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Technique in the Presence of Structural Breaks**

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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 Zivot-Andrews (1992) model. The empirical results based on this model indicate that there is not enough evidence against the null hypothesis of unit roots for all of the variables under investigation. Taking into account the resulting endogenously determined structural breaks; the Saikkonen and Luetkepohl (2000) cointegration approach is then employed to determine the long-run drivers of economic growth. This cointegration technique accommodates potential structural breaks that could undermine the existence of a long-run relationship between GDP growth and its main determinants. Empirical estimates indicate that in the long-term, policies aimed at promoting various types of physical investment, human capital, trade openness and technological innovations will improve economic growth.

JEL classification numbers: C12, C22, C52.

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

I. 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):¹

$$Y=F(K, L, X, M) \tag{1}$$

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

¹ For detailed specifications of this model, see Pahlavani (2005).

modified Feder-Salehi model in logarithm form is used to examine the trade-growth nexus in an oil- based economy like Iran:

$$Ly_t = \beta_0 + \beta_1 Lk_t + \beta_2 Lhc_t + \beta_3 Lx_o_t + \beta_4 Lx_{no}_t + \beta_5 Lm_t + e_t \quad (2)$$

Here the possible effects of exports on economic growth have been disaggregated into oil (x_o) and non-oil (x_{no}). 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 x_o and x_{no} , respectively.

The structure of the rest of the paper is as follows. Section II explains and applies unit root test based on the Zivot-Andrews (1992) model, which take into account the existence of potential structural breaks in the data. Section III discusses the results of cointegration analysis in the presence of pre-determined structural breaks using the Saikkonen and Lutkepohl (2000) approach. Finally, section IV presents some concluding remarks.

II. 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). Perron (1989, 1994, 1997) and Zivot-Andrews (1992) attempt to overcome this difficulty. In the following section, The Zivot-Andrews 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.

Zivot-Andrews unit root test with structural break

Zivot and Andrews (ZA, 1992) propose a variation of Perron's (1989) original test in which the time of the break is estimated, rather than known as an exogenous phenomenon. The null hypothesis in their method is that the variable under investigation contains a unit-root with a drift that excludes any structural break, while the alternative hypothesis is that the series is a trend stationary process with a one-time break occurring at an unknown point in time. By endogenously determining the time of structural breaks, ZA argue that the results of the unit root hypothesis previously suggested by earlier conventional tests such as the ADF test may change.

In this methodology, TB (the time of break) is chosen to minimize the one-sided t -statistic of $\alpha=1$. In other words, a break point is selected which is the least favorable to the null hypothesis. The ZA model endogenises one structural break in a series (such as y_t) as follows:

$$H0: \quad y_t = \mu + y_{t-1} + e_t \quad (3)$$

$$H1: \quad \Delta y_t = \mu + \beta t + \theta DU1_t + \gamma DT1_t + \alpha y_{t-1} + \sum_{i=1}^k c_i \Delta y_{t-i} + \varepsilon_t \quad (4)$$

Equation (4), which is referred to as model C by ZA, accommodates the possibility of a change in the intercept as well as a trend break. ZA also consider two other alternatives where a structural break impacts on the intercept only (model A) or trend only (model B). Model C is the least restrictive compared to the other two models; we thus base our empirical investigation on this model. In equation (4) DUI_t is a sustained dummy variable capturing a shift in the intercept, and DTI_t is another dummy variable representing a shift in the trend occurring at time TBI . The alternative hypothesis is that the series, y_t , is $I(0)$ with one structural break. TB is the break date, and the dummy variables are defined as follows:

$$DU1_t = \begin{cases} 1 & \text{if } t > TB1 \\ 0 & \text{if } t \leq TB1 \end{cases} \quad \text{and} \quad DT1_t = \begin{cases} t - TB1 & \text{if } t > TB1 \\ 0 & \text{if } t \leq TB1 \end{cases}$$

The null is rejected if the α coefficient is statistically significant. The optimal lag length is determined on the basis of the t-test or SBC. The “trimming region” where we search for the minimum t-ratio is assumed to be within 0.05T-0.95T or $0.05T \leq TB1 \leq 0.95T$.

