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Keywords

Application, Cointegration, Techniques, Export, GDP, Nexus, Iran

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AN APPLICATION OF THE NEW COINTEGRATION TECHNIQUES IN EXPORT-GDP NEXUS IN IRAN

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Abstract

This paper examines the major determinants of GDP growth in Iran using annual time series data spanning from 1960 to 2003. The Iranian economy has been subject to a multitude of structural changes and regime shifts during the sample period. Thus, time series properties of the data are first analysed by Perron's Innovational outlier (IO) and additive outlier (AO) models. The empirical results based on both IO and AO models indicate that there is not enough evidence against the null hypothesis of unit roots for all of the variables under investigation. The resulting endogenously determined structural breaks coincide with the important phenomena in the economy such as the 1979 Islamic revolution, and the Iran-Iraq war beginning in 1980. Then, the Saikkonen and Luetkepohl (2000) cointegration approach are employed to determine the long-run drivers of economic growth in the presence of structural breaks. This new cointegration technique accommodates potential structural breaks, which could undermine the existence of a long-run relationship between GDP growth and its main determinants. Finally, an ARDL methodology is employed to obtain the short and long-term determinants of economic growth. The results show that while the effects of gross capital formation and oil exports are highly significant, as expected, non-oil exports and human capital have an even smaller effect than had been anticipated.

JEL classification numbers: C12, C22, C52.

Key words: structural break, unit root tests, cointegration technique, and Iranian economy.

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1. Introduction

When in the 1980s, export promotion policies in Asian Newly Industrialized Countries (NICs) led to remarkable economic growth, attention was placed on the linkage between exports and economic growth in other developing countries. Feder (1982), Balassa (1985) and Ghatak et al. (1997) suggested that export expansion might generate positive externality through more efficient allocation of resources, efficient management and improved production techniques, specialization, competition and the economy of scale. Hence various development theories have emerged in the literature suggesting that export expansion further accelerates economic growth due to the above-mentioned factors. This is referred to as the export-led growth (ELG) hypothesis.

Endogenous growth models make use of the same idea to analyze the broad externality effects of exports on the economy, but they address the role of imports as well. These models emphasize the fact that trade works as a conduit of knowledge spillover. In turn, this knowledge spillover enables the economy to achieve increasing returns, and human capital also has a role in increasing economic growth through the same knowledge spillover effect of trade (Sengupta, 1993). In fact, according to the endogenous growth theory factors such as: physical capital (R&D effects), human capital (representing knowledge spillover effects), exports expansion (proxying positive externality effects), and capital and intermediate imports (capturing learning-by-doing effects) are the major determiners of economic growth.

Following empirical studies of the sources of growth by such researchers as Ram(1987), Salehi (1991), Sengupta (1993), Van Den Berg (1997), and Ibrahim and MacPhee (2003) and which have followed the Feder (1982) model, we include export in the typical production function. In addition, like Salehi and Ven Den Berg, we include total imports as a new factor in the following equations. According to Salehi, by providing better quality inputs, capital and

intermediate imports may affect productivity. This model is a kind of production function, which is augmented by the addition of trade factors, exports (X) and imports (M):²

$$y=F(K, L, X, M) \quad (1)$$

It should be noted that in Feder-type models, GDP is considered to be simply a function of ordinary labour force growth together with other relevant factors. We follow the endogenous growth theory and consider instead, human capital (the number of employed workforce with a university degree) rather than the total labour force in our empirical models. The following modified Feder-Salehi model in logarithm form is used to examine the trade-growth nexus in an oil- based economy like Iran:

$$Ly_t = \beta_0 + \beta_1 Lk_t + \beta_2 Lhc_t + \beta_3 Lxo_t + \beta_4 Lxno_t + \beta_5 Lm_t + e_t \quad (2)$$

Here the possible effects of exports on economic growth have been disaggregated into oil (xo) and non-oil (xno). The data are expressed in 1997 constant prices and have been collected from the Central Bank of Iran, and the International Financial Statistics (IFS). In the above equation (2), y denotes real GDP, k is gross capital formation, m is total real imports and hc is human capital (represented in this research by the number of employed persons with a tertiary education). In this equation, oil and non-oil exports are shown by xo and xno , respectively.

