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Research Report 2000:1
ISSN 0349-8034

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Multivariate Based Causality Tests of Twin Deficits in the US

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ABSTRACT

This paper provides an alternative methodology for testing the causality direction between Twin deficits in the US. Rao's multivariate F-test combined with bootstraps simulation technique has appealing properties, especially when the data generating process is characterised by unit roots. In addition the results show that the effect of structural breaks are of paramount importance when the causality tests are conducted.

Keywords: Bootstrap Simulation; Multivariate tests; Twin deficits; Granger causality; Structural breaks

JEL classification: C32; H62

Running title: Multivariate Based Causality Tests of Twin Deficits

1. Introduction

In the literature it has been established that there is a positive relationship between budget deficits and current account deficits and it is termed as the twin deficits phenomena.[1] There are several ways in which budget deficits can affect current account deficits. In a conventional Mundell-Fleming model, it is assumed that an increase in budget deficit would cause an increase in interest rates, with capital inflows and appreciation of exchange rates as effects. These effects in turn result in an increase in current account deficit. According to Keynesian absorption theory an increase in budget deficit would induce domestic absorption and hence import expansion, which will increase current account deficits. Feldstain and Horioka (1980) find that saving and investment are highly correlated in the US economy, causing current account deficits and budget deficits to move together. Another contrary view regarding these two macro-aggregates is provided by the Ricardian Equivalence theorem, which claims that changes in the path of government expenditures (or taxes) do not affect real interest rates, the quantity of investment, and/or current account deficits.

Several empirical studies have confirmed the existence of a positive relationship between the twin deficits in the US economy. The purpose of the present study is to investigate the direction of causality between these variables. This issue is important from a policy-making point of view in order to remedy the twin deficits. Removing twin deficits is assumed to be a precondition for the economy to thrive.

Here, in addition to the singlewise Likelihood Ratio test (LR) and the systemwise Rao's F-test, we apply the bootstrap multivariate simulation technique in combination with Rao's F-test, to see which deficit precedes the other, or whether they cause each other simultaneously. The advantages of last mentioned test method are that it performs well even when the time series are non-stationary, it is not based on a specific distribution and, finally, it can be used irrespective of the cointegration properties of the data.

[1] See Kearney and Monadjemi (1990) and references therein. Kasa (1994) reports a positive relationship between twin deficits in the U.S., Japan, and Germany. Islam (1998) finds a positive relationship between budget deficits and trade deficits for Brazil. McNelis and Siddiqui (1994) can not find any empirical evidence that the twin deficits establish a long-run equilibrium in New Zealand. Normandin (1999) indicates that there is a positive comovement between the external and internal budget deficits in Canada and USA, in particular since 1980s.

The paper is organised as follows: Section 2, presents the basis of our data set. Section 3, discuss the order selection of the model. Section 4, describes the multivariate tests methodology for Granger causality, while in Section 5, we present and discuss our main test results. Finally, in Section 6, we give a brief summary and conclusions.

2. Data

The data used in this study consists of budget deficits (BD) and current account deficits (CAD) on the quarterly basis for the period 1975Q1-1998Q2 from *International Financial Statistics*. We have seasonally adjusted the data by running each variable through the X-11 filter.

Tests for nonstationarity have been applied using the KPSS (Kwiatkowski et al. 1992) and Perron (1989) unit root test methods. The results, presented in Table 1 and 2, reveal that each variable is characterized by one unit root. This is in accordance with the graphical inspection of the time series provided in the following figures.

Figure 1: Budget deficits in the level form.

