Twin Deficits in Sri Lanka in The Presence of Trade Liberalisation

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ABSTRACT

This paper examines the long run and short run relationships between the current account deficit, budget deficit, saving and investment gap and trade openness in Sri Lanka using the Autoregressive Distributive Lagged (ARDL) approach. Time series properties of the variables, in the presence of endogenous structural break, have been analysed by using Additive Outlier (AO) and Innovational Outlier (IO) models of Perron (1997). The empirical analysis supports the Keynesian view that there is a linkage between the current account, budget deficit and saving and investment gap. Trade openness was found to have a positive effect on the current account deficit but was statistically insignificant. Strategies to stabilise the budget deficit and current account deficits are provided in this paper.

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I. Introduction

There is an extensive theoretical and empirical literature that has examined the relationship between current account deficits and other specified macroeconomic variables. The Keynesian school of thought argues that budget deficit does have a significant impact on current account deficit. Studies by Fleming (1962), Mundell (1963), Volcker (1987), Kearney and Monadjemi (1990), Smyth *et al.* (1995) have argued 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 interest rates, thereby, causing capital inflows, causing the exchange rate to appreciate. Therefore, the current account balance deteriorates. 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 impact 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 does not alter the mix of current consumption and investment since rational agents foresee the present tax cut as a tax burden in future. In other words, Ricardian Equivalence Hypothesis negates any link between the two deficits.

There is a vast empirical literature testing the two paradigms and a comprehensive review of the literature can be found in Saleh and Harvie (2005).

Most empirical studies examined the twin deficits hypothesis for developed countries. However, empirical studies on developing countries are sparse, even though the relationship is much stronger in the developing countries.

From the literature of the recent past the following salient features emerges: first, the crucial role played by financial variables such as interest rate and exchange rate in the budget-saving-investment-current account nexus. Most of the earlier studies have ignored the role of these two financial variables in the evolution of these deficits. Second, unlike the debt crises of the 1980s that were driven by budget deficits, the 1994 Mexican and the 1997-98 East Asian crises precipitated due to overwhelming imbalances in the current account. Third, the body of evidence has not yielded a consensus on the causal relationship between the two deficits.

Turning to the empirics, the evidence so far does not provide a clear consensus on the debate. Researchers like 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 with two other competing hypotheses: namely (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 as ‘current account targeting’. Surprisingly, the contributions of saving-investment imbalance and other relevant macroeconomic variables to the current account deficit are considered minor and are naively 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. Firstly, this is the first time the twin deficits are examined in the presence of saving and investment gap and trade openness for Sri Lanka. Saleh *et al.* (2005) study on Sri Lanka only concentrated on the relationship between current account imbalance and budget deficit. We would have liked to include the financial variables like exchange and interest rates in our analytical framework. 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 to boost 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 the current account difficulties and promote economic growth. The East Asian miracle and recently China and India are examples of effects of trade liberalisation on economic growth.

Secondly, Sri Lanka is a very interesting case since the country has been experiencing both current account deficits and budget deficits since 1960s. Sri Lanka's budget has been in deficit during the entire period of investigation (1970-2005). The data indicates that this deficit as a percentage of GDP has increased significantly after 1977. The significant increase in budget deficit can be attributed to many factors such as decreased government revenue (due to narrow tax base and inefficiency of tax collection) and increased public expenditure especially on food subsidy and defence. An overview of Sri Lankan fiscal deficits can be found in Saleh *et al.* (2005).

However, the paper is organised as follows. Section II discusses the conceptual framework of the study. In section III, the time series properties of the variables have been analyzed by using Additive Outlier (AO) model and Innovational Outlier (IO2) models of Perron (1997). This exercise is done to test the robustness of the traditional unit root tests in the presence of a structural break in the data. A brief discussion of the methodology is reported in the Appendix 1. The estimation methodology used here is the Autoregressive Distributed Lag (ARDL) developed by Pesaran and Shin (1999) to examine if the current account and saving and investment gap, budget deficit and trade openness are cointegrated in the long run. The ARDL framework used in this paper 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 small sample. Discussion on short run dynamics and adjustment toward long run equilibrium will be reported and analyzed in section IV. Finally, policy implications and conclusions are discussed in Section V.

