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The Endogeneity of the Natural Rate of Growth: An Application to Turkey

Summary: The purpose of this paper is to examine the sensitivity of the Turkish economy's natural rate of growth to the actual rate of growth, covering the period 1980-2008. To determine the reason why the natural rate of growth is endogenous, the long-run and the causality relationships between real gross domestic product and each of the production factors (labour force and physical capital stock) are investigated with the bounds test. The natural rate of growth for the Turkish economy is found to be at 4.97 percent and it increases approximately 35.6 percent in the boom periods; indicating endogeneity. However, according to the causality test results, the endogeneity of the natural rate of growth may be attributed to the total factor productivity rather than the labour force and physical capital stock. This result is important and the debate on this subject may lead to further studies.

Key words: The natural rate of growth, The endogeneity of the natural rate of growth, ARDL approach, Causality tests.

JEL: O40, E10, E23, C22.

The endogeneity of the natural rate of growth was demonstrated by Miguel Léon-Ledesma and Anthony P. Thirlwall (2002) in their study on Organization for Economic Co-operation and Development (OECD) countries; whereas the Harrod, neoclassical and endogenous growth models assume the natural rate of growth to be exogenous. The present study aims to use the least squares and autoregressive distributed lag methods to examine the Turkish economy for the period 1980-2008. The areas for investigation include: *i*) What is the natural rate of growth for Turkey? *ii*) What is the sensitivity of the natural rate of growth to the actual rate of growth? *iii*) If the natural rate of growth sensitive to the actual rate of growth, so, if the natural rate of growth is endogenous, what is the reason for the endogeneity?

Léon-Ledesma and Thirlwall (2002) tested the reasons for the endogeneity applying causality tests between the real gross domestic product and total factor inputs. In this study, the causality relationships among the real gross domestic product and each of the production factors, i.e. labour force and physical capital stock, are analyzed. We investigate whether the reason for the endogeneity of the natural rate of growth stems from an increase in labour force or an increase in labour productivity over an increase in the physical capital stock. This decomposition is critical, particularly in developing countries, because the positive and negative effects of the endogeneity of the natural rate of growth can be highlighted.

We investigate the causality relationships among the real gross domestic product, labour force and physical capital stock. If a causality relationship from the real gross domestic product to labour force is established, then a reason for endogeneity can be shown. Also, if a causality relationship from the real gross domestic product to physical capital stock is established, another reason for endogeneity can be revealed, in the sense that more capital intensive methods causes an increase in labour productivity.[1]

In order to investigate the reasons behind the endogeneity of natural rate of growth, the bounds testing approach to cointegration, developed by M. Hashem Pesaran, Yongcheol Shin, and Richard J. Smith (2001) is used. Compared to the other tests – two stage estimation of Robert F. Engle and Clive W. J. Granger (1987) and full information method of Soren Johansen (1988), Johansen and Katerina Juselius (1990) – the bounds testing approach can be applied irrespective of whether the underlying regressors are purely $I(0)$, purely $I(1)$, fractionally integrated, or mutually co-integrated and it has better small sample properties.[2]

As pointed out in Narayan and Seema Narayan (2005, p. 425), an important advantage of the autoregressive distributed lag approach is that it has better small sample properties than the widely used approaches of Engle and Granger (1987) and Johansen (1988), Johansen and Juselius (1990).

Interestingly, empirical results indicate that although the natural rate of growth is endogenous for the Turkish economy, there are no causality relationships from the real gross domestic product to labour force and physical capital stock. If the natural rate of growth is endogenous, there must be a reason for the endogeneity. So, this finding may emphasize the role of the total productivity in the growth process as it will be mainly discussed in the conclusion section.

The paper is organized as follows: the literature review and theoretical foundations are found in Section 1, the methodology in Section 2, results and discussion in Section 3, and finally the concluding remarks are found in Section 4.

1. Literature Review and Theoretical Considerations

The endogeneity of the natural rate of growth was tested by Léon-Ledesma and Thirlwall (2002) on OECD countries (Australia, Austria, Belgium, Canada, Denmark, France, Germany, Greece, Italy, Japan, the Netherlands, Norway, Spain, the U.K., and the U.S.) for the period 1960-1995. They used the ordinary least squares method and autoregressive distributed lag approach based on Pesaran and Shin (1999). They found that the natural rate of growth is not an exogenously given

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[1] Capital intensive methods may also result in substitution of capital to labour, so, if there is a causality relationship from real GDP to physical capital stock, it may imply a decrease in labour force and an increase in output-labour ratio (labour productivity).

[2] Paresh Kumar Narayan (2004, 2005) examined the small sample problem within the context of the bounds testing approach. He generated the critical values for F-statistics to accommodate small sample sizes. There are several studies with small samples which are employed the bounds test. Charalambos A. Pattichis (1999) applied the bounds test with 20 observations. Jai S. Mah (2000) and Tuck Cheong Tang and Mahendhiran Nair (2002) have observations of 18 and 28, respectively. Imam Alam and Rahim Quazi (2003) test their hypothesis with 27 observations.

rate due to the fact that labour force and labour productivity are both elastic to the output growth (Léon-Ledesma and Thirlwall 2002, p. 455). Based on this study, Lena Vogel (2009) analyzed the endogeneity of the natural rate of growth for the 11 Latin American countries (Argentina, Bolivia, Brazil, Chile, Costa Rica, Columbia, Mexico, Nicaragua, Paraguay, Peru and Venezuela) for various periods using seemingly unrelated regression method. The results of the Vogel (2009) support the hypothesis of the Léon-Ledesma and Thirlwall (2002). Gilberto A. Libânio (2009) provided empirical evidence that the natural rate of growth is endogenous in 10 Latin American Countries (Argentina, Brazil, Chile, Colombia, Costa Rica, Ecuador, Mexico, Peru, Uruguay, Venezuela) in the various periods. The author emphasized aggregate demand fluctuations which affect the potential output in the long run. Libânio (2009) also analyzed whether the real GDP series are stationary or not. The author found that the real GDP series are non-stationary, so the real GDP series have unit roots. Therefore, Libânio (2009), documented that both supply and demand sided shocks may have significant impacts on the 12 Latin American economies (Argentina, Brazil, Chile, Colombia, Costa Rica, Dominican Republic, Ecuador, Guatemala, Mexico, Peru, Uruguay, Venezuela) in the period 1970-2004.

