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# Technological Progress, Innovation and Economic Growth; the Case of Turkey

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## Abstract

This paper focuses on the influence of technological progress and innovation on the Turkish economy. The economic structure of Turkey has changed dramatically over the last three and a half decades during which technology has become a crucial endogenous variable in aggregate production function. The new technology investments brought with them high productivity rates and rapid, positive economic growth. The inter-relation between technological progress and economic growth is summarized and analyzed using quantitative methods. The Econometric results show a significant effect of technological progress and innovation on economic growth.

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*Keywords:* Economic Growth; Innovation; Technological Progress

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## 1. Introduction

Turkey has been experiencing very rapid growth rate over the last 3 and half decades. This period can be easily segmented into three decades; 80s, 90s and the turn of the twenty first century. The first election after the army revolution took place in 1983. The liberal party won the election and their administration worked on turning the local sticky economy into an open competitive economy for the following 10 years. The open economy brought new opportunities to Turkey. International trade instantly began to increase. National production was being shaped according to the new foreign trade demand.

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New and modern production systems were imported. Local entrepreneurs began producing cheap spare parts substituting imported products. Universities found new opportunities in new founded industrial zones. The industry's specific labor demand brought new opportunities and targets for Universities.

However, the 90s and beginning of 2000 saw a slowdown in the economic growth rate. During those years, Turkey had a coalition administration. Political stability was not strong like the 80s and the financial market was very fragile. There were two big devaluations which occurred in 1994 and 2001. Economic growth was somewhat sustained but the new technological investments could not find a secure place during those years.

The election in the year 2002 was another critical year in Turkish economic history. A majority party was legislated. The new administration managed new policies in technological development. New ideals included focus on technology exports. A new Research and Development act was legislated in parliament. R&D activities were boosted by the new act. Main cost items in R&D companies such as social insurance payments, cooperate and income taxes, energy and communication costs and depreciations were covered more easily than ever before. These new methods gave their fruits immediately. The productivity and production growth raised rapidly.

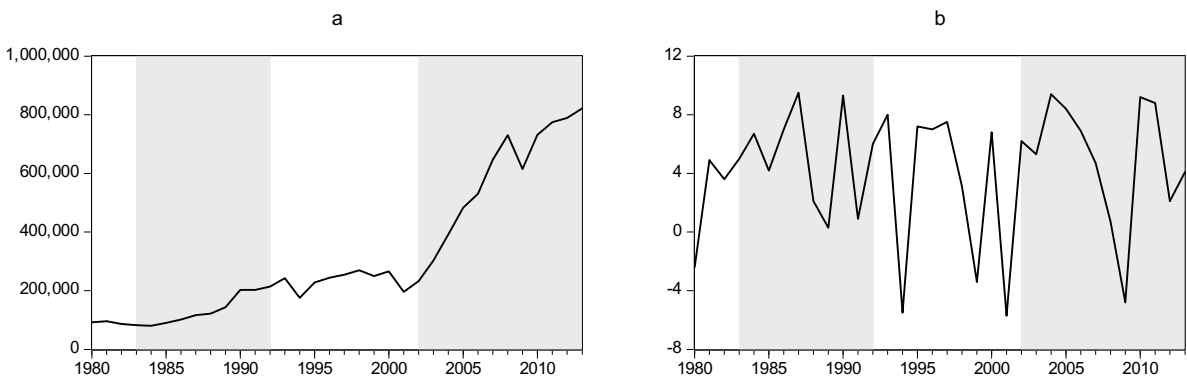


Fig. 1. (a) GDP; (b) GDP growth rate.

Figure 1 gives insight into the GDP in terms of current US Dollars and the GDP growth rate. The 80s embodied the speed up years for the Turkish economy. GDP was 83 million Dollars in 1983, the value increased to 213 million Dollars in 1992 when the new coalition government took up the administration. In the year 2002 the GDP had just reached 232 million US Dollars. After ten years, in 2013 the GDP went up to 822 million US Dollars. The growth rate graphs also summarize the same period with similar conclusions. Three negative growth rates were experienced in the years between 1992 and 2002 due to political and domestic unrest. The negative growth rate in 2009 was caused by a global crisis.

