

# THE ROLE OF EDUCATION IN ECONOMIC GROWTH: A TIME SERIES ANALYSIS OF TURKEY 1960-2005

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**ABSTRACT:** *This examines the effects of different levels of education on Turkey's economic performance. The study employs a Cobb-Douglas production function under two assumptions: exogenous technology versus endogenous technology. The econometric methodology used in this study is Autoregressive Distributed Lag (ARDL). Further, distinguishing between the levels of education and using them as separate proxies for education gives the opportunity to examine the differences in the effects of secondary and higher levels of schooling on growth. Findings suggest that, for all specifications Turkey benefits from lower levels of schooling more than the tertiary levels. When Foreign Direct Investment (FDI) is added to the regressions the effect on FDI coefficient is positive along with the other elasticities.*

**Keywords:** Human Capital, Economic Growth, Time Series, Turkey

## Introduction

This paper aims to investigate the empirical relevance of Human Capital theories for the Economic performance of Turkey over the period from 1960 to 2005. There are two main branches of the Human Capital theory of growth, namely exogenous and endogenous models.<sup>1</sup> Although both support the idea that human capital matters for economic performance, the first follows the footsteps of the neoclassical theory in terms of relating the human capital to the output as an ordinary input in the production function [12]. The endogenous theory of human capital, on the other hand, mainly takes technological progress to be determined within the system and human capital is taken as the main component of technological improvement [4] [12] [16].

Turkey's real GDP per capita has grown on average by three percent per annum between 1960 and 2005. A simple growth accounting indicates that over this period 15 percent of the change in total output can be explained by the change in human capital as measured by the average years of schooling completed by the labor force.<sup>2</sup>

A standard Cobb-Douglas function with constant returns to scale is used for the time series analysis. In order to test the empirical relevance of the two theories, two models are regressed. The first one is the Cobb Douglas human capital augmented production function originated by Mankiw *et.al.* [13]. The second model uses the ratio of foreign direct investment as a proxy for technology with the same Cobb Douglas production function. Main measure of human capital is the lagged school enrollment ratios. Taking enrollment ratios separately for secondary and tertiary levels of schooling has an advantage of discriminating the relevant effects of higher levels of schooling.

One criticism in the literature, as proposed by Pritchett (2001) is that the time series studies especially for developing countries, where long-run data is not available, yields insignificant results. For that reason this study employs the Autoregressive distributed Lag (ARDL) approach which is a more statistically significant approach for determining cointegrating relationships in small samples. Further, the financial instability of countries like Turkey makes it harder to distinguish between the growth trend and the business cycles. In order to overcome this problem, this study uses year dummies for crisis years.

The long-run elasticity of output with respect to human capital as measured with secondary years of schooling is 37 percent when exogenous model is selected and above 12 percent when technology is assumed to be endogenous. When human capital is measured as tertiary school enrollment ratios the corresponding elasticity is 21 percent for the exogenous model and 17 percent for endogenous model. In all regressions the human capital proxies are statistically significant. Physical capital on the other hand has an elasticity of around 35 percent for all versions of the models, which is close to that of

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developed countries. The lower returns to university level education compared to secondary level, supports the fact that Turkey is a developing country which adopts technology rather than creating it.

## Theoretical framework and testing strategy

### Human Capital as a factor input

The main argument of Mankiw, Romer, and Weil, (henceforth MRW) [15], is that if Solow's production function were augmented with Human Capital, the problem of unexplained factors in the growth process would be eliminated. In this section we attempt to examine the growth performance of Turkey within this neoclassical perspective of human capital. The model represented in this section takes the neoclassical assumption of exogenous technological progress.

If we assume that the technological progress is determined outside the system and human capital is an ordinary input in production just as physical capital, following MRW, we can start with the general Cobb-Douglas production function

$$Y_t = K_t^\alpha H_t^\beta A_t L_t^{1-\alpha-\beta} \quad (1)$$

where  $Y_t$  is the real GDP at time  $t$ ,  $K_t$  is the physical capital,  $H_t$  is the human capital, as measured with levels of education,  $A_t$  is the total factor productivity and  $L_t$  is the total labor force at time  $t$ . Dividing both sides with the labor force and denoting the per worker variables with lower case letters:

$$y_t = k_t^\alpha h_t^\beta A_t^{1-\alpha-\beta} \quad (2)$$

After taking the natural logs of equation 2 and adding a crises dummy:

$$\ln y_t = A + \alpha \ln k_t + \beta \ln h_t + \psi DUMMY_t + u_t \quad (3)$$

Here the dummy variable is equal to 1 Here the dummy variable is equal to 1 for the crisis years of 1979, 1980, 1989, 1991, 1994, 1999, and 2001, and zero in other years.  $A$  is the constant parameter and  $u_t$  is the white noise error term. As we have mentioned previously the neoclassical model takes the technology to be determined exogenously and the constant term,  $A$ , in this model captures the total factor productivity. The sign of the constant elasticity coefficient  $\alpha$  and  $\beta$  are expected to be positive and indicates the elasticity of output with respect to physical and human capital.

### Endogenous Technology Model

In contrast to the human capital augmented growth model however, total factor productivity is considered to be a function of exogenous variables, namely level of education and foreign investment. Benhabib and Spiegel [4] postulate that educated labor force may play a key role in determining productivity rather than entering on its own as a production factor. In the interest of simplicity, they assume that human capital is exogenously given and that higher levels of  $h$  cause increased productivity. In their empirical growth model human capital affects total factor productivity through two channels. First, higher levels of human capital directly influence productivity via its impact on domestic innovation. Secondly, higher levels of human capital cause improvements in total factor productivity by facilitating the adoption and implementation of foreign technology and therefore reducing the knowledge gap between the technologically leading nations and the developing world.