The structure of the rest of the paper is as follows. Section 2 explains and applies unit root test based on the Perron (1997) Innovational and additive outlier models, which take into account the existence of potential structural breaks in the data. Section 3 discusses the results of cointegration analysis in the presence of pre-determined structural breaks using the Saikkonen and Lutkepohl (2000) approach. Finally, section 4 presents ARDL testing procedures followed by some concluding remarks in section 5.

² For detailed specifications of this model see (Pahlavani, 2005)

2. Unit Roots Tests with Structural Break

The issue of structural break is of considerable importance in the analysis of macroeconomic time series. Such breaks occur in many time series for any number of reasons and this makes it difficult to test the null hypothesis of structural stability against the alternative of a one-time structural break. When present in the data generating process, but not allowed for in the specification of an econometric model, results may be biased towards the erroneous non-rejection of the non-stationarity hypothesis (Perron 1989; Perron 1997; Leybourne and Newbold; 2003). Peron (1989, 1994, 1997) and Zivot-Andrews (1992) attempt to overcome this difficulty. In the following section, The Perron (1997) methodology for testing the unit root hypothesis in the presence of structural break is explained and then this method is applied for the variables under investigation.

2.1 Innovational Outlier Models (IO)

According to Perron (1997), the IO1 model allows for gradual changes in the intercept and the IO2 model accommodates gradual changes in both the intercept and the slope of the trend function, such that:

$$\text{IO1: } x_t = \mu + \theta DU_t + \beta t + \delta D(T_b)_t + \alpha x_{t-1} + \sum_{i=1}^k c_i \Delta x_{t-i} + e_t \quad (3)$$

$$\text{IO2: } x_t = \mu + \theta DU_t + \beta t + \gamma DT_t + \delta D(T_b)_t + \alpha x_{t-1} + \sum_{i=1}^k c_i \Delta x_{t-i} + e_t \quad (4)$$

where T_b denotes the time of break ($1 < T_b < T$) which is unknown, $DU_t = 1$ if $t > T_b$ and zero otherwise, $DT_t = T_t$ if $t > T_b$ and zero elsewhere, $D(T_b)_t = 1$ if $t = T_b + 1$ and zero otherwise, x_t is any general ARMA process and e_t is the residual term assumed white noise. The null hypothesis of a unit root is rejected if the absolute value of the t -statistic for testing $\alpha = 1$ is greater than the corresponding critical value. Perron (1997) suggests that T_b (the time of structural break) can be determined by two methods. In the first approach, equations (1) or (2) are sequentially estimated assuming different T_b with T_b chosen to minimize the t -ratio for $\alpha = 1$. In the second approach, T_b is chosen from among all other possible break point values to minimize the t -ratio on the estimated slope coefficient (γ)

The truncation lag parameter or k is determined using the data-dependent method proposed by Perron (1997). In this the choice of k depends upon whether the t -ratio on the coefficient associated with the last lag in the estimated autoregression is significant. The optimum k (or

k^*) is selected such that the coefficient on the last lag in an autoregression of order k^* is significant and that the last coefficient in an autoregression of order greater than k^* is insignificant, up to a maximum order k (Perron, 1997). With quarterly data, $k_{\max} = 8$ (Lumsdaine and Papell, 1997). The IO2 model allowing for a change in both the intercept and slope is also specified.

2.2. Additive Outlier Model (AO)

In contrast to the gradual change in the IO model, the AO model assumes structural changes take place instantaneously. Testing for a unit root in the AO framework is then given by a two-step procedure (Perron, 1994). To start with, the trend is removed from the series:

$$y_t = \mu + \beta t + \gamma DT_t + \tilde{y}_t \quad (5)$$

where \tilde{y}_t is the detrended series. Since equation (5) assumes that a structural break only impacts on the slope coefficient, the following is then estimated to test for a change in the slope coefficient:

$$\tilde{y}_t = \alpha \tilde{y}_{t-1} + \sum_{i=1}^K c_i \Delta y_{t-i} + e_t \quad (6)$$

Similarly to the IO methodology, these equations are estimated sequentially for all possible values of T_b ($T_b = k + 2, \dots, T-1$) where T is the total number of observations so as to minimise the t -statistic for $\alpha = 1$. The lag length is data-determined using the general to specific, and the break date is assumed to be unknown and endogenously determined by the data. The null hypothesis is rejected if the t -statistic for α is larger in absolute value than the corresponding critical value. An alternative, which is more widely used is to select T_b as the value, over all possible break dates, that minimizes (or maximizes) the value of the t -statistic on $\gamma=0$ (Harris and Sollis 2003). This approach has been used in this study. Empirical result based on the IO and AO model are reported in table 1 and 2.