The above studies rested on the argument that the natural rate of growth is not exogenous in contrast to the Harrod, neoclassical and endogenous growth models. Roy Harrod (1939) described the natural rate of growth as a maximum rate of growth which is determined by exogenous factors such as population growth, physical capital stock growth etc. Robert Solow’s (1956) main critique of the growth models “in the line of Harrod-Domar” is based on the issue of the substitution of capital and labour. However, Solow did not deal with the exogenously given natural rate of growth. Likewise with the Harrod and neoclassical growth models, the new growth theories, or so called the endogenous growth theories (Paul Romer 1986; Robert Lucas Jr. 1988), also did not consider the endogeneity of the natural rate of growth. The seminal works of Nicholas Kaldor (1957) and Kaldor (1961) emphasize the effects of the demand conditions on the economic growth process. These effects depend on Petrus Johannes Verdoorn’s law (1949), where the natural rate of growth can be considered as endogenous rather than exogenous. If demand conditions matter, the actual rate of growth exceeds the natural rate of growth in the boom periods. As Léon-Ledesma and Thirlwall (2002, p. 442) puts it briefly, the reasons for this situation may be as follows: i) increase in labour force, ii) increase in labour productivity in the boom periods. Thus, in these periods, if the actual rate of growth exceeds the natural rate of growth, this means that the labour force and/or labour productivity have increased due to, for example, increase in participation rates, immigration of labourers, economies of scale, etc. (Léon-Ledesma and Thirlwall 2002, p. 442). Therefore, there are two major consequences of the endogeneity of the natural rate of growth: 1) Since the natural rate of growth is the ceiling of the full-employment, unemployment may still be a problem even in the boom periods. 2) Demand constraints can be considered as a major determinant of the economic growth.

The method on the estimation of the natural rate of growth depends mainly on the work of Thirlwall (1969). Thirlwall (1969) estimated the natural rate of growth following Arthur Okun (1962). Okun (1962) analyzed the relationship between the change in the percentage level of unemployment and the output growth rate using equation (1).

$$\Delta\%U = \alpha - \beta g \tag{1}$$

where U represents the level of unemployment, $\Delta\%U$ shows the change in the percentage level of unemployment, g gives growth rate of real output. α and β are parameters to be estimated.

When $\Delta\%U = 0$, i.e. there is no change in the percentage level of unemployment, the natural rate of growth equals to α/β. Thirlwall (1969) estimated this relationship using equation (2) where dependent variable is the growth rate of real output.

$$g = \gamma - \lambda(\Delta\%U) \tag{2}$$

where γ and λ are parameters to be estimated. Therefore, when $\Delta\%U = 0$, γ gives the natural rate of growth. It can be recognized that g represents both the actual and natural rate of growth. Then, it is expected that the actual rate of growth deviates from the natural rate of growth in the boom periods, if the natural rate of growth is endogenous. In order to find the deviation, a dummy variable is described. This variable is defined as $D = 1$ for the years that actual rate of growth exceeds the natural rate of growth and $D = 0$ for the other years.

$$g = \theta + \phi D - \psi(\Delta\%U) \tag{3}$$

If the parameter ϕ is statistically significant, it means $g = \theta + \phi$ when $\Delta\%U = 0$. Besides, when the sum of $\theta + \phi$ is greater than γ ($\theta + \phi > \gamma$), then this means the natural rate of growth increases in the boom periods. This situation implies that the natural rate of growth, i.e. the growth rate which keeps the unemployment constant, rises in the boom periods. This is why the natural rate of growth is called endogenous.

Léon-Ledesma and Thirlwall (2002), attribute endogeneity to two reasons: increase in labour force and increase in labour productivity. They analyzed the causality relationship between the real gross domestic product and total factor inputs which is defined as follows:

$$LTFI_t = wL_t + (1 - w)K_t \tag{4}$$

where $LTFI$, L and K represent natural logarithmic form of the total factor inputs, labour and capital stock, respectively. w indicates the weight of employees' compensation in the national account.

However, in this study, contrary to Léon-Ledesma and Thirlwall (2002), causality tests are applied in order to investigate the relationships among the real gross domestic product, labour force and physical capital stock. A causality relationship from the real gross domestic product to labour force and/or physical capital stock can account for the endogeneity of the natural rate of growth. Léon-Ledesma and Thirlwall (2002) implicitly assume that if there is a causality relationship from the real gross domestic product to physical capital stock, an increase in physical capital stock causes an increase in labour productivity. Thus, while the causality relationship from the real gross domestic product to labour force indicates labour force itself, the causality relationship from the real gross domestic product to physical capital stock indicates labour productivity.

If labour force and labour productivity are analyzed separately in contrast to Léon-Ledesma and Thirlwall (2002), it allows decomposing the positive and negative effects of the endogeneity of the natural rate of growth, especially for the developing economies. Unemployment, informal economy and low level of productivity are critical issues for the developing economies. If the main reason of the endogeneity of the natural rate of growth is the increase in labour force, it means that a rise in demand may cause an increase in unemployment and/or informal economy. If the main reason of the endogeneity of the natural rate of growth is an increase in labour productivity, it means that a rise in demand may result in an increase in labour productivity.[3] Hence, the former and the latter situations emphasize the negative and positive effects of the endogeneity of the natural rate of growth, respectively. So, these two effects must be decomposed especially for the developing economies.

However, if there is no causality relationship from the real gross domestic product to the labour force and physical capital stock, then the importance of the total factor productivity as a production factor apart from labour force and physical capital stock can be emphasized. Moreover, since an increase in total factor productivity means technological progress, it gives another dimension to the endogeneity of the natural rate of growth debate regarding the nature of the technological progress, i.e. Solow-neutral, Hicks-neutral etc. This will be discussed further in the conclusion section in the light of the empirical results.

2. Methodology

In the first part of empirical study, the natural rate of growth for the Turkish economy is estimated using ordinary least squares (OLS) estimation method. In the second stage, causality relationships among output and factor inputs are investigated. It is necessary to establish that there is a long-run relationship among the variables. For this purpose, the long-run relationships among the variables are investigated by the bounds test of Pesaran, Shin, and Smith (2001) based on the autoregressive distributed lag approach (ARDL) of Pesaran and Shin (1995, 1999).

The ARDL approach to testing for the existence of a relationship between variables in levels which is applicable irrespective of whether the underlying regressors are purely $I(0)$, purely $I(1)$, or mutually cointegrated. The statistic underlying the procedure is the familiar Wald or F-statistic in a generalized Dickey-Fuller type regression used to test the significance of lagged levels of the variables

[3] However, as it is noted in the second footnote, capital intensive methods may also lead to substitution of capital to labour. Therefore, unemployment may also rise due to this effect.

under consideration in a conditional unrestricted equilibrium correction model (Pesaran, Shin, and Smith 2001, pp. 289-290). This approach is summarized as follows.

The empirical model specification which relates the real gross domestic product (GDP) (Y_t) to physical capital stock (K_t) and labour force (L_t) is given by equation (5).[4]

$$\ln Y_t = \beta_0 + \beta_1 \ln K_t + \beta_2 \ln L_t + \varepsilon_t \tag{5}$$

where the variables are taken in their natural logarithm; ε_t indicates the random error term. Equation (5) is a long-run level relationship and provides the basis for the models estimated in this study. The major empirical question in this study is the existence of the level relationship in equation (5). This relationship should be estimated using co-integration estimation methods due to the nonstationarity of the data.

