The Role of Education and Human Capital for Economic Growth in Middle Income Countries: Egypt's Case

Khaled El-Mattrawy[*]and Willi Semmler[†]

June, 2006

Abstract

The paper studies the role of education and human capital for economic growth of a medium income country. Empirical cross section studies on the sources of growth in general and in education, human capital and growth specifically, have not been able to form a consensus on the causality between human capital and growth. This paper employs a time series perspective on this issue and uses the most comprehensive data available on a middle income country. We use the example of Egyptian economy and refer to the time period 1959 until 2002. The analytical work of the paper starts with the study of the Solow residual by using only capital and labor as inputs. The Solow residual, measuring total factor productivity, turns out to be huge. Thus, output increase cannot be explained solely by an increase of labor force and capital accumulation. Therefore, following the endogenous growth literature the contribution of education and human capital formation is studied and its contribution to growth evaluated by using a very detailed data base on the educational system of Egypt. Our approach can account for a significant part of total factor productivity. Yet, there is still a residual left to be explained. Therefore, there are still other forces to be considered such for example, the role of knowledge, external shocks, international trade, and public infrastructure.

[*]The City University of New York (CUNY).

[†]SCEPA nd Dept. of Economics, New School, New York and CEM, Bielefeld University

1

1 Introduction

The long run per capita output growth is the most important measure of economic performance (Obstfeld and Rogoff, 1996). Yet, there are many forces for the long-run increase of the welfare of a country - investment, education and human capital, technology and growth of knowledge, infrastructure investment, international trade and so on. Economic literature is rich with models on many forces of economic growth.

Much research of the older literature has concentrated on exogenous technological change, measuring it by changes in a variable such as Total Factor Productivity (TFP). Some of these older studies are Copeland (1937), followed by Copeland and Martin (1938), Stigler (1947), Griliches (1956, 1957b, 1958a), Schultz (1953), and Ruttan (1954, 1956). The topic was transformed by Solow (1956), in his theory of economic growth: subsequently it was recognized that a major share of the observed growth in output could be attributed to a "residual" to be measured by the Solow residual. The Solow residual is a standard measure of the contribution of total factor productivity to growth. It represents that the part of output growth that cannot be explained by the growth of the primary factors of production, i.e. capital and labor.

It has become of vital importance to the study of economic growth to better understand the TFP. Recently modern growth theory has embarked to attempt to decompose TFP into identifiable factors. This literature had started with publications by Romer (1986 and 1990), Lucas (1988), Grossman and Helpman (1991), Aghion and Howitt (1998) and Greiner, Semmler and Gong (2005). What has become important here is to understand the critical role of externalities and economies of scale, see Romer (1986). Furthermore, another important force is education, as an investment in what is called human capital, see Uzawa (1965) and Lucas (1988). This research direction produced a variety of opinions on the effect of education and human capital on economic growth. Yet, most economists from different schools of economic thought still regard education and human capital accumulation as key factor driving economic growth.

The increase in per capita income during the last four decades in many countries, was seen as a result of the human capital formation and expansion of technology and scientific research that raised the productivity in several countries.[1] In particular, rapid growth rates in the East Asian economies led

---

[1]See De La Croix Vandenberghe, and Vincent, 2004: p 2

to increased attention to education and human capital (Den Berg, 2000: p1) as well as the growth of knowledge as important forces of economic growth.[2]

A good summary of some of these studies is presented in Tilak (1989) and Patrinos of the World Bank in its Internet memo.[3] The World Bank study in 1993 found that improving the quality of primary education helped improve growth trends in East Asian countries. Young (1995) studied the Asian growth miracle. He compared the Asian growth rates to the G7 growth rates along historical lines. Young found that, in order for both of them to grow faster, they must have a higher rate of transformation from human capital into new ideas and technological progress (Young, 1995: pp 641-679).

As aforementioned, in economic theory the importance of education and human capital was restored by Lucas (1988) who has based his work on Uzawa (1965). Subsequently numerous cross-sectional empirical tests have been developed. Bils and Kelnow, (1996) studied the relationship between each additional year in education and the wage level in 48 countries. They found that the ratio was 1:10 due to the increase in the workers skills. Redding (1996) studied the influence of expectation as a determinant of human capital formation. [4] In another cross-section study, Barro found that schooling was positively related to economic growth. The growth in per capita GDP over the period 1960 to 1990 has significantly been caused by increasing the total number of schooling years by one year (Barro, 1991: pp 407-444).

Barro and Sala-i-Martin (1995) presented regression results for per capita GDP; they did not present a particular model to explain the rate of growth. However, they used the growth rate as a dependent variable of some exogenous variables. One variable was human capital, which was the outcome of the average years of both sexes in high schools, and it was significantly correlated with growth rate in the periods of their study. Barro and Sala-i-Martin stated that human capital is not enough by itself to affect the growth trends; it must be associated with other factors such as life expectancy, health, government polices. In addition Klenow and Rodriguez (1997) found that human capital has only a small role in explaining the change of GDP.[5]

Overall, empirical cross-sectional studies on the sources of growth in general and in education, human capital and growth specifically, have not been able to form a consensus or prove the causality between human capital and

---

[2]For the role of the latter, see Romer (1990)

[3]http://www.worldbank.org/html/extdr/hnp/hddflsh/hcwp/hrwp036.html.

[4]See also Boucekkine, Raouf, Tamarit and Ramon (2000)

[5]As concerning stocks Kendrick (1976) found that human capital represents more than 50% of the total of capital stock in the United States of America: more than 93% of its estimated aggregate wealth. Jorgenson and Frumeni (1989) found that human capital generates close to 67% of the total income of the factors of production.

growth (Den Berg, 2000: p 384). Recent examples of the controversies are the two studies that were conducted by BenHobeb (1994) and Temple (1998), which used the same data set in their analysis, yet produced different results. However, BenHobeb used a larger number of countries, and education was not clearly correlated to economic growth. Temple found that the two were clearly correlated.[6]

Gupta (1999) and others tested the statistical relationship between education and economic growth by examining the distribution of educational expenditure to different levels of education. He found that total education spending may not be so important, compared with importance of the allocation of this expenditure. They were in favor of allocating more funds toward primary and secondary education.

