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Keywords
structural break, unit root test, Iranian economy.

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Structural Changes in the Iranian Economy: An Empirical Analysis with Endogenously Determined Breaks

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Abstract

This paper employs annual time series data (1960-2003) and the ZA (Zivot and Andrews, 1992) and the LP (Lumsdaine and Papell, 1997) approaches to determine endogenously the more likely time of major structural breaks in various macroeconomic variables of the Iranian economy. We have considered the presence of one and two unknown structural breaks in the data. The results obtained from these two approaches are consistent in that the time of one structural break in eight out of the ten variables examined in the paper is the same. The resulting structural breaks coincide with important phenomena in the economy such as the 1974 oil shock, the 1979 Islamic revolution, the Iraqi war or the implementation of the exchange rate unification policy in 1993 in the case of the official exchange rate.

JEL classification numbers: C12, C22, C52.

Key words: structural break, unit root test, Iranian economy.

I. INTRODUCTION

The Iranian economy has been subject to numerous shocks and regime shifts such as the 1974-75 oil shock, the upheavals consequential to the 1979 Islamic Revolution, the destructive eight-year (1980-1988) war with Iraq, the freezing of the country's foreign assets, a volatile international oil market, economic sanctions, and international economic isolation. In March 1993 the Iranian government embarked upon the exchange rate unification policy with consultation of the International Monetary Fund. The major objective of this policy was to unify the multiple exchange rate regime into a single equilibrium rate by the massive intervention of the Iranian Central Bank. In other words, almost every year there has been an unusual policy change and/or an external shock to the economy resulting in the occurrence of multitude of structural breaks in macroeconomic variables. Knowing the exact time of these structural breaks is of paramount importance in any empirical analysis. Discussion of the above-mentioned events is beyond the scope of this study. See, *inter alia*, Amuzegar (1992, 2000), Farzin (1995) and Pesaran (1995) for a detailed account of these issues.

Leybourne and Newbold (2003) argue that if structural breaks are not dealt with appropriately, the empirical results obtained from the use of cointegration techniques could be spurious and misleading. In the context of Iran, only a few studies considered the issue of structural breaks in the data. For example, Bahmani-Oskooee (1993) examined the presence of structural break associated with the 1979 revolution in the black market exchange rate and relative prices using the method proposed by Perron (1989). Bahmani-Oskooee (1993) assumed that the structural break occurred in 1979. Since it is highly likely that there could be more than one structural break in the data, it can be very difficult to introduce only one structural break to Perron's model. Therefore, we use two tests proposed by Zivot and Andrews (ZA, 1992) and Lumsdaine and Papell (LP, 1997) to examine the unit root hypothesis with one structural break and two structural breaks, respectively without imposing predetermined dates for structural breaks.

The objective of this paper is to identify major structural breaks in various macroeconomic variables of the Iranian economy using annual time series data (1960-2003). This analysis sheds some light on whether a particular break has an immediate or gradual effect on the series. For example if the results show that X has been subject to a structural break in 1975 and we also know that for sure that the oil shock occurred say in 1974, then one can conclude that X was affected gradually by this structural break. However, if the time of the break, according to the above tests, happened to be 1974 (*i.e.*

the same as actual shock), then one can support the immediate effect argument. The structure of the rest of the paper is as follows: Section II uses the ZA method to test the unit root hypothesis assuming one major unknown structural break. Following LP (1997) and Ben-David, Lumsdaine and Papell (2003), Section III reports the times of two data-dependent structural breaks, which are determined by a recursive, rolling or sequential approach, in each of the ten variables analysed in the paper. Section IV presents some concluding remarks.

II. ZIVOT AND ANDREWS UNIT ROOT TEST WITH ONE STRUCTURAL BREAK

As discussed earlier, many practitioners use the Augmented Dickey–Fuller (ADF) test to examine time series properties of the data. For the sake of comparison, the ADF regression is presented in the following equation:

$$\Delta y_t = \mu + \beta t + \alpha y_{t-1} + \sum_{j=1}^{k} c_j \Delta y_{t-j} + \varepsilon_t \qquad (1)$$

Where y_t is the time series being tested, t is a time trend variable, Δ denotes the first difference operator, and k is the number of lags which are added to the model to ensure that residuals, ε_t , are white noise. The Akaike Information Criterion (AIC) and the Schwartz Bayesian information criterion (BIC) are commonly used to determine the optimal lag length or k.