[Table 1 and 2 about here]

As can be seen from table 2, empirical result reveals that innovational outlier (IO) models provide no evidence against unit root hypothesis in the presences of structural break. Using the IO model proposed by Perron (1997), the general break dates obtained correspond closely with the expected dates associated with the effects of the 1979 revolution and the gradual effect of the Iran-Iraq war beginning in 1980. The results based on this model reveal that applying the (AO) method strengthens our finding based on the (IO) model. Applying the (AO) model, we could not find enough evidence against the null hypothesis of unit root for all of the variables under this analysis, (at 5 percent level or better). Moreover, the results of the

(AO) method show that most of the break dates occur in the late seventies and early and mid eighties. These dates can be associated with and the effect of revolution in 1979 and war with Iraq beginning in 1980 and finally the oil crash in 1986. The last date shows the huge oil price decline, which had a negative effect on the Iranian economy since it is a major oil exporting country.

3. Cointegration Analysis with Structural Breaks

As had been noted as far back as 1989 by Perron, ignoring the issue of potential structural breaks can render invalid the statistical results not only of unit root tests but of cointegration tests as well. Kunitomo (1996) explains that in the presence of a structural change, traditional cointegration tests, which do not allow for this, may produce “spurious cointegration”. In the present research, therefore, considering the effects of potential structural breaks is very important, especially because the Iranian economy has been faced with structural breaks like revolution and war in addition to some policy changes.

Saikkonen and Lütkepohl (2000a, b, c) have proposed a test for cointegration analysis that allows for possible shifts in the mean of the data-generating process. Because many standard types of data generating processes exhibit breaks caused by exogenous events that have occurred during the observation period, they suggest that it is necessary to take into account the level shift in the series for proper inference regarding the cointegrating rank of the system. They argued that “structural breaks can distort standard inference procedures substantially and, hence, it is necessary to make appropriate adjustment if structural shifts are known to have occurred or are suspected” (2000b: 451).

The Saikkonen and Lütkepohl (SL) test investigates the consequences of structural breaks in a system context based on the multiple equation frameworks of Johansen-Jeslius, while earlier approaches like Gregory-Hansen (1996) considered structural break in a single equation framework and others did not consider the potential for structural breaks at all. According to Saikkonen and Lütkepohl (2000b) and Lütkepohl and Wolters (2003), an observed n -dimensional time series $y_t = (y_{1t}, \dots, y_{nt})$, y_t is the vector of observed variables ($t=1, \dots, T$) which are generated by the following process:

$$y_t = \mu_0 + \mu_1 t + \gamma_1 d_{1t} + \gamma_2 d_{2t} + \gamma_3 d_{3t} + \delta Dt_{0t} + \delta_2 Du_{1t} + x_t \quad (7)$$

Where Dt_{0t} and Du_{1t} are impulse and shift dummies, respectively, and account for the existence of structural breaks. Dt_{0t} is equal to one, when $t=T_0$, and equal to zero otherwise. Step (shift) dummy (Du_{1t}) is equal to one when $(t>T_1)$, and is equal to zero otherwise. The parameters γ_i ($i=1,2,3$), μ_0 , μ_1 , and δ are associated with the deterministic terms. The seasonal dummy variables d_{1t} , d_{2t} , and d_{3t} are not relevant to this research since our data are yearly. According to SL (2000b), the term x_t is an unobservable error process that is assumed to have a VAR (p) representation as follows:

$$x_t = A_1 x_{t-1} + \dots + A_p x_{t-p} + \varepsilon_t \quad t=1,2, \quad (8)$$

By subtracting x_{t-1} from both sides of the above equation and rearranging the terms, the usual error correction form of the above equation is given by:

$$\Delta x_t = \Pi x_{t-1} + \sum_{j=1}^{p-1} \Gamma_j \Delta x_{t-j} + u_t \quad (9)$$

This equation specifies the cointegration properties of the system. In this equation, u_t is a vector white noise process; $x_t = y_t - Dt$ and Dt are the estimated deterministic trends. The rank of Π is the cointegrating rank of x_t and hence of y_t (SL, 2000b).