II. 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)

$$Y = C + I + G + (X - M) \qquad (1)$$

Alternatively,

$$Y = C + S + T \qquad (2)$$

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

$$(X - M) = (S - I) + (T - G) \qquad (3)$$

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

Hard line critics dismiss equation (3) as a mere identity and its estimation as a trivial exercise. However, others consider equation (3) to be misspecified to the extent that financial variables like exchange rate and interest rates are omitted and their role ignored. They believe that a worsening of the budget deficit causes the domestic interest rate to increase which results in net capital inflow 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 should be explicitly taken into account. 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, relaxation of trade and exchange controls, yet there are a lot of regulatory measures in place in Sri Lanka. Therefore, we have included a surrogate variable of openness [(X+M)/Y] in our specification to capture the combined effect of exchange rate and interest rate. Hence, our augmented model is expressed in equation (4):

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

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

$$CA_t = \alpha_0 + \alpha_1 SI_t + \alpha_2 BD_t + \alpha_3 OPEN_t + \varepsilon_t \quad (5)$$

where, ε_t is an error term.

III. Data Sources and Unit Root Test

In this study, we used annual data from 1970 to 2005 from various sources. The data for saving and investment were extracted from World Bank World Table, openness data was obtained from Heston *et al.* (2006) Penn World Table Version 6.2, data for budget deficits and current account balance were obtained from the Central Bank of Sri Lanka, Annual Reports. All the variables were measured as percentage of GDP.

Equation (4) can be analysed by cointegration test. Prior to conducting the cointegration test, it is essential to check each time series for stationarity. If a time series is nonstationary, 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 are going to use in this paper. A succinct review is given in Appendix 1.

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

One of the main concerns in this study is to evaluate the implication of structural break[1] on the time series properties of the variables. Since the ADF and PP tests suffer from power deficiency in the presence of structural breaks, we applied 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 AO model represents the change that is *rapid*.

We applied both AO and IO2 models to the data and we reported the results in Tables 1 and 2. Of the two models, the Innovational Outlier (IO2)

[1] It is widely known that 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.

Model is preferred (reported in Tables 1 and 2) since this model captures the gradual change in the variables rather than picking up an abrupt change, and 2) the endogenously determined break dates seem more plausible with the events occurring in the Sri Lankan economy.

The IO2 model finds additional evidence of no unit root (i.e., 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 5 per cent level of significance for all the 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. The break dates seem plausible. The United National Party (UNP) government came to power in July 1977. Immediately, the new government initiated many far-reaching economic and financial policy changes[2]. These changes provided new directions in the Sri Lankan economy. The new policy reforms seem to have immediately impacted on all variables except for the openness.

The structural break for openness occurred in 1998 and it seems plausible too. For the past three decades structural adjustment and economic reform has been the foundation stone of Sri Lankan economic policy. But the implementation

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

of these policies has been slow and patchy. However, tax and trade reforms[3] made improvement during 1997 and 1998 and the privatisation program has been the most flourishing area of structural reform. Further, the Asian Financial Crisis of 1997 left a mark on Sri Lanka's openness.

Table 1: Unit Root Tests in the Absence and Presence of a Structural Break
[Current Account Balance (CA) and Saving 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

Note: S = stationary; NS = nonstationary; 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

Note: S=stationary; NS=nonstationary; 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.

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

IV. Empirical Findings

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

$$\Delta CA_t = \alpha_0 + \delta_1 CA_{t-1} + \delta_2 SA_{t-1} + \delta_3 BD_{t-1} + \delta_4 OPEN_{t-1} + \\ + \sum_{i=1}^{n} b_i \Delta ca_{t-i} + \sum_{i=0}^{n} c_i \Delta SI_i + \sum_{i=0}^{n} d_i \Delta BD_{t-i} + \sum_{i=0}^{n} e_i \Delta OPEN_{t-i} + u_t \qquad (6)$$

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

$$\Delta CA_t = \alpha_0 + \delta_1 CA_{t-1} + \delta_2 SA_{t-1} + \delta_3 BD_{t-1} + \delta_4 OPEN_{t-1} + \delta_5 DU_{CA} \\ + \sum_{i=1}^{n} b_i \Delta ca_{t-i} + \sum_{i=0}^{n} c_i \Delta SI_i + \sum_{i=0}^{n} d_i \Delta BD_{t-i} + \sum_{i=0}^{n} e_i \Delta OPEN_{t-i} + u_t \qquad (7)$$

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, 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 we used here is the restricted intercept with no trend (Case V in Pesaran *et al.*, 2001).

