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Structural breaks, unit roots and postwar slowdowns in Iranian economy

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STRUCTURAL BREAKS, UNIT ROOTS AND POSTWAR SLOWDOWNS IN IRANIAN ECONOMY

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Abstract

This paper employs annual time series data (1970-2003) using Perron (1997) approaches to determine endogenously the more likely time of major structural breaks in various macroeconomic variables of the Iranian economy. Several methodologies like Innovational Outlier model (IO) and Additive Outlier model (AO) have been conducted to re-examine the stationary of the Iranian macroeconomic time series data. The resulting structural breaks coincide with important phenomena in the economy such as the 1979 Islamic revolution, and the Iran-Iraq war beginning in 1980. Following Perron and others, this study provides some evidence on the unit root hypothesis in the presence of structural break in Iranian economy.

Keywords: Structural Break; Unit Root Test; Iranian Economy.

1. Introduction

It is argued that the usual 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 tests result towards nonrejection of unit root hypothesis. Since Perron's (1989) procedures assume the break point to be known a priori, subsequent studies have criticized the exogenous determination of the break dates. They developed methodologies for endogenising the time of the break. According to Zivot and Andrews (1992), using the endogenously determined structural breaks favours the rejection of the unit root hypothesis in some cases and weakens it in others. In the following section, firstly, the methodologies for testing the unit root hypothesis in the presence of structural break is explained and then these methods is applied for the variables of under investigation.

2. Unit Root Test in the Presence of Structural Change

It is well recognized that structural breaks have occurred in many economic time series due to an economic crisis, changes in institutional arrangements, war, etc. The majority of previous studies have failed to check for the structural break properties of the time series data. Using recent developments in time series studies, that is, a unit root test which takes into consideration structural change, several studies have been conducted to re-examine the stationarity of the macroeconomic time series variables. It is believed that the usual unit root tests can have little power when the true data generating process of a broken linear trend is stationary.

Perron (1989) introduced a way to determine the existence of a structural break in a series, which appears to be non-stationary. Perron's procedure enables us the use of the complete sample period at one time, rather than considering this period in two sub-samples. The null hypothesis in Perron methodology is the presence of a unit root against the alternative that the series is trending stationary. Perron showed theoretically that if the data generating process has "a kink or jump" in the deterministic

trend, a unit root test which did not consider this as a possibility, tended towards a bias for accepting the null hypothesis of unit root. He presented evidence that most economic time-series are trending stationary if one allows a single change in intercept. In his research he found that many of the variables that had previously been judged as non-stationary were actually stationary.

It should be noted, however, that Perron applied his procedure using a known date of the potential break. The assumption of a known break, which is treated as an exogenous event, raises the problem of pre-testing and data mining regarding the choice of the break date. Since Perron's (1989) procedures assume the break point to be known *a priori*, subsequent studies (e.g. Zivot and Andrews, 1992; Perron and Vogelsang, 1992; Perron, 1997) have criticized the exogenous determination of the break dates. They developed methodologies for endogenising the time of the break. These procedures incorporate the estimation of the break point and use sequential methods. For instance, taking issue with Perron's treatment of the oil price shock as an exogenous event, Zivot and Andrews (1992) argue that the date of the break should be treated as unknown. They point out that Perron's crash and trend break dates cannot be regarded as exogenous events because they are based on pre-test examination of the data. They extend Perron's model by incorporating an endogenous break point into the model specifications. According to Zivot and Andrews (1992), using the endogenously determined structural breaks favors the rejection of the unit root hypothesis in some cases and weakens it in others. Overall, the authors conclude that in the case of an unknown break point, there is less evidence against the unit root hypothesis than was found by Perron (1989) in his original paper.

Perron and Vogelsang (1992) employ a similar methodology to that used by Zivot and Andrews. They propose a class of test statistics, which allows for two alternative forms of change: the Additive Outlier (AO) model, which is best suited for series exhibiting a sudden change in the mean, and the Innovational Outlier (IO) model, which permits that changes take effect gradually over time. In other words, the Additive outlier model is best suited for series exhibiting a sudden change in mean, whereas the innovational outlier model (IO) is best suited if the change takes effect gradually.