Suppose that with respect to our model, the theory predicts that there is a long-run relationship among the variables ln$Y$, ln$K$, and ln$L$. Without having any prior information about the direction of the long-run relationship among the variables, the bounds testing approach estimates an unrestricted error-correction model (UECM) taking each of the variables in turn as dependent variable. For instance, UECM, when ln$Y$ is dependent variable, takes the following general form:

$$\begin{aligned}\Delta \ln Y_t &= c_0 + c_1 t + \delta_1 \ln Y_{t-1} + \delta_2 \ln K_{t-1} + \delta_3 L_{t-1} \\ &\quad + \sum_{j=1}^{p} \lambda_j \Delta \ln Y_{i-j} + \sum_{j=1}^{p} \omega_j \Delta \ln K_{t-j} + \sum_{j=1}^{p} \phi_j \Delta \ln L_{t-j} + \psi D_t + u_t\end{aligned} \tag{6}$$

where D_t is a vector of exogenous variables such as the structural change dummies and Δ indicates first difference operator. The first stage in bounds testing approach is to estimate equation (6) by OLS. According to our model, the null hypothesis of no co-integration ($\delta_1 = \delta_2 = \delta_3 = 0$) against the alternative of a long-run levels relationship ($\delta_1 \neq \delta_2 \neq \delta_3 \neq 0$) is performed as a Wald restriction test. The asymptotic distributions of the F-statistics are non-standard under the null hypothesis of no co-integration among the variables in the UECM given in equation (6), irrespective of whether the variables are purely $I(0)$, purely $I(1)$, or mutually co-integrated.

Two sets of asymptotic critical values are provided by Pesaran, Shin, and Smith (2001, pp. 300-301, pp. 303-304). In the first and second set, it is assumed that all variables are $I(0)$ and all variables are $I(1)$, respectively. Decision rules to reject the null hypothesis are as follows:

[4] Human capital stock is not included in the regression model following Léon-Ledesma and Thirlwall (2002, p. 452). As the authors pointed out in their paper, it can be admitted that "most of the human capital and new invention are introduced in the production process through labour and capital inputs". Therefore, theoretically, the exclusion of the human capital from the production function can be accepted. Additionally, as it is shown in Pesaran and Shin (1999), the bounds testing approach is possible even when the explanatory variables are endogenous.

- Reject the null hypothesis of no co-integration and conclude that there exists a long-run equilibrium among the variables, if the computed F-statistics is greater than the upper bound critical value (second critical value set);
- Accept the null hypothesis of no co-integration, if the computed F-statistics is less than the lower bound critical value (first critical value set); and
- The bounds test is inconclusive, if the computed F-statistics falls within the lower and upper bound critical values.

If a long-run relationship has been established in the first stage, a two-step procedure is followed. In the first step, a conditional ARDL(p_1,q_1,q_2) long-run model for ln$Y$ can be estimated as given in equation (7).

$$\ln Y_t = c_0 + \sum_{j=1}^{p_1} \alpha_j \ln Y_{t-j} + \sum_{j=0}^{q_1} \theta_{1j} \ln K_{t-j} + \sum_{j=0}^{q_2} \theta_{2j} \ln L_{t-j} + \psi' D_t + u_t \tag{7}$$

where all variables are defined as above and the lag lengths p_1,q_1,q_2 relating to three variables in the model are selected using the Akaike (AIC) or Schwarz Bayesian (SBC) Information Criterion.

The second step of the second stage of the bounds testing ARDL approach involves estimating a conditional error-correction model. The conditional error-correction model is specified as follows:

$$\begin{aligned}\Delta \ln Y_t = \mu + \sum_{j=1}^{p} \lambda_j \Delta \ln Y_{t-j} + \sum_{j=0}^{p} \omega_j \Delta \ln K_{t-j} + \sum_{j=0}^{p} \phi_j \Delta \ln L_{t-j} \\ + \upsilon ECM_{t-1} + \psi' D_t + u_t\end{aligned} \tag{8}$$

where λ_j, ω_j and ϕ_j are the coefficients relating to the short-run dynamics of the model's convergence to the equilibrium. The coefficient of error correction term (ECM), υ measures the speed of adjustment and the ECM term is defined as given in equation (9).

$$ECM_t = \ln Y_i - \hat{\beta}_0 - \hat{\beta}_1 \ln K_t - \hat{\beta}_2 \ln L_t \tag{9}$$

The long-run parameters $\hat{\beta}_0, \hat{\beta}_1$ and $\hat{\beta}_2$ in equation (9) can easily be obtained from the OLS estimates of the conditional ARDL model given in equation (7).

As pointed out in Narayan (2004, p. 7), the estimates obtained from ARDL approach of co-integration analysis are unbiased and efficient given the fact that: (a) it can be applied to studies that have a small sample; (b) it estimates the long-run and the short-run components of the model simultaneously and (c) the ARDL method can distinguish between dependent and independent variables. For these reasons, the ARDL approach of Pesaran, Shin, and Smith (2001) is employed in this part of the study.

In terms of the causal relationships between real GDP and production factors, Engle and Granger (1987) show that if the series X and Y are $I(1)$ and co-integrated then there would be a causal relationship at least in one direction. The variable X is said to be the Granger cause of the variable Y if the prediction error of the variable Y decreases by using past values of the variable X in addition to past values of the variable Y. In this study, tests for Granger causality are made on the vector error-correction models (VECM) of long-run co-integrating vectors. These VECMs are given below.

$$\begin{aligned}\Delta \ln Y_t &= \pi_{10} + \sum_{j=1}^{p} \pi_{11,j} \Delta \ln Y_{i-j} + \sum_{j=1}^{p} \pi_{12,j} \Delta \ln K_{t-j} \\ &\quad + \sum_{j=1}^{p} \pi_{13,j} \Delta \ln L_{t-j} + \phi_1 ECM_{t-1} + u_{1t}\end{aligned} \tag{10}$$

$$\begin{aligned}\Delta \ln K_t &= \pi_{20} + \sum_{j=1}^{p} \pi_{21,j} \Delta \ln Y_{t-j} + \sum_{j=1}^{p} \pi_{22,j} \Delta \ln K_{i-j} \\ &\quad + \sum_{j=1}^{p} \pi_{23,j} \Delta \ln L_{t-j} + \phi_2 ECM_{t-1} + u_{2t}\end{aligned} \tag{11}$$

$$\begin{aligned}\Delta \ln L_t &= \pi_{30} + \sum_{j=1}^{p} \pi_{31,j} \Delta \ln Y_{i-j} + \sum_{j=1}^{p} \pi_{32,j} \Delta \ln K_{t-j} \\ &\quad + \sum_{j=1}^{p} \pi_{33,j} \Delta \ln L_{t-j} + \phi_3 ECM_{t-1} + u_{3t}\end{aligned} \tag{12}$$

In equations (10), (11) and (12), π's are parameters to be estimated, u_t's are serially uncorrelated error terms, and ECM_t is the error correction term estimated from equation (9). The F-statistics on the lagged explanatory variables in these error-correction models indicates the significance of the short-run causal effects. The t-statistics on the coefficients of the lagged ECM terms (ϕ_j) in equations (10)-(12) indicate the significance of the long-run causal effects.