The main argument in this model is that an educated labor force performs a major role in the determination of the productivity level instead of simply entering the production function as a factor. As the level of human capital increases, the adoption of new technologies, that is expected to balance the knowledge gap between the developed and developing countries, accelerates [15]. Further Foreign direct investment (FDI) often involves the transfer of knowledge from one country to another [6], making it a potentially important vehicle for international technology diffusion.

The basic specification for the second model is also the Cobb-Douglas production function with constant returns to scale. However, in this model A is not exogenous and instead it is a function of human capital and technology which is measured with Foreign Direct Investment (FDI)

$$Y_t = A_t K_t^\alpha L_t^\beta \quad (4)$$

$$A_t = f(C_t, H_t, T_t) = C_t H_t^\phi FDI_t^\delta \quad (5)$$

Combining equations (4) and (5), dividing the equation with labor, and taking the natural logarithms we get

$$\ln y_t = c + \alpha \ln k_t + \phi \cdot \ln h_t + \delta \cdot FDI_t + \psi \cdot DUMMY_t + u_t \quad (6)$$

Where all the coefficients are as defined, the sign of the constant elasticity coefficients ( $\phi$  and  $\delta$ ) are all expected to be positive, as in the previous model. [10]

### Testing Methodology

#### Growth Accounting Framework

Starting with the Human Capital Augmented Solow model employing a Cobb-Douglas production function with constant returns to scale, that is equation 1 and taking natural logarithms of both sides, we have the following equation:

$$\ln y(t) = \alpha \ln k(t) + \beta \ln h(t) + (1 - \alpha - \beta) A(t), \quad (7)$$

From this equation we can decompose differences in output per worker across time into differences in the capital output ratio, differences in educational attainment, and differences in productivity. In this equation, however, the share of physical capital should be set *a priori*.

#### ARDL Model Specification

To empirically analyze the long run relationships and dynamic interactions among the variables of interest, the model has been estimated by using the bounds testing (or autoregressive distributed lag, ARDL) cointegration procedure, developed by Pesaran *et.al.*[18] and clearly summarized by Halicioglu [9],[10]. There are three distinct advantages of the ARDL model. First, the method is simple in terms of allowing estimating the cointegrating relationship via Ordinary Least Squares (OLS), once the lag of order of the model is identified. Second, the model is applicable irrespective of their order of integration [19]<sup>3</sup>. Third, the procedure is relatively more efficient in small samples, which is also the case in this study [16].

The error correction representation of the ARDL of the exogenous model can be shown as follows

$$\begin{aligned} \Delta \ln y_t = & c_0 + \sum_{j=0}^p \phi_1 \ln y_{t-j} + \sum_{j=1}^p \phi_2 \Delta \ln k_{t-j} + \sum_{j=1}^p \phi_3 \Delta \ln h_{t-j} \\ & + \delta_1 \cdot \ln y_{t-1} + \delta_2 \ln h_{t-1} + \delta_3 \ln k_{t-1} \\ & + \psi DUMMY_t + \varepsilon_t \end{aligned} \quad (8)$$

In this model  $\delta_i$ 's are the corresponding long-run multipliers,  $\phi_i$ 's are the short-run dynamic coefficients of the underlying ARDL model,  $c_0$  is the drift and  $\varepsilon_t$  are white errors.

The ARDL representation of the endogenous model in similar format is as follows

$$\begin{aligned} \Delta \ln y_t = & c_0 + \sum_{j=0}^p \phi_1 \ln y_{t-j} \cdot \sum_{j=1}^p \phi_2 \Delta \ln k_{t-j} + \sum_{j=1}^p \phi_3 \Delta \ln h_{t-j} + \sum_{j=1}^p \phi_4 \Delta FDI_{t-j} \\ & + \delta_1 \cdot \ln y_{t-1} + \delta_2 \ln h_{t-1} + \delta_3 \ln k_{t-1} + \delta_4 FDI_{t-1} \\ & + \psi DUMMY_t + \varepsilon_t \end{aligned} \quad (9)$$

The first step in the ARDL bounds testing approach is to estimate equations (8) and (9) by ordinary least squares (OLS) in order to test for the existence of a long-run relationship among the variables by conducting an F-test for the joint significance of the coefficients of the lagged variables. In other words, the null hypothesis  $H_0: \delta_1 = \delta_2 = \delta_3 = 0$  in the exogenous model and  $H_0: \delta_1 = \delta_2 = \delta_3 = \delta_4 = 0$  in the endogenous model would be tested against the alternative hypothesis  $H_A: \delta_1 \neq \delta_2 \neq \delta_3 \neq 0$   $H_A: \delta_1 \neq \delta_2 \neq \delta_3 \neq \delta_4 \neq 0$  for both models respectively. We denote the test which normalizes on  $y$  by  $(y | k, h)$ . (In the second model normalization is on  $y$  by  $(y | k, h, FDI)$ ). Two asymptotic critical values bounds provide a test for cointegration when the independent variables are  $I(d)$  (where  $0 \leq d \leq 1$ ): a lower value assuming the regressors are  $I(0)$  and an upper value assuming purely  $I(1)$  regressors. If the F-statistic is above the upper critical value, the null hypothesis of no long-run relationship can be rejected irrespective of the orders of integration for the time series. Conversely, if the test statistic falls below the lower critical value the null hypothesis cannot be rejected. Finally, if the statistic falls between the lower and upper critical values, the result is inconclusive.