Greiner, Semmler, and Gong (2005, ch. 4) conducted another empirical study to assess the role of human capital for economic growth. They used a time series approach studying the role of education and human capital for economic growth of the USA and Europe. The authors applied a modified version of the Uzawa/Lucas growth model, and they tested the model using time series data for the USA and Germany from 1962 to 1996. The results of their estimates show some nonlinear relationship. Educational effort, the growth rate of human capital and output may not be linearly related. In other words, human capital and economic growth cannot go up without an upper bound (Greiner, Semmler, and Gong, 2005, ch. 4).

We here follow also a time series approach. In section 2 we first study the TFP for a medium income country such as Egypt. Section 3 presents a growth model that specifies the relationship between human capital accumulation and economic growth. We here utilize a model such as in Lucas (1988), which is based on Uzawa (1956) and as modified in Greiner, Semmler and Gong (2005, ch. 4). Section 4 discusses some measures of human capital. Section 5 presents and identifies the method used to estimate the model components. Section 6 evaluates the results and section 7 concludes the paper. The appendices collect the data sources, discuss data constructions and report data sets.

---

[6]The important study is examined by Turnovsky and Fisher (1995) they explore the relationship between human capital, physical capital and spending on one side, and financing the ideal type of education on the other side (Canning, 1999: 4). In another study by Gallup, Sachs, and Mellinger,(1998) human capital was found insignificant. In Canning (1999) and Canning, and Pedroni, (1999), human capital tend to have small statistically insignificant coefficients (ibid: p 5).

2   The Total Factor Productivity

The analytical work of this paper starts with the study of the Solow residual by using only capital and labor as inputs. We start with the production function of the firm sector employing inputs such as capital (K) and labor (L) producing an output (Y) with a Cobb-Douglas production function. Production at time (t) is given by

$$Y_t = A_t K_t^{\alpha}, L_t^{1-\alpha} \tag{1}$$

where $0 < \alpha < 1$ and Y_t is the flow of GDP at time t. $A > 0$ is the level of the technology in an economy, changing with the level of A. The level of technology would yield a larger quantity of output.

Then the growth rate of total factor productivity can be computed according to

$$\frac{\dot{A}_t}{A_t} = \frac{\dot{Y}_t}{Y_t} - \left(\alpha \frac{\dot{K}_t}{K_t} + (1 - \alpha) \frac{\dot{L}_t}{L_t} \right) \tag{2}$$

Where α is the elasticity of output with respect to capital at time t, and $1 - \alpha$ is the elasticity of output with respect to labor at time (t). Then total factor productivity can be directly computed from equ. (2) as a residual.

Details of the data sources for the estimation of the TFP for Egypt can be found in Appendix A. Here a brief summary is given. The gross domestic product Y_t and investment I, data were obtained from the Nehru and Dhareshwa Data Set for the years (1959-1990). Data for the years (1991-2002) were obtained from the World Bank data indicator compact disk (2003). The population data for the period (1991-2002) were obtained from the World Bank Data Compact Disk 2003. The human capital H_t data for the entire period used to estimate the model variables were obtained from the Central Agency for Public Mobilization and Statistics (CAPMAS). The labor data L_t was obtained from The Central Bank of Egypt for the years (1968-2002). However, this data for the years (1959-1967) was estimated using the population growth rates.

Data on physical capital stock for the period (1959-1990) after making the necessary adjustment was obtained from Nehru and Dhareshwa Data. Physical capital of the years (1991-2004) was computed using the perpetual inventory method. The 5% depreciation rate of physical capital δ was used according to the Egyptian accounting standard that assumes that the project wears out in 20 years.

Calculations of total factor productivity have been made for Egypt for

the period 1950-2004 using two different values for α.[7] The first value was estimated using the available data on K, L, and Y. We obtained an $\alpha = 0.694$. The second value was what Mankiw, Romer, and Weil (1992) used. They estimated, in a large cross-sectional study $\alpha = 0.666$. The main reason behind using Mankiw et al. is to compare our estimated results with standard results. Therefore, equation (2) can be written as follows:

$$\frac{\dot{A}_t}{A_t} = \frac{\dot{Y}_t}{Y_t} - \left(0.694 \frac{\dot{K}_t}{K_t} + 0.306 \frac{\dot{L}_t}{L_t} \right) \tag{3}$$

$$\frac{\dot{A}_t}{A_t} = \frac{\dot{Y}_t}{Y_t} - \left(0.666 \frac{\dot{K}_t}{K_t} + 0.333 \frac{\dot{L}_t}{L_t} \right) \tag{4}$$

The results for total factor productivity growth for Egypt are calculated using equations (3) and (4).

Results for both computations of TFP were plotted in figure 1. The figure shows that the Egyptian GDP growth rates and the fluctuation of the TFP. The figure also indicates that capital and labor by themselves are not enough to explain the forces of growth in Egypt, which is clear from the gap between both TFP curves and the economic growth curve. These results lead to the need to include other forces in order to explore the determinants of economic growth in a middle income country such as Egypt.

---

[7]It is difficult for a country such as Egypt as an emerging country to construct a production function with stable parameters, mostly because of the instability in its development of factors of production such as physical capital and labor during the economic growth's path. Another factor is the availability of accurate and sufficiently long time series data. So, total factor productivity, has to be seen as a rough measure only discover the basic sources and direction of economic growth in Egypt.
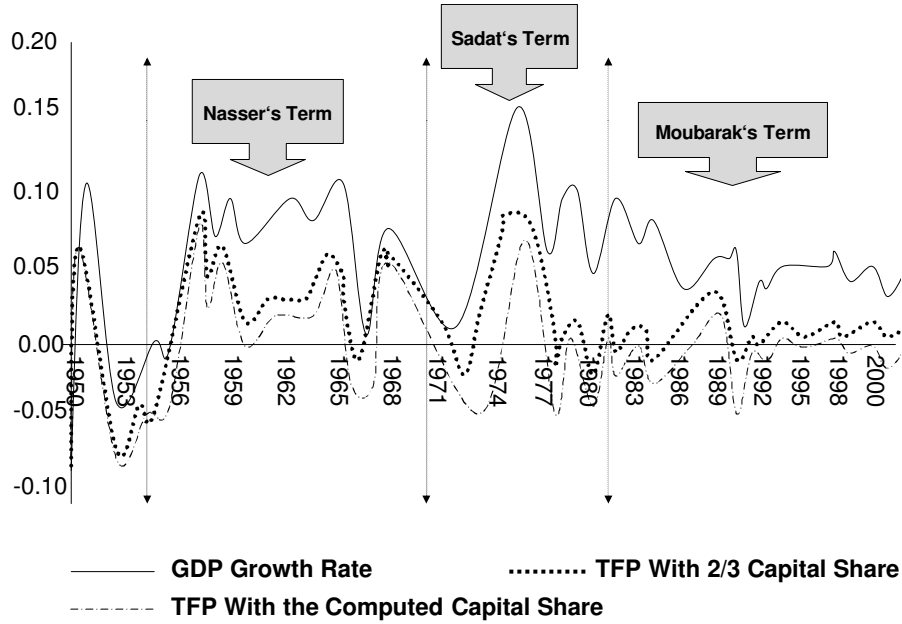
Figure 1: Total Factor Productivity