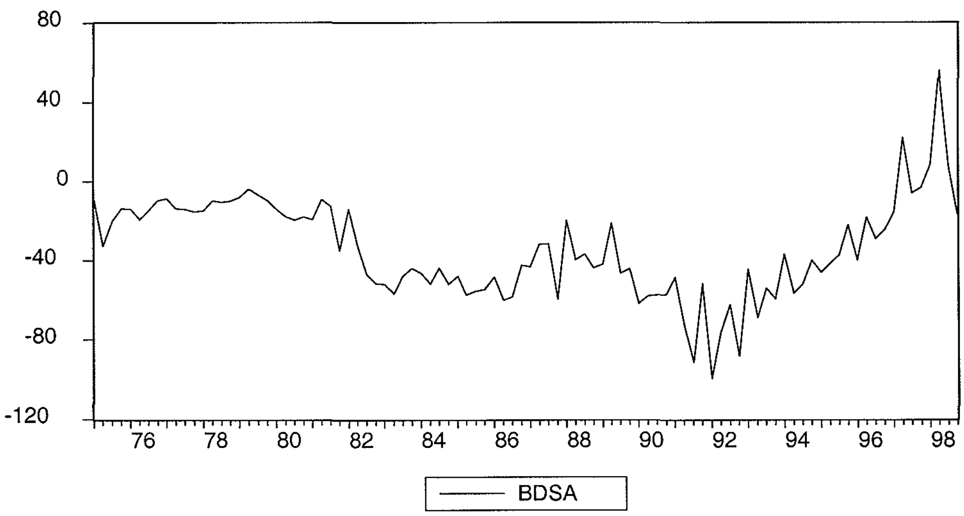


Figure 2: Budget deficits in the first difference form.

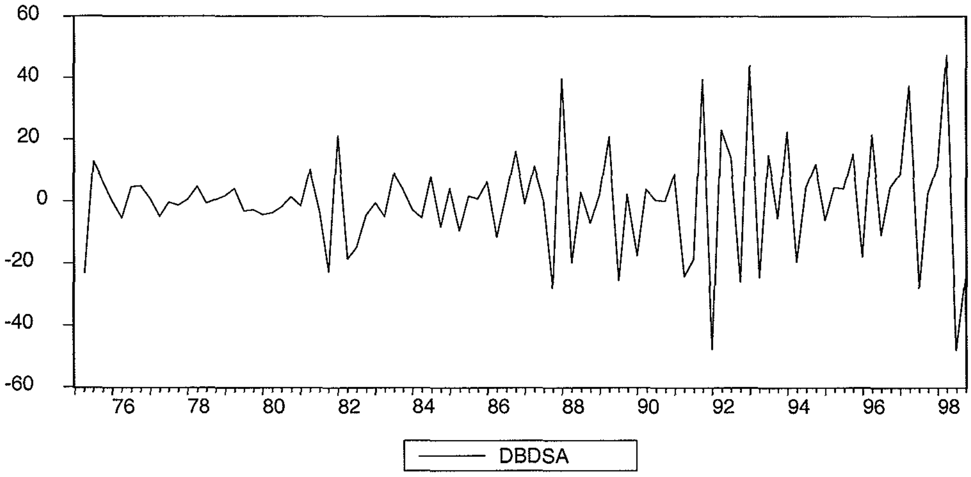


Figure 3: Current account deficits in the level form.

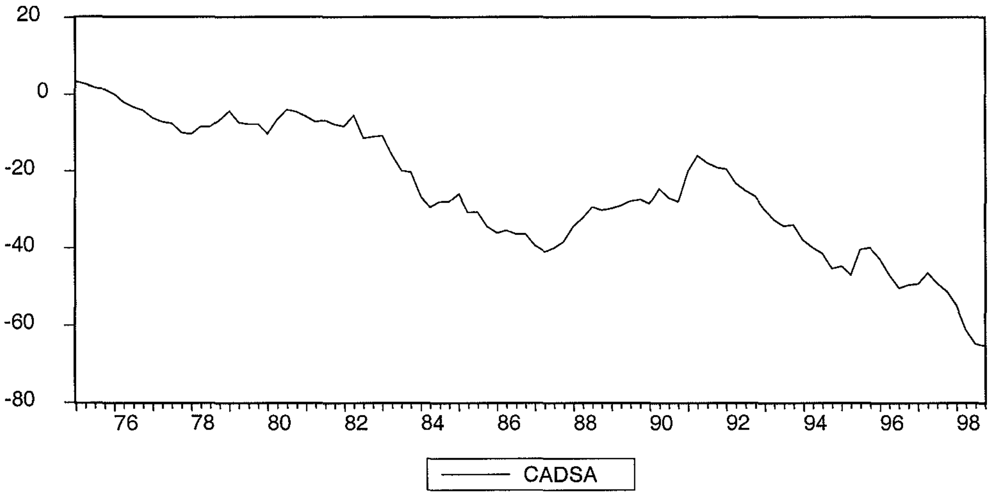
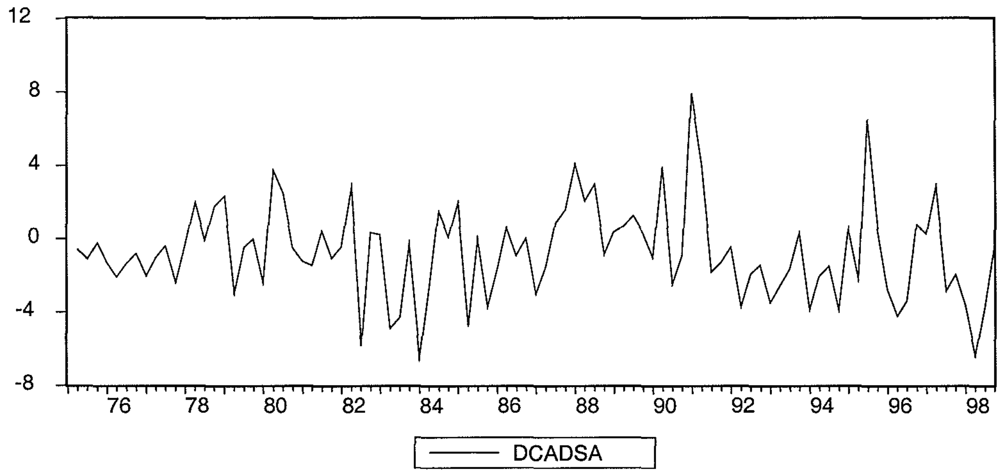