Two sets of critical values are reported in Pesaran and Pesaran [17] as well as in Pesaran *et al.* [18]. The two sets of critical values (CV) provide critical value bounds for all classifications of the regressors into purely  $I(1)$ , purely  $I(0)$  or mutually cointegrated. However, these CVs are generated for sample sizes of 500 and 1000 observations and 20 000 and 40 000 replications respectively. Given the relatively small sample size in the present study (45 observations in model 1 and 35 observations in model 2) the approximate critical values for the F-test were obtained from Narayan [1].

Once the cointegration is proved, the conditional ARDL long-run model for  $Y_t$  can be estimated as:

$$\begin{aligned} \Delta \ln y_t = & c_0 + \sum_{j=0}^p \phi_1 \ln y_{t-j} \cdot \sum_{j=1}^p \phi_2 \Delta \ln k_{t-j} \\ & + \sum_{j=1}^p \phi_3 \Delta \ln h_{t-j} + \psi DUMMY_t + \varepsilon_t \end{aligned} \quad (10)$$

$$\begin{aligned} \Delta \ln y_t = & \alpha_0 + \sum_{j=1}^p \phi_1 \cdot \Delta \ln y_{t-j} + \sum_{j=0}^p \phi_2 \cdot \Delta \ln k_{t-j} + \sum_{j=0}^p \phi_3 \Delta \ln h_{t-j} \\ & + \sum_{j=1}^p \phi_4 \Delta FDI_{t-j} + \psi DUMMY_t + \varepsilon_t \end{aligned} \quad (11)$$

Using the Akaike Information Criteria (AIC) the orders of the ARDL models would be selected. In the final step, short-run dynamic parameters are obtained by estimating an error correction model associated with the long-run estimates, which is specified as follows for both models:

$$\begin{aligned} \Delta \ln y_t = & \alpha_0 + \sum_{j=1}^p \phi_j \Delta \ln y_{t-j} + \sum_{j=0}^p \phi_2 \Delta \ln k_{t-j} + \sum_{j=0}^p \phi_3 \Delta \ln h_{t-j} \\ & + \lambda ECM_{t-1} + \varepsilon_t \end{aligned} \quad (12)$$

$$\begin{aligned} \Delta \ln y_t = & \alpha_0 + \sum_{j=1}^p \phi_j \cdot \Delta \ln y_{t-j} + \sum_{j=0}^p \phi_2 \cdot \Delta \ln k_{t-j} + \sum_{j=0}^p \phi_3 \Delta \ln h_{t-j} \\ & + \sum_{j=1}^p \phi_4 \Delta FDI_{t-j} + \lambda ECM_{t-1} + \varepsilon_t \end{aligned} \quad (13)$$

In these models the term  $\lambda$  is the speed of adjustment parameter and ECM is the residual obtained from the cointegration model of equation 1.  $\phi$ 's are the short-run dynamic coefficients of the model's convergence to equilibrium.

### **Stability of the Model**

Establishing a long-run cointegration between the variables of interest in our case physical capital human capital and the output per worker, is necessary but not sufficient, since the existence of a cointegration does not imply that the estimated coefficients are stable, as clearly summarized by Halicioglu (2009) among the many that test stability, tests that of Brown et al (1975) proposed which are also known as cumulative sum (CUSUM) and cumulative sum of squares (CUSUMQ) tests based on the recursive regression residuals will be employed in this study. The short run dynamics are also integrated in to long run through residuals in these tests. The CUSUM and CUSUMQ statistics are updated recursively and plotted against the break points of the model. Provided that the plots of these statistics fall inside the critical bounds of 5% significance, one assumes that the coefficients of a given regression are stable. These tests results are implemented by means of graphical representation [10].

## **Empirical Results**

### **Data**

The analysis in this study uses the data on real output, labor input, physical capital input, human capital input, rate of Foreign Direct Investment (FDI) and the relative shares of capital. Except for the FDI (within the period 1970-2005) data are constructed for Turkey over the period 1960-2005.

Output is measured by GNP (at 2000 prices). The output per worker variable is constructed by dividing the GNP to labor force for each year. The data comes from State Planning Organization, *Main economic indicators 2007*. Labor force data is taken from the State Institute of Statistics. FDI data comes from the Treasury of Turkish Government. The school participation rates are constructed from State Institute of Statistics data.

Since there is no direct measure of capital stock, this study uses the perpetual inventory method (PIM) to estimate the physical capital stock. PIM is used from the flow of investments assuming the depreciation rate to be 5 percent [15]. Investment series are taken from and the initial stock is constructed for the 1950-1960 period. There are two main measures of human capital in the literature; the average years of schooling completed by the active labor force (either over the age 15 or over 25) and the school enrollment rates.

The educational level of the active labor force, however, is constructed in 5 years lags. Hence, there exist only 10 observations between 1960 and 2005. The sample size would be very small if the data is not interpolated, but interpolation has also its own drawbacks.