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

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'. Based on the 'bounds test' (given in Table 3), the computed *F*-statistic is 4.125, is above the upper critical bound (*UCB)* at the 10 per cent significance level. Hence, there exists a long-run relationship between current account deficits and the relevant macroeconomic variables.

Table 3: Bounds Test for Cointegration Analysis in Sri Lanka

Computed *F*-Statistics (F_{Bounds})	4.125	
Critical Bounds (10 per cent)	*LCB*: 2.711	*UCB*: 3.800
Critical Bounds (5 per cent)	*LCB*: 3.219	*UCB*: 4.378

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

The estimated long-run coefficients for the ARDL model are given in Table 4. In the long-run, a one per cent increase in the saving and investment gap will lead to 0.67 increase in current account deficit, while a one per cent increase in the budget deficit will lead to 0.20 increase in the current account deficit. The empirical result shows that the budget deficit and saving-investment balance have

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

a statistically significant effect on current account deficit. Of the two, saving-investment balance has a dominant effect on the current account balance.

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
INTERCEPT	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.

This is in sharp contradiction to Saleh *et al.* (2005) finding where the computed elasticity of budget deficit on the current account was 0.63 per cent. This high elasticity value is due to the misspecification of the model where saving-investment balance was omitted thereby invoking a naïve assumption that saving = investment. Econometrically, the coefficient estimated by Saleh *et al.* (2005) is not only biased but also inconsistent if budget deficit and saving-investment are correlated. The variance of the estimated coefficient will also be 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).

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[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).

The dummy variable is found to have a positive effect but is statistically insignificant. The effect of trade openness on current account is positive implying that a one per cent increase in trade openness leads to 0.013 per cent increase in current account deficit. The coefficient is very small and statistically insignificant. Despite the reforms in 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) find no long run relationship between trade liberalisation and productivity growth. Thus 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 not at all unusual in the short run for any economy.

Various diagnostic analyses for serial correlation, heteroskedasticity, normality of residuals and other tests are reported in Appendix 2, Table A2.1. These tests indicate that the specified model pass all the diagnostic tests. As can be seen, there is no evidence of autocorrelation and the model passes the test of normality. Furthermore, Figure A2.1 of Appendix 2 indicates the stability of both long and short run coefficients since the residuals lie within the upper and lower bounds of the critical values.

Short Run Dynamics

The short run dynamics and the long run equilibrium for the estimated ARDL model is given in Table 5. 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 the negative sign and statistically significant. As shown in Table 5, the estimated coefficient for ECM is equal to -0.66 for the specified model and highly significant, indicating 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 current account deficit and the relevant macroeconomic data.

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.

V. Summary and Conclusion

The purpose of this paper was to add new insights to the twin deficits literature, especially on Sri Lanka. Saleh *et al.* (2005) studied the twin deficit hypothesis in Sri Lanka and found that budget deficits contributed overwhelming to current account imbalances. We find this model grossly mis-specified since other relevant variables (like saving-investment balance) were excluded from the analysis. Our paper differs from the previous studies on twin deficits phenomena by the inclusion of trade openness in the analysis. Trade openness is an all-inclusive surrogate that captures various trade and financial reforms[6]. Secondly, we tested the time series properties of the variables in the presence of structural break since traditional unit root tests (ADF and PP) suffer from power deficiency. Thirdly, a flexible, robust econometric framework called the ARDL modelling was applied to estimate long and short term relationships among variables.

Our empirical results support the Keynesian view that there is a strong, positive link between the current account deficit, saving-investment balance and budget deficit in Sri Lanka during the period of 1970-2005. We found that a one per cent increase in the saving and investment gap will lead to 0.67 increase in current account deficit, while a one per cent increase in budget deficit will increase current account deficit by 0.20 per cent. If we consider the effect of trade openness on current account, a one per cent increase in trade openness leads to 0.013 per cent increase in current account deficit, but the result is not statistically significant. The structural break dummy variable was found to have a positive effect but was also statistically insignificant.