3. Innovational Outlier Models

According to Perron and Vogelsang (1992), the (IO) model tests whether the change in the level occurs gradually, that is, whether there is a transition period. Based on this method, the (IO) model is estimated by the equation below:

$$x_t = \mu + \theta DU_t + \delta D(T_b)_t + \alpha x_{t-1} + \sum_{i=1}^{K} c_i \Delta x_{t-i} + e_t \tag{1}$$

Where T_b is the time of the break, and DU_t is equal to one *if (t > T_b)*, and zero otherwise, $D(T_b)_t = 1$ *if (t=T_b+1)*, and zero otherwise. The null hypothesis of unit root is rejected if the t-statistic for α is sufficiently large (in absolute value). Perron's and Vogelsang's method (1992), which is applied to non-trending data, can be seen in equation (1) above. While, Perron's method (1997), which is applied for trending data, is shown in equations (2) and (3) below. Equation (2) shows the gradual effect of change in intercept, while equation (3) determines the gradual effect of change in both intercept and slope. [1]

$$IO1: \quad x_t = \mu + \theta DU_t + \beta t + \delta D(T_b)_t + \alpha x_{t-1} + \sum_{i=1}^{K} c_i \Delta x_{t-i} + e_t \tag{2}$$

$$IO2: \quad x_t = \mu + \theta DU_t + \beta t + \gamma DT_t + \delta D(T_b)_t + \alpha x_{t-1} + \sum_{i=1}^{K} c_i \Delta x_{t-i} + e_t \tag{3}$$

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[1] These tests allow for only a single break for each series. Tests which allow for multiple breaks, such as Bai and Perron (1995) only been developed for stationary and non-trending data (Ben-David and Papell, 1998).

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where x_t is the variable being tested; T_b is the break date, and $DU_t =1$ if $t > T_b$, and zero otherwise, $D(T_b)_t$ is equal to one, if $t=T_b+1$, and zero otherwise and finally DT_t is equal to $(t > T_b)$ t. The null hypothesis of unit root is rejected if the t-statistic for α is sufficiently large (in absolute value). As discussed in Perron (1997), the break date, T_b, can be determined by sequentially estimating the above equations for all possible values of the break date, and choosing the time of the break by minimizing the t-statistic for testing $\alpha =1$ or $\theta =0$, that is, the t-statistic on the parameter associated with the change in intercept in equation (2) and testing $\alpha =1$ or $\gamma =0$, that is, the t statistic on the parameter associated with the change on slope in equation (3). A data dependent method is employed to choose the optimal number of lags (k).

4. Additive Outlier Model

As we explained earlier, according to Perron and Vogelsang (1992) and also Perron (1997), in the Additive Outlier Model (AO), change is assumed to take place instantaneously. Testing for a unit root in the AO framework is given by a two-step procedure. According to Perron, cited in Rao (1994: 134), first the series is detrended by using the following regressions:

$$y_t = \mu + \beta t + \theta DU_t + \tilde{y}_t \tag{4}$$

$$y_t = \mu + \beta t + \theta DU_t + \gamma DT_t * + \tilde{y}_t \tag{5}$$

$$y_t = \mu + \beta t + \gamma DT_t * + \tilde{y}_t \tag{6}$$

where dummy variables defined as $DT_t* = 1(t > T_b)(t - T_b)$, and like before DU_t is equal to one if t $> T_b$, and zero otherwise. In the above equation, $\tilde{y}_t$ is defined as the detrended series. The second step depends on whether the first step includes dummy variables for the change intercept or not. If in the first step we estimate equation (4 and 5), which we include dummy for the change in the intercept (DU_t), in the next step following regressions will be estimated:

$$\tilde{y}_t = \alpha \tilde{y}_{t-1} + \sum_{j=0}^{K} d_j D(Tb)_{t-j} + \sum_{i=1}^{k} \alpha_i \Delta \tilde{y}_{t-1} + e_t \tag{7}$$