Indeed, these results may point to many factors that affected and are still affecting economic growth of Egypt.[8]

3   A Model of Growth and Human Capital

As the above computation of the TFP indicates economic growth depends not only on labor and physical capital, but also on other forces of economic growth. We here want to study the role of education and human capital for economic growth. Human capital is embodied in workers who accumulate skills. As to formal education the fraction of time that households will reserve to develop their skills and increase their human capital can be defined by $(1 - u)$. The fraction u is devoted to production. We thus have

$$\dot{h} = h_t \kappa (1 - u) \tag{5}$$

---

[8]The assumption of the Solow residual to be the accurate measurement of technological change, or the exogeneity of the TFP, may be of course questioned. For a detailed discussion on this issue see Gong and Semmler (2006, ch. 5).

7

Thus (h) will affect the current and the future production process through the accumulated knowledge embodied in persons. The following equation represents knowledge accumulation:

$$h_a = \frac{\int_0^\infty h L_h dh}{\int_0^\infty L_h dh} \tag{6}$$

However, the higher the level of human capital, the more difficult it might be to generate additional human capital. In other words, there might be decreasing returns to scale. Further, as we depreciate physical capital we may also allow human capital to depreciate. This can be represented as follows:

$$\frac{\dot{h}_t}{h_t} = h^{\rho_1 - 1} \kappa (1 - u_t)^{\rho_2} - \delta_h \tag{7}$$

Where δ_h is the depreciation rate of human capital and $(\rho_1, \rho_2) \in (0,1)$ parameters; ρ_1 representing the elasticity of the growth rate of human capital with respect to human capital, ρ_2 represents the elasticity of the growth rate of human capital with respect to schooling hours, and κ is a coefficient.[9]

The accumulated human capital might create positive externalities in the goods and services sector. This can be represented by a modified production function which can be written as:

$$L_t c_t + K_t = A K_t^{l-\alpha} [u_t h_t L_t]^\alpha h_a^\zeta \tag{8}$$

Where $Yt = L_t c_t + \dot{K}_t$ denoting the aggregate output of the economy. A is the constant level of technology, $(1-\alpha)$ is the share of physical capital in GDP, and $\zeta \geq 0$ represents externalities arising from human capital. Therefore, in general equ. (1) could be rewritten as follows:

$$Y_t = A K_t^{1-\alpha} [u_t h_t L_t]^\alpha h_a^\zeta$$

Finally, we presume that households will maximize a utility function with two choice variables c_t and $u_t, \forall, \geq 0$ where consumption, c_t, is measured as per capita consumption. Beside choosing consumption, households have to choose between working or going to school. They face the following optimization problem:

$$\max_{c,u} \int_0^\infty L_t \frac{c_t^{1-\sigma} - 1}{1 - \sigma} e^{-\rho} dt \tag{9}$$

---

[9]Some economists call it the efficiency parameter that represents the impact of the technology level on the education (Boucckkine 2001). For more details see Greiner et al. (2005, ch. 4).

Subject to

$$\dot{K}_t = AK_t^{1-\alpha}(u_t h_t L_t)^\alpha h_a^\zeta - L_t c_t \tag{10}$$

$$\dot{h}_t = h_t \kappa (1 - u_t) - \delta_h h_t \tag{11}$$

Where: $K_0 > 0$ and $h_0 > 0$ physical capital stock and human capital stock are both given and are always positive. Here, c_t is the stream of real per capita consumption. The optimization problem is represented by a CRRA utility function where $\sigma > 0$ represents the parameter of relative risk aversion. The labor force at the time t is $L_t . \rho$ is the rate of time preference. Y_t represents output, which may be allocated to consumption and capital accumulation. It depends on the inputs (u_t, L_t, h_t, K_t). The parameter $(1 - \alpha) \in (0, 1)$ is the elasticity of output with respect to physical capital, and ζ is assigned to collect the external effects of human capital.

The solution of the problem (9), subject to (10)-(11), can be described by the following equations that give us the modified Uzawa-Lucas model in per capita terms which we call Lucas II:

$$\frac{\dot{k}}{k} = Ak^{-\alpha} h^{\alpha+\zeta} u^\alpha - \frac{c}{k} - n - \delta_k \tag{12}$$

Equ. (12) represents the physical capital accumulation process in per capita terms that we want to use. Furthermore, from (11) we have

$$\frac{\dot{h}}{h} = h^{\rho_t - 1} \kappa (1 - u)^{\rho_2} - \delta_{h_t} \tag{13}$$

Equ. (13) represents the human capital accumulation process. From the Euler equation for consumption (see Greiner, Semmler and Gong, 2005, ch. 4) one obtains

$$\frac{\dot{c}}{c} = \frac{A(1-\alpha)\kappa^{-\alpha} h^{\alpha+\zeta} u^\alpha}{\sigma} - \frac{(\rho + \delta_k)}{\sigma} \tag{14}$$

Equ. (14) represents the consumption growth in per capita terms. From the Euler equation for the choice variable u one obtains[10]

---

[10]See Greiner, Semmler and Gong (2005, ch. 4).

$$\frac{\dot{u}}{u} = \frac{\delta_k \alpha - \delta_{h_t}}{1 + (1 - \alpha) - \rho_2} + \frac{h^{\rho_1 - 1} - \kappa(1 - u)^{\rho_1 - 1}\rho_2 u}{1 + (1 - \alpha) - \rho_2}$$

$$\frac{\alpha n}{1 + (1 - \alpha) - \rho_2} + \frac{\rho_1 h^{\rho_{t-1}} - \kappa(1 - u)^{\rho_2}}{1 + (1 - \alpha) - \rho_2} + \frac{\alpha + \zeta - \rho_1}{1 + (1 - \alpha) - \rho_2} \quad (15)$$

$$(h^{\rho_{t-1}} - \kappa(1 - u)^{\rho_2} - \delta_h)\frac{1 - \alpha}{1 + (1 - \alpha) - \rho_2}\left(\frac{c}{k}\right)$$

Equ. (15) represents the time spent in the production process, here denoted as growth rate.

$$\frac{\dot{L}}{L} = n \quad (16)$$

Equ. (16) denotes the population growth rate.