## 2. Literature

The innovation and research sector relation was first focused upon at the beginning of the 90s (Aghion & Howitt, 1992). They built an endogenous growth model with simulations. Positive effects of investing in technology was defined in literature by Romer (Romer, 1990). Johns claimed that the long run growth could be possible by R&D activities (Jones, 1995). R&D effects on aggregate production functions were tested by national research centers in the early 2000s (Sveikauskas, 2007). R&D activities and productivity growth were most clearly analyzed in literature by Loo and Soete (Loo & Soete, 1999). Small enterprise R&D activities were shown to bring big returns on the national economy by bringing new technologies (Comin, 2004). Recent studies are focusing on patenting and economic growth (Westmore, 2013). Some new approaches explain today's endogenous growth functions with the Shumpeterian model (Aghion, Akcigit, & Howitt, 2013). More recently, entrepreneurship innovation and economic growth relations are researched in today's economic literature (Galindo & Méndez, 2014).

### 3. Data Set

The data set was sourced from different data bases. The GDP is sourced from OECD data base. The series was in current US dollar form. The economic growth rate is performed by annual percentage changes. The patent series were sourced from Turkish Patent Institute and World Bank Data Base. Two series are announced each year as residence and non-residence patent applications. The two series were summed up and used in the model as total patent applications. Technological inputs' data have been deduced from the Turkish Statistical Institute. Electronics, electrical devices (which are registered under tariff item 85) and machines, mechanic tools, reactors which are registered under tariff item 84, are annually announced by the Institute in US Dollars.

### 4. The Model

The model is built in two stages as given in figure 2. Firstly, the innovation process is defined. Innovations are represented by a patent variable. Innovation is influenced by technological development. The technology level of a country is usually raised by importing new technological tools, equipment and machines. The new technology accumulation is used in the process of patent producing. The number of total patent applications becomes a dependent variable while electronic and mechanical annual import series are used as independent variables

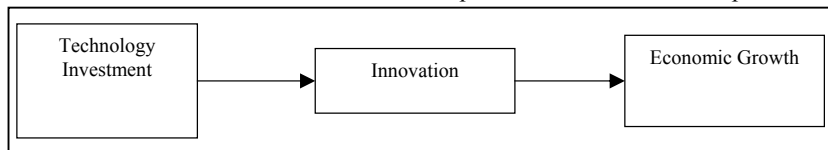


Fig. 2. Model Summary.

In the second stage, new patents are employed as independent variables in aggregate production function. The recent and productive production lines began to produce more value added products in less unit time and with less labor than before. The patent applications are the independent variables and the GDP is a dependent variable.

### 5. Analysis

#### 5.1. Innovation Model Estimation

The innovation model is estimated by Ordinary Least Square method. There are two independent and one dependent variable. The functional and OLS model is given below;

$$\text{Total Patent Applications (TPA)} = \text{TPA}[\text{electronic devices imports (EDI), machinery imports (MI)}]$$

$$\ln(\text{TPA}) = \beta_0 + \beta_1 \ln(\text{EDI}) + \beta_2 \ln(\text{MI})$$

Each variable series' natural base logarithm is used in the analysis. Each series has a positive increase in the analysis period.

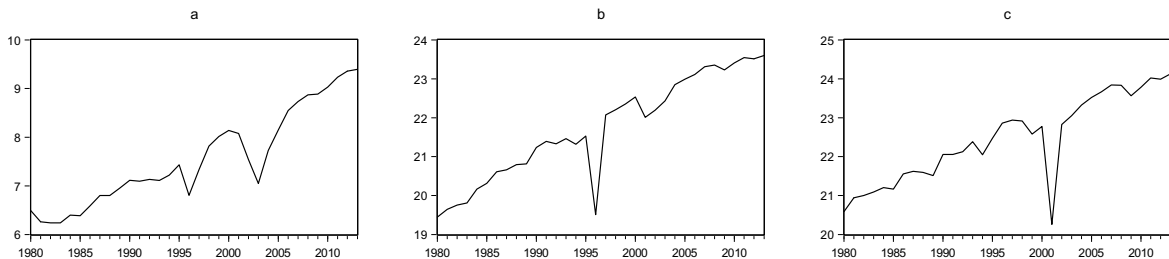


Fig. 3. (a)  $\ln(\text{TPA})$ ; (b)  $\ln(\text{EDI})$ ; (c)  $\ln(\text{MI})$

Unit root tests were employed in every series. The series were found stationary at level.