Figure 4: Current account deficits in the first difference form.



As is evident from the figures, the data generating process for each variable seems to be well described by one unit root, since each variable appear to be stationary after being differenced once.

3. The Order of the VAR Model

The order of the VAR model often plays a crucial role in empirical analysis and hence special care should be taken in selecting the optimal lag length. To this end, we applied AIC, SBC information criteria and the multivariate likelihood ratio (LR) test. We first estimated the AIC and SBC that indicated the lag length two and three respectively. To choose between these two lags we performed LR multivariate test adjusted for small samples. The result was in favour of lag length two. It is important to mention that we have tested for autocorrelation in the residuals by using Breuch-Godfrey multivariate test. The null hypothesis of no autocorrelation could not be rejected at the conventional significance levels. When testing for normality, the results indicated some slight departure from normality. This will not affect the bootstrap based causality test however, since it is based on the true distribution of the underlying data, which does not necessarily have to be normally distributed.

4. Multivariate Causality Tests

In the vector autoregressive (VAR) framework, the Wald test for testing the Granger-causality may have non-standard asymptotic properties if the variables considered in the VAR are integrated or cointegrated. However, Dolado and Lütkepohl (1996) proposed a solution that guarantees standard χ^2 asymptotic distribution for the Wald tests performed on the coefficients of cointegrated VAR processes with I(1) variables, if at least one coefficient matrix is unrestricted under the null hypothesis. Similarly, if all the matrices are restricted, it is shown that adding one extra lag to the process and concentrating on the original set of coefficients, result in Wald tests with standard asymptotic distributions. This result leads to a number of interesting implications, which stem from the possibility of expressing null hypotheses as restrictions on coefficients of stationary variables.

Shukur and Mantalos (1998) have considered the size and power of various generalisations of tests for Granger-causality in integrated-cointegrated VAR systems. The authors used Monte Carlo methods to investigate the properties of eight versions of the test in two different forms, the standard form and the modified form by Dolado and Lütkepohl (1996). In both studies, the standard and the modified Wald tests have shown to perform badly, especially in small samples. In Shukur and Mantalos (1998), however, the authors found that the *small-sample corrected* LR-tests, and especially the Rao's multivariate *F*-test, exhibit best performances regarding both size and power, even in small samples. In the case when we use the standard test and when there is no cointegration, however, all the tests have shown to perform poorly, especially in small samples. Mantalos (1998) studied the properties of Wald, corrected-LR and Bootstrap tests for the same purpose. The author showed that, even when the non-stationary variables are not cointegrated, the Bootstrap test exhibits the best performance in almost all situations. Hatemi-J and Shukur (1999) have applied these test methods when investigating the fiscal policy in Finland, and found that the methods almost indicated the same results. Note that in all the previously mentioned studies, the authors use the Ordinary Least Squares (OLS) method in the test regression, while we in this study use Zellner's (1962) Iterative Seemingly Unrelated Regression (ISUR) method. The ISUR technique provides parameter estimates that converge to the maximum likelihood parameter estimates which are unique.

