A Re-Examination of Kaldor's Engine-of-Economic Growth Hypothesis for the Turkish Economy

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Abstract: The purpose of this study is to re-examine the validity of Kaldor's engine-of-economic growth hypothesis (1966) for the Turkish economy in the context of time series analyses. The data used in this study are quarterly and cover the period of 1998:Q1-2015:Q4. The Autoregressive Distributed Lag (ARDL) bounds testing approach to co-integration was used to investigate the long-run dynamic relationship between industrial and non-industrial aggregate outputs. The results identify the long-run relationship between industrial and non-industrial economic performance. The Toda-Yamamoto approach to Granger causality test was employed to detect the causal links between industrial output and non-industrial aggregate output. Causality test results also support the causal implication of the engine-of-growth hypothesis for the case of Turkey.

Keywords: ARDL Bounds Testing Approach; Kaldor's Engine-of-Economic Growth Hypothesis; Toda-Yamamoto Approach

JEL Classification: C32; O41

1. Introduction

In the growth and development literature, the hypothesis that industrial sector is the engine of the economic growth is known as Kaldor's engine-of-growth hypothesis. There has been a limited body of works which have attempted to test empirically the Kaldor hypothesis. Some early studies investigated the validity of the hypothesis simply by regressing industrial output on the aggregate output or the rest sectors' output, separately. If the coefficient of the growth of industrial output is found to be significant and positive, it is then concluded that the growth rate of industrial production totally or partially determines the growth rates of other sectorial outputs and, consequently determines the economic growth. Yamak (2000) has argued that this kind of methodology is not appropriate and sufficient to test the hypothesis especially for two reasons. First, the issue of the direction of bi-variate causality can

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not be identified using that kind of methodology. The regression equations constructed in the previous studies naturally imply causality running from the growth rate of industrial output to the growth rates of other sectors as well as aggregate output growth. However, it is important that this uni-directional causality is established if unambiguous support for the hypothesis is to be inferred. Secondly, the hypothesis to long-term economic growth can not be tested using the simple regression analysis[1]. This kind of regression analysis does not take into account the long-run relationship between the two variables. Instead of the simple regression analysis, co-integration techniques can be performed to determine whether there is a long-run relationship between industrial growth and aggregate output growth.

Another issue in this subject is related to the choice of the independent variable in the regression equation. In the literature, most studies such as Stoneman (1979), McCombie (1981), Drakopoulos and Theodossiou (1991), Dutt and Lee (1993), Yamak and Sivri (1997), Millin and Nichola (2005), Dasgupta and Singh (2006), Libanio and Moro (2006) and Arısoy (2013) regressed the growth rate of industrial output on the growth rate of aggregate output. It is important that the use of aggregate output as the dependent variable will probably produce the bias and spurious coefficient of the industrial output because aggregate output includes industrial output. Instead, to validity the Kaldor hypothesis, industrial output must be regressed on the non-industrial aggregate output or service and agricultural output. Briefly, in order to support the validity of the Kaldor hypothesis, we must observe that there must be a long-run relationship between industrial output and non-industrial output and then there must be a causal relationship running from industrial output to non-industrial aggregate output.

The aim of this study is to re-examine the Kaldor hypothesis for the case of Turkey, by focusing the long-run relationship and causality between industrial and non-industrial aggregate outputs. The long-run relationship between two variables was investigated by implementing Autoregressive Distributed Lag (ARDL) bounds test. After detecting the long-run relationship, Augmented Granger Causality test developed by Toda and Yamamoto was performed to determine the presence of the causal relationships between industrial and non-industrial aggregate outputs.

[1]Atesoglu (1993) and Bairam (1991) constructed and utilized the long-term time series data instead of using the time series analysis such as co-integration that can capture the long-term relationship between two or more variables. Atesoglu (1993) simply smoothed the annual growth of each variable in time series analysis with a moving average while Bairam (1991) took averages of the growth rates of the sub-periods.