The possible options in the SL procedure, as in Johansen, are three: a constant, a linear trend term, or a linear trend orthogonal to the cointegration relations. In this methodology, the critical values depend on the kind of the above-mentioned deterministic trend that included in the model. More interestingly, in SL, the critical values remain valid even if dummy variables are included in the model, while in the Johansen test; the critical values are available only if there is no shift dummy variable in the model. The SL approach can be adopted with any number of (linearly independent) dummies in the model. It is also possible to exclude the trend term from the model; that is, $\mu=0$ maybe assumed *a priori*. In this methodology, as in Johansen's, the model selection criteria (SBC, AIC, and HQ) are available for making the decision on the VAR order. In the following section, we have applied SL tests for the cointegration rank of a system in the presence of structural breaks.

3.1 Empirical Results based on the SL Procedures

As explained above Saikkonen and Lütkepohl (2000b) derived the likelihood ratio (LR) test in order to determine the number of cointegrating relations in a system of variables, by considering for the presence of the potential structural breaks. We now apply a maximum likelihood approach; based on SL; for testing and determining the long-run relationship in the model under investigation. As mentioned earlier, in this procedure SL assumed that the break point is known a priori. In the last section, we determined the time of the break endogenously by Perron (1997) procedures. The empirical result based on this method showed that the most significant break for variables of under investigation are consistent with time of revolution and Iraqi-war. Therefore, at this stage we include two dummies variable of regime change (revolution in 1979) and Iraqi war; beginning in 1980; in order to take into account the structural breaks in the system. Since there is no lag structure for the dummy series, these two dummies are included in the system, but not in the cointegration space. For this reason, the dummy result is not present in the cointegration results. Following the SL procedure we consider three cases: impulse dummy and shift with intercept included; impulse dummy and shift with trend and intercept included; and finally, impulse dummy and shift with a trend statistically independent (orthogonal) to cointegration relation included. The cointegration results in these three cases are presented in tables (3) the optimal number of lags is determined by SBC, which is more appropriate for the short span of the data. The hypothesis of the long-run relationship among non-stationary variables is tested and the result is reported in table (3). These tables indicates that the hypothesis of no cointegration ($r=0$) is rejected at the 5% significance level and the existence of one cointegration vector is not rejected in any of the three cases mentioned above.

(Table 3 about here)

4. The ARDL Cointegration Approach

The autoregressive distributed lag (ARDL) approach is a more statistically significant approach for determining cointegrating relationships in small samples, while the Johansen cointegration techniques require larger samples for the results to be valid (Ghatak and Siddiki, 2001). A further advantage of the ARDL is that while other cointegration techniques require all of the regressors to be integrated of the same order; the ARDL can be applied irrespective of their order of integration. It thus avoids the pre-testing problems associated with standard cointegration tests (Pesaran *et al.*, 2001). The error correction representation of the ARDL model is as follows:

$$\begin{aligned} \Delta \ln y = & \alpha_0 + \sum_{j=1}^n b_j \Delta \ln y_{t-j} + \sum_{j=0}^n c_j \Delta \ln k_{t-j} + \sum_{j=0}^n d_j \Delta \ln lhc_{t-j} + \sum_{j=0}^n e_j \Delta \ln xo_{t-j} + \sum_{j=0}^n f_j \Delta \ln xno_{t-j} \\ & + \sum_{j=0}^n g_j \Delta \ln m_{t-j} + \delta_1 \ln y_{t-1} + \delta_2 \ln k_{t-1} + \delta_3 \ln lhc_{t-1} + \delta_4 \ln xo_{t-1} + \delta_5 \ln xno_{t-1} + \delta_6 \ln m_{t-1} + \varepsilon_{1t} \end{aligned} \quad (10)$$