In order to examine the time series properties of data, we first use the ADF test during the period 1960-2003. As expected, the null hypothesis of a unit root in all ten variables cannot be rejected at the 10 percent significance level. The ADF test results are not reported but they are available from the authors upon request. Since macroeconomic variables in Iran could be subject to several structural breaks or regime shifts, the ADF test is considered biased towards not rejecting the unit root (especially with short time spans of data).

It is argued that the conventional unit root tests can have little power when the true data generating process of a broken linear trend is stationary. According to Perron (1989), failing to account for at least one time structural break in the trend function, may bias the usual unit root results towards their non-rejection of the null. In other words, tests such as the ADF test or the Phillips-Perron test may incorrectly indicate

that there is a unit root in a series, whereas in actual fact this series can be stationary around a one-time structural break (ZA, 1992).

It should be noted, however, that Perron (1989) applied his procedure assuming or visually detecting a particular year as the starting point for the structural break. The assumption of a known break is subject to a criticism as one may choose a particular date which conforms with his or her results by resorting to pre-testing and data-mining. Furthermore, a particular event may have occurred in time *t* but its gradual effects would not eventuate until subsequent years. New studies now endogenise the time of structural breaks. These procedures involve the estimation of the break point in an iterative process. ZA propose a variation of Perron's test in which the time of break is estimated rather than assumed 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 in the trend variable occurring at an unknown point in time. In this methodology, they run a regression for every possible break date sequentially. 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 be reversed.

In the rest of this section a brief description of the ZA approach is discussed followed by some empirical results. Their test is different from the usual unit root tests with respect to the treatment of the alternative hypothesis. The alternative hypothesis considered in the ZA method is more general and allows for shifts in the level or the growth rate of the series. In this methodology, *TB* (the time of break) is chosen to minimize the one-sided *t*-statistic of α=1 in equations 3 to 5 below or α_2=1 in equation 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:

$$y_t = \mu + y_{t-1} + e_t \qquad (2)$$

H1:

Model A

$$\Delta y_t = \mu + \beta t + \theta DU1_t + \alpha y_{t-1} + \sum_{j=1}^{k} c_i \Delta y_{t-j} + \varepsilon_t \qquad (3)$$

Model B

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

Model C

$$\Delta y_t = \mu + \beta t + \theta DU1_t + \gamma DT1_t + \alpha y_{t-1} + \sum_{j=1}^{k} c_i \Delta y_{t-j} + \varepsilon_t \quad (5)$$

As can be seen, Model A allows for a one-time change in the intercept. Model B is used to test for stationarity of the series around a broken trend and finally Model C accommodates the possibility of a change in the intercept as well as a broken trend. $DU1_t$ is a sustained dummy variable capturing a shift in the intercept, and $DT1_t$ is another dummy variable representing a shift in the trend occurring at time *TB1*. The alternative hypothesis is that the series, y_t, is I(0) with one structural break. *TB1* is the break date, and $DU1_t$ =1 if *t* > *TB1*, and zero otherwise, $DT1_t$ is equal to (*t-TB1*) if (t >*TB1*) and zero otherwise. The null is rejected if α coefficient is statistically significant.

More specifically, according to the ZA test *TB* is endogenously estimated by running the above three equations (models A, B and C) sequentially allowing for *TB* to be any year with the only exceptions being the first and last years. The optimal lag length is determined on the basis of the SBC and the most significant *t* ratio known as the general to specific approach. Both criteria in this paper generated similar results. Table 1 summarizes the result of the ZA test in the presence of only one structural break allowing for a change in both the intercept and trend (Model C). As mentioned earlier, the ADF test results reveal that all the ten variables examined in this paper were I(1), whereas the results of the ZA test show that of the ten variables three, *i.e. Ln(OER)*, *Ln(PC)* and *Ln(GFCF)* are stationary. The remaining seven variables still contain a unit root. Table 1 also shows that the corresponding time of structural break (*TB*) for each variable. The reported *TBs* are endogenously determined in the ZA testing procedure and presented in the third column of Table 1. It is interesting to note that the most significant structural break in these variables occurred in the war period 1980-1988. See *TBs* for *Ln(P) Ln(CPI)*, *Ln(GDP)*, *Ln(GC)* and *Ln(GFCF)*. The ZA test also provides empirical support that the break in *Ln(OER)* takes effect in 1993. As discussed earlier, we already know that in March 1993 the exchange rate unification policy was implemented by Iran's Central Bank. Thus, one can conclude that this policy