To avoid the problems of interpolation, this study takes the school enrollment ratios at the time. The enrollment ratio gives the proportion of the age group that is enrolled at an institution for the specified educational level. There is one thing to be concerned about the enrollment ratios. These enrollment ratios show the educational level of the population that is not yet in the active labor force. Some studies take the assumption that individuals take place in the active labor force by the age 15.4

However, this assumption is not realistic. Using longer lags this study takes 25 years of age to be the age that workers enter the active labor force. In order to use this assumption the average graduation age is taken as the age of the individual at the median level for corresponding schooling level. In this respect the average lag needed to be in the labor force for secondary years of schooling (high school) is 9 years and for tertiary level the 5 years.<sup>5</sup>

**Table 1:** Decomposition of output assuming the Physical Capital Share ( $\alpha$ ) is 35 percent

Period	Growth of GDP per worker <sup>6</sup>	Growth of Physical capital per worker	Contribution of Physical capital per worker	Growth of human capital per worker	Contribution of human capital per worker	Growth of TFP	Contribution of TFP
1960-1969	4.20%	1.45%	34.53%	0.11%	2.72%	2.64%	62.75%
1970-1979	3.05%	2.18%	71.58%	0.38%	12.56%	0.48%	15.86%
1980-1989	2.34%	1.03%	43.85%	0.82%	35.04%	0.49%	21.11%
1990-1999	1.80%	1.15%	63.80%	0.67%	36.98%	-0.01%	-0.79%
2000-2005	4.60%	0.83%	17.99%	0.32%	6.93%	3.45%	75.07%
1960-2005	3.05%	1.34%	43.96%	0.48%	15.73%	1.23%	40.31%
1960-1980	3.20%	1.74%	54.34%	0.29%	8.92%	1.18%	36.74%
1980-2005	2.93%	1.02%	34.87%	0.63%	21.70%	1.27%	43.43%

### Decomposition of Growth

Table 1 summarizes the Growth Accounting exercise of Turkey within the 1960-2005 periods. The share of physical capital is assumed to be 0.35 for two main reasons. First, a number of studies indicate that Turkey has a pattern of a developed nation in terms of the share of Capital, much lower than the developing nations have which is around 35 percent and further, as shown in the second part of this paper under different methodologies time series evidence suggest that the share of Physical Capital is around 35 percent in Turkey.<sup>7</sup>

Output per worker has grown by 3.2 percent per annum over the period 1960-2005. There exist certain jumps in the growth rates after crises years. Over the 1960-2005 period change in the human capital explains 15 percent of the total change in output per worker. After 1980s the relative importance of human capital increases in terms of explaining the change in output growth. For this sub-period the relative share of human capital in explaining the total change in output growth is 21 percent. For the period between 2000 and 2005 the contribution of human capital is relatively low which could be due to the severe financial crisis in 2001 and the shorter time span.

Growth accounting may be able to provide a mechanical decomposition of the growth output ratio into growth of an array of inputs and growth of total factor productivity. Successful accounting of this sort is likely to be useful and may simulate the development of useful theories of economic growth. Growth Accounting does not, however, constitute a theory of growth because it does not attempt to explain how the changes in inputs and the improvements in TFP relate to elements such as aspects of preferences, technology and government policies that can reasonably be viewed as fundamentals [3].

### Time Series Analysis Unit Root Test

Before proceeding with the ARDL bounds test, we test for the stationarity status of all variables to determine their order of integration. Although the bounds test for cointegration does not depend on pre-testing the order of integration, all variables need to be integrated of order one in order to apply the Gregory Hansen (1996) test. This is to ensure that the variables are not integrated of order two or more so as to avoid spurious results. According to Ouattara (2004) in the presence of integrated of order two variables the computed F-statistics provided by Pesaran (2001) are not valid because the bounds test is integrated of order one. Therefore, the implementation of unit root tests in the ARDL procedure might still be necessary in order to ensure that none of the variables is integrates of order two or beyond.

The order of integration is computed through applying the Augmented Dickey Fuller (ADF) and Phillips Perron (PP) unit root tests.[14] The test regression included a constant with no trend for both

the log-levels and for the first differences of the variables. The ADF of Dickey and Fuller and Phillips Perron unit root tests results for the variables reported in Table 2 [7]. Test results reported in Table 2 indicate that all variables are integrated of order one. The null hypothesis of unit root process is rejected based on the Akaike Information Criteria (AIC) and serial correlations diagnostics test from the unit root test results.

**Table 2** Unit root tests

Variable	ADF test statistic					Philips-Perron test statistic				
	Levels	AIC lag	1 <sup>st</sup> differences	AIC lag	I(d)	Level s	PP lag	1 <sup>st</sup> differences	PP lag	I(d)
y	-1.42	1	-8.70	1	I(1)	-1.19	2	-8.70	1	I(1)
k	-0.20	1	-5.18	1	I(1)	-2.20	2	-5.26	3	I(1)
secondary	1.31	6	-3.80	2	I(1)	1.06	6	-4.73	8	I(1)
tertiary	-2.06	4	-3.12	4	I(1)	1.08	1	-4.65	2	I(1)
FDI	-1.36	1	-6.23	1	I(1)	-0.71	1	-3.16	1	I(1)

**Notes:** All variables are in logs except the Foreign direct investment ratios. <sup>a</sup> Lag length is obtained via Newey-West using Bartlett kernel selection criteria Results obtained from Eviews5.1.

### Bounds Tests for Cointegration

**Table 3:** Results of Bounds test on equation 8 and 9

EXOGENOUS MODEL-EQUATION 8			ENDOGENOUS MODEL-EQUATION 9		
DEPENDENT VARIABLE	AIC LAGS	F- STATISTICS	DEPENDENT VARIABLE	AIC LAGS	F- STATISTICS
<b>Secondary Enrollment as a proxy</b>					
F <sub>y</sub> (y   k, sec)	2	7,149***	F <sub>y</sub> (y   k, sec, FDI)	2	3.980*
F <sub>k</sub> (k   y, sec)	2	7,390***	F <sub>k</sub> (k   y, sec, FDI)	2	2.078
F <sub>sec</sub> (sec   y, k)	2	2,391	F <sub>sec</sub> (lsec   y,k, FDI)	2	0.479
			F <sub>FDI</sub> (k   y, k, sec)	2	1.007
<b>Tertiary Enrollment as a proxy</b>					
F <sub>y</sub> (y   k, ter )	2	5,164**	F <sub>y</sub> (y   k, ter, FDI)	2	3,572*
F <sub>k</sub> (k   y, ter)	2	3,272*	F <sub>k</sub> (k   y, ter, FDI)	2	5,070**
F <sub>ter</sub> (ter   y, k)	2	7,891***	F <sub>lsec</sub> (ter   y,k, FDI)	2	2,722
			F <sub>FDI</sub> (k   y, k, ter)	2	2,460