The parameter δ_i , where $i=1,2,3,4,5,6$ is the corresponding long-run multipliers, while the parameters $b_j, c_j, d_j, e_j, f_j, g_j$, are the short-run dynamic coefficients of the underlying ARDL model. The null hypothesis (*i.e.* $H_0: \delta_1 = \delta_2 = \delta_3 = \delta_4 = \delta_5 = \delta_6 = 0$, implying no cointegration) in the first step is tested by computing a general F-statistic using all the variables appearing in log levels. To begin with, one has to estimate equation (10) excluding the ECM. This term is subsequently incorporated into the ARDL model. At this stage, the calculated F-statistic is compared with the critical value tabulated by Pesaran *et al.* (2001). The null hypothesis of no cointegration will be rejected if the calculated F-statistic is greater than the upper bound. If the computed F-statistic falls below the lower bound, then the null hypothesis of no cointegration cannot be rejected. Finally, the result is inconclusive if it is between the lower and the upper bound. In such an inconclusive case an efficient way of establishing cointegration is by applying the ECM version of the ARDL model (Bahmani-Oskooee and Nasir, 2004).

Empirical results show that the null hypothesis of no cointegration cannot be rejected and the possibility of a long-term relationship exists if and only if Ly appears as a dependent variable followed by its 'forcing variables' (i.e. Lxo , $Lxno$, Lm , Lk , and Lhc).

Next we estimate the long-run coefficients of the ARDL model. One of the more important issues in applying ARDL is choosing the order of the distributed lag function. Pesaran and Smith (1998) argue that the SBC should be used in preference to other model specification criteria because it often has more parsimonious specifications: the small data sample in the current study further reinforces this point. The optimal number of lags for each of the variables is shown as ARDL (1,2,0,2,1,1). Table 4 shows the long-run coefficients of the variables under investigation.

(Table 4 about here)

The empirical results reveal that in the long run, even a one percent increase in physical capital leads to a 0.55 percent increase in GDP. While, a one percent increase in human capital leads to a 0.02 percent rise in GDP. This indicates that human capital in Iran does not have a substantial or statistically significant effect on GDP. Similarly, a one percent increase in oil exports leads to a 0.37 percent increase in GDP. Moreover, empirical results in Table 3 show that a one percent increase in non-oil exports leads to 0.036 percent increases in GDP. It is obvious that non-oil exports have an effect on the Iranian economy which, though statistically significant, is less so than expected. It is the oil sector which still generates the bulk of total exports (petrodollars) and acts as the leading sector of the economy. After estimating the long-term coefficients, we obtain the error correction representation of the ARDL model. Table 3 reports also the short-run coefficient estimates obtained from the ECM version of the ARDL model.

The error correction term indicates the speed of the equilibrium restoring adjustment in the dynamic model. The ECM coefficient shows how quickly/slowly variables return to equilibrium and it should have a statistically significant coefficient with a negative sign. Bannerjee *et al.* (1998) holds that a highly significant error correction term is further proof of the existence of a stable long-term relationship. Table 3 shows that the expected negative sign

of the ECM is highly significant. The estimated coefficient of the ECM (-1) is equal to -0.60, suggesting that deviation from the long-term GDP path is corrected by 0.60 percent over the following year. This means that the adjustment takes place relatively quickly. Figure 1 represents the forecasting errors and the plots of the actual and forecast values. The graphical evidence presented in Figure 1 indicates the estimated model tracks the historical data very well.

(Figure 1 and 2 about here)

Diagnostic tests for serial correlation, functional form, normality, heteroscedasticity, and structural stability of the model show that there is no evidence of autocorrelation and that the model passes the test for normality. In addition, when analysing the stability of the long-run coefficients together with the short-run dynamics, the cumulative sum (CUSUM) and the cumulative sum of squares (CUSUMQ) point to the in-sample stability of the model (see CUSUM and CUSUMQ in Figure 2).

5. Conclusion

The objective of this paper was to examine the long-run determinants of GDP in Iran during the period 1960-2003 employing the Saikkonen and Lutkepohl (2000) cointegration method. Prior to the cointegration analysis, Perron (1997) test was applied in order to endogenously determine the most significant structural breaks in the major drivers of economic growth, *viz.*, physical and human capital exports and imports. The empirical results based on the Perron model indicate that we cannot find enough evidence against the null hypothesis of unit root for all of the variables under investigation. Moreover, we found that the most significant structural breaks over the last forty years occurred as a result of the political regime change in 1979 and the outbreak of eight years war with Iraq beginning in 1980. These results provide complementary evidence to models employing exogenously imposed structural breaks in the Iranian macroeconomy.