caused an immediate structural break in the official exchange rate. Table 1 also shows that the structural break in *Ln(BMER)* was in 1979 which coincided with the Islamic revolution of 1979 which led to the overthrow of the Shah and the House of Pahlavi. The Iranian rial in the black market has depreciated substantially since then and this phenomenon can be refereed to as a regime shift in the data. It also appears that the 1974-1975 oil shock created a major structural break in *Ln(IM)* and *Ln(PC)*. This oil boom in Iran (or an oil shock in the western countries) resulted in quadrupling petrodollars which in turn led to a sharp increase in both private consumption and the imports of goods and services.

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

Variable		*TB*	*K*	$t_{\hat{\alpha}}$	Inference	Correspond break time
Description	Symbol					
GDP price deflator	*Ln(P)*	1984	0	-3.36	Unit root	Middle of the war
Consumer price index	*Ln(CPI)*	1984	1	-3.61	Unit root	Middle of the war
Official exchange rate (Iranian rials per $US)	*Ln(OER)*	1993	0	-11.32*	Stationary	Launch of exchange rate unification policy
Real gross domestic Product	*Ln(GDP)*	1986	1	-4.63	Unit root	Middle of the war
Real private consumption	*Ln(PC)*	1974	0	-5.10**	Stationary	1974-75 oil shock
Real government consumption	*Ln(GC)*	1986	2	-3.89	Unit root	Middle of the war
Real gross fixed capital formation	*Ln(GFCF)*	1984	1	-4.87***	Stationary	Middle of the war
Real total exports	*Ln(TX)*	1980	0	-4.62	Unit root	Beginning of the war
Real total imports	*Ln(IM)*	1975	1	-4.08	Unit root	1974-75 oil shock
Black market exchange rate (Iranian rials per $US)	*Ln(BMER)*	1979	0	-4.04	Unit Root	1979 Islamic revolution

Notes: (1) Critical Values at 1, 5 and 10% levels are -5.57, -5.08 and -4.82, respectively (Zivot and Andrews, 1992). (2) *, ** and *** indicate that the corresponding null is rejected at 1, 5 and 10% levels, respectively.

Sources: The raw data for these 10 variables collected from World Bank (2004), Central Bank of Iran (2003), and Tabibian et al. (2000).

III. UNIT ROOT WITH TWO STRUCTURAL BREAKS

As noted earlier, the ZA test captures only one (the most significant) structural break in each variable. What if, there have been multiple structural breaks in a series? Considering only one endogenous break may not be sufficient and it could lead to a

loss of information particularly when in reality there are more than one break (LP, 1997). On this same issue, Ben-David *et al*. argued that "just as failure to allow one break can cause non-rejection of the unit root null by the Augmented –Dickey –Fuller test, failure to allow for two breaks, if they exist, can cause non-rejection of the unit root null by the tests which only incorporate one break" (2003: 304). LP introduced a new procedure to capture two structural breaks. They argued that a unit root test that account for two structural breaks is more powerful than those which allows for only one single break.

LP uses a modified version of ADF test which specifies two endogenous breaks as follows:

$$\Delta y_t = \mu + \beta t + \theta DU1_t + \gamma DT1_t + \omega DU2_t + \psi DT2_t + \alpha y_{t-1} + \sum_{j=1}^{K} c_i \Delta y_j + e_t \qquad (6)$$

Where $DU1_t$=1 if $t > TB1$ and otherwise zero; $DU2_t$=1 if $t > TB2$ and otherwise zero; $DT1_t = t\text{-}TB1$ if $t > TB1$ and otherwise zero; and finally $DT2_t = t\text{-}TB2$ if $t > TB2$ and otherwise zero.

