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TOTAL FACTOR PRODUCTIVITY AND ECONOMIC GROWTH

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ABSTRACT
The causality between TFP (Total Factor Productivity) and economic growth will be analyzed in this paper. The analysis is covering the years between 1987 and 2007. Firstly, TFP values are calculated for every year then the TFP values are regressed with annual Economic Growth rates by the least square method. Statistics show a significant linear relation between TFP and Economic Growth Rate.

Keywords: Cobb-Douglas Production Function, Economic Growth, Total Factor Productivity,

TOPLAM FAKTÖR VERİMLİLİĞİ ve EKONOMİK BÜYÜME

ÖZET
Bu çalışmada Toplam Faktör Verimliliği (TFV) ile Ekonomik Büyüme arasındaki nedensellik ilişkisi analiz edilmeye çalışılmıştır. Araştırma 1987 ile 2007 yılları arasını kapsamaktadır. İlk olarak analiz süresini kapsayan 20 yıllık dönem için TFV hesaplanmış daha sonra bulunan bu değerler ile yıllık Ekonomik Büyüme rakamları ile birlikte azalan kareler yöntemi aracılığı ile regresyon analizi yapılmıştır. Analiz sonuçlarına göre yıllık TFV ile Ekonomik Büyüme Rakamları arasında yüksek istatistiki güvenilirlik şartları altında doğrusal bir ilişkiye ulaşılmıştır.

Anahtar Kelimeler: Cobb-Douglas Üretim Fonksiyonu, Ekonomik Büyüme, Toplam Faktör Verimliliği

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1. INTRODUCTION

There is evidence of a dramatic increase in economic growth in recent decades in Turkey. The per capita income was 3178 US Dollars in 1988. This number was nearly doubled by 2007 when it reached 5053 US Dollars. This sharp increase can be explained by new production systems which had been imported from developed industrial countries.[†] The Turkish foreign trade regime started to suit global trade system in the 1980s and became a member of The European Union Custom in 1996. The new imported production systems triggered domestic industrial production and productivity as the new production units were more productive than the previous ones.

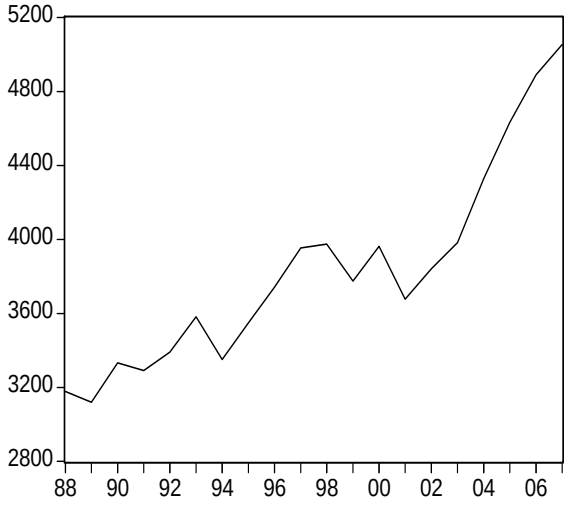

Figure 1 Per capita income in US$ (2000 price)

The productivity issue of Turkey will be examined in this paper. The TFP productivity has been measured for each year between 1987 and 2007. The causality between TFP and economic growth is presented econometrically. The two series were both found to fluctuate together. The technological progress has been measured

[†] The structure of Turkey changed dramatically in the late 1980s. Turkish local currencies became convertible, foreign investment, privatization, free trade and low import tax, free zones, export industry strategies expanded, telecommunication investment and transportation links such as high ways all came into the scene in those years.

3 The TFP residual depends on growth rates of inputs which are taking place in growth functions. The difference of growth rate of production and sum of all inputs' growth rate gives the TFP residual. As such, this practical frame work became the most used indicator for explaining the productivity growth in economic growth literature.

by TFP as the TFP residual is one of the most well known determinants of economic growth and hence, it is also accepted as the most practical indicator.(3)
In section 2 some theoretical background of the models is discussed. Section 3 gives general information about the data set which was used in the analysis. Finally, the econometric analysis will be explained in section four.