3. Empirical Results

3.1 Data

The variables considered in the first part of the application are the rate of growth of the real gross domestic product (g_t) and the change in the percentage level of unemployment ($\Delta\%U_t$). Growth rate is defined as the first-difference in the logarithmic form of the real GDP calculated with 1998 prices in domestic currency. $\Delta\%U_t$ is defined as the change in the percentage level of unemployment. Data of the real GDP and unemployment are obtained from Turkish Statistical Institute data base[5] and Tuncer Bulutay (1995), respectively.

The physical capital stock data used in the second part of the application are calculated by the authors using gross capital investments defined as 1998 prices in domestic currency. Following Vikram Nehru and Ashok Dhareshwar (1993), Abdelhak Sendhadji (2000), and Barry Bosworth and Susan M. Collins (2003), the physical capital stock series are computed as given in equation (13).

$$K_t = (1-d)K_{t-1} + I_t \tag{13}$$

In equation (13), K_{t-1} indicates the physical capital stock in the initial period. d is the depreciation rate ($0 < d < 1$) and I_t is the gross capital investment in period t. K_{t-1} is computed as given in the equation (14).

$$K_{t-1} = I_t / (g + d) \tag{14}$$

where g indicates the average growth rate. Following Mustafa Ismihan and Kivilcim Metin-Ozcan (2006), d is taken 0.05 for Turkey.

Quarterly unemployment and labour force data of Turkey have started to be published officially since 2000 [although data are available beginning from 2000, we again constrained with small sample (28 observations)]. The gross capital investment data are taken from Seref Saygili and Cengiz Cihan (2008). The data set generated in Saygili and Cihan (2008) are the combined data which are given by Turkish Statistical Institute for the post-1987 period, and the State Planning Organization for the pre-1987 period. Therefore, this data set can be assessed more appropriately for the present study. Because of data problems, quarterly data cannot be used to estimate the natural rate of growth and to analyze the reasons for its endogeneity.

Finally, in the first and second part of the application, all empirical results are obtained using yearly data covering the period of 1980-2008.

3.2 Estimation of the Natural Rate of Growth

Estimation of the natural rate of growth and test for its endogeneity are performed in two stages. In the first stage, following Léon-Ledesma and Thirlwall (2002), the natural rate of growth equations (2) and (3) defined in the previous section are estimated and tested for the endogeneity of the natural rate of growth using OLS estimation method. In the second stage, long-run and causality relationships among the variables are tested and investigated.

Parameter estimates are presented in Table 1, where g and $\Delta\%U$ are defined as above. Two different models are used in order to estimate the natural rate of growth

[5] **Turkish Statistical Institute**. 2009. Employment, Unemployment and Wages: Labour Statistics. http://www.tuik.gov.tr/isgucuapp/isgucu.zul (accessed June 29, 2009).

for the Turkish economy and to test whether it is endogenous or not. Estimation results given in the first column belong to the basic model (equation (2)). The second column indicates the parameter estimates for the natural rate of growth employing a dummy variable (D_t) for the years when actual rate of growth is greater than the natural rate of growth. We also consider the negative growth periods of the growth process for the Turkish economy. In order to account for the effect of depression years (1994 and 2001) and the earthquake year (1999), another dummy variable (D_{1t}) is added to the model. Parameter estimates of this model are given in the third column of Table 1.

Before discussing all the findings, it is necessary to explain some econometric issues. Firstly, due to the short time series, the results obtained here have to be interpreted carefully.

Secondly, as pointed out in Léon-Ledesma and Thirlwall (2002), the change in the percentage level of unemployment should be regarded as an endogenous variable which will bias the coefficient estimates in equation (2). Under this problem, instrumental variable (IV) estimation method is performed to analyze whether the values obtained for the intercept term (i.e., the natural rate of growth) are biased or not. The IV method produces a consistent estimator in a situation in which a regressor is contemporaneously correlated with the error term. The most difficult aspect of IV estimation is, in general, to find instruments that are both relevant and exogenous. Therefore, the lagged values of the variables are used as instruments in this study.[6] Following Russell Davidson and James G. MacKinnon (1993), the endogeneity of the change in the percentage level of unemployment is tested using these instruments.[7] Under the null hypothesis that "the variables in instrument variables set are exogenous", with only one endogenous variable and relatively small sample, adding the fitted value of $\Delta\%U_t$ to the Equation (2) and obtaining the t-statistic of its coefficient can be considered as sufficient to do the test. This testing procedure, originally proposed by James Durbin (1954) and then extended by De-Min Wu (1973) and Jerry Hausman (1978), is called the Durbin-Wu-Hausmann test.

In order to apply the testing procedure, a number of combinations of the lagged variables are tried. The t-statistics of the coefficients of the fitted value of the $\Delta\%U_t$ variable obtained in the most of these specifications are statistically insignificant, implying that the null hypothesis can be accepted at the 1% and 5% significance levels. These results can be interpreted as the $\Delta\%U_t$ variable is not endogenous. However, the failure to reject the null hypothesis at a specific probability of a Type I error does not prove exogeneity. For this reason, Equation (2) is also estimated using the IV method. According to the IV estimates, the estimated values of the natural growth rate change between 0.0441 and 0.0469. Briefly, when performing the IV method, the values obtained for the natural rate of growth are not

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[6] As noted in Peter Kennedy (2003, p. 162), it may be possible to use as an instrument the lagged value of the independent variable in question; it is usually correlated with the original independent variable, and although it is correlated with the disturbance vector, because it is lagged it is not contemporaneously correlated with the disturbance – assuming the disturbance is not autocorrelated.

[7] A lagged value of the endogenous regressor may not be a good instrument. For this reason, more than one lagged values of both growth rate and the $\Delta\%U_t$ variable are used together in the estimation process.

quite different from those obtained using least squares, but in some cases, the lags of the variables do not seem to be appropriate as instruments. Dynamic specifications of Equation (2) which include lags of the variables are also estimated. These results also change between 0.0455 and 0.0525 and close to its OLS estimate. According to these results, the bias can be ignored in the study.

Thirdly, residuals from equation (2) and (3) – first two columns – have heteroskedasticity problem at the 1% and 5% significance levels when it is tested using Breusch-Pagan-Godfrey (BPG) and White tests.[8] Breusch-Pagan LM test statistics indicate that there are not the first, second and higher order autocorrelation problem in the residuals obtained from all equations (see Table 1). For this reason, standard errors for the coefficient estimates given in the first two columns are computed using heteroskedasticity consistent covariances of Halbert White (1980), because this estimator provides correct estimates of the coefficient covariances in the presence of heteroskedasticity.

The OLS estimates of the natural rate of growth and the coefficient the $\Delta\%U$ variable given in the first column of Table 1 are statistically significant at the 1% level. F-statistic indicates that the model is significant entirely at the 5% level. According to the coefficient estimates, a 1 percent increase in the $\Delta\%U$ leads on the average, to about a 2 percent statistically significant decrease in the rate of growth of the real GDP as expected. Holding the unemployment constant (i.e., $\Delta\%U = 0$), the estimate of the constant term indicates the natural rate of growth which is estimated at 4.97% for the Turkish economy.