The findings suggest that reducing the budget deficit and/or reducing the saving and investment gap in Sri Lanka may well assist in improving the current account deficit. The above requires drastic trade and financial sector reforms to

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

bring efficiency in 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. Policies must be put in place for increasing exports and benefit from trade liberalisation policies in the area of specialisation to increase external competitiveness. The findings of this paper could be vital for a small open economy like Sri Lanka to be aware of such relationships among the key macroeconomic variables in the country in order to employ appropriate policies to avoid any crises in its external balance.

Appendix 1

A Review of Unit Root Tests with Endogenous Structural Break

Traditional tests for unit roots (such as Dickey-Fuller, Augmented Dickey-Fuller and Phillips-Perron) have low power in the presence of structural break. Perron (1989) demonstrated that, in the presence of a structural break in time series, many perceived nonstationary series were in fact stationary. Perron (1989) re-examined Nelson and Plosser (1982) data and found that 11 of the 14 important US macroeconomic variables were stationary when known exogenous structural break is 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- 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)

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[7] However, subsequent studies using endogenous breaks have countered this finding with Zivot and Andrews (1992) concluding that 7 of these 11 variables are in fact nonstationary.

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 (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 date 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 (1989) models, they form the foundation of subsequent studies that we are going to discuss hereafter. Zivot and Andrews (1992), Perron and Vogelsang (1992), and Perron (1997) among others have developed unit root test methods which include one endogenously determined structural break. Here we review these models briefly and detailed discussions are found in the cited works.

Zivot and Andrews (1992) models are as follows:

Model with Intercept

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

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 the Perron (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. 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

$$y_t = \mu + \delta DU_t + \tilde{y}_t \qquad \text{(A 11)}$$

and

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

$\tilde{y}$ 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.

Innovational Outlier Model allowing one time change in intercept only (IO1):

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

Innovational Outlier Model allowing one time change in both intercept and slope (IO2):

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

Additive Outlier Model allowing one time change in slope (AO)*:*

$$y_t = \mu + \beta t + \delta DT_t^* + \tilde{y}_t \quad \text{(A 15)}$$

where $DT_t^* = 1(t > T_b)(t - T_b)$

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

The Innovational Outlier models represent the change that is gradual whereas Additive Outlier model represents the change that is rapid. All the models considered above report their asymptotic critical values.

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

Regarding the power of tests, the Perron and Vogelsang (1992) model is robust. The testing power of Perron (1997) models and Zivot and Andrews models (1992) are almost the same. On the other hand, Perron (1997) model is more comprehensive than Zivot and Andrews (1992) model as 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

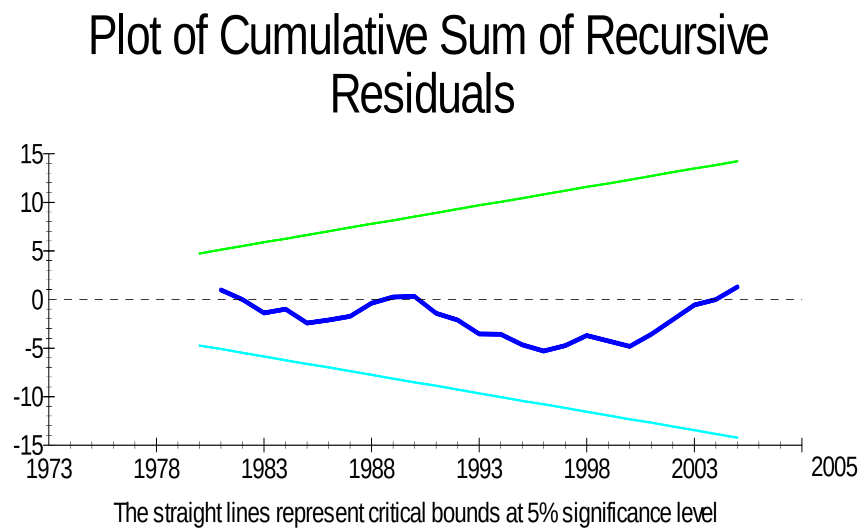
R-Squared	0.967	R-Bar-Squared	0.959
S.E. of Regression	0.755	F-stat. F(6, 26)	126.652 [0.000]
Mean of Dependent Variable	-4.537	S.D. of Dependent Variable	3.739
Residual Sum of Squares	14.804	Equation Log-likelihood	-33.599
Akaike Info. Criterion	-40.599	Schwarz Bayesian Criterion	-45.836
DW-statistic	1.667	Durbin's h-statistic	1.843 [0.065]