2. Methodology and Data

In this study, the ARDL co-integration approach developed by Pesaran and Shin (1999) was used to examine the long-run relationship between industrial and non-industrial aggregate outputs. The ARDL approach does not require prior knowledge on the order of integration of the variables. It can be easily used for the variables with different orders of integration. At this point, it should be noted that all variables must be I(0) or I(1), but not higher than I(1). The ARDL approach has some certain advantages in comparison with other conventional co-integration methods such as Engle-Granger (1987) and Johansen-Juselius (1990) methods. Among others, the most important advantage of this technique is that it gives the possibility of short and long run parameters of the model simultaneously by using the unrestricted ARDL error correction model. The ARDL bounds testing methodology to co-integration involves estimating the following regression.

$$\Delta LNIGDP_t=\alpha_0+\sum_{i=1}^{k}\beta_i\,\Delta LNIGDP_{t-i}+\sum_{i=1}^{k}\gamma_i\,\Delta LIND_{t-i}+\delta_1 LNIGDP_{t-1}+\delta_2 LIND_{t-1}+\varepsilon_{1t} \quad \textbf{(1)}$$

where the coefficients β_i and γ_i represent the short-run dynamics of the variables and the coefficients δ_1 and δ_2 represent the long-run relationship between industrial output and non-industrial aggregate output. After estimation of the above regression, the following null hypothesis of no co-integration is tested against the alternative hypothesis of the presence of co-integration by using F-statistics.

$H_0 : \delta_1 = \delta_2 = 0$

$H_1 : \delta_1 \neq 0, \delta_2 \neq 0$

After detecting the long-run relationship between the variables, the Augmented Granger causality test developed by Toda and Yamamoto (1995) is applied to investigate the causal relationship between the variables. The Toda and Yamamoto causality approach uses levels of the variables in a VAR system regardless of whether they are integrated, co-integrated, or not. This approach is based on estimation of an Augmented VAR model ($k+d_{max}$). The Augmented VAR model incorporates two types of lag lengths. The first one is the optimal lag length (k) of the standard VAR system. The second type of lag length is maximal order (d_{max}) of integration of the variables in the standard VAR system. (Sims, 1980). In the Toda and Yamamoto causality test, a bivariate VAR system is represented as follows:

$$LNIGDP_t=\beta_0+\sum_{i=1}^{k}\beta_{1i}LNIGDP_{t-i}+\sum_{i=k+1}^{k+d_{max}}\beta_{2i}LNIGDP_{t-i}+\sum_{i=1}^{k}\delta_{1i}LIND_{t-i}+\sum_{i=k+1}^{k+d_{max}}\delta_{2i}LIND_{t-i}+\varepsilon_{1t} \quad \textbf{(2)}$$

$$LIND_t=\alpha_0+\sum_{i=1}^{k}\alpha_{1i}LIND_{t-i}+\sum_{i=k+1}^{k+d_{max}}\alpha_{2i}LIND_{t-i}+\sum_{i=1}^{k}\emptyset_{1i}LNIGDP_{t-i}+\sum_{i=k+1}^{k+d_{max}}\emptyset_{2i}LNIGDP_{t-i}+\varepsilon_{2t} \quad \textbf{(3)}$$

After estimation of the VAR system, the Wald tests are applied to the first k coefficients of the right-hand side variables using the classic χ^2 statistics. The first null hypothesis indicates that industrial output, LIND, does not cause non-industrial aggregate output, LNIGDP, whereas the second one specifies that non-industrial aggregate output, LNIGDP, does not cause industrial output, LIND.

For Equation 2*; H_0: LIND↛ LNIGDP*

For Equation 3*; H_0: LNIGDP↛ LIND*

The data used in this study are quarterly and cover the period of 1998:Q1-2015:Q4. All variables were measured in real terms and seasonally adjusted using Census X-12 process. After seasonal adjustment, a logarithmic transformation was done on the data. The letter "L" in front of each variable indicates logarithm form. The details of all variables are given in Table 1.