4.1. The Systemwise Rao's *F*-Test

Here, we present the Granger-causality test by using the multivariate Rao's F-test (Rao, 1973). Consider the following VAR(p) process:

$$y_t = \eta + A_1 y_{t-1} + \ldots + A_p y_{t-p} + \varepsilon_t, \quad (1)$$

where $\varepsilon_t = (\varepsilon_{1t}, \ldots, \varepsilon_{kt})'$ is a zero mean independent white noise process with nonsigular covariance matrix Σ_ε and, for j = 1, ... , k, $E|\varepsilon_{jt}|^{2+\tau} < \infty$ for some $\tau > 0$. The order p of the process is assumed to be known. Now, by portioned y_t in (m) and (k-m) dimensional subvectors y_t^1 and y_t^2 and A_i matrices portioned comformably then y_t^2 does not Granger-cause the y_t^1 if the following hypothesis:

$$H_0 : A_{12,i} = 0 \quad \text{for} \quad i = 1, ..., p - 1 \tag{2}$$

is true.

Let us define:

$Y: = (y_1, \cdots, y_T)$ $(k \times T)$ matrix,

$B: = (v, A_1, \cdots, A_p)$ $(k \times (kp + 1))$ matrix,

$$Z_t: = \begin{bmatrix} 1 \\ y_t \\ \vdots \\ y_{t-p+1} \end{bmatrix} \quad ((kp + 1) \times 1) \text{ matrix,}$$

$Z: = (Z_0, \cdots, Z_{T-1})$ $((kp+1) \times T)$ matrix, and

$\delta: = (\varepsilon_1, \cdots, \varepsilon_T)$ $(k \times T)$ matrix.

By using this notation, for t = 1, …, T, the VAR(p) model including a constant term (v) can be written compactly as:

$$Y = BZ + \delta. \tag{3}$$

We first estimate model (3), equation by equation, using the OLS method. The whole VAR system is then estimated using Zellner's (1962) Iterative Seemingly Unrelated Regression (ISUR) method. As we previously mentioned, the ISUR technique provides parameter estimates that converge to the maximum likelihood parameter estimates which are unique.

Let us denote by $\hat{\delta}_U$ the $(k \times T)$ matrix of estimated residuals from the *unrestricted* regression (3) and by $\hat{\delta}_R$ the equivalent matrix of residuals from the *restricted* regression with H_0 imposed. The matrix of cross-products of these residuals will be defined as $S_U = \hat{\delta}_U{}'\hat{\delta}_U$ and $S_R = \hat{\delta}_R{}'\hat{\delta}_R$ respectively. The Rao test can be then written as:

$$RAO = (\phi/q)(U^{1/s} - 1), \tag{4}$$

where, $s = \sqrt{\dfrac{q^2 - 4}{k^2(G^2 + 1) - 5}}$,

$r = q/2 - 1$, $\phi = \Delta s - r$, $\Delta = T - (k\,(kp+1) - Gm) + ½\,[k(G-1) - 1]$, $U = \det \mathbf{S}_R / \det \mathbf{S}_U$. $q = Gm^2$ is the number of restrictions imposed by H_0, where G is the p restriction in (3) and m is the dimension of the subvector y_t^1. *RAO* is approximately distributed as $F(q,\ \phi)$ under the null hypothesis, and reduces to the standard *F* statistic when $k = 1$.

4.2. The Bootstrap Testing Approach

In this sub-section we present the Bootstrap testing procedure (Efron, 1979). Generally, the distributions of the test statistics we use are known only asymptotically, which means that the tests may not have the correct size, and inferential comparisons and judgements based on them could be misleading. However, several studies (e.g. Horowitz, 1994; Mantalos and Shukur, 1998; Shukur and Mantalos, 1997, have shown the robustness of the bootstrap critical values.

From regression (3), a direct residual resampling gives:

$$Y^* = \hat{B}Z^* + \delta^* \qquad (3a)$$

where δ^* are i.i.d. observations $\delta_1^*, ..., \delta_T^*$, drawn from the empirical distributions ($\hat{F}_\delta$) putting mass 1/T to the adjusted OLS residuals ($\hat{\delta}_i - \bar{\delta}$), i = 1, . . ., T. The basic principle of the Bootstrap testing is to draw a number of Bootstrap samples from the model under the null hypothesis, calculate the Bootstrap test statistic (T_s^*). The Bootstrap test statistic (T_s^*) can then be calculated by repeating this step N_b times. We then take the (α)*th* quintile of the bootstrap distribution of T_s^* and obtain the α-level "bootstrap critical values" ($c_{t\alpha}^*$). We then calculate the test statistic (T_s) which is the estimated test statistic using the actual data set. Finally, we reject the null hypothesis if $T_s \leq c_{t\alpha}^*$.