4 Proxies for Human Capital

There is no single way to compute human capital. However, there are a few well known methods to compute human capital that can be broken down into input-based measures that approximate human capital stock by looking at the inputs of the education and training process, and output-based measures that take the output of the education process into account when the human capital stock is computed. A snapshot of these measures is summarized here, for details see Greiner et al. (2005: pp 81-84).

$$H_t = \int_0^\infty \theta_t(s)\eta_t(s)ds$$

This proxy computes human capital stock (h) using the following. $\eta_t(s)$ is the population school years ratio, with (s) signifying years of schooling and $\theta_t(s)$ is the efficiency parameter after each school year. Mulligan and Sala-i-Martin (1993) use the wage level as a scaling factor in order to distinguish between the different levels of human capital that should differ according to number of years. Each cohort of human capital is computed through a wage-schooling relationship as follows:

$$\frac{w_t(s)}{w_t(0)} = \frac{\theta_t(s)}{\theta_t 0}$$

This proxy was used by Pasacharopulos and Arriagada (1986) and by Barro and Lee (1993). One can also use school years (s) as a replacement for $\theta_t(s)$ as follows:

$$H_t = \int_0^\infty s\eta_t(s)ds$$

However, economists argue that this proxy might not be an accurate measurement for human capital, especially in the case of the cross-section analysis. The criticism comes from the fact that the number of school years and the school systems vary across countries; the analysis does not take into consideration, for example, the repeaters who failed to complete their degrees. Therefore, it may not be a good approximation for the stock of human capital stock (Greiner et al., 2005: pp. 82). Another one is the following:

$$H_{g_t} = \sum_x \sum_t s_{gt}$$

This proxy uses the sum of individual schooling years where s_{gt} is the addition to human capital stock of each extra year in education, using the enrollment rate, and ignoring the drops and repeats: (g) stands for the grade, and (t) stands for the years. The following

$$l_t = \int_0^\infty w_t(s)u_t(s)\eta_t(s)ds$$

is one of the output based proxies that uses the wage level of workers as a function of school years, where l_t is the earnings of all residents, $u_t(s)$ stands for the educated worker with (s) years of school population ratio, $w_t(s)$ is the individual wage level after (s) years of school, and η_t is the share of population with (s) signifying years of schooling.

The above first proxy is used in our study but we will use rough estimates of wage differentials as proxy for efficiency parameters. For the specifics of our measure and data sources, see appendix B.

5   Analysis of Results

In our estimation of the equations of our growth model with human capital we successively modify the production function for final output as well as for the formation of human capital by including further specified human capital variables.

5.1 Estimates of the Production Functions

The production function[11], appearing in equ. (10) was estimated for different cases. Our first regression examined the production function in its constrained form $Y_t = AK_t^\alpha L_t^{1-\alpha}$, assuming that physical capital and labor are the only two factors of production. The regression results showed a constant return to scale production function with 0.61 of capital share in GDP compared to 0.59 of labor share. The second regression examined the same production function unconstrained; $Y_t = AK_t^\alpha L_t^\beta$. The regression results, reported in table 1, showed an increasing return to scale production function with 0.59 capital share and 0.45 of labor share.

Regressions		Parameter	Coefficient	Std.Error
Number	Equation			
1	$Y_t = AK_t^\alpha L_t^{1-\alpha}$	α	0.61	0.01
		$1-\alpha$	0.39	N/A
2	$Y_t = AK_t^\alpha L_t^\beta$	α	0.59	0.059716
		β	0.45	0.195551
3	$Y_t = AK_t^\alpha (h_t L_t)^{1-\alpha}$	α	0.39	0.122804
		$1-\alpha$	0.61	N/A
4	$Y_t = AK_t^\alpha (u_t h_t L)^{1-\alpha}$	α	0.36	0.115796
		$1-\alpha$	0.64	N/A
5	$Y_t = AK_t^\alpha (u_t h_t L_t)^{1-\alpha}(u_t, h_t)^\zeta$	α	0.47	0.026700
		$1-\alpha$	0.53	N/A
		ζ	-0.35	0.012651
6	$Y_t = AK_t^\alpha (u_t h_t L_t)^\zeta$	α	0.53	0.021908
		ζ	0.225	0.024442

Table 1: The Production Function Estimates

Human capital was then introduced in the third regression using the constrained version of the production function $Y_t = AK_t^\alpha (h_t L_t)^{1-\alpha}$. For details of the computation of the human capital variables, see appendix B. The results showed a drop in the share of physical capital to 0.39, and an increase in the share of labor to reach 0.61, indicating that human capital explains

---

[11]It is important to mention that all production functions used to be estimated were transformed in logarithmic form.

part of the capital share in the Egyptian GDP. In the fourth regression, the time spent on education was introduced and examined in a constrained production function of the type $Y_t = AK_t^\alpha (u_t h_t L_t)^{1-\alpha}$. The share of physical capital dropped even more to reach 0.36 and the share of labor picked up to reach 0.64.

In the fifth regression, the externalities effect of human capital was examined for constrained labor and physical capital coefficients and another coefficient to examine the externalities effect of human capital and time spent in education $Y = AK_t^\alpha (h_t L_t)^{1-\alpha} (u_t h_t)^\zeta$. The results showed that there is a negative externality effect arising from human capital, indicated by -0.35. Here we find 0.47 of physical capital share, and 0.53 as labor share in the Egyptian GDP. In the sixth regression, the constraints on the estimated production function were removed using $Y_t = AK_t^\alpha (u_t h_t L)^\zeta$. The results were: 0.53 physical capital share, and the labor share after including the school hours and human capital stock, was 0.225. However, despite the positive results, the total of the two coefficients capturing the capital share and the labor share $\alpha + \zeta$ was less than one, indicating that the production function is a decreasing returns to scale production function confirming the negative externalities from human capital and the school hours.

