journal of Applied Econometrics*, 18, 1–22.

Barro, R.J. (1989), "The Ricardian Approach to Budget Deficits", *Journal of Economic Perspectives*, 3, 37–54.

Central Bank of Sri Lanka, *Annual Reports*, Colombo, Sri Lanka, various years.

Evans, P. and Hasan, I. (1994), "Are Consumers Ricardian? Evidence for Canada", *Quarterly Review of Economics and Finance,* 34, 25–40.

Fidrmuc, J. (2003), "The Feldstein-Horioka Puzzle and Twin Deficits in Selected Countries", *Economics of Planning*, 36(2), 135–152.

Fleming, J.M. (1962), "Domestic Financial Policies Under Fixed and Under Floating Exchange Rates", *International Monetary Fund Staff Papers*, 10, 369–380.

Heston, A., Summers, R. and Aten, B. (2006), *Penn World Table Version 6.2*, Centre for International Comparisons of Production, Income and Prices at the University of Pennsylvania.

Ibrahim, S.B. and Kumah, F.Y. (1996), "Comovements in Budget Deficits, Money, Interest Rate, Exchange Rate and the Current Account Balance: Some Empirical Evidence", *Applied Economics,* 28, 117–130.

Islam, M.F. (1998), "Brazil's Twin Deficits: An Empirical Examination", *Atlantic Economic Journal*, 26 (2), 121–128.

Judge, G.G., Griffiths, W.E., Hill, H., Lutkepohl, R.C. and Lee, T.C. (1985), *The Theory and Practice of Econometrics*, Second edition, John Wiley & Sons, New York.

Kaufmann, S., Scharler, J. and Winckler, G. (2002), "The Austrian Current Account Deficit: Driven by Twin Deficits or by Intertemporal Expenditure Allocation?", *Empirical Economics,* 27, 529–542.

Kearney, C. and Monadjemi, M. (1990), "Fiscal Policy and Current Account Performance: International Evidence on the Twin Deficits", *Journal of Macroeconomics*, 12, 197–220.

Kmenta, J. (1985), *Elements of Econometrics*, Second Edition, New York: Macmillan.

Leachman, L.L. and. Francis, B. (2002), "Twin Deficits: Apparition or Reality?", *Applied Economics,* 34, 1121–1132.

Lumsdaine, R. and Papel, D.H. (1997), "Multiple Trend Breaks and the Unit Root Hypothesis", *Review of Economics and Statistics,* 79, 212–218.

Maddala, G.S and Kim, I.M. (2003), *Unit Roots, Cointegration, and Structural Change*, Cambridge: Cambridge University Press.

Miller, S.M. and. Russek, F.S. (1989), "Are the Twin Deficits Really Related?", *Contemporary Policy Issues,* 7, 91–115.

Mundell, R.A. (1963), "Capital Mobility and Stabilisation Policy Under Fixed and Flexible Exchange Rates", *Canadian Journal of Economics and Political Science*, 29, 475–485.

Nelson, C. and Plosser, C. (1982), "Trends and Random Walks in Macroeconomic Time Series: Some Evidence and Implications", *Journal of Monetary Economics*, 10, 139–162.

Perron, P. (1989), "The Great Crash, the Oil Price Shock, and the Unit Root Hypothesis", *Econometrica*, 57, 1361–1401.

Perron, P. (1997), "Further Evidence on Breaking Trend Functions in Macroeconomic Variables", *Journal of Econometrics,* 80, 355–385.

Perron, P. and Vogelsang, T.J. (1992), "Non-stationary and Level Shifts with an Application to Purchasing Power Parity", *Journal of Business and Economic Statistics,* 10: 301–320.

Pesaran, M.H. (1997), "The Role of Economic Theory in Modelling the Long Run", *The Economic Journal*, 107, 178–191.