Two structural breaks are allowed in both the time trend and the intercept which occur at *TB1* and *TB2*. The breaks in the intercept are shown in equation (6) by $DU1_t$ and $DU2_t$, respectively, whereas the slope changes (or shifts in the trend) are represented by $DT1_t$ and $DT2_t$.

The optimal lag length (*k*) is determined based on the general to specific approach suggested by Ng and Perron (1995). Table 2 presents the two most important structural breaks which affected the 10 macroeconomic variables of the Iranian economy using the procedure proposed by Lumsdaine and Papell (1997). In order to facilitate the cross-model comparison, the time of the most significant structural break in the data obtained by applying the ZA procedure (already reported in the third column of Table 1) is once again presented in the last column of Table 2. The results from both tests are quite consistent in identifying major structural breaks in the data. It is interesting to note that of ten variables examined in Table 2, the year in which structural break occurs in eight variables in the ZA test (TB) is exactly the same as that of either *TB1* or *TB2* in the LP test. These years have been highlighted in Table 2. Only the CPI and the GDP deflator show different years in relation to the occurrence

of breaks. However, as can be seen from Table 2, *TB1* or *TB2* in the LP test are very close to the *TBs* generated by the ZA approach for these two variables. [1]

Table 2. *Estimating the time of structural break in both the Lumsdaine and Papell test and the Zivot-Andrews test*

Variable		Lumsdaine and Papell test (two structural breaks)			*Zivot-Andrews test (one structural break)*
Description	Symbol	*TB1*	*TB2*	*t*-statistic for α	*TB*
GDP price deflator	*Ln(P)*	1969	1985	-5.058	1984
Consumer price index	*Ln(CPI)*	1986	1995	-4.839	1984
Official exchange rate (Iranian rials per $US)	*Ln(OER)*	1983	**1993**	-15.769*	**1993**
Real gross domestic Product	*Ln(GDP)*	1976	**1986**	-13.523*	**1986**
Real private consumption	*Ln(PC)*	**1974**	1986	-7.483*	**1974**
Real government consumption	*Ln(GC)*	1974	**1986**	-9.94*	**1986**
Real gross fixed capital formation	*Ln(GFCF)*	1975	**1984**	-8.449*	**1984**
Real total exports	*Ln(TX)*	1975	**1980**	-8.106*	**1980**
Real total imports	*Ln(IM)*	**1975**	1995	-6.344	**1975**
Black market exchange rate (Iranian rials per $US)	*Ln(BMER)*	**1979**	1990	-7.023*	**1979**

Note: (1) The critical values at 1, 5 and 10 % are –7.34, -6.82 and –6.49, respectively (Lumsdaine and Papell, 1997). (2) * indicates that the corresponding null is rejected at the 1% level.

IV. CONCLUSION

This paper uses annual time series data (1960-2003) to determine the most important years when structural break occurred in the ten macroeconomic variables in the Iranian economy. First, the Zivot and Andrews (1992) approach (ZA) is adopted to allow the data to determine the single most important structural break in each series. Then we have employed the Lumsdaine and Papell (1997) procedure (LP) to specify a model which accommodate two significant structural breaks in the data. The results from

[1] By considering more than one structural break in the data most of the conclusions on the time series properties of the data in the literature will be reversed. That is to say, the I(1) series such as the US GDP, becomes I(0). Similar results have also been obtained in this paper in that (a) the ADF test results indicate that all the 10 variables are I(1); (b) the ZA test results show that most (7 out of 10) variables are I(1); and finally based on the LP approach, most variables (8 out of 10) are I(0). These results are consistent with the results obtained by (LP, 1997) and Perron (1997) for other countries. These results are available from the authors on request.

these two tests are consistent as in most cases they pinpoint to the same year as the time of one of the structural breaks. In other words, the *TBs* generated by the ZA approach are the same as the estimated *TB1s* or *TB2s* based on the LP method. It seems that the most significant structural breaks in these variables occurred either in the war period 1980-1988 or in those years when a regime shift or a policy change or external factors, such as the 1974-75 oil shock, affected the economy. The paper determines the year(s) in which each variable was subject to a one or two major structural breaks. These interesting findings are not counter-intuitive.

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