As regards N_b, the number of the bootstrap samples used to estimate bootstrap critical value, Horowitz (1994) used the value of N_b = 100, while Davidson and Mckinnon (1996) used N_b=1000 to estimate the *P*-value. In this study we estimate the *P*-value for the test using N_b=1000.

4. Causality tests results and conclusions

In this section we present and discuss the results of the Bootstrap test, Rao's F-test and singlewise LR test for causality that are applied to the VAR(2) model for the quarterly data of CADsa and BDsa in the US. When looking at the entire sample period, all these test methods lead us to draw the inference that these variables does not Granger cause each other (see Table 3).

However, during the analysed period of this study, especially in the early nineties, several events occurred (among others oil crisis, the Gulf war and collapse of the Soviet Union), which may have caused structural breaks. This is likely to have a substantial effect on analysing the causality nature between those two variables. Therefore, tests for parameter stability have been conducted by applying recursive estimates and CUSUMSQR tests. The plots are presented in the Appendix. Based on the plots of the recursive estimates of CUSUMSQR tests for each equation in the VAR model, we can conclude that the parameters are not stable during the entire sample period. Applying one-step-ahead systemwise ANOVA tests, for parameter stability and detection of break points, show that structural change could have happened after 1989.[2] Hence, we decided to split the data into two sub-periods and made two separate estimations for the two subperiods. We used the same earlier mentioned criteria to select the order of the suitable VAR model, and found that VAR(2) still had to be chosen in both sub-periods.

When using the same methods to test for causality, the results indicated that, during the first period, i.e. 1975 to 1989, only BDsa Granger causes CADsa (see Table 4). On the other hand, when analysing the second sub-period, i.e. 1990 to 1998, we find that the causality nature has almost changed direction from CADsa to BDsa (see Table 5). This means that, during the second sub-period, i.e. 1990 to 1998, the causality nexus between these two variables has a one-directional form in the opposite direction from the first sub-period. The policy implication of this result is that reducing trade deficits will result in decreasing budget deficits in the US economy. Reducing imports, increasing exports, or a combination of both measures can achieve decreasing trade deficits. Which alternative is the appropriate one can only be answered by another study that explicitly finds out the direction of causality between imports and the exports in the US during the period 1990-1998.

[2] The results of ANOVA tests are not presented here but are available from the authors on request.

It is important to mention that, if tests for parameter stability had not been used, the implausible results from Table 1, i.e., results from the whole sample period, could be used without question. This, of course, stress the importance of using the diagnostic checking of the model and test for parameter stability even if the previously mentioned information criteria recommend using a specific model. However, the implication of the estimated results is only valid for the period we have investigated. The causality may change direction again in the future.

5. Conclusions

In this study, we investigate the direction of causality relation between budget deficits and trade deficits in the US economy, which has been termed as the twin deficits phenomena. This issue is important from a policy-making point of view in order to remedy twin deficits, which is assumed to be a condition for the economy to thrive. For this purpose, quarterly data for the period 1975Q1-1998Q2, from *International Financial Statistics*, have been used. Note that in all cases the variables have been showed to integrate the first order I(1). Moreover the VAR(2) model has been chosen throughout in this study.

We use singlewise test, multivariate Rao's *F*-test and Bootstrap test applied to VAR(2) model. When using the whole sample period, the results from our study indicate that these two variables does not Granger cause each other. When splitting the sample into two sub-periods, however, the results show that only BDsa Granger causes CADsa in the first sub-period, while the opposite is right when considering the second sub-period.[3] This means that, during the second sub-period, the causality nexus between these two variables has a one-directional form in the opposite direction from the first sub-period. The policy implication of this result is that reducing current account deficits will result in decreasing budget deficits in the US economy. Decreasing trade deficits can be achieved by reducing imports, increasing exports or a combination of both measures. Reduction in budget deficits can also be achieved through measures that induce capital inflows.

[3] It should be mentioned the our empirical results are not consistent with Ahmed and Guan (1999) who find that the direction of causality is running from budget deficits to current account deficits for 1950-1994. A direct comparison is difficult, however, because of differences in the estimation periods as well as differences in the models and test methods applied.