Notes: Asymptotic critical value bounds are obtained from Appendix Case II restricted intercept and no trend for k=3 for the exogenous model and k=4 for the endogenous model in Narayan (2005). For k=3 the lower and upper bound is 4.428 and 5.816 respectively for 1 percent level of significance, 3.164, and 4.194 respectively for 5 percent significance and for 10 percent the bounds are 2.618 and 3.532. For k=4 the lower and upper bound is 4.093 and 5.532 respectively for 1 percent level of significance, 2.947, and 4.088 respectively for 5 percent significance and for 10 percent the bounds are 2.460 and 3.460. A\*\*\* denotes the significance at 1 percent \*\* denotes the significance at 5 percent and \* denotes significance at 10 percent

In the first step of the ARDL analysis, the presence of long-run relationships using equation (8) and (9) are tested. General-to-specific modeling approach guided by the short data span and AIC respectively to select a maximum lag order of 2 for the conditional ARDL VECM is used. We first estimated an OLS regression for the first differences part of equation (8) and (9) and then test for the joint significance of the parameters of the lagged level variables when added to the first regression. According to Pesaran [20], this OLS regression in first differences is of no direct interest to the bounds cointegration test. The F-statistic tests the joint null hypothesis that the coefficients of the lagged level variables are zero (i.e. no long-run relationship exists between them). Table 3 reports the results of the calculated F-statistics for ARDL-OLS regressions. According to findings in Table 3 the calculated F-statistics both F<sub>y</sub>(y | k, sec) F<sub>y</sub>(y | k, ter ) F<sub>y</sub>(y | k, sec, FDI) F<sub>y</sub>(y | k, ter, FDI) is higher than the upper critical value although the F-statistics of the exogenous model yields higher confidence levels the hypothesis of no cointegration is rejected in all versions. Also when regressors are normalized on capital it is rejected that there exist no long run relationship in the exogenous models. However, based on the growth theory, this study uses the output (y) as the dependent variable.

**Table 4: ARDL Representations**

Dependent variable y							
Equation 10 ARDL(1,2,0)				Equation 11 ARDL (1,2,1,1)			
Human Capital Proxy				Human Capital Proxy			
Long-run Elasticities							
	secondary	tertiary		secondary	tertiary		tertiary
<b>C</b>	8.842*** (2.437)	8.596*** (1.948)		6.119** (3.305)			9.017** (3.432)
<b>k</b>	0.326* (0.197)	0.389*** (0.135)		0.544** (0.253)			0.364 (0.233)
<b>secondary</b>	0.367* (0.215)			0.124 (0.222)			
<b>tertiary</b>		0.205*** (0.101)					0.167 (0.128)
<b>FDI</b>				0.483** (0.253)			0.273 (0.217)
<b>Dummy</b>	-0.422*** (0.221)	-0.377*** (0.183)		-0.069*** (0.013)			-0.068*** (0.012)
Computed Short-Run Elasticities							
<b>k</b>	0.887	<b>k</b>	0.901	<b>k</b>	0.750	<b>k</b>	0.742
<b>secondary</b>	0.061	<b>tertiary</b>	0.038	<b>secondary</b>	0.022	<b>tertiary</b>	0.043
				<b>FDI</b>	-0.006	<b>FDI</b>	-0.005
Short Run Diagnostics test Statistics				Short Run Diagnostics test Statistics			
$\chi^2_{SC} (1)= 0.688[0.407]$		$\chi^2_{SC} (1)=0.857[0.355]$		$\chi^2_{SC} (1)=0.903[0.342]$		$\chi^2_{SC} (1)= 0.222[0.638]$	
$\chi^2_{FC} (1)=0.316[0.574]$		$\chi^2_{FC} (1)=0.000[0.995]$		$\chi^2_{FC} (1)=3.767[0.052]$		$\chi^2_{FC} (1)= 1.617[0.204]$	
$\chi^2_N (2)=1.133[0.567]$		$\chi^2_N (2)=1.337[0.512]$		$\chi^2_N (2)= 1.315[0.518]$		$\chi^2_N (2)= 0.947[0.623]$	
$\chi^2_H (1)=0.088[0.766]$		$\chi^2_H (1)=0.049[0.825]$		$\chi^2_H (1)= .0592[0.808]$		$\chi^2_H (1)= 0.037[0.847]$	

Notes: Standard errors in parentheses. \*, \*\*, and \*\*\* indicate the level of significance at 10 percent, 5 percent, and 1 percent respectively.  $\chi^2_{SC}$ ,  $\chi^2_{FC}$ ,  $\chi^2_N$ , and  $\chi^2_H$  are Lagrange multiplier statistics for tests of residual correlation, functional form misspecification, non-normal errors and heteroskedasticity, respectively

The ARDL presentations of both models are given in Table 4. From the bottom part of Table 4 we may conclude that human capital does not pay off in the short-run like the physical capital. Although the return to physical capital stock is around 30 percent in both versions of the model, the short run elasticity is around 90 percent. On the other hand, human capital has an elasticity of 6 percent when measured as high school enrollment rates and 3 percent when measured in university enrollment rates in the short run, whereas this elasticity is five times higher in the long run for secondary years of schooling and around 6 times higher at university level. Secondary enrollment ratio proxy has a higher return than the university level of education in the exogenous model, when technology is assumed to be exogenous. This finding is also meaningful. According to the findings of Table 4 we may also conclude that the return on capital would be realized in longer time spans. This finding is also consistent with the theory of human capital [12].