When there is no dummy variable for the change in the intercept, the following regresseion will be estimaeted based on the residual obtained from the equation (6):

$$\tilde{y}_t = \alpha \tilde{y}_{t-1} + \sum_{i=1}^{K} c_i \Delta y_{t-i} + e_t \tag{8}$$

According to Perron, in this case , two segments of the trend are joined at the break date and there is no need to incclude dummy variables in the second step regression.

Similar to (IO) methodology, the above equations are estimated sequentially for each break year(T_b=k+2,..,T-1),where T is the number of observations. The time of the break that is chosen is the one which minimizes the t-statistic for $\alpha =1$. The lag length is data-determined from general to specific (see below), and the break date is assumed to be unknown and is endogenously determined by the data. The null hypothesis of unit root is rejected in favor of an alternative of stationarity around the

time of the break (T_b), if the t-statistic for α is larger in absolute value than the appropriate critical values.[2]

4. Empirical Findings

According to Ben-David and Papell (1997), we can find little evidence in the literature indicating which model is appropriate for estimation. If the data is trending, then estimating a model that does not contain the appropriate trend may fail to capture something significant. On the other hand, when a break does occur, the power to reject the no-break null hypothesis is reduced when estimating using a model that includes a trend, which is not contained in the data (because the critical values increase with the inclusion of more trends). In this research because we are dealing with some macroeconomic trending series, like GDP, exports and imports, etc., we apply the Innovational and Additive Outlier model based on Perron's methodology (1997), which is appropriate for trending series. Therefore, in order to decide which method is most appropriate to this research, we use the following model selection procedure. First, the least restrictive model (IO2) based on Perron (1997) is estimated. If the result is significant at the 10 percent or higher level, then the results are reported. If the result (IO2) for trending data is not significant, then model (IO1) is estimated and its results are reported. In addition, in order to determine the sudden effect of the structural breaks, the Additive Outlier (AO) model is also estimated and if they are significant, results are reported.

Taking advantage of the Perron model (1997), we identify the years in which structural break occurs. The result is reported in the Table 1. The results are then analyzed to explain the reason(s) for the breaks. We apply the method of endogenously determining the appropriate lag length. A data-dependent method for selecting the value of lag length K is applied in this research. According to Ng and Perron (cited in Ben-David and Papell, 1998: 562), it is better to use the data-dependent method rather than making an a priori choice of a fixed K. Ng and Perron suggest starting with an upper bound of $Kmax$. K is considered, as $Kmax$ if the last lag included in the model is significant and K is reduces by one, if the last lag that we included in the model is not significant. This procedure is continued until the last lag become significant. However, it should be noted that, K is set to zero if no any lags included in the model are significant. Following Lumsdaine and Papell (1997), we consider the maximum ($Kmax$) equal to eight and if the coefficient on the eighth lag is significant based on a t-test (i.e. at least 1.645 in absolute value), then we let $K=Kmax$. If not, K is reduced by one until significance is reached. Otherwise K is equal to zero.

Using the sequential approach, the regression equation is run with the values T_b of (2...t-1), for each time series. The values of the t-statistic for variable α are recorded and compared. From this comparison, the break point is then selected by the value of T_b, which minimizes the t-statistic on the coefficient α. The unit root null hypothesis is rejected in favor of the alternative of stationarity if the t-statistic for α is significant and greater than the critical values tabulated by Perron (1997). The result of the Innovational Outlier (IO) model is reported in Table 1.