Table 1. Symbols Used for Variables

IND	*Level of Industrial Output*
AGR	*Level of Agricultural Output*
SER	*Level of Service Output*
GDP	*Gross Domestic Product*
NIGDP	*Non-Industry Gross Domestic Product*
NAGDP	*Non-Agriculture Gross Domestic Product*
NSGDP	*Non-Service Gross Domestic Product*

3. Empirical Findings

Even though the ARDL approach does not require prior knowledge on the order of integration of the variables, the order of integration must be determined for each variable in order to decide whether the use of the ARDL is appropriate. For this purpose, the Augmented Dickey-Fuller (ADF) (Dickey and Fuller, 1979) unit root test was first performed for the level and first difference of each variable. Table 2 presents the results of the ADF test statistics with and without the inclusion of a trend detecting a unit root in the levels and first differences of the variables[1]. As seen from the table, the ADF- t statistics calculated for the levels of the variables indicate that the non-stationary of the levels of the variables can not be rejected at any significant level. However, the first difference of each variable, the growth rates of agricultural output, industrial output, the output of service sector and gross domestic product, appears to be stationary according to the ADF test statistics.

[1]The number of lags used in the ADF regressions were selected using the information criterion provided by Akaike (1973).

Table 2. ADF Unit-Root Test Results

Variables	Level		First Difference	
	Constant	Constant+ Trend	Constant	Constant + Trend
LIND	-0.226	-2.734	-6.315 ***	-6.302 ***
LAGR	0.142	-3.906 ***	-6.299 ***	-6.334 ***
LSER	-0.031	-3.508 **	-5.572 ***	-7.579 ***
LGDP	-0.095	-2.905	-6.581 ***	-6.563 ***
LNIGDP	-0.074	-3.023	-7.025 ***	-6.996 ***
LNAGDP	-0.085	-3.289 *	-7.102 ***	-7.075 ***
LNSGDP	-0.434	-2.899	-5.477 ***	-5.435 ***

Note: Lag length was selected by using Akaike information criteria (AIC). The maximum lag length was set to 8. ***, ** and * denote significance level of 1%, 5% and 10%, respectively.

As noted before, in the ARDL approach all variables should be I(0) or I(1), but not higher than I(1). According to the ADF unit root test results, all variables are found to be stationary in their first differences. Thus, the ARDL approach can be easily employed to examine the possible long-run relationship between industrial and non-industrial aggregate outputs. As required by ARDL approach, firstly bounds test was applied to determine the presence of long-run relationship between the variables. The results of the ARDL bounds test are shown in Table 3. As seen from the table, only one of the F-statistics, calculated as 2.371, is not greater than the upper critical value bounds at 10% significance level. Thus, the null hypothesis of no long-run relationship between aggregate and agricultural outputs can not be rejected. For other co-integration regressions, the calculated F- statistics are greater than the upper critical value bounds, so the null hypotheses of no long-run relationship between the variables are rejected at least at 10% significance level. According to the ARDL bounds test results, all bi-variate relationships except the relationship between agricultural and aggregate outputs are co-integrated. In the other words, all bi-variates including the industrial and non-industrial aggregate outputs are linked in a common long-term equilibrium. The existence of long-run relationship between industrial and non-industrial outputs may not make a difference for the validity of Kaldor's hypothesis at least at this point. So, the same relationship also exists for other two sectors.

Table 3. ARDL Bounds Test Results

Variables Dependent	Independent	F-Statistics	Conclusion
LGDP	*LIND*	4.148 **	**Co-integrated**
LNIGDP	*LIND*	4.192 **	**Co-integrated**
LGDP	*LAGR*	2.371	Not co-integrated
LNAGDP	*LAGR*	3.576 *	**Co-integrated**
LGDP	*LSER*	8.234 ***	**Co-integrated**
LNSGDP	*LSER*	8.257 ***	**Co-integrated**

Note: ***, ** and * denote significance at the 1%, 5% and 10% levels, respectively. Critical value bounds are 5.58 for 1%, 4.16 for 5% and 3.51 for 10%, respectively.