The second analysis is aimed to test the empirical relevance of endogenous technology to the growth process of Turkey for the 1970-2005 period. The reason for a shorter time span is the lack of data for Foreign Direct Investment rates within the years between 1960 and 1970. The share of high school enrollment was 0.36 in the previous model and around 0.12 in this model.

However if we check the table, the share of human capital as measured with university enrollment ratios is 0.16 and the share of FDI declines. When technology is assumed to be exogenous the share of human capital as measured with the university level enrollment rates is around 0.20. When, on the other hand, FDI is included into model, the estimated coefficient of human capital decline in all measures as one should expect since one more explanatory variable decreases the magnitude of others. However, the magnitude of the decrease is lower in higher levels of education. This finding suggests that when technology is assumed to be endogenous the contribution of high skilled workers would be higher than the contribution of the non skilled workers (0.16 and 0.12 respectively), as opposed to the finding in which technology was not included into the model.

A common practice in applied economics tells us that when a variable is added into model, the explanatory power of the previous regressors decreases. The share of foreign direct investment is also significant determinant of the output per worker; the effect is a 0.48% increase in output per worker when the FDI increases by 1%. This finding is clearly against the opinion that the foreign direct investment has no effect or has a negative effect on the economic performance of an economy. However, there is one crucial detail that should be mentioned about this finding, one should be aware of the fact that the human capital and capital stock are kept constant.

In all specifications estimated coefficient on the dummy variable is negative and highly significant, indicating that the Turkish economic growth process suffers from the financial crises. Hence, in order to eliminate these cycle effects it is crucial to include crisis year dummies into the system.

After estimating the long-term coefficients we obtain the error correction representation of the ARDL model. (Equations 12 and 13) Empirical results show that this model passes all the diagnostic tests, and supports the overall validity of the short-run model. Table 5 reports the short-run coefficient estimates obtained from the ECM version of the ARDL model. The error correction term indicates the speed of adjustment in restoring equilibrium in the dynamic model. The ECM coefficient shows how quickly/slowly variables return to equilibrium, and it should have a statistically significant coefficient with a negative sign. A highly significant error correction term is further proof of the existence of a stable long-term relationship. [11],[17]

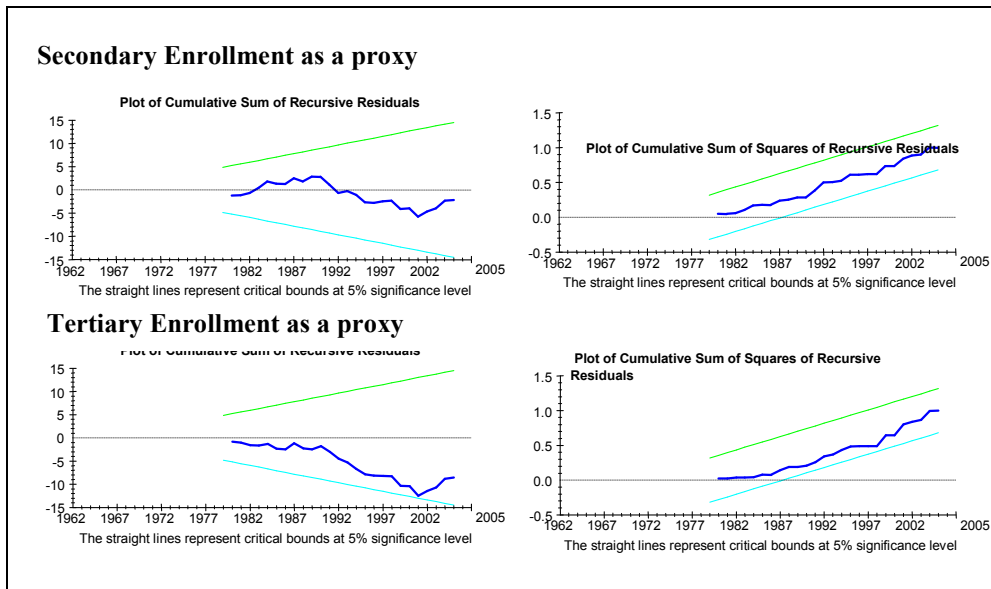
### **Stability test Results**

Figure 1-1 and 1-2 display the Cumulative Sum of Residuals (CSUM) and Cumulative Sum of Residuals Squares(CSUMQ) of the second model with high school enrollment proxy of human capital. Both CSUM and CSUMQ support the stability of the coefficients for the Error Correction Model.