Table 1

Test for unit roots using the KPSS test.[a]

Truncation lags →	*0*	*1*	*2*	*3*	*4*
H_0: I(0), H_1: I(d)					
BDsa series	1.21	0.69	0.49	0.38	0.32
CADsa series	0.57	0.30	0.20	0.16	0.13
H_0: I(1), H_1: I(d)					
BDsa series	0.01	0.03	0.04	0.04	0.05
CADsa series	0.14	0.12	0.11	0.10	0.10

[a]. The KPSS test is based on the following model:

$$y_t = \xi t + r_t + \varepsilon_t ,$$

where t denotes the linear trend term ε_t is a stationary random error, and r_t is a random walk:

$$r_t = r_{t-1} + u_t$$

The initial value (r_0) is treated as fixed and serves the role of an intercept. The stationary hypothesis is that the variance of the residuals in the random walk component (u_t) is zero.

The critical values are 0.12, 0.15, 0.18 and 0.22 at the 10%, 5%, 2.5% and 1% significance level, respectively. For more details regarding KPSS test see Hatemi-J (1999).

Table 2

Test for unit roots using the Perron test.[a]

	H_0: $I(1)$, H_1: $I(0)$	H_0: $I(2)$, H_1: $I(1)$
BDsa series	-2.03 (1)	-18.70 (0)
CADsa series	-1.90 (5)	-9.17 (3)

[a] The Perron regression is of the following form:

$$y_t = c + \beta t + dDTB_t + \theta DUM_t + \alpha y_{t-1} + \sum_{i=1}^{n} b_i \Delta y_{t-i} + v_t,$$

where t = linear trend term, DTB = 1 if t = TB + 1 (TB = time break = 1990: 01) and DTB = 0 otherwise, DUM = 0 if t <= TB and DUM = 1 if t > TB, and Δ denotes the first difference. This regression allows for a structural break in both the mean value and the deterministic trend of the variable under investigation. The null hypothesis of a unit root is $\alpha = 1$. The appropriate number of lagged differences (n) is determined by adding lags until the Ljung-Box test fails to reject no serial correlation of v_t at the 5% significance level.

The critical values are -3.69, -4.04, -4.31 and -4.70 at the 10%, 5%, 2.5% and 1% significance level, respectively. Note that the lambda (defined as pre-break sample size per after-break sample size) is around 0.8 in our case.

Table 3

Different test results for causality in the Granger sense, for the period 1975:1 to 1998:4.

Null Hypothesis	P-values		
	Bootstrap test	Rao's F-test	LR singlewise
CADsa does not Granger Cause BDsa	0.6940	0.6009	0.5974
BDsa does not Granger Cause CADsa	0.9740	0.9768	0.9765

Table 4

Different test results for causality in the Granger sense, for the period 1975:1 to 1989:4.

Null Hypothesis	P-values		
	Bootstrap test	Rao's *F*-test	LR singlewise
CADsa does not Granger Cause BDsa	0.6160	0.5811	0.5750
BDsa does not Granger Cause CADsa	0.0100	0.0062	0.0057

Table 5

Different test results for causality in the Granger sense, for the period 1990:1 to 1998:4.

Null Hypothesis	P-values		
	Bootstrap test	Rao's *F*-test	LR singlewise
CADsa does not Granger Cause BDsa	0.0240	0.0412	0.0273
BDsa does not Granger Cause CADsa	0.5930	0.5831	0.6892

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Acknowledgment

The authors are very grateful to Professor Börje Johansson for interesting and helpful comments on an early version of this paper. The authors are also grateful to Professor Marianne Frisén for encouragement and support.

Appendix

Diagram 1: Recursive estimates of the first equation in the VAR model with BDsa as dependent variable.