Then, we employed the Saikkonen and Lutkepohl (2000) cointegration approach to determine the long-run factors contributing to economic growth in Iran. It is important to use

this approach in our cointegration test as during the sample period, the Iranian economy has been subject to serious structural breaks such as: the upheavals of the 1979 Islamic Revolution and the Iran/Iraq war beginning in 1980, among others. In the presence of such structural breaks, the SL cointegration tests conducted in this paper indicate that there is one cointegrating vector which links GDP with physical and human capital, imports and exports(oil and non-oil).

Applying the ECM version of the ARDL model shows that the error correction coefficient, which determines the speed of adjustment, has an expected and highly significant negative sign. The results indicate that deviation from the long-term growth rate in GDP is corrected by approximately 60 percent in the following year. The estimated model passes a battery of diagnostic tests and the graphical evidence (CUSUM and CUSUMQ graphs) indicate that the model is fairly stable during the sample period. Finally, the estimated long-term coefficients show that while the effects of gross capital formation and oil exports are highly significant and impact strongly on GDP, those of the non-oil exports and human capital remain even less substantial than previously expected.

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Table 1. Innovational Outlier Model For Determining The Break Date In Intercept (IO1) Or Both Intercept And Slope (IO2)

Series	Model	Tb	K	$t_{\hat{\gamma}} \setminus t_{\hat{\delta}}$	$t_{\hat{\alpha}}$	Result
LY	IO1	1982	2	-3.52	-4.42	Unit root
LYno	IO1	1982	3	-3.82	-6.78	Stationary
LX	IO2	1980	8	4.92	-2.29	Unit root
LIM	IO1	1982	1	-1.35	-3.78	Unit root
LK	IO1	1982	4	-3.21	-4.20	Unit root

Note: critical value at 1%, 5% and 10% are equal to -5.92, -5.23 and -4.92 respectively for IO2 and For IO1 model, critical value at 1%, 5% and 10% are equal to -6.07, -5.33 and -4.94 respectively. The innovational outlier model (IO2) allows for breaks in both intercept and slope., while(IO1)allows for break just in intercept. In these methodologies, changes are assumed to occur gradually

Table 2. Additive Outlier Model (AO) For Determining The Time Of The Break

Series	TB	K	$\hat{\eta}$	$t_{\hat{\gamma}}$	$t_{\hat{\alpha}}$	Result
LY	1979	1	-0.03	-3.093	-2.5348	Unit root
LYno	1981	7	-0.05	-9.33	-2.4597	Unit root
LX	1979	0	-0.23	-7.11	-2.9072	Unit root
LIM	1980	1	-0.15	-7.22	-3.6841	Unit root
LK	1980	1	-0.08	-4.74	-3.6143	Unit root

Note: critical value at 1%, 5% and 10% are equal to -5.38, -4.67 and -4.36 respectively
The additive outlier model (AO) allows for a break in the slope and in this methodology, changes are assumed to occur rapidly. Tb is selected as the value, which minimizes the absolute value of the t-statistic on the parameter associated with change in slope in (AO) model.

Table 3. Saikkonen and Lutkepohl cointegration test results

Intercept included (C)						Intercept and trend included (C/T)						Trend orthogonal to cointegration relation (C/O)					
r0	LR	p-value	90%	95%	99%	r0	LR	p-value	90%	95%	99%	r0	LR	p-value	90%	95%	99%
0	96.92*	0.0036	79.51	83.80	92.26	0	104.77*	0.0031	86.64	90.95	99.40	0	97.10 *	0.0006	73.31	77.41	85.50
1	53.71	0.1545	56.28	59.95	67.24	1	63.60	0.0812	62.45	66.13	73.42	1	50.59	0.1101	51.10	54.59	61.53
2	39.90	0.0522	37.04	40.07	46.20	2	33.19	0.4630	42.25	45.32	51.45	2	47.81	0.0014	32.89	35.76	41.58
3	15.25	0.4437	21.76	24.16	29.11	3	23.32	0.1988	26.07	28.52	33.50	3	24.10	0.0177	18.67	20.96	25.71
4	7.05	0.3248	10.47	12.26	16.10	4	10.07	0.3319	13.88	15.76	19.71	4	9.20	0.0656	8.18	9.84	13.48

Note: * Indicates that the corresponding null hypothesis is rejected at 5% level. Critical values are tabulated by SL (2000b). The optimal number of lags (searched up to 4 lags) is determined by the SBC.