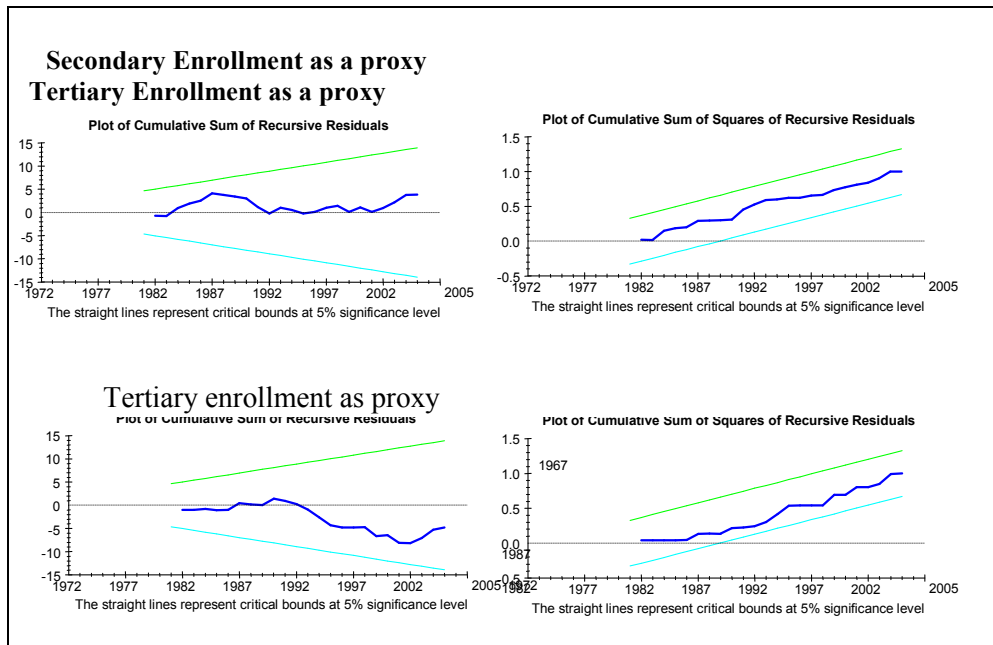
**Table 5 ECM Representations**

Dependent variable is $\Delta \ln y$				
ARDL (1,2,0) Equation 12			ARDL (1,2,1,1) equation 13	
Regressor				
$\Delta k_t$	0.887 *** (0.188)	0.901 *** (0.186)	0.728 *** (0.209)	0.742 *** (0.204)
$\Delta k_{t-1}$	-0.567 *** (0.201)	-0.507 *** (0.205)	-0.442 ** (0.248)	-0.471 ** (0.233)
$\Delta$ secondary	0.062 ** (0.034)		-0.111 (0.142)	
$\Delta$ tertiary		0.038 ** (0.018)		0.044 (0.041)
$\Delta$ FDI			-0.002 (0.034)	-0.005 (0.033)
Ecm(-1)	-0.168 ** (0.079)	-0.186 ** (0.0795)	-0.223 ** (0.116)	-0.260 ** (0.130)
Dummy	-0.070 *** (0.013)	-0.070 *** (0.0124)	-0.068 *** (0.013)	-0.068 *** (0.013)
Constant	1.484 ** (0.629)	1.598 *** (0.612)	1.368 (1.09)	2.340 (1.590)
R-Squared =0.797		R-Squared =0.803		R-Squared =0.859
R-Bar-Squared =0.764		R-Bar-Squared =0.771		R-Bar-Squared =0.806
F-stat. F(5, 38)= 29.0393[.000]		F-stat. F(5, 38)=30.111[.000]		F-stat. F(6, 27)=24.282[.000]
SER=0.025 RSS=0.023		SER=0.025 RSS= 0.022		SER=0.025 RSS= 0.015
DW-statistic=2.220		DW-statistic=2.192		DW-statistic=2.1661
AIC= 96.917		AIC= 96.92		AIC= 73.511
SBC=90.672		SBC= 91.31		SBC=65.879
ECM <sub>SEC</sub> = Y -0.367*SEC -0.326*K - 8.842*C + 0.422*DUMMY			ECM <sub>SEC</sub> = Y -0.544*K -0.124*LSEC - 0.483*FDI -6.119*C +0.306*DUMMY	
ECM <sub>TER</sub> = Y -0.205*TER -0.389*K - 8.596*C + 0.377*DUMMY			ECM <sub>TER</sub> = Y-0.364*K -0.168*LTER - 0.273*FDI -9.017*C + 0.262*DUMMY	

**Notes:** Standard errors in parentheses. \*, \*\*, and \*\*\* indicate the level of significance at 10 percent, 5 percent, and 1 percent respectively.



**Fig. 1** CSUM and CSUMQ Plots for the exogenous model



**Fig. 2** CSUM and CSUMQ Plots for the endogenous model

Table 6 summarizes the estimated long-run elasticities of human capital, physical capital, and technology. The elasticity of physical capital in Turkey with respect to output is around 35 percent (except for the endogenous model where the human capital proxy is high school enrollment rates) Turkey exhibits a developed country trend in this respect. The elasticity of output with respect to human capital, which is measured in levels of education is between 12 to 37 percent for different measures and models, but even in the worst case scenario the elasticity is considerably high indicating that 10 percent increase in the high school enrollment ratios leads to a 1.2 percent increase in output per worker keeping FDI and Physical capital constant.

**Table 6** Estimated Long-Run Elasticities

	Exogenous technology		Endogenous technology	
	High School Enrollment proxy	University Enrollment proxy	High School Enrollment proxy	University Enrollment proxy
Physical Capital	0.33	0.39	0.54	0.36
Human Capital	0.37	0.21	0.12	0.17
Technology			0.48	0.27

### Conclusion

In this study bounds testing approach to Cointegration (ARDL) is used to estimate the long-run and short-run relationships between education (at different levels), physical capital stock, foreign direct investment, and economic growth in two distinct growth models for Turkey.

Education at all levels has a significant and a positive impact on long-run growth in Turkey. Further, FDI has a positive effect on the economic performance of the Turkey, suggesting that Turkey could benefit more from FDI in terms of knowledge spillovers. The total elasticity of human capital and technology is above 50 percent for both human capital proxies.

Turkish economy suffers from severe financial crises within the past 50 years, sustaining the financial stability of the economy would also increase the potential gains from physical and human capital.