Because the actual rate of growth is either above or below the natural rate of growth, a dummy variable is defined. The dummy variable (D_t) takes on the value of 1 when the actual growth rate is greater than the natural growth rate (for boom periods).These estimates are given in the second column of the Table 1. All the coefficient estimates except for the constant terms are statistically significant in the second column.

As mentioned above, we added another dummy variable to consider negative growth periods of the growth process for the Turkish economy. As can be seen from the third column of Table 1, all the coefficient estimates are statistically significant at the 1% level. The coefficient of dummy variable (D_{1t}) indicating negative growth process of the Turkish economy shows that there is an approximately 7.7% decrease in the growth rates in the crises and earthquake years than the other years. The coefficient of dummy variable (D_t) is significantly positive, and the sum of the constant term and the coefficient of the dummy variable indicate that the natural rate of growth in boom periods is greater than the natural rate of growth by approximately 35.6%. These empirical results emphasize that the natural rate of growth is endogenous for the Turkish economy. However, it should be emphasized again that the OLS estimates of the parameter should be interpreted carefully.

[8] BPG heteroskedasticity test is an asymptotic test. It should be noted that in small samples, the test is sensitive to the assumption that the residuals are normally distributed. In our case, the *JB* test indicates that residuals obtained from all equations are normally distributed at the 1% level.

Table 1 Estimation Results for the Natural Rate of Growth

Dependent Variable: $\hat{g}_t$	Natural Rate of Growth	Natural Rate of Growth in the Boom Periods	
	(I)	(II)	(III)
Constant	0.0497 (9.398)***	0.01359 (1.383)	0.0228 (6.294)***
$\Delta\%U$	– 0.1892 (– 2.882)***	– 0.1441 (– 3.906)***	– 0.0540 (– 1.947)*
D_t	-	0.0609 (6.076)***	0.04457 (7.830)***
D_{1t}	-	-	– 0.0773 (– 7.700)***
R^2	0.211	0.697	0.912
***F*-stat.**	6.951**	28.711***	83.537***
DW	2.178	1.888	2.554
F_{BP}-stat.	0.168 [0.846]	0.184 [0.832]	2.043 [0.138]
F_{BPG}-stat.	11.299 [0.004]	3.023 [0.067]	1.451 [0.253]
F_{WHITE}-stat.	5.862 [0.008]	2.368 [0.083]	0.733 [0.628]
***JB*-stat.**	0.766 [0.681]	1.958 [0.375]	1.825 [0.401]

Notes:

D_t = 1 the actual rate of growth is grater than the natural rate of growth
0 the actual rate of growth is smaller than the natural rate of growth

D_{1t} = 1 1994, 1999, 2001
0 the other years

t-statistics are given in brackets, and ***, ** and * indicate that the test statistic is statistically significant at the 1%, 5% and 10% levels, respectively.
F_{BP} is the Breusch-Pagan LM test for autocorrelation. Maximum lag length is taken 4, but the results are for lag 2.
F_{BPG} is the Breusch-Pagan-Godfrey LM test for heteroskedasticity.
F_{WHITE} is the White test for heteroskedasticity and it includes cross-term.
JB-stat. is the Jarque-Berra normality test statistic.
p-values of F_{BP}, F_{BPG}, F_{WHITE} and *JB* are given in square brackets.

Source: Authors' estimations.

3.3 Causality Relationships between Output and Factor Inputs

In the previous section, it is shown that the empirical results support the hypothesis of the endogeneity of the natural rate of growth for the Turkish economy. In this section, the possible reasons for the endogeneity can now be analyzed. For this purpose, the long-run and causality relationships between the output and factor inputs are investigated. In the first step, time series properties of the series are examined via unit root tests and through their descriptive statistics.

Before applying the ARDL bounds test, the stationarity status of all variables is investigated to determine their order of integration. The augmented Dickey-Fuller

(ADF) test (David A. Dickey and Wayne A. Fuller 1979), the generalized least squares detrended Dickey-Fuller (DF-GLS) test (Graham Elliot, Thomas J. Rothenberg, and James H. Stock 1996), and the Kwiatkowski-Phillips-Schmidt-Shin (KPSS) test (Denis Kwiatkowski, Peter C. B. Phillips, Peter Schmidt, and Yongcheol Shin 1992) are used in order to determine the order of integration of the series. The ADF, DF-GLS, and KPSS test results are given in Table 2.

The ADF, the DF-GLS and the KPSS test results show that real GDP is the first-difference stationary series at the 1% level. The ADF test and DF-GLS unit root tests results point out that physical capital stock is the first-difference series at the 1% and 10% levels, respectively. The first two unit root tests show that the integration order of the natural logarithmic form of the labour force is 1, whereas the KPSS test results indicate that it has neither 0 nor 1 integration order.[9] Although the unit root test results differ from each other, all series considered in this study can be accepted as $I(1)$ series but not $I(2)$.[10]

Table 2 Unit Root Test Results

Series	ADF ^{a}		ADF ^{b}		DF-GLS ^{a}		DF-GLS ^{b}		KPSS ^{a,c}		KPSS ^{b,c}	
	k	*t*-stat.	*k*	*t*-stat.	*k*	*t*-stat.	*k*	*t*-stat.	*k*	*LM*-stat.	*K*	*LM*-stat.
ln*Y*	0	-0.687	0	-2.666	2	0.016	0	-2.667	2	15.845	0	0.391
Δln*Y*	0	-6.462***	0	-6.355***	0	-6.588***	1	-3.767**	0	0.060♣	1	0.046♣
ln*K*	2	-1.915	1	-3.281*	1	3.162	1	-0.333	1	252.4	1	14.795
Δln*K*	0	-11.732***	1	-2.960	0	-1.740*	0	-3.074*	0	8.247	0	1.246
ln*L*	0	-1.404	2	0.705	0	-0.362	0	-1.549	0	52.946	0	1.240
Δln*L*	0	-5.855***	1	-6.028***	0	-5.898***	0	-6.122***	6	4.077	6	0.976

Notes:
^{a} The test regression includes an intercept but no trend.
^{b} The test regression includes an intercept and a linear trend variable.
^{c} Spectral estimation method is AR spectral GLS-detrended.
The appropriate lag length is chosen by SBC.
The null hypothesis of the ADF and DF-GLS tests is "the series is non-stationary" and ***, ** and * indicate "the unit root hypothesis" is rejected at the 1%, 5% and 10% significance levels, respectively.
The null hypothesis of the KPSS test is that "the series is stationary" and ♣ indicates the rejection of the alternative hypothesis.

Source: Authors' estimations.

Descriptive statistics for the first differences of all the data are given in Table 3. There are 28 observations available for estimation. The variables indicate positive kurtosis and negative skewness except for Δln*K* leading to the rejection of the normality for three series. In our data set, only ln*K* series are affected outlier corresponding to the year of 1981 which is normal because of computing the initial year value of the physical capital stock data.