After determining the presence of long-run relationship between the bi-variates, the long-run elasticity of sectorial output is estimated for each sector and the results are given in Table 4. As seen from the table, all estimated long-run elasticities are positive and statistically significant at 1% level. The size of the long-run elasticity coefficient is almost the same for industry and service sectors. For agriculture sector, it is about three times bigger than industrial output's. Especially, when industrial output is regressed on the non-industrial aggregate output, the estimated long-run elasticity coefficient is found to be 0.884. This coefficient implies that non-industrial aggregate output increases (decreases) by 8.84 percent if industrial output increases (decreases) by 10 percent. However, the rest sectors of the economy have also similar impact on aggregate output. There is no significant difference among three sectors. Even though the findings on the long-run elasticities support the validity of Kaldor's hypothesis, at this stage it is very difficult to differentiate the industrial sector from the rest sectors in terms of the sign and size of the elasticity.

Table 4. Long-Run Coefficients

Dependent Variable	$LIND$	$LAGR$	$LSER$	ARDL Model
Industry				
$LGDP$	0.924 ***			(3,2)
$LNIGDP$	0.884 ***			(3,1)
Agriculture				
$LNAGDP$		2.471 ***		(1,1)
Service				
$LGDP$			0.853 ***	(1, 2)
$LNSGDP$			0.661 ***	(1, 2)

Note: ***, denotes significance at the 1% levels. The optimum ARDL model order is determined by the information criteria based on Akaike information criteria (AIC).

The results of diagnostic tests on the residuals for serial correlation, normality, heteroscedasticity and stability are reported in Table 5. Firstly, there is no any model suffering from any autocorrelation problem. In all estimated models for three sectors, the calculated χ^2 is not greater than the critical value. Therefore, the null hypothesis that indicates non-existence of autocorrelation can not be rejected for each sector of the economy at any significant level. Secondly, the residuals of service sector suffer from heteroscedasticity. For both industry and agriculture sectors, heteroscedasticity does not appear to be a diagnostic problem on residuals. Thirdly, the JB tests indicate that the residuals only in two models are normally distributed. One of them is industrial and non-industrial aggregate outputs. The other is service and non-service aggregate outputs. At this point, we have only two sectors passing the diagnostic tests of the ARDL model. However, the ARDL model for service sector is not stable according to CUSUM and CUSUMSQ tests[1]. The ARDL model passing CUSUM and CUSUMSQ tests is the model of industry sector. Figures 1-2 present CUSUM and CUSUMSQ of industrial and non-industrial aggregate output models, respectively whereas Figures 3-4 demonstrate the same statistics for industrial and aggregate outputs, respectively. As can be seen from Figures 1-4, the plots of CUSUM and CUSUMSQ statistics stay within the critical bonds of 5% level of significance. Thus, the null hypothesis that all coefficients in the given regression are stable can not be rejected at the 5% level. After diagnostic tests of ARDL models, the only model which comes to the forefront is the model of industrial and non-industrial aggregate outputs in accordance with Kaldor's engine-of-economic growth hypothesis.

Table 5. Diagnostic Test Results of ARDL Model

Dependent Variable	**Heteroscedasticity** χ^2	**Serial Correlation** χ^2	**Normality** JB	**Is model stable?**
Industry				
LGDP	6.101	1.268	6.948 **	**YES**
LNIGDP	4.929	1.475	2.673	**YES**
Agriculture				
LNAGDP	5.981	1.484	7.068 **	NO
Service				
LGDP	12.717 **	1.741	5.618 *	NO
LNSGDP	11.985 **	2.438	3.028	NO

Note: ** and * denote significance at the 5% and 10% levels, respective

[1]Pesaran and Pesaran (1997) suggest using Brown et al. (1975) stability test. This technique is also known as cumulative sum (CUSUM) and cumulative sum of squares (CUSUMSQ). The CUSUM and CUSUMSQ statistics are updated recursively and plotted against the breaks points (Jalil and Mahmud, 2009).