In general, we can claim that, in Egypt, education and human capital formation have no positive externality effects. Both time to education and human capital have only a weak effect on GDP. Note that $(1-\alpha) - \zeta = 0.18$. A thorough review of the education policy in Egypt has to be undertaken in order to explain the results, see sect. 6.

5.2   Human Capital Formation Estimates

Table 2 represents the results of the parameters for matching two variants of the model. We match $\dot{K}_t, \dot{h}_t$, in Lucas-I and $\frac{\dot{k}}{k}, \frac{\dot{h}}{h}$ in Lucas-II using the indicated equations in table 2.

Regressions	Variables	Coefficient	Std.Error
Lucas I			
Equation Number (10)			
$\dot{K}_t = AK_t^{\alpha}(u_t h_t L_t)^{1-\alpha}h_{\alpha}^{\zeta} - L_t c_t$	A	264.4093	23.21782
	α	0.29	0.016637
	ζ	-0.43	0.009095
Equation Number (11)			
$\dot{h}_t = h_t \kappa(1 - u_t) - \delta_h h_t$	κ	0.77	0.078051
Lucas II			
Equation Number (12)			
$\frac{\dot{k}}{k} = Ak^{-\alpha}h^{\alpha+\zeta}u^{\alpha} - \frac{c}{k} - n - \delta_k$	A	1.056232	0.793329
	α	0.33	0.146490
	ζ	-0.63	0.299932
Equation Number (13)			
$\frac{\dot{h}}{h_t} = h_t^{\rho_2 - 1}\kappa(1 - u_t)^{\rho_2} - \delta_h$	κ	0.028	0.058351
	ρ_1	0.53	0.334129
	ρ_2	-0.49	0.323901

Table 2: The Estimates of Lucas I and Lucas II

For the Lucas I model, as specified in the upper part of table 2, the parameter for matching $\dot{K}_t$ shows that the physical capital share in Egypt is significant at about 0.29, which is reasonable. Concerning the externality effect of human capital, ζ, this parameter again is negative at -0.431, which is comparable with our earlier estimates for the Egyptian production function, indicating that human capital stock does not generate positive externalities in Egypt. With regards to the time spent on education and the changes in the human capital stock, the results were positive, with κ equal to 0.77. This could be acceptable in the case of a developing country like Egypt. The more time people spend on education, the higher the growth rate of human capital, the faster the human capital accumulation. Moreover, the computed human capital growth rate - after inserting the estimated value of κ into equ. (11) - gives us the same numerical value as the growth rate of human capital using the empirical observation, making us comfortable with the estimated value of κ using the linear Lucas model; both are equal to 2.4%.

The reported results in table 2 with regards the parameter matching $\frac{\dot{k}}{k}, \frac{\dot{h}}{h}$ for Lucas-II show a reasonable physical capital share with 0.33, yet the externality parameter ζ continues to show a negative value at -0.63, confirming that human capital has no positive externality effect on GDP.

The human capital accumulation process was examined again after eliminating the scale effect by using a nonlinear form of the Lucas model to estimate the parameters for matching $\frac{\dot{h}}{h}$. This time, the value of the parameter, that catches the school hours effect on human capital growth κ dropped to 0.028. Regarding the parameter ρ_1, representing the elasticity of the growth rate of human capital with respect to human capital input, the result was positive at 0.53, which is compatible with our nonlinear Lucas model of equ. (13). Accordingly, the higher the human capital inputs, the higher the growth rate of human capital. Regarding the elasticity of the growth rate of human capital accumulation with respect to school hours, ρ_2, the estimates showed that it is statistically insignificant.

The above result could be interpreted in two ways; the nonlinear form of the Lucas model (Lucas II) does not work for the less developed nations, and/or the school hours demand better allocation. This could confirm what Greiner et. al. (2004, ch. 4) proved: the modified Lucas model in its nonlinear form is compatible with the cases of developed nations, in particular Germany and the United States. We here find that the nonlinear model functions in an opposite manner for less developed nations than it does in developed nations. Or, in other words, for the less developed nations we may find a linear effect of education on human capital accumulation.

6   Evaluation of the Results

The above results need some broader discussion. We have shown, when human capital was introduced into the constrained production function, the results showed a drop in the share of physical capital from 0.61 to 0.39, and an increase in the share of labor from 0.39 to 0.61, indicating that human capital has absorbed part of the capital share in the Egyptian GDP. The share of physical capital dropped even more when the school hours parameter was introduced and examined in a constrained production function, reaching 0.36; the share of labor picked up to reach 0.64. These are very reasonable results.

Another coefficient was introduced to capture the externality effect of human capital in constrained labor and physical capital coefficients. The results showed that a negative externalities effect arises from human capital. Furthermore, when the production function was estimated after removing the constraints and aggregating labor, human capital and schooling hours under one coefficient, the results were 0.53 of physical capital share. The labor share was 0.225. Yet, the total of the coefficients was less than one, confirming the negative externalities from human capital in Egypt. The sur-

prising result of our study is again that human capital might not necessarily have positive externality effects in less developed nations. For Egypt the negative externalities were obtained as soon as the externality parameter was introduced.

On the other hand our study indicates that education and human capital formation are quite linearly related, in a positive way. With regards to the time spent in education and the changes in the human capital stock, the results were positive, with κ, equal to 0.77, in the linear model. The linear model looks acceptable in the case of a developing nation like Egypt. This is especially true since the human capital stock did not possess a solid base from previous generations. Yet, overall the educational efforts did not end up in the decreasing returns to scale case, with respect to building up of human capital.

For the nonlinear case our study estimated the parameter ρ_1, representing the elasticity of human capital with respect to growth rate of human capital. Regarding human capital inputs, the result was positive with $\rho_1 = 0.53$, which is compatible with the Lucas model. On the other hand, regarding the elasticity of the growth rate of human capital accumulation with respect to school hours ρ_2, the estimates showed that it is statistically insignificant. Overall, our results could be interpreted as saying, that for more advanced countries, see Greiner et al. (2005, ch. 4), the nonlinear form may be operative but for developed nations, one may find a linear effect of education on the build up of human capital.

Overall, we see for Egypt that human capital has been built up effectively, but it does not generate positive externalities in production activities. At this point therefore, some remarks on the educational system in Egypt are at place. Historically, the lack of public and private investment in education in Egypt until 1952 had pushed Egypt into a low income-development trap. After the revolution and through the 1990s reform program, educational investments were not well-allocated enough to generate the right human capital. Moreover, the lack of proper institutional framework prevented the harvesting of positive effects from education.