2. THEORY

TFP was first discussed in literature by Robert Solow (Solow, 1956:58).‡ Solow explains the issues by Cobb-Douglas production function as follows:

$$Y = F(A, K, L)$$

Y represents the aggregate production. *A* is the technology, *K* is the physical capital and *L* is the labor force. The technology is an independent variable like the others. The production functions modified in Hicks-Natural form:

$$Y = A \cdot F(K, L) \tag{1}$$

As seen in equation (1) the technological progress influenced the whole production function. By taking differences of the equation (1), the function can be written in terms of growth rates:

$$\frac{\dot{Y}}{Y} = \frac{\dot{A}}{A}\left(\frac{F_A A}{Y}\right) + \frac{\dot{L}}{L}\left(\frac{F_L L}{Y}\right) + \frac{\dot{K}}{K}\left(\frac{F_K K}{Y}\right) \tag{2}$$

F_K and F_L are the social marginal product of capital and labor. If ;

$$\frac{F_L L}{Y} = \frac{wL}{Y} = s_L$$

$$\frac{F_K K}{Y} = \frac{RK}{Y} = s_K$$

$$\frac{\dot{A}}{A}\left(\frac{F_A A}{Y}\right) = g$$

w is the income of the labor force and *R* is the income of physical capital. The s_L is the share of labor and s_K is the share of physical capital in production or income. The equation (2) can be written as:

$$g = \frac{\dot{Y}}{Y} - \frac{\dot{L}}{L}s_L + \frac{\dot{K}}{K}s_K$$

The summation of s_K and s_L is equal to 1 in constant return to scale production function. The total factor productivity growth (*g*) can be written as

‡ Solow studied on a growth model for USA economics and he received Nobel Price in 1987 for this study.

$$g = \frac{\dot{y}}{y} - \frac{\dot{k}}{k} s_K$$

with per capita terms.

3. DATA

The data set were sourced from The World Bank's world development data base. Gross saving was calculated by subtracting the total amount of consumption and current transfers from the national income. The gross saving rate is the friction of the gross investment to national income. The saving rates were calculated with the World Bank national accounts data by World Bank's statistics office. The Gross Fixed Capital Formation values were also calculated in US Dollars with fixed prices of the year 2000. The labor force statistics is the count of the population whose age is between 15 and 65 for each year.

The GDP per capita values were calculated with the year 2000 fixed prices in US Dollar. The series of economic growth was calculated as growth rate of this series.

As seen in the graphs both series fluctuate during the analysis period. The negative growth can be clearly recognized in both graphs during the economical crises in 1994, 1999 and 2001.

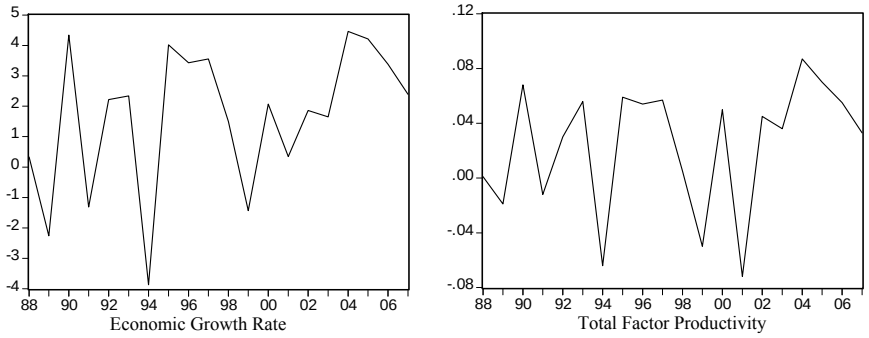

Figure 2 Economic Growth Rate and Total Factor Productivity

The statistical properties of the series are given in the table below. Each series has 20 observations. Standard deviation value of the Economic Growth rate has been assessed in the descriptive statistic table.