[9] KPSS test is sensitive to the spectral estimation methods. When Bartlett kernel spectral estimation method is used, ln*L* and ln*K* are found to be first-difference stationary series. It is also investigated whether or not ln*K* and ln*L* series are trend-stationary. We find no evidence that these series are trend-stationary series.

[10] When the empirical analysis indicates that the estimated *F*- or *t*-statistics is higher than the upper bound of the critical value, then the null hypothesis of no cointegration is rejected. When the computed test statistic falls inside the upper and lower bounds, a conclusive inference cannot be made without knowing the integration order of the regressors.

Table 3 Descriptive Statistics

Series	No. of Obs.	Mean	Std. Error	Skewness	Kurtosis	Minimum	Maximum	*JB*-stat.
$\Delta\ln Y$	27	0.044	0.043	-1.576	2.004	-0.077	0.088	15.701*
$\Delta\ln K$	27	0.126	0.110	2.668	8.541	0.023	0.554♣	114.106*
$\Delta\ln L$	27	0.011	0.026	-0.689	2.313	-0.055	0.074	8.153*

Notes:
Descriptive statistics based on the first-difference order of the series.
♣ indicates that the data has outlier at 5% significance level.
* indicates that the data are not normally distributed at the % 1, 5 and 10 significance level.

Source: Authors' estimations.

The first step in ARDL bounds testing approach is to estimate equation (6) by OLS in order to test for the existence of a long-run relationship among the variables. The unrestricted error-correction model is estimated by taking each one of the variables ln*Y*, ln*K* and ln*L* as the dependent variable. The linear trend term in the unrestricted error-correction model may cause a misspecification when the data are not indeed trending. In order to be robust against the misspecification of the linear trend, each model is estimated with or without a linear deterministic trend.

Before estimating the conditional error-correction models, it is necessary to specify the lag length *p* for each model to be estimated. Maximum lag length is chosen as 3 because of having a small sample. In this stage of the study, a dummy variable is not used in the estimation process because of the same reason. When maximum lag length is chosen as 2 and a dummy variable indicating economic crises is used, all estimation process produce similar results according to *p* chosen by AIC or SBC.

Table 4 Statistics for Selecting the Lag Order of the ln*Y*, ln*K* and ln*L* Equations

Series	With Constant				With Constant and Deterministic Trend			
	p	AIC	$\chi^2(1)$	$\chi^2(4)$	*p*	AIC	$\chi^2(1)$	$\chi^2(4)$
ln*Y*	2	-4.574	0.011 (0.917)	0.853 (0.931)	3	-4.939	6.517 (0.011)	7.043 (0.134)
ln*K*	2	-6.999	0.044 (0.833)	2.697 (0.609)	2	-7.079	0.522 (0.469)	4.417 (0.352)
ln*L*	3	-4.772	0.575 (0.448)	10.738 (0.030)	3	-4.819	0.018 (0.892)	11.472 (0.023)
Series	**With Constant**				**With Constant and Deterministic Trend**			
	p	SBC	$\chi^2(1)$	$\chi^2(4)$	*p*	SBC	$\chi^2(1)$	$\chi^2(4)$
ln*Y*	2	-4.141	0.011 (0.917)	0.853 (0.931)	2	-4.417	4.484 (0.034)	6.922 (0.140)
ln*K*	2	-6.567	0.044 (0.833)	2.697 (0.609)	2	-6.599	0.522 (0.469)	4.417 (0.352)
ln*L*	1	-4.474	0.000 (0.998)	8.992 (0.061)	1	-4.398	0.113 (0.736)	10.080 (0.039)

Notes:
p is the lag order chosen according to Akaike (AIC) and Shwarz Bayesian (SBC) Information Criterion. $\chi^2(1)$ and $\chi^2(4)$ are LM statistics for testing no residual serial correlation against order 1 and 4, respectively. p-value of χ^2 statistics are given in brackets.

Source: Authors' estimations.

In order to determine p, both AIC and SBC are used. For each lag length, are the first and fourth order residual autocorrelations or serial correlations are also tested using the Breusch-Pagan Lagrange Multiplier (LM) statistics. These autocorrelations are distributed as $\chi^2(1)$ and $\chi^2(4)$, respectively. AIC, SBC, and LM test statistics are computed for each model. Table 4 reports these optimal lag lengths and corresponding AIC, SBC values as well as the LM tests with their p-values. The lag lengths chosen by AIC and SBC are different except for ln$K$. Residual autocorrelation can be rejected at 1% level at the lags chosen by AIC and SBC. In order to be robust against the lag length choice, the bounds tests are performed at p values chosen by both AIC and SBC.

Table 5 F- and t-statistics for Testing the Existence of Levels in ln$Y$, ln$K$ and ln$L$ Equations

	Series		With Deterministic Trend				Without Deterministic Trend	
		p	F-iv	F-v	t-v	p	F-iii	t-iii
AIC	ln$Y$	3	6.279 [c]	6.497 [c]	-4.991 [c]	2	6.832 [c]	-2.242 [a]
	ln$K$	2	20.219 [c]	12.327 [c]	-2.556 [a]	2	23.592 [c]	-1.938 [a]
	ln$L$	3	3.549 [a]	2.194 [a]	-2.392 [a]	3	3.958 [b]	-1.954 [a]
			With Deterministic Trend				Without Deterministic Trend	
		p	F-iv	F-v	t-v	p	F-iii	t-iii
SBC	ln$Y$	2	9.285 [c]	7.931 [c]	-3.909 [b]	2	6.832 [c]	-2.242 [a]
	ln$K$	2	20.219 [c]	12.327 [c]	-2.556 [a]	2	23.592 [c]	-1.938 [a]
	ln$L$	1	3.248 [a]	2.794 [a]	-2.886 [a]	1	4.040 [b]	-2.738 [a]

Notes:
F-iv is the F-statistics for testing $\delta_1 = \delta_2 = \delta_3 = 0$ and $c_1 = 0$ in equation (6); F-v is the F-statistics for testing $\delta_1 = \delta_2 = \delta_3 = 0$ in equation (6); t-v is the t-statistics for testing $\delta_1 = 0$ in equation (6). F-iii is the F-statistics for testing $\delta_1 = \delta_2 = \delta_3 = 0$ in equation (6) with c_1 set equal to 0, and t-iii is the t-statistics for testing $\delta_1 = 0$ in equation (6) with c_1 set equal to 0 when the linear trend is excluded from equation (6).
[a] indicates that the statistic lies below the 5% lower bound.
[b] indicates that the statistic falls within the 5% bounds.
[c] indicates that the statistic lies above the 5% upper bound.
For k = 2, 5% critical value bounds of F-iv are [3.88 4.61].
For k = 2, 5% critical value bounds of F-v are [4.87 5.85].
For k = 2, 5% critical value bounds of t-v are [-3.41 -3.95].
For k = 2, 5% critical value bounds of F-iii are [3.79 4.85].
For k = 2, 5% critical value bounds of t-iii are [-2.86 -3.53].

Source: Authors' estimations.