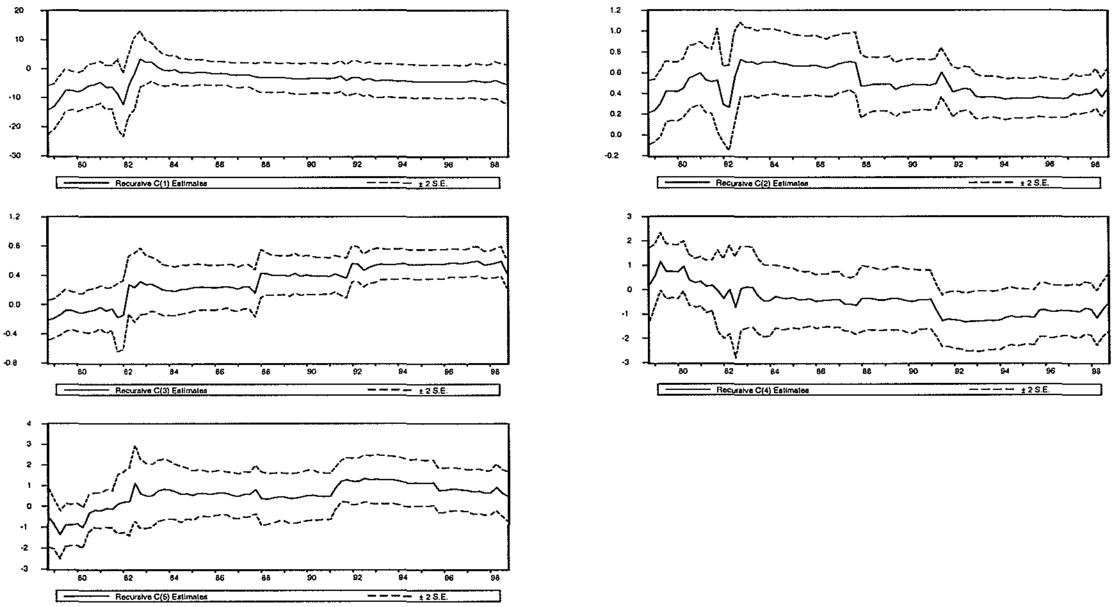


Diagram 2: Recursive estimates of the second equation in the VAR model with CADsa as dependent variable