Based on the results reported in Tables 1 and 2, the primary findings of the analysis are as follows. First, the results of the ZA models indicate that all series under investigation are non-stationary. Pahlavani (2005) employs the Innovational Outlier (IO) and Additive Outlier (AO) models and yearly data on the same Iranian macroeconomic series and the empirical results similarly do not provide any evidence against the null hypotheses of unit roots in all series.²

Second, the timing of any structural break (T_b) for each series using the ZA approach is also shown in Table 1. The computed break dates correspond closely with the expected dates associated with the effects of the oil boom in 1974, the Islamic revolution in 1979 and the effects of the Iran-Iraq war beginning in 1980. Third, the reported t statistics in Table 1 for μ , β , θ , γ , and a are significant in the majority of cases. Given the fact that all of the estimated coefficients for the indicator and trend dummy variables are statistically significant (in four out of six series for both intercept and trend and in the other remaining two series only for the intercept), one can argue that the estimated structural break dates are indeed statistically significant.

[Tables 1 about here]

III. 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

² We also applied conventional unit root tests (i.e. ADF and Philips and Perron) and found that all of the variables of under investigation are non-stationary at log level. These results are not reported here but are available from the authors upon request.

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:

$$y_t = \mu_0 + \mu_1 t + \gamma_1 d_{1t} + \gamma_2 d_{2t} + \gamma_3 d_{3t} + \delta DT_{0t} + \delta DU_{1t} + x_t \quad (5)$$

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:

$$x_t = A_1 x_{t-1} + \dots + A_p x_{t-p} + \varepsilon_t \quad t=1,2 \quad (6)$$

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:

$$\Delta x_t = \Pi x_{t-1} + \sum_{j=1}^{p-1} \Gamma_j \Delta x_{t-j} + u_t \quad (7)$$

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.

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 allowing for the presence of 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 Zivot-Andrews (1992) procedure. 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 dummy variables 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 (2) 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 (2). 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 2 about here)

IV. 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, the Zivot-Andrews (1992) 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 ZA 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.

Finally, 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. These cointegration test results also remain robust despite disaggregating exports into the two categories of oil and non-oil exports.

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Table 1. The Zivot-Andrews test results: break in both intercept and trend

(model C) $\Delta y_t = \mu + \beta t + \theta DU_{1t} + \gamma DT_{1t} + \alpha y_{t-1} + \sum_{i=1}^k c_i \Delta y_{t-i} + \varepsilon_t$

Variable	TB1	μ	β	θ	γ	α	k	Possible causes for TBs
<i>Ln (Y)</i>	1979	1.280 (3.91)	0.014 (3.92)	-0.072 (-4.95)	-0.009 (-3.32)	-0.277 (-3.84)	1	The 1979 Islamic revolution
<i>Ln (X)</i>	1980	1.849 (4.78)	0.017 (2.76)	-0.311 (-4.06)	-0.008 (-1.37)	-0.432 (-4.65)	1	Beginning of the war with Iraq
<i>Ln (Xo)</i>	1980	2.14 (5.06)	0.021 (2.97)	-0.336 (-4.20)	-0.014 (-2.02)	-0.504 (-4.93)	1	Beginning of the war with Iraq
<i>Ln (Xno)</i>	1980	1.362 (3.97)	0.024 (2.63)	-0.432 (-3.27)	0.01 (0.76)	-0.456 (-3.92)	0	Beginning of the war with Iraq
<i>Ln (M)</i>	1974	1.919 (4.48)	0.035 (3.73)	0.157 (2.58)	0.0395 (-3.82)	-0.519 (-4.49)	1	The 1973-74 Oil shock
<i>Ln (K)</i>	1979	1.841 (3.96)	0.029 (3.42)	-0.152 (-3.09)	-0.024 (-3.02)	-0.471 (-3.85)	1	The 1979 Islamic revolution

Notes: (a) Critical values at 1 and 5 percent levels are -5.57 and -5.08, respectively (Zivot and Andrews, 1992). (b) All variables under investigation contain unit root.

Table 2. 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.