Inconsistent educational polices and the absence of proper institutional organization, along with the absence of the right method of evaluation, did not let human capital accumulation impact economic growth. The main problems were the failure to disseminate information about the government policy to parents, budget constraints on households, and continual changes in education policy that forced the key players involved in the education process to relinquish their votes and disengage from policymaking.

Moreover, even though the government of Egypt focused on increasing the level of education by facilitating a free education, the absence of an effective

long term plan and the increasing population, created many problems. These problems included high classroom density, a high dropout rate in primary school, high spending on private tutoring, and a mismatch between education curriculums and what the market needs and thus a misdirected human capital formation. As we saw in sect. 5, the Egyptian human capital did not generate the needed positive externalities.

The mismatch between the number of graduates from all majors and the labor demand led to an increase in the unemployment rate. The rate in general started to increase; during a large part of the 1990s and in the early 2000s, it wavered around 11%. The highest recent unemployment rates were between the main sources of human capital that we used in our study: 55% for high school graduates, 11% among tertiary level graduates, and 14% among university graduates. Comparatively, it was 8% among the illiterates, 4% among read and write only, and 8% for primary graduates. The growth rate of new job creation was not high enough to create sufficient job opportunities and to build the capacity to absorb an increasing number of graduates.[12]

This growing evidence of educated unemployed and the low rate of return to education expenditure, especially at the secondary, tertiary, and university and higher levels, resulted in some unfavorable allocation of government resources, which hurt the poor segment of the society unable to benefit from the subsidies[13]. This caused a negative reaction on human capital: graduates started to work in places unrelated to their education. This, in turn, led to a deterioration of the accumulated knowledge and a loss of benefits from their years of school. Due to unemployment pressures, those able to create and increase the knowledge level in Egypt and potentially impact the economic growth with their high capacity of creativity- mainly scientists, engineers, chemists, and mathematicians- were not well placed.

Another possible reason of weak effect of the human capital on economic growth and the negative externalities is "the labor exports". This includes those seeking income through job opportunities outside Egypt because of high unemployment, graduates from certain majors who cannot practice their specialty after graduation inside Egypt, or those with comparable low level of

---

[12]Although the Egyptian Structural Reform Program (ESRP) introduced some important reform. Yet, a lot of social problems either developed or increased. A recommended key tool of the International Monetary Fund and The World Bank- the privatization program and the plan to give the private sector more space to replace the public sector investment- actually increased structural and cyclical unemployment in Egypt, along with the over-employed public sector. The private sector was unable to create more jobs to compensate for laying off employees.

[13]For more about the education policy dilemmas, see Booth, Ann(1994), and Jimenez (1991).

income in Egypt. The worker remittances coming back into Egypt should certainly be studied carefully to assess the cost and the benefit of labor exports on the long run. This includes determining which segments of graduates should be encouraged to stay in Egypt with good incentives in order to stop the "brain drain"[14]. The "brain drain" is a barrier against building a base to study new techniques and technologies and adapting them to the domestic needs.

The ESRP reform program of the 1990's aggravated the problems. Education became a significant item in the household budget. In reality, a good education has become costly. A quality education and a good degree became available only to those with higher income. The absence of the capital markets, and the class tension between the poor and the wealthy, prompted the well-off to send their kids to private schools. Accordingly, a poverty trap developed. Public education might limit the poor Egyptian's current and future quality of education and decent job opportunities as an active factor in the human capital accumulation process, which may lead to the dynamic of a poverty trap, resulting in an inequality of income distribution as studied in Cardak (1999). In other words, the poverty and income distribution problem as a result of low economic growth increased the number of those who live under the poverty line associated with a high illiteracy rate. The high illiteracy rate created poor judgment concerning the current and future importance of education between parents and their children.

Another factor aggrevating the problem was that the government did not make enough effort to create a last resort for the lower and middle class in Egypt to cover education costs through student loans, grants, and scholarships- at least for the talented poor students. Subsequently, most of the heads of households were not optimistic about sending their kids to school, especially if they had more than one child in the education system. The increasing burden of covering education costs with limited income, coupled with an uncertainty about the return on this long-term investment, made many parents and their children question the importance of education. This is another reason behind the absence of incentives to obtain a quality education and the decrease in quality of the human capital.[15]

---

[14]It makes sense that those who are highly educated and have good experience would try hard to get a chance to leave the country for higher pay and better living conditions.

[15]Regardless of the controversy over what has happened in the Egyptian educational system in the past and the current years, the government of Egypt should realize that the demand for both public and private education will increase very rapidly. The high growth of population and the Egyptian age structure will further complicate the problem, leading to a higher demand on teachers, buildings, etc., which will create more challenges for the Egyptian government in the near future- with its loaded budget- to

7 Conclusions

In this paper we have shown that in a middle income country, such as Egypt, output growth is not sufficiently explained by capital and labor input. The TFP is too large. We have examined education and human capital formation as an important factor for the increase in GDP. Our paper explicitly introduces a model to account for education and human capital formation as effective factors in the production function and human capital build up.

Our results show that education is a key component in the creation of human capital and an important factor for growth. Yet our study on Egypt also shows that one will not yield the most fruitful harvest of education if human capital formation is misdirected and misguided policies do not enable the county to translate the accumulated knowledge into ideas, innovations and new productive activities. This means ultimately, the country in question must also encourage productive activities so that the skilled and educated can find employment.

Indeed, empirical evidence seems to schow that only if there is a sufficient rate of job creation the build up of human capital can foster technological progress and, consequently, an increase in creativity, productivity and output. In this respect, the role of the R&D sector was a bottle neck. It is unlikely that Egyptian firms sector, the government sector, or the scientific research centers spend enough on R&D: There is lack of finances, for R&D, and the lack of attention paid to have technology. This situation translated into a lower diffusion of existing technology, a smaller amount of new technology, and, accordingly, a slower growth rate. Overall, human capital was created but the rate of creation of new productive jobs was too low.