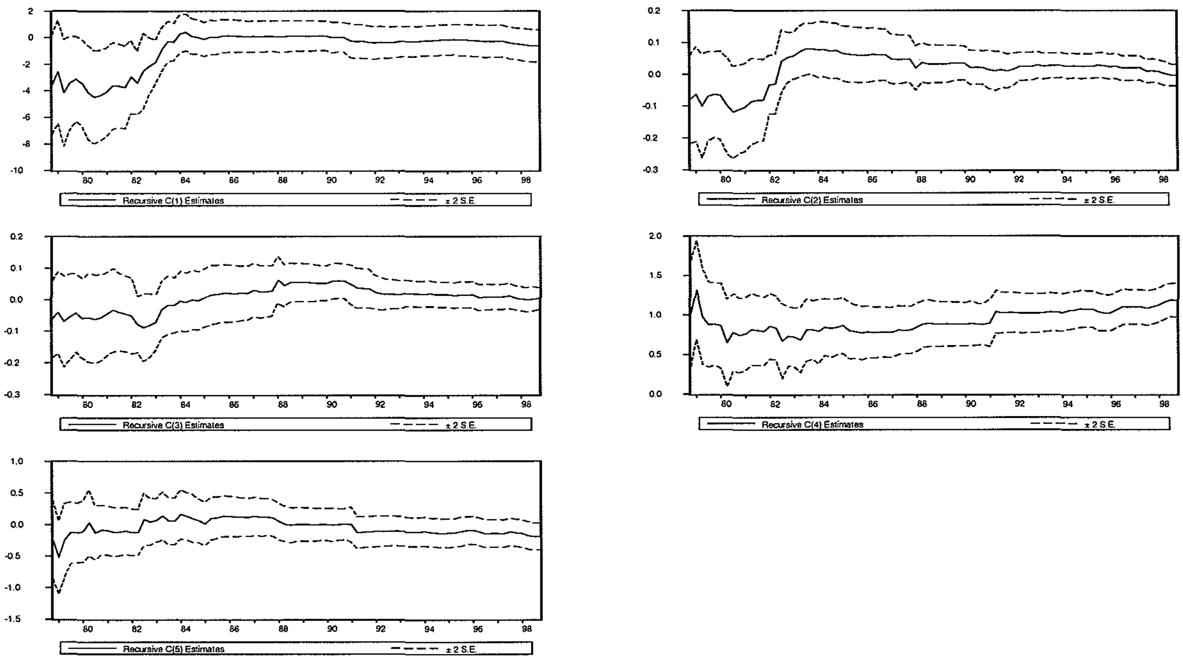
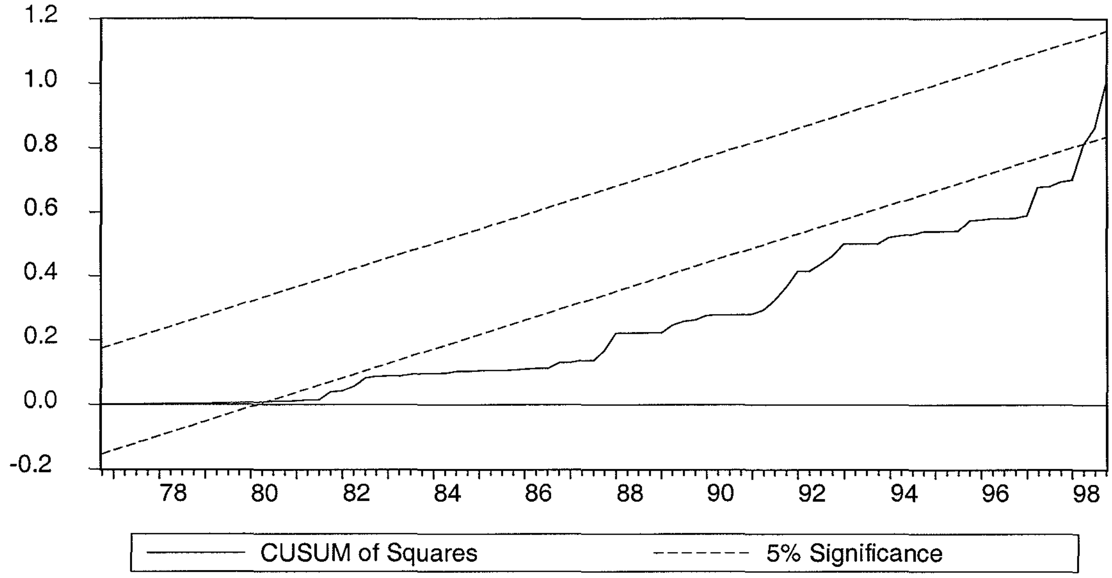
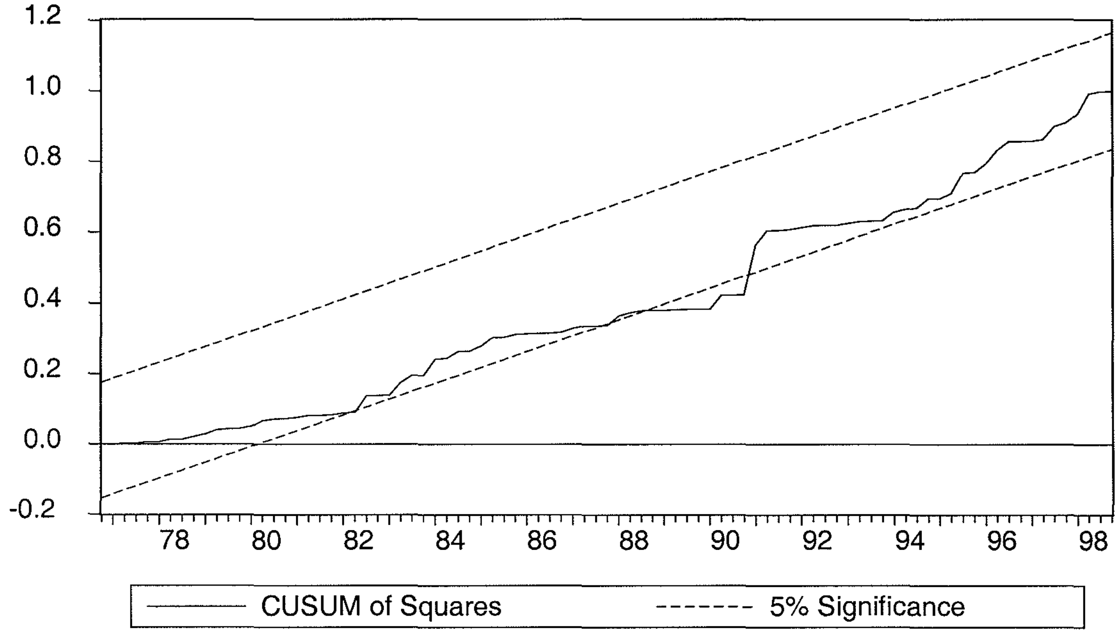


Diagram 3: CUSUMSQR tests

BDsa is the dependent variable.



CADsa is the dependent variable.



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