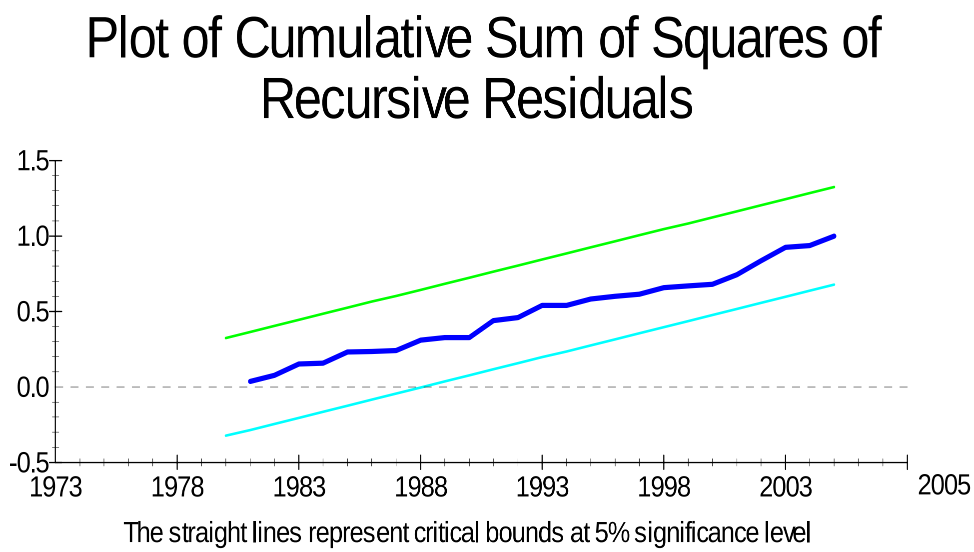
Diagnostic Tests

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





References

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

Bai J and P. Perron (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*, Vol. 3, pp. 37-54.

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

Evans P. and I. Hasan (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*, Vol. 36 (2): 135-152.

Fleming, J. M. (1962), 'Domestic Financial Policies Under Fixed and Under Floating Exchange Rates', *International Monetary Fund Staff Papers*, No. 10: 369-380.

Heston, A., R. Summers, and B. Aten (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 F. Y. Kumah, (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., W. E. Griffiths, R. C. Hill H. Lutkepohl and T. C. Lee (1985), *The Theory and Practice of Econometrics*, Second edition, John Wiley and Sons, New York.

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

Kearney, C. and M. Monadjemi, (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, Macmillan, New York.

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

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

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

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

Mundell, R.A. (1963), 'Capital Mobility and Stabilization Policy Under Fixed and Flexible Exchange Rates', *Canadian Journal of Economics and Political Science*, 29: 475-485.

Nelson C. and C. Plosser (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 T.J. Vogelsang (1992), 'Nonstationary 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 Y. Shin, (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 University Press, Cambridge.

Pesaran, M.H., Y. Shin, and R.J. Smith, (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 B. Mishra, (1992), 'Cointegration of US Budget and Current Account Deficits: Twin or Strangers?', *Journal of Economics and Finance*, 16: 119-127.

Saleh, A. S. and C. Harvie,. (2005), 'The Budget Deficit and Economic Performance: A Survey', *Singapore Economic Review*, 50 (2): 211-243.

Saleh, A. S., N. Mehandhiran, and T. Agalewatte, (2005), 'The Twin Deficits Problem in Sri Lanka: An Econometric Analysis', *South Asia Economic Journal* 6 (2): 221-239.

Smyth, D. and Y. Hsing, (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, Fredrick. pp. 154-161.

Weiss, J and K. Jayanthakumaran (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*, Vol. 27 (3):273-84.

World Bank, World Tables (Various years), Washington, D. C.

Zivot E. and D.W. Andrews (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.