Finally, it has to be mentioned that the model variants presented here neglected to examine other factors, most of them related to macroeconomic shocks or policies that caused growth rate fluctuations. A partial list of these external shocks are the following: the 1973 war, the decline in the oil prices at the end of 1970, the debt problem in the 1980s, the Iran war, the fact that Egypt is a country in transition, and regional circumstances with respect to the tension in the Middle East. Furthermore, the rapid increase in population during the 1980s and 1990s generated, along with the other structural problems, a low productivity of labor and poor absorption of new technology. In El-Mattrawy (2006) further factors are studied, for example, worker remittances are examined in connection to the Egyptian GDP as a possible source of economic growth. Official data partly used there in order examine the relationship between remittances and the real GDP, show, when

---

translate it to useful human capital.

employed in a test, that the path of the Egyptian GDP is not affected by the path and trend of remittances influx. In the 1990s, after the implementation of more openness policies within the economic reform, there was a gradual transition period toward a market-based economy, with a better reallocation of the economic resources, but it created, as discussed in sect. 6, also new problems for the Egyptian education system.

Appendix A: Data Construction

Source of Date

The sources of data used in this paper are as follows: the gross domestic product Y_t and investment I_t data were obtained from the Nehru and Dhareshwa Data Set for the years 1959-1990. Data for the years 1991-2002 were obtained from the World Bank data indicator compact disk 2003. The population data for the period 1959-1990 are from the Nehru and Dhareshwa Data Set. However, the years 1991-2002 were obtained from the World Bank Data Compact Disk 2003. The human capital H_t data for the entire period used to estimate the model variables were obtained from the Central Agency for Public Mobilization and Statistics (CAPMAS). The labor data L_t was obtained from The Central Bank of Egypt for the years 1968-2002. However, this data for the years 1959-1967 was estimated using the population growth rates.

Data on physical capital stock for the period 1959-1990 was obtained from Nehru and Dhareshwa Data. Physical capital of the years 1991-2002 was computed using the perpetual inventory method. The 5% depreciation rate of physical capital δ_h was used according to the Egyptian accounting standard that assumes that the project wears out in 20 years. The 5% depreciation rate of human capital δ_h was used following Greiner, Semmler and Gong (2005, ch. 4).

Physical Capital

One of the common techniques for the calculation of physical capital stock techniques is the perpetual inventory method, which comes out to be the following:

$$K_t = I_t + (1 - \delta)K_{t-1} \tag{17}$$

Where: I_t is the gross domestic investment, and δ is the rate of depreciation. δ was calculated as a fixed rate, i.e. the physical capital wears out by 5% annually, which means that the full depreciation of any capital unit occurs within 20 years. The choice of this value is not arbitrary; it is based on Egyptian commercial law and estimates in many conducted studies.

For the computation of human capital we used the following: η_t is the number of graduates from high schools and colleges, with (s) years of schooling, and $\theta_t(s)$ is an efficiency parameter reflecting wage differentials used for each type of school. The 5% depreciation rate of human capital δ_t was used

following Greiner et al., 2005. For details of the sources on the Egyptian education system, see appendix B.

Appendix B: Computation of Human Capital

Note that for the actual regressions all data was smoothed using the Hodrick-Prescott Filter which is widely used among macroeconomists to obtain a smooth estimate of the long-term trend component of time series. Since trend components are produced by some moving window this allows for the use of delayed effects of independent variables on dependent variables. For our approach to approximate the Egyptian human capital stock we used the following formula:

$$h_t = \int_0^x \theta_t(s)\eta_t(s)ds$$

Where: η_t is the number of graduates from high schools and colleges, with (s) years of schooling, and $\theta_t(s)$ is an efficiency parameter after each schooling year. In the following section, Egyptian human capital is broken down into its main components as follows:

B.1) High School Human Capital

The Egyptian high school system has three main components. The first component consists of general high school graduates. In general high schools, students receive a general science education that covers math, science, literature, history, language, and one or two religion subjects. Students recently have been able to major either in science or literature, whereas before there were three majors: science, math and literature. The high school certificate is a centralized national certificate. It is usually used as a bridge to get into college. The graduates with a literature high school diploma had the opportunity to find a place in a theoretical base college, according to their geographical location and their GPA, which may have resulted in placing most of the students into a college that they did not like. Some exemptions were made regarding the geographical location condition.

The second type of high school is the Al-Azhar high school system, which teaches religion science side by side with other types of science. Graduates must spend four years in the school with outstanding grades in order to earn the high school certificate. Graduates have the right to get into Al-Azhar University colleges according to their GPA, or into the other types of colleges after review.

The last category of high schools includes technical high schools. In these schools, the students have the opportunity to major in Industrial Science, Agriculture, or Commerce; the period of education is either three or four years. The certificate is enough to qualify graduates to join the job market. Good students have the right to continue their study in one of the colleges according to their GPA. Then, the high school human capital (HSHC) can be computed as follows:

$$h_{HS} = \sum_{l \to n} 3G_{GHS} + 3G_{TS} + 4G_{ALZ} \qquad \text{(B1)}$$

Where: h_{HS} is the high school human capital, G_{GHS} is the number of graduates from general high schools, G_{TS}, is the number of graduated from technical high schools and G_{ALZ} is the number of graduates from Al-Azhar schools. The numbers 3,3,4 respectively in (B1) are the average of the schooling years in each type of high school education. Some types of high schools, such as the teachers high school graduates, were taken into consideration. The years where Al-Azhar high school years dropped from 4 to 3 as well were taken into consideration, as well as the 4 year technical high school graduates.

B.2) Human Capital of Technical Institutes

Egypt has another level of education from the technical institutes that is lower than a college degree and equivalent to an associate degree in the USA. Students have to have a high school degree in order to enroll in any of these institutes; it lasts for two or four years. However, the four-year institutes are going to be treated as equal to college degrees. Then, technical institutes can be computed as follows:

$$h_{TI} = \sum_{l \to n} 2G_{TI} \qquad \text{(B2)}$$

Where: h_{TI} is the technical institutes' human capital and G_{TI} is the number of graduates from the technical institutes time years at institutes.

B.3) College Human Capital

The college system in Egypt can be divided into two types; the first are the theoretical science colleges, and the second are the applied science colleges. High school graduates from the literature or general science section can get

into the first type of colleges; however, the second type is restricted to students from the general science section. The length of study at the college level varies between four, five and six years.

$$h_{CHCt} = \sum_{l \to n} 4G_{tgt} \tag{B3}$$

$$h_{CHCa} = \sum_{l \to n} 5G_{cga} \tag{B4}$$

Where: h_{CHCt} and h_{CHCa} is the human capital stock from theoretical based colleges and applied based college respectively. G_{Cgt} and G_{Cga} is the number of college graduates from theoretical based colleges and applied based colleges respectively time the average years in college. It should be mentioned that the four and five-year institutes were taken into account when the college human capital was computed.