Five variants of the bounds test are used when a linear deterministic trend is present or not as used in Pesaran, Shin, and Smith (2001). The bounds test results are given in Table 5 when each of all variables is taken as dependent variable. The "no co-integration" hypothesis is rejected at the 5% level according to F-iii, F-iv, F-v and t-v statistics when ln$Y$ is dependent variable. Thus, there is evidence that ln$Y$ cointegrates with factor inputs. There is a co-integration relationship among the variables at the 5% level according to F-iv and F-v statistics when ln$K$ is taken as dependent variables. We find no evidence of co-integration when ln$L$ variable is taken as the dependent variable.

Although we have 29 observations (T), the critical values of the F-statistics modified by Narayan (2005) to accommodate small sample sizes are reported here. For $k = 2$ and $T = 30$, 5% critical value bounds of F-iv, F-v and F-iii are [4.54 5.42], [5.55 6.75] and [4.27 5.47], respectively. It can be said that the bounds test results are supported in most cases when using critical values tabulated in Pesaran, Shin, and Smith (2001).

The coefficients of the long-run levels equation (5) are estimated with parameters obtained using the ARDL approach. The conditional ARDL(p_1,q_1,q_2) long-run model given in equation (7) is estimated by selecting the lag length according to SBC, and then the long-run parameters are computed from equation (7).[11] The standard errors of these long-run parameter estimates are computed using the Delta-method. The estimated coefficients of the long-run relationship are given in Table 6.

The coefficient estimates of ln$K$ and ln$L$ have the correct sign and magnitude as expected for the Turkish economy when ln$Y$ is taken as dependent variable in both equations (with or without linear deterministic trend). In other words, physical capital stock and labour force are positively related to the real GDP. These estimates are also interpreted as output elasticities of the physical capital stock and labour force. According to level estimations with constant, over the period of the study, holding the labour input constant, a 1 percent increase in the physical capital stock input leads on the average to about a 0.64 percent statistically significant increase in the output. This result is consistent with 0.41 elasticity coefficient for the model with linear deterministic trend. On the other hand, output elasticities of labour estimated in the constant model differ significantly from the trend model for ln$Y$. The sum of these two output elasticities indicates that the Turkish economy can be characterized by diminishing returns to scale, over the period of the study.

Table 6 Estimates of Long-run Parameters

Variables	with Constant	with Deterministic Trend	Variables	with Constant	with Deterministic Trend
	lnY^{a}	lnY^{aa}		lnK^{b}	lnK^{bb}
Constant	-2.753 (-0.704)	3.360 (1.481)	**Constant**	8.309 (1.103)	-1.864 (-0.298)
ln*K*	0.639 (10.892)*	0.414 (5.819)*	**ln*Y***	1.597 (10.524)*	2.228 (5.827)*
ln*L*	0.220 (0.469)	0.0101 (0.038)	**ln*L***	-0.777 (-0.882)	-0.443 (-0.298)

Notes:
t-statistics are given in brackets.
* indicates that the test statistic is statistically significant at 1% level.
[a] selected model is ARDL(1,2,0) [aa] selected model is ARDL(1,2,0)
[b] selected model is ARDL(2,1,0) [bb] selected model is ARDL(2,1,0)

Source: Authors' estimations.

[11] We prefer to use SBC in the second stage of ARDL approach, because of p-values of LM statistics computed for the chosen lags with SBC are greater than those with AIC in most cases to accept "no serial autocorrelation" hypothesis.

Since there is a co-integration relationship among the variables when ln*K* is taken as dependent variable, the long-run estimates of this relationship are also estimated. The coefficient of the real GDP is estimated positively and statistically significant with or without linear deterministic trend.

The results of the short-run dynamic coefficients associated with the long-run relationships which are obtained from the error-correction models for ln*Y* and ln*K* are presented in Table 7. The sign of the short-run dynamic impact of the labour force is found to be negative and statistically insignificant. The sign of the short-run dynamic impact of the physical capital stock on the real output is estimated to be positively significant; however, its magnitude in the short-run is greater than in the long-run. In particular, the *ECM* terms are statistically significant and negative in all equations, implying a fairly high speed of convergence to equilibrium with the estimated magnitudes which are given in Table 7.

The equilibrium correction coefficient is estimated -0.091. It is highly significant, has the correct sign and implies a very low speed of adjustment to equilibrium after a shock for ln*K* variable.

Table 7 Estimates of Error-Correction Models' Parameters

Variables	With Constant $\Delta \ln Y^{a}$	with Deterministic Trend $\Delta \ln Y^{aa}$	Variables	with Constant $\Delta \ln K^{b}$	With Deterministic Trend $\Delta \ln K^{bb}$
Constant	0.0023 (0.251)	0.0112 (1.433)	***Constant***	-0.00005 (-0.001)	-0.002 (-0.899)
$\Delta \ln K$	2.298 (8.468)***	2.717 (11.237)***	$\Delta \ln K_{t-1}$	0.309 (9.479)***	0.318 (11.487)***
$\Delta \ln K_{t-1}$	-0.869 (-6.103)***	-0.857 (-7.449)***	$\Delta \ln Y$	0.260 (8.423)***	0.293 (10.842)***
$\Delta \ln L$	-0.059 (-0.332)	-0.039 (-.287)	$\Delta \ln L$	-0.070 (-1.300)**	-0.055 (-1.169)***
ECM_{t-1}	-0.461 (-5.282)***	-	ECM_{t-1}	-0.091 (-9.694)***	-
	-	-0.666 (-7.382)***		-	-0.091 (-11.164)***
R^2	0.817	0.881	R^2	0.994	0.994
***F*-ist.**	24.687**	40.779***	***F*-ist.**	858.9***	1088.6***
$\chi^2(1)$	0.000 [0.997]	1.225 [0.281]	$\chi^2(1)$	0.363 [0.553]	0.409 [0.529]
$\chi^2(4)$	0.104 [0.979]	0.806 [0.537]	$\chi^2(4)$	0.319 [0.861]	0.759 [0.565]
***JB*-stat.**	1.163 [0.558]	0.142 [0.931]	***JB*-stat.**	1.140 [0.865]	0.295 [0.862]
F_{BPG}	0.623 [0.651]	3.767 [0.018]	F_{BPG}	0.944 [0.457]	4.154 [0.012]
F_{RESET} (2)	5.959 [0.001]	5.209 [0.015]	F_{RESET} (2)	2.158 [0.142]	0.136 [0.872]
CUSUM	Stable	Stable	Stable	Stable	Unstable
CUSUMQ	Stable	Stable	Stable	Stable	Stable

Notes:
t-statistics are given in brackets.
***, ** and * indicate that the test statistic is statistically significant at the 1%, 5% and 10% levels, respectively.
$\chi^2(1)$ and $\chi^2(4)$ are the Breusch-Godfrey LM test for the first and forth order autocorrelation.
F_{BPG} is the Breusch-Pagan-Godfrey LM test for heteroskedasticity.
F_{RESET} (2) is the Ramsey test for omitted variables/functional form.
p-values of these statistics are given in square brackets.