Table 4. Estimated long-run coefficients and short-run error correction model (ECM)

The long-run coefficients results ARDL (1,2,0,2,1,1)			ECM-ARDL: dependent variable: ΔLY		
Regressor	Coefficient	t-Ratio[Prob]	Regressor	Coefficient	Coefficient
Lk_t	0.5551	16.240[.000]	ΔLk_t	0.293	8.055[.000]
Lhc_t	0.0205	1.4227[.167]	ΔLk_{t-1}	-0.079	-2.516[.017]
Lxo_t	0.3725	8.9805[.000]	ΔLhc_t	0.012	1.397[.173]
$Lxno_t$	0.0368	3.0845[.005]	ΔLxo_t	0.245	12.018[.000]
Lm_t	-0.1348	-6.0801[.000]	ΔLxo_{t-1}	-0.071	-3.827[.001]
<i>Intercept</i>	1.2093	12.652[.000]	$\Delta Lxno_t$	-0.004	-.4933[.625]
<i>D79</i>	0.0978	5.0622[.000]	ΔLm_t	-0.018	-0.838[.409]
<i>DU80</i>	0.1870	10.6545[.000]	<i>Intercept</i>	0.727	5.037[.000]
			<i>D79</i>	0.058	5.048[.000]
			<i>DU80</i>	0.112	6.253[.000]
			ECM_{t-1}	-0.601	-6.360[.000]
			$\bar{R}^2 = .92822$ F(10, 30) 53.1224[.000]		

Note: The SBC is used to select the optimum number of lag in the ARDL model.

Figure 1. Plots of the actual and forecasted values for the level of LY and change in LY

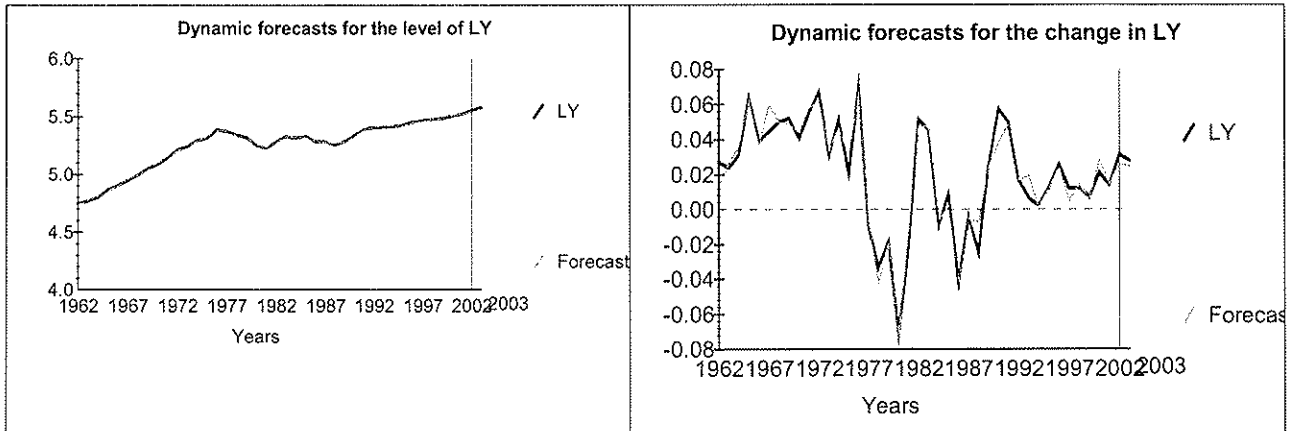


Figure 2. Plots of CUSUM and CUSUMQ statistics for coefficients Stability Tests