Table 1 Descriptive Statistics

	Economic Growth	Total Factor Productivity
Mean	1.661500	0.024450
Median	2.145000	0.032924
Maximum	4.460000	0.073498
Minimum	-3.870000	-0.072498
Std. Dev.	2.363114	0.041417
Skewness	-0.821931	-0.821931
Kurtosis	2.781905	2.781905
Jarque-Bera	2.291540	2.291540
Probability	0.317979	0.317979
Sum	33.23000	0.489000
Sum Sq. Dev.	106.1019	0.032592
Observations	20	20

Covariance and correlation matrix for both series are found as shown below. A strong causality can be easily seen in the two tables.

Table 2 Covariance Matrix

	TFP	Growth Rate
TFP	5.30509	0.09297
Growth Rate	0.09297	0.00162

Table 3 Correlation Matrix

	TFP	Growth Rate
TFP	1	1
Growth Rate	1	1

4. ANALYSIS

The econometric analysis depends on linear least square method. Where the TFP is defined as independent and Economic Growth (ΔY) is defined as dependent variable;

$$\Delta y = \beta_0 + \beta_1 TFP + e \quad (3)$$

e is the disturbance term of regression analysis.

Each parameter sign has been calculated as expected before. There is a negative intercept term were t-statistic's value could not exceed the significance interval. The TFP parameter's t-statistics value is calculated as significant. The standard error term of each parameter is very low.
The adjusted R square value is about 78 percent, which means that independent variable statistically has a high explanation capability on the dependent variable. The F statistic value exceeds the critical values of significance. Standard error of regression and sum squared residual statistics found are significantly low. Moreover, the summary of the least square method results give strong support for the model.

Table 4 The Regression Analysis Output

Dependent Variable: Δy				
Method: Least Squares				
Sample: 1988 2007				
Included observations: 20				
Variable	Coefficient	Std. Error	t-Statistic	Prob.
Intercept	-0.004670	0.005982	-0.780752	0.4451
TFP	0.017527	0.002106	8.321139	0.0000
R-squared	0.793676	Mean dependent var.		0.024450
Adjusted R-squared	0.782213	S.D. dependent var.		0.046490
S.E. of regression	0.021696	Akaike info criterion		-4.728762
Sum squared resid	0.008473	Schwarz criterion		-4.629189
Log likelihood	49.28762	F-statistic		69.24136
Durbin-Watson stat	2.572323	Prob(F-statistic)		0.000000

The Durbin-Watson statistics, which expounds on autocorrelation, has found 2.57. Durbin-Watson statistics are compared with the critical value of 2. Our output is close to 2, which means that there is no autocorrelation in our model.

The significance of regression analysis depends on the characteristics of the series. All series stationary tests have been done and each series were found stationary at level *I(0)*.[§]

[§] Ordinary least squares method depend on the stochastic process being stationary. However if the stochastic process is non-stationary, the use of OLS can produce invalid estimates. Granger and Newbold (1974) called such estimates 'spurious regression' results: high R^2 values and high t-ratios yielding results with no valid economic meaning.

Table 5 Stationary Test Results of Economic Growth

			t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic			-4.691375	0.0017
Test critical values:	1% level		-3.831511	
	5% level		-3.029970	
	10% level		-2.655194	

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Each test has been calculated with the Augmented Dickey Fuller method with Schwartz info Criteria. The intercept has been included in the model. Because all series were found stationary at level I(0), the regression analysis has been found to depend on consistent outputs in the long-run.

5. CONCLUSION

After examining the TFP and Economic Growth casualty, calculating the TFP and checking the regression results, we can conclude that there is a significant econometrically linear relation between TFP and Economic Growth rates. Developing countries such as Turkey, have a high TFP output which correlates with positive and sharp economic growth, however it is not regular and sustainable. In contrast, the opposite can be said for developed countries where economic growth rates may be low but it is smooth and sustainable in the long run.[**]

[**] The existence of analysis for long-run has been tested by a co-integration method. The test was performed with Engle-Granger Methodology. The residual of the regression analysis is in Table 4 and Equation 3 was performed by Augmented-Dickey Fuller Test. Given that Δy and TFP were both found to be I(0) and that the residuals are stationary, we can conclude that the series are co-integrated of order (0,0).

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