Figure 1. CUSUM

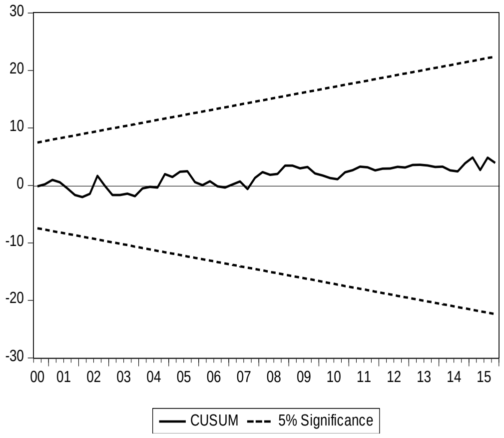

Figure 2. CUSUMSQ

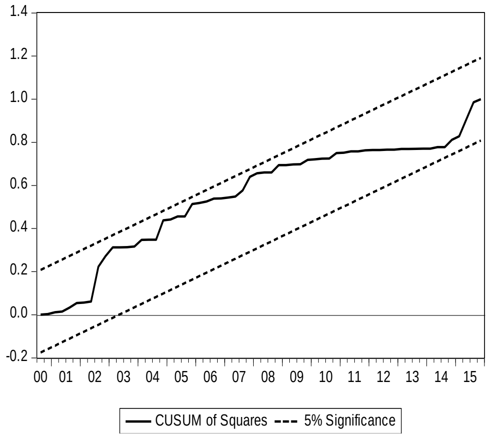

Figure 3. CUSUM

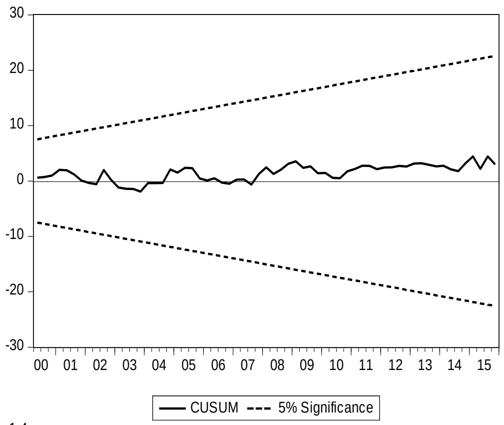

Figure 4. CUSUMSQ

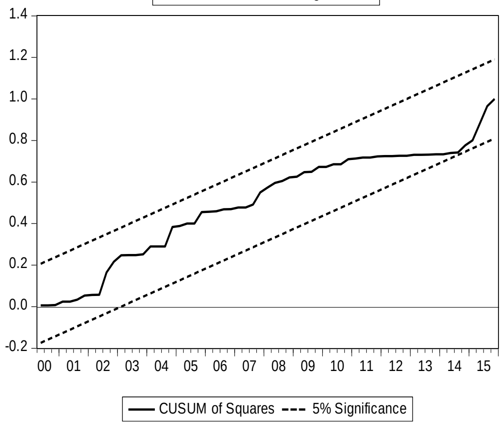

Table 6 presents the results of Toda-Yamamoto causality test. As seen in Table 6, the null hypotheses of no-causality from industrial output to aggregate output and from industrial output to non-industrial aggregate output are rejected at the 5% level. In addition, the null hypotheses for the reverse causality between bi-variates are also rejected at the 5% level. Thus, there appears to be a two-way causality between industrial output and non-industrial aggregate output (also aggregate output). The fact that industrial output causes non-industrial aggregate output to rise supports the Kaldor hypothesis for Turkey during the period under consideration. The findings of causality for agriculture sectors indicate that there is no causal relationship between agricultural output and aggregate output. In all cases, the null hypothesis of no-causal relationship between the bi-variates is not rejected at any significant level. Finally, the causality test results for service sector demonstrate a two-way relationship between service output and aggregate output.