Table 1. Unit Root Test of ln(TPA), ln(EDI) and ln(MI)

Variable	t-statistics	Probability	Model	
ln(TPA)	-3.288957	0.0862	in level	trend and intercept
ln(EDI)	-5.300636	0.0007	in level	trend and intercept
ln(MI)	-4.810704	0.0026	in level	trend and intercept

The OLS model is then run by these stationary variables. The OLS model output is given in table 2.

Table 2. OLS of Innovation Model

Dependent Variable: ln(TPA)				
Sample : 1981 2013				
Included observations: 33				
Variable	Coefficient	Std. Error	t-Statistic	Prob.
Constant	-9.754714	1.215996	-8.021996	0.0000
ln(EDI <sub>t-1</sub> )	0.469999	0.083998	5.595334	0.0000
ln(MI <sub>t-1</sub> )	0.319768	0.101444	3.152154	0.0037
R-squared	0.893108	Mean dependent var		7.590019
Adjusted R-squared	0.885981	S.D. dependent var		0.981452
S.E. of regression	0.331403	Akaike info criterion		0.715546
Sum squared resid	3.294841	Schwarz criterion		0.851592
Log likelihood	-8.806501	Hannan-Quinn criter.		0.761321
F-statistic	125.3281	Durbin-Watson stat		1.924052
Prob(F-statistic)	0.000000			

A significant relation was found between independent and dependent variables. Coefficients' signs were found as expected. Their t-statistics of coefficients are quite high. The Breusch-Pagan-Godfrey Heteroskedasticity test and Breusch-Godfrey Serial Correlation LM tests were run. Null hypothesis of no heteroskedasticity is accepted at the 95% confidence level in addition to the no serial correlation found at the 95% confidence level. The residual is distributed normally.

We can summarize the innovation model as;

$$TPA = - 9.75 + 0.46 \ln (EDI_{t-1}) + 0.31 \ln (MI_{t-1})$$

### 5.2. Economic Growth Model Estimation

The economic growth model is designed as;

$$Gross Domestic Product (GDP) = GDP [Total Patent Applications (TPA)]$$

There are two variables, as GDP is dependent and the Total Patent Applications are independent variables. Two variables' time series graphs are given below;

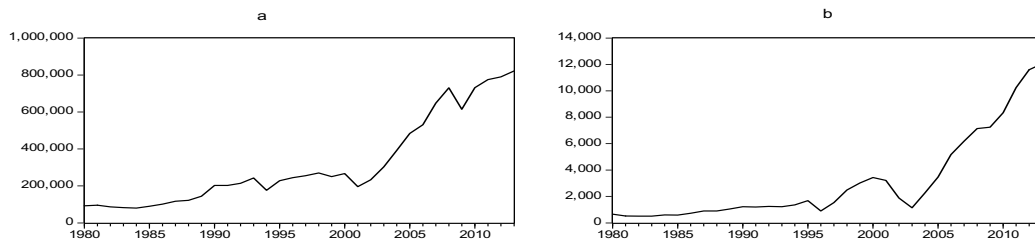


Fig. 4. (a) GDP; (b) Total Patent Applications.

The two series were found non-stationary at level. They have unit roots. The series' Augmented Dickey Fuller Test Results is given in Table 2. The series' first difference were found stationary.

Table 3. Unit root test of GDP and TPA

Variable	t-statistics	Probability		Model
GDP	-1.267158	0.8786	in level, I(0)	trend and intercept
TPA	-1.033449	0.9247	in level, I(0)	trend and intercept
$\Delta$ GDP	-6.212018	0.0001	first difference	trend and intercept
$\Delta$ TPA	-4.144205	0.0139	first difference	trend and intercept

The OLS model with the series which are at level may give spurious results. So the Engel Granger Error Correction Model is employed in this section.