Pesaran, M.H. and Shin, Y. (1999), "An Autoregressive Distributed Lag Modelling Approach to Cointegration Analysis", in Strom, S. (Ed.) *Econometrics and Economic Theory in the 20th Century: the Ragnar Frisch Centennial Symposium*, Chapter 11, Cambridge: Cambridge University Press.

Pesaran, M.H., Shin, Y. and Smith, R.J. (2001), "Bounds Testing Approaches to the Analysis of Level Relationships", *Journal of Applied Econometrics*, 16, 289–326.

Piersanti, G. (2000), "Current Account Dynamics and Expected Future Budget Deficits: Some International Evidence", *Journal of international Money and Finance*, 19 (2), 2555–71.

Rahman, M. and Mishra, B. (1992), "Cointegration of US Budget and Current Account Deficits: Twin or Strangers?", *Journal of Economics and Finance,* 16, 119–127.

Saleh, A. S. and Harvie, C. "The Budget Deficit and Economic Performance: A Survey", *Singapore Economic Review*, 50(2), 211–243.

Saleh, A.S., Mehandhiran, N. and Agalewatte, T. (2005), "The Twin Deficits Problem in Sri Lanka: An Econometric Analysis", *South Asia Economic Journal,* 6(2): 221–239.

Smyth, D. and Hsing, Y. (1995), "In Search of an Optimal Debt Ratio for Economic Growth", *Contemporary Economic Policy*, 13(4), 51–59.

Vamvoukas, G.A. (1999), "The Twin Deficits Phenomenon: Evidence from Greece", *Applied Economics*, 31, 1093–1100.

Volcker, P.A. (1987), "Facing Up to the Twin Deficits", in Fink, R. and High, J. (Eds), *A Nation in Debt: Economists Debate the Federal Budget Deficit*, Maryland: University Publications of America.

Weiss, J. and Jayanthakumaran, K. (1995), "Trade Reform and Manufacturing Performance: Evidence from Sri Lanka, 1978–89", *Development Policy Review*, 13, 65–83.

Wheeler, M. (1999), "The Macroeconomic Impacts of Government Debt: An Empirical Analysis of the 1980s and 1990s", *Atlantic Economic Journal*, 27(3), 273–84.

World Bank, *World Tables*, Washington D.C., various years.

Zivot, E. and Andrews, D.W. (1992), "Further Evidence on the Great Crash, the Oil-Price Shock, and the Unit-Root Hypotheses", *Journal of Business and Economic Statistics,* 10, 251–270.

Notes

[1] Macroeconomic series often experience various breaks in their realisations. This is especially true for transition and emerging market economies, which often experience shocks due to radical policy changes or crises. The examples of policies with break consequences include frequent devaluations, deregulation of both real and financial sectors and policy regime shifts.

[2] These reforms include trade liberalisation, increased capital expenditure and exchange rate reform, among others.

[3] Sri Lanka made significant progress in cutting trade restrictions through tariff liberalisation and standardisation, the elimination of virtually all quantitative restrictions, the termination of many state trading monopolies and the continued opening of some service industries to international investors and suppliers.

[4] All commonly used model selection criteria (AIC, HQ, SBC and so on) are functions of residual sums of squares, and are asymptotically equivalent (Judge et al., 1985: 869).

[5] Suppose the true model is: $Y_t = \beta_1 + \beta_2 X_{2t} + \beta_3 X_{3t} + u_t$, but we estimate the following model: $Y_t = \alpha_1 + \alpha_2 X_{2t} + v_t$. It can be shown that $E(\hat{\alpha}_2) = \beta_2 + b_{32}\beta_3$, where b_{23} is the slope coefficient of regression of X_3 on the included variable X_2 . It can be shown that $Var(\hat{\alpha}_2)$ will be biased. Refer to Kmenta (1985: 443–46).

[6] Athukorala and Rajapatirana (1993) found complementarity between financial sector reforms and trade liberalisation in Sri Lanka.

[7] Subsequent studies using endogenous breaks counter this finding. Zivot and Andrews (1992) conclude that seven of these 11 variables are in fact non-stationary.