Table 6. Toda-Yamamoto Causality Test Results

H_0	χ^2	df	Result
Industry			
LIND ↛ LGDP	15.746 **	6	**REJECT**
LIND ↛ LNIGDP	14.279 **	6	**REJECT**
LGDP ↛ LIND	16.741 **	6	**REJECT**
LNIGDP ↛ LIND	16.961 ***	6	**REJECT**
Agriculture			
LAGR ↛ LGDP	0.227	1	**NOT REJECT**
LAGR ↛ LNAGDP	0.017	1	**NOT REJECT**
LGDP ↛ LAGR	1.719	1	**NOT REJECT**
LNAGDP ↛ LAGR	1.179	1	**NOT REJECT**
Service			
LSER ↛ LGDP	22.756 ***	5	**REJECT**
LSER ↛ LNSGDP	19.457 ***	5	**REJECT**
LGDP ↛ LSER	13.313 **	5	**REJECT**
LNSGDP ↛ LSER	11.485 **	5	**REJECT**

Note: ***, ** denote significance at the 1%, 5% levels, respectively.

4. Conclusion

The hypothesis that industrial sector is the engine of the economic growth is known as Kaldor's engine-of-growth hypothesis. Most of the studies have investigated the validity of the hypothesis by regressing the growth rate of industrial output on the growth rates of aggregate and other sectors, separately ignoring both long-run and causal relationships between the variables. Another issue is related to the choice of the independent variable in the regression equation. Many studies have used aggregate output as dependent variable in their regression analyses. Since this dependent variable includes also industrial output, the estimated coefficient of the industrial output will probably bias and spurious. In order to support the validity of the Kaldor hypothesis, we must observe first that there must be a long-run relationship between industrial output and non-industrial output and then there must be a causal relationship running from industrial output to non-industrial aggregate output.

In this study, we re-examined the Kaldor hypothesis for the case of Turkey, by focusing the long-run and causal relationships between industrial and non-industrial aggregate outputs. The data used in this study are quarterly and cover the period of 1998:Q1-2015:Q4. The long-run relationship between two variables was investigated by implementing ARDL bounds test. After detecting the long-run relationship between industrial and non-industrial aggregate outputs, Augmented Granger Causality test developed by Toda and Yamamoto was performed to determine the presence of the causal relationships between industrial and non-industrial aggregate outputs. The ARDL results identify strong long-run relationship especially between industrial sector and non-industrial economic performance, supporting the Kaldor hypothesis for the case of Turkey. The evidence on the Toda-Yamamoto approach to Granger causality shows that there exists a two-way causality between industrial and non-industrial aggregate outputs. Causality test results support also the causal implication of the engine-of-growth hypothesis for Turkey.

5. References

Akaike, H. (1973). *Information Theory and an Extension of the Maximum Likelihood Principle*. In 2nd International Symposium on Information Theory, edited by B. N. Petrov and F.Craki. Budapest: Akademiai Kiado.

Arısoy, İ. (2013). Kaldor Yasası Çerçevesinde Türkiye' de Sanayi Sektörü ve İktisadi Büyüme İlişkisinin Sınanması. *Eskişehir Osmangazi Üniversitesi İktisadi ve İdari Bilimler Dergisi*, Vol. 8, No. 1, pp. 143-162.

Atesoglu, H.S. (1993). Manufacturing and Economic Growth in the United States. *Applied Economics*, Vol. 25, No. 1, pp. 67-69.

Bairam, E. (1991). Economic Growth and Kaldor's Law: The Case of Turkey, 1925-78. *Applied Economics*, Vol. 23, No. 8, pp. 1277-1280.