The OLS model is designed as:

$$GDP = \beta_0 + \beta_1 TPA$$

Output is given in Table 4.

Table 4. The Model with Non Stationary Series at Level

Dependent Variable: GDP				
Sample: 1980 2012				
Included observations: 33				
Variable	Coefficient	Std. Error	t-Statistic	Prob.
Constant	105728.7	17868.23	5.917132	0.0000
TPA	67.91566	3.934792	17.26029	0.0000
R-squared	0.903006	Mean dependent var		317951.1
Adjusted R-squared	0.899975	S.D. dependent var		239036.6
S.E. of regression	75599.44	Akaike info criterion		25.36131
Sum squared resid	1.83E+11	Schwarz criterion		25.45109
Log likelihood	-429.1422	Hannan-Quinn criter.		25.39193
F-statistic	297.9177	Durbin-Watson stat		0.510782
Prob(F-statistic)	0.000000			

The R-square value is almost 93 percent and Durbin-Watson statistics is 0.77. The second step is to check the residual. If the residual of OLS model is stationary at level there can be a long run relation between variables. The residual time series' graph and Augmented Dickey Fuller test results are given in figure 5 and table 5.

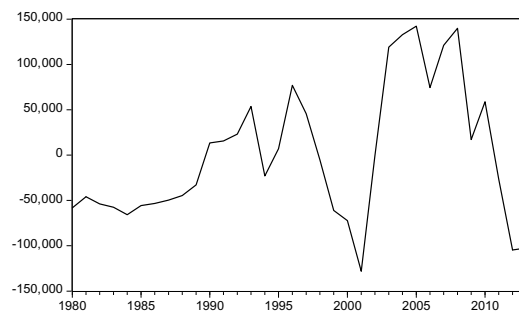


Fig. 5. Residual of OLS Model

Table 5. Unit Root Test of Residual

Variable	t-statistics	Probability		Model
residual	-3.941588	0.0252	in level, I(0)	trend and intercept

We have to use the critical value of regression-residual based on the co-integration test. The critical value of Angel Granger test at 10% is -3.28. The absolute value of t-statistic is greater than the absolute value of critical value. The residual is stationary. It means that GDP and TPA are co-integrated, they have a long run relationship.

The Error Correction Model is written as;

$$\Delta GDP = \beta_0 + \beta_1 \Delta TPA$$

There is only one independent variable and there is only one single equation hence there is one way causation. The Error Correction model is written by first difference of variable. The variables become stationary after the first difference. One period lag of residual of the model ( $GDP = \beta_0 + \beta_1 TPA$ ) is error correction term.

Table 6. Error Correction Model

Dependent Variable: $\Delta GDP$					
Sample (adjusted): 1981 2013					
Included observations: 33					
Variable	Coefficient	Std. Error	t-Statistic	Prob.	
constant	12384.85	9583.417	1.292321	0.2061	
$\Delta TPA$	28.41425	14.95431	1.900071	0.0671	
residual <sub>t-1</sub>	-0.027115	0.141774	-0.191253	0.8496	
R-squared	0.142311	Mean dependent var			22111.46
Adjusted R-squared	0.085132	S.D. dependent var			49412.98
S.E. of regression	47262.90	Akaike info criterion			24.45135
Sum squared resid	6.70E+10	Schwarz criterion			24.58739
Log likelihood	-400.4472	Hannan-Quinn criter.			24.49712
F-statistic	2.488859	Durbin-Watson stat			2.232043
Prob(F-statistic)	0.099988				

Error correction term corrects the equilibrium system. The annual data is employed in the model. The speed of adjustment is 2.7% annually. The sign is negative. Error correction term is correcting the model at the rate of 2.7 percent annually. However the error correction term is not statistically significant.

## 6. Conclusion

Technological progress, innovation and economic growth inter-relation was analyzed in two steps. Firstly, the Technological progress and innovation relation was tested by OLS method. A significant relation was found between technological import and the number of total patent applications. Total patent applications and GDP relation was tested in the next step. Consequently, a long run relation can be seen between the two variables by Engel Granger and Error Correction Models.

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