As can be seen from Table 1, the critical values are higher in absolute value than the t-statistic of $\alpha = 1$ (unit root null hypothesis), which means that the unit root null hypothesis cannot be rejected for all of the variables under study except Lyno, Lnox. Our inability to reject the unit root null hypothesis for the majority of the variables under study reveals that innovational outlier (IO) models provide little evidence against unit root hypothesis in the presences of structural break. The dates of the breaks and t-statistics on the coefficients of the dummy variables are also presented in this table. 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 1978 revolution and the gradual effect of the Iran-Iraq war beginning in 1980. Now we report our findings based on the Additive outlier (AO) model. In order to do this, Unit root tests are performed again on each series using the (AO) model, allowing for breaks in the slope. Before performing the AO tests, an appropriate lag length is determined. Similar to the (IO) procedure and following Ng and Perron (cited in Ben-David and Papell, 1998: 562), a general to

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[2] Vogelsang and Perron (1992) find that there is not much loss in size and power if the AO model is incorrectly applied to IO data and vice versa which implies that the choice of one or the other should not affect the outcome of the tests.

specific procedure, which starts with a maximum of eight lags, is used to determine the optimal number of lags. The lag length is reduced until reducing the lag length is rejected. Table 2 reports the unit root results for an endogenous break trend along with the critical values based on the AO method.

Table 1
Innovational Outlier Model for Determining the
Break Date in Intercept (IO1) or Both Intercept and Slope (IO2)

Series[3]	Model	T_b	K	$t_{\hat\gamma} \setminus t_{\hat\theta}$	$t_{\hat\alpha}$	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
LXO	IO2	1980	8	2.59	-2.55	Unit root
LNOX	IO1	1978	7	-1.76	-5.39	Stationary
LIM	IO1	1982	1	-1.35	-3.78	Unit root
LK	IO1	1982	4	-3.21	-4.20	Unit root

Notes: 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	T_b	K	$\hat\gamma$	$t_{\hat\gamma}$	$t_{\hat\alpha}$	Result
LY	1979	1	-0.03	-3.093	-2.5348	Unit root
LYno	1981	7	-0.05	-9.33	-2.4597	Unit root
LXO	1986	1	0.07	5.62	-3.8450	Unit root
LTX	1979	0	-0.23	-7.11	-2.9072	Unit root
LNOX	1988	8	0.07	5.26	-4.8279	Stationary
LIM	1980	1	-0.15	-7.22	-3.6841	Unit root
LK	1980	1	-0.08	-4.74	-3.6143	Unit root

Notes: 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. T_b 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, (kMax= 8).

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[3] LY=log of real GDP at constant price, LYNO=Log of real GDP excluding oil at constant price, LX=Log of total export at constant price, LXO=Log of real oil export at constant price, LNOX=Log of non-oil export ($US million), LIM=Log of total import ($US million), LK=Log of gross capital formation at constant price).

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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, (except Lnox at 5%). 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 1978 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.

5. Conclusion

This paper uses annual time series data (1970-2003) to determine the most important years when structural break occurred in the some macroeconomic variables in the Iranian economy. First, the Perron (1997) Innovational Outlier model and Additive Outlier model are adopted to allow the data determine the single most important structural break in each series. The break date for each series based on these models is determined from well known events like the revolution, and the Iran-Iraq war. However, the empirical result based on Innovational outlier and Additive outlier model does not provide much evidence against the null hypothesis of unit root. However, it should be noted that, Perron (1997) methodologies are some of the most advanced methodologies so far achieved for the examination of structural break in non-stationary time series analysis, it is important also to note that these tests are unable to detect the presence of multiple structural breaks. Therefore the possibility exists for other potentially significantly breaks to have occurred in reality for the series under study. Using the models proposed by Perron (1997), only the most significant of such breaks will be detected. Future work in this area, therefore, will need to consider multiple structural breaks. Such investigation, however, is beyond the scope of this present study. In addition, it should be noted that the short span of the data in investigating the multiple structural breaks makes this problematic. Finally, according to Ben-David and Papell (1998), tests, which allow for multiple structural breaks, such as Bai and Perron, are restricted for statioinary and non-trending data.

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