Brown, R.L., Durbin, J. & Evans, J.M. (1975). Techniques for testing the Constancy of Regression Relations over Time. *Journal of the Royal Statistical Society*, Vol. 37, No. 2, pp. 149–163.

Dasgupta, S. & Singh, A. (2006). Manufacturing, Services and Premature Deindustrialization in Developing Countries: A Kaldorian Analysis. *UNU-WIDER Jubilee Paper Series, Research Paper,* No. 2006/49, pp. 435-454.

Dickey, D. & Fuller, W. A. (1979). Distribution of the Estimates for Autoregressive Time Series with a Unit Root. *Journal of the American Statistical Association*, Vol. 74, No. 266a, pp. 427–431.

Drakopoulos, S.A. & Theodossiou, I. (1991). Kaldorian Approach to Greek Economic Growth. *Applied Economics*, Vol. 23, No. 10, pp. 1683-1689.

Dutt, A.K. & Lee, K.Y. (1993). The Service Sector and Economic Growth: Some Cross-Section Evidence. *International Review of Applied Economics*, Vol. 3, No. 3, pp. 311-329.

Engle, R.F. & Granger, C.W.J. (1987). Cointegration and Error Correction: Representation, Estimation and Testing. *Econometrica*, Vol. 55, No. 2, pp. 251-76.

Jalil, A. & Mahmud, S. F. (2009). Environment Kuznets Curve for CO2 Emissions: A Cointegration Analysis for China. *Energy Policy,* Vol. 37, No.12, pp. 5167-5172.

Johanson, S. & Juselius, K. (1990). Maximum Likelihood Estimation and Inference on Cointegration with Applications to the Demand for Money. *Oxford Bulletin of Economics and Statistics*, Vol. 52, No. 2, pp. 169-210.

Kaldor, N. (1966). *Causes of the Slow Rate of Growth of the United Kingdom*. Cambridge: Cambridge University Press.

Libanio, G. & Moro, S. (2006). Manufacturing Industry and Economic Growth in Latin America: A Kaldorian Approach. *Paper Presented at the Second Annual Conference for Development and Change.* Campos Do Jordão, Brazil.

McCombie, J.S.L. (1981). What Still Remains of Kaldor's Laws?. *Economic Journal*, Vol. 91, No. 361, pp. 206-216.

Millin, M. & Nichola, T. (2005). Explaining Economic Growth in South Africa: A Kaldorian Approach. *International Journal of Technology Management and Sustainable Development*, Vol. 4, No 1, pp. 47-6.

Pesaran, M.H. & Pesaran, B. (1997). *Working With Microfit 4.0: Interactive Econo-metric Analysis.* Oxford University Press, Oxford.

Pesaran, M.H. & Shin, Y. (1999). *Autoregressive Distributed Lag Modelling Approach to Cointegration Analysis*. In: Storm S, editor. Econometrics and Economic Theory in the 20th Century: the Ragnar Frisch Centennial Symposium. Cambridge: Cambridge University Press.

Sims, C.A. (1980). Macroeconomics and Reality. *Econometrica*, Vol. 48, No. 1, pp. 1-49.

Stoneman, P. (1979). Kaldor's Law and British Economic Growth: 1800-1970. *Applied Economics,* Vol. 11, No. 3, pp. 309-319.

Toda, H.Y. & Yamamoto, T. (1995). Statistical Inference in Vector Autoregressions with Possibly Integrated Processes. *Journal of Econometrics,* Vol. 66, No.1, pp. 225-250.

Yamak, N. (2000). Cointegration, Causality and Kaldor's Hypothesis: Evidence from Turkey, 1946-1995. *G.Ü. İ.İ.B.F. Dergisi*, Vol. 2, No.1, pp. 75-80.

Yamak, R. & Sivri, U. (1997). Economic Growth and Kaldor's Law: The Case of Turkey, 1979-1994 (in Turkish*). İktisat, İşletme ve Finans*, Vol. 12, No. 139 (October), pp. 9-21.