Source: Authors' estimations.

We applied a number of diagnostic tests to the error-correction model. There is no evidence of autocorrelation in the residuals of all equations. The JB test statistics computed for the residuals of all error-correction models indicate that the residuals are normally distributed. The RESET test indicates that the model is correctly specified for $\Delta\ln Y$ with deterministic trend and $\Delta\ln K$ at 1% significance level. The stability of the regression coefficients is detected using the cumulative sum and the cumulative sum of squares (CUSUM and CUSUMQ) test for structural stability. The regressions, except for $\Delta\ln K$ equation with deterministic trend, appear stable according to CUSUM and CUSUMQ test statistics which are within the 95% critical bounds.

Results of the short-run and long-run Granger causality tests are reported in Table 8. The short-run causality tests show some sensitivity to whether a deterministic trend is included or not in the error correction models for the $\Delta\ln Y$. The test results indicate no short-run Granger causality for the $\Delta\ln K$ and $\Delta\ln L$. There is a one-direction short-run causality relationship from $\Delta\ln L$ to $\Delta\ln Y$ at the 10% level when the deterministic trend is including in the error correction model for $\ln Y$. For the $\Delta\ln Y$ series the long-run causality hypothesis is not rejected at the 10 % level.

Table 8 Results of Granger Causality Tests

		Without Deterministic Trend		
Y / X	**Δln*K* *F*-stat.**	**Δln*L* *F*-stat.**	**Δln*Y* *F*-stat.**	**ECM $_{t-1}$ *t*-stat.**
Δln*K* *F*-stat.	-	2.491 (0.111)	0.219 (0.806)	1.951 (0.067)
Δln*L* *F*-stat.	1.639 (0.222)	-	0.287 (0.754)	-0.706 (0.489)
Δln*Y* *F*-stat.	0.056 (0.945)	1.790 (0.195)	-	0.318 (0.754)
		With Deterministic Trend		
Y / X	**Δln*K* *F*-stat.**	**Δln*L* *F*-stat.**	**Δln*Y* *F*-stat.**	**ECM$_{t-1}$ *t*-stat.**
Δln*K* *F*-stat.	-	2.092 (0.152)	0.295 (0.747)	0.196 (0.846)
Δln*L* *F*-stat.	1.202 (0.323)	-	0.205 (0.816)	-0.155 (0.878)
Δln*Y* *F*-stat.	1.611 (0.227)	3.022 (0.074)	-	-1.797 (0.089)

Notes:
H_0: The variable *X* does not Granger cause of the variable *Y*.
p-values are given in brackets.
The lags chosen by SBC for bounds test with/without deterministic linear trend are also used in causality test equations.

Source: Authors' estimations.

4. Conclusion

In this paper, the sensitivity of the natural rate of growth to the actual rate of growth is analyzed for the Turkish economy for the period 1980-2008. The results indicated that the natural rate of growth is 4.97% and it increases approximately 35.6% in the boom periods. Thus, the natural rate of growth is endogenous for the Turkish economy.

Our study provides empirical evidence to the argument that the natural rate of growth is endogenous and there is no fixed full employment ceiling. This finding is especially important in that it emphasizes the demand-constrained growth. In other words, economic growth can be stopped due to demand constraints before reaching the full employment ceiling as Léon-Ledesma and Thirlwall (2002) indicated, because the full employment ceiling also increases. Thus, since it is found that the natural rate of growth is endogenous, one may consider the possibility of the demand constrained growth in the case of Turkey.

In this study, in contrast to Léon-Ledesma and Thirlwall (2002), the positive and negative effects of the endogeneity of the natural rate of growth are decomposed. On the other hand, the causality test results indicate that there is no causality relationship from the real GDP to the labour force or physical capital stock, i.e. there are neither positive nor negative effects of the endogeneity of the natural rate of growth. Thus, increases in participation rates, immigration, etc. are not the reasons for the endogeneity of the natural rate of growth since there is no causality relationship from the real GDP to labour force. Likewise, an increase in labour productivity stemming from the use of more capital intensive methods is not a reason for the endogeneity, since there is no causality relationship from the real GDP to physical capital stock. So, what is the reason for the endogeneity?

This finding implies that the reason of the endogeneity may be total factor productivity in the sense that it embodies factor apart from labour force and physical capital stock. Indeed, for example, Ismihan and Metin-Özcan (2006) documented that total factor productivity is the main source of growth for Turkey for the period 1960-2004. Saygili and Cihan (2006) found that the growth rate of total factor productivity accelerated for the post-1980 period relative to the pre-1980 period. Sumru Altug, Alpay Filiztekin, and Sevket Pamuk (2006), using 8 different models, estimated that the percentage contribution of the total factor productivity to the output growth rate was between 24.4% and 94.5%.

We can now discuss the results with regards to boom periods corresponding to the years 1983, 1984, 1986, 1987, 1990, 1992, 1993, 1995, 1996, 1997, 2000, 2002, 2003, 2004, 2005 and 2006. The common major feature of these years is the increasing total factor productivity (TFP) as pointed out by Saygili and Cihan (2008), Ismihan and Metin-Ozcan (2006).These studies have reported TFP increases with respect to the previous year. In contrast, TFP decreases were observed in the years which have smaller growth rate than the natural rate of growth corresponding to the years 1985, 1988, 1989, 1991, 1994, 1998, 1999 and 2001. Although the years 1981, 1982 and 2007 are the years which have smaller growth rate than the natural rate of growth, TFP increases at small rates in comparison with the other years. Thus, it can be possible to claim that our findings are justified by the other studies.

Moreover, our findings on the total factor productivity being the main reason for endogeneity, means that, theoretically, an increase in the total factor productivity may cause an increase in the labour force and/or labour productivity. Since an increase in total factor productivity means a rise in the level of technology, i.e.

technological progress, the exact nature of the technological progress is an important subject that should be examined. Therefore, [holding physical capital stock (K) constant] i) if an increase in total factor productivity causes an increase in labour force (L) but does not cause an increase in the labour productivity (Y/L), this means that the technological progress must be Solow-neutral, ii) if an increase in total factor productivity causes an increase in labour productivity (Y/L) but does not cause an increase in labour force (L), this means that the technological progress must be Hicks-neutral and iii) if an increase in total factor productivity causes an increase in labour force (L) and labour productivity (Y/L) together, this means that the technological progress must be Harrod-labour using.

That "the endogeneity of the natural rate of growth implies automatic convergence of the actual rate to the steady-state equilibrium cannot be expected" (Vogel 2009, p. 49) neither can it be expected that the nature of technological progress is Harrod-neutral since steady-state growth can only occur if the nature of the technological progress is Harrod-neutral.

Theoretically speaking, if our logic on the relationship among technological progress, labour force and labour productivity is valid, it implies that there exists a significant connection between demand conditions and the nature of technological progress. In contrast to the supply-side explanation, the pattern of the demand structure in the boom periods is one of the factors that determine the nature of technological progress. This is a significant interpretation and a suggestion of the present study for further analysis.

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