### References

1. **Aghion, P. and P. Howitt.** *Endogenous growth theory*, MIT Press, Cambridge. 1998
2. **Abu-Qarn, A. S. and Abu-Bader, S.** "Sources of Growth Revisited: Evidence from Selected MENA Countries," *World Development*, 2007 35(5), 752-771,
3. **Barro, R.J.** "Economic growth in a cross section of countries", *Quarterly Journal of Economics*, 1991, 106(2), 407-443
4. **Barro, R.J. and X. Sala-i-Martin.** *Economic growth*, McGraw-Hill, New York. 1995
5. **Benhabib, J. and M.M. Spiegel.** "The role of human capital in economic development: evidence from aggregate cross-country data," *Journal of Monetary Economics*, 1994, 34(2), 143-173.
6. **Brown, R.L., Durbin, J., Evans, J.M.,** "Techniques for testing the constancy of regression relations over time." *Journal of the Royal Statistical Society*, 1975, Series B 37, 149–163.
7. **Carr, D., J. Markusen, and K. Maskus.** "Estimating the knowledge-driven model of the multinational enterprise," *American Economic Review* 2001, 91: 693-708.
8. **Dickey, D.A. and Fuller, W.A.** "Likelihood ratio statistics for autoregressive time series with a unit root," *Econometrica*, 1981, Vol.49: 1057-1072
9. **Gregory, A.W., and B.E. Hansen.** "Residual-based Tests for Cointegration in Models with Regime Shifts," *Journal of Econometrics*, 1996, 70(1): 99-126.
10. **Halcioğlu, F.** "An ARDL Model of International Tourist Flows to Turkey," *Global Business and Economic Review* 2004 Anthology, 614-624
11. **Halcioğlu, F.** " An Econometric Study of CO2 emissions, energy consumption, income and foreign trade in Turkey," *Energy Policy* 2009, 37:1156-1164
12. **Loening, J.L.** "Time series evidence on Education and Growth:The case of Guatemala,1951-2002" *Revista de Analisis Economico*,2004,19,(2), 3-40.
13. **Lucas, R.E.** "On the mechanics of economic development," *Journal of Monetary Economics*, 1988, 22, 3-42.

14. **Mankiw, N.G., D. Romer and D. Weil**, “A contribution to the empirics of economic growth,” *Quarterly Journal of Economics*, 1992, 107, 407-437.
15. **Narayan P.K.**, “The saving and investment nexus for China: evidence from cointegration tests”, *Applied Economics*, 2005, 37, 1979-1990
16. **Nehru, V. and A. Dhareshwar** “A New Database on Physical Capital Stock: Sources and Methodology,” *Revista Analisis de Economico*, 1993, 8(1), pp.37-59.
17. **Nelson, R., Phelps, E.**, “Investment in humans, technological diffusion, and economic growth.” *American Economic Review: Papers and Proceedings*, 1966, 51 (2), 69-75.
18. **Ouattara, B.**, Foreign Aid and Fiscal Policy in Senegal. Mimeo University of Manchester 2004,
19. **Pahlavani, M.**, “Cointegration and Structural Change in the Exports-GDP Nexus: The Case of Iran,” *International Journal of Applied Econometrics and Quantitative Studies*, 2 (4) 2005.
20. **Pesaran, M.H. and B. Pesaran**, “Working with Microfit 4.0: Interactive Econometric Analysis.” Oxford, Oxford University Press, 1997
21. **Pesaran, M.H, Shin Y., and Smith R.J.**, “Bounds Testing Approaches to the analysis of level relationships”, *Journal of Applied Econometrics*, 2001, 16,289-326
22. **Pritchett, L.** “Where has all the education gone?” *World Bank Policy Research Department* working paper No. 1581. 2001
23. **Romer, P.M.** “ Endogenous technological change,” *Journal of Political Economy*, 1990,98(5), S71-S102.
24. **Saygili, S., C. Cihan ve H. Yurtoglu** , “Turkiye Ekonomisinde Sermaye Birikimi Verimlilik ve Buyume: 1972-2003,” DPT Yayin NO: 2686. 2005,
25. **Solow R.M.**, “ A Contribution to the Theory of Economic Growth.” *Quarterly Journal of Economics*, 1956,70 (1): 65–94.
26. **State Planning Organization (SPO)** (2007), Main Economic Indicators
27. **Turkish Statistical Institute(TurkStat)** [www.turkstat.gov.tr](http://www.turkstat.gov.tr)
28. **Republic of Turkey Prime Ministry Under Secretariat of Treasury**, *Treasury Statistical Yearbook2007*  
<http://www.treasury.gov.tr/irj/go/km/docs/documents/Treasury%20Web/Statistics/Annual/V-%20Yabancı%20Sermaye/YSGM.xls>

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<sup>1</sup> For detailed discussion see Aghion and Howitt (1998)

<sup>2</sup> Average annual growth rate based on the data of State Institute of Statistics,

<sup>3</sup> Although the procedure is not applicable in the presence of I(2) series,

<sup>4</sup> (see Saygili *et.al.* 2005)

<sup>5</sup> There is one more thing to be concerned about examining the effect of school enrollment rates effects on economic growth. Since many of the high school graduates continues to their education the effect of this variable might be insignificant or inconsistent. In this respect Barro and X. Sala-i-Martin (1995) in their panel study mostly could not find any significant effect of secondary schooling especially for females.

<sup>6</sup> All growth rates are Annual Average Growth rates for the corresponding period and are computed as the average exponential growth within the specified time period.

<sup>7</sup> Abu-Qarn, A. S. and Abu-Bader, S., 2007 report that the share of physical capital for Turkey as 0.37