B.4) Human Capital (Total)

The total human capital can be computed by adding equation (B2) to (B4), which would give us equation

$$H_t = \sum_{l \to n} h_{HS} + h_{TI} + h_{CHCt} + h_{CHCa} \tag{B5}$$

Yet, we have to introduce also human capital depreciation; therefore, we have to adjust it to the depreciation rate:

$$H_t = \sum_{l \to n} (h_{HS} + h_{TI} + h_{CHCt} + h_{CHCa} - \delta_h H \tag{B6}$$

Human Capital Per Capita

$$h_t = H_t / p_t \tag{B7}$$

Where h_t stands for human capital per capita, H_t the total human capital by schooling years method, and p_t is the population at time (t).

B.6) Human Capital Index

In order to get an index for the Egyptian human capital stock at time (t), a normalization process has to be applied according to the following

$$x_t = \eta_t(\text{Primary})/p_t \qquad (\text{B8})$$

Where, x_t is the normalization index, $\eta_t(\text{Primary})$ is the number of students enrolled in primary education and p_t is the Egyptian population at time (t).

$$h_{\text{index}} = h_t/x_t \qquad (\text{B9})$$

Where h_{index} stands for total human capital per capita normalized by the primary enrollment to population ratio.

B.7) Schooling Hours (1-u)

$$1 - u_t = (\eta_{col}/L_t)S \qquad (\text{B10})$$

Equation (B10) states that the time spent in education $1 - u_t$ is equal to the number of college graduates at time (t) divided by the labor force and multiplied by the school years.

Appendix C : Sources and Trends of Educational Indicators

Next we describe some characteristics and educational indicators of Egypt and report some trends. After the independence in 1952 the government expanded the educational system and facilitated free education for every Egyptian. Here only some main trends are discussed, in Appendix D the graphs of the major time series trends are shown.

C.1) Public Expenditure on Education

The government expenditure on education data was obtained from the (IDSC-Egypt) for the period 1982-2004. The data shows that, after the reform program in the 1990s, the government of Egypt began to pay more attention to education. Public expenditure on education as a percentage of GDP in constant Egyptian Pounds was 4.8%, or LE 15180 million on average for the period 1991-2004, compared to a figure close to 2% of the Egyptian GDP or LE 2110 million for the period 1982-1990.

The per capita total education expenditure, including Al-Azhar expenditure, increased almost 5.6 times from LE 43.3 Egyptian Pounds for the period 1982-1990 to LE 241.6 after the reform program. The before college

education expenditure increased 7.9 times from LE 1337 million on average for the period (1982-1990) to LE 10531 million for the period (1991-2004). The per capita expenditure also increased 6.1 times on average for the reform period from LE 27.4 per citizen for the period (1982-1990) to LE 167.4 for the reform period (1991-2004).

The college education expenditure, excluding Al-Azhar, jumped from LE 697.3 million or 0.006% of GDP for the period (1982-1990) to LE 4241 million in average or 2% of GDP for the period (1991-2004). However, Al-Azhar colleges' expenditure climbed from LE 75.7 million or 0.0006 percent of GDP to LE 408 million or 0.002 percent of GDP. Figure 4.3 shows the total expenditure on education for the period (1982-2004) in local currency.

Figure C.1: The Total Expenditure on Education (1982-2004)
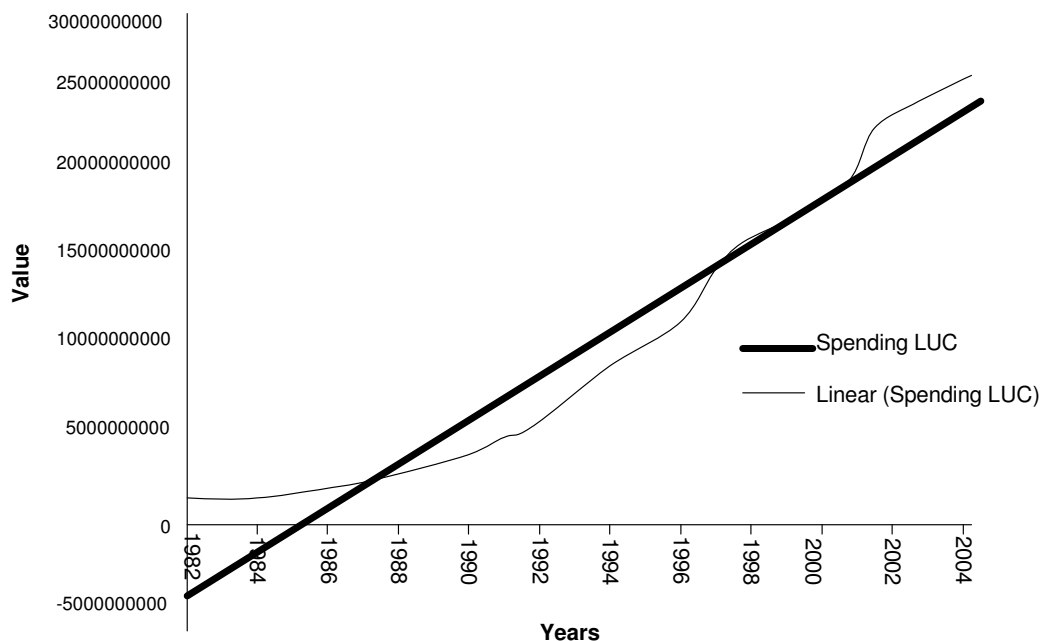
C.2) Number of Students

The time series data for the number of schools, classrooms, and students is much longer than the expenditure data- it covers the period (1959-2002). Regarding the school statistics for the period (1959-1990), the data shows that

more schools were built, more teacher colleges were opened, more training programs were adapted, and more technology was introduced in the classrooms. The Egyptian government issued a credit line for parents to buy subsidized computers and software.

Egypt started to achieve good academic enrollment rates for males and females according to international standards (Galal, 2001: 2). Its rates showed a 100% primary education enrollment rate, and a high secondary and tertiary level enrollment rate comparable to the fast growth Asian economies (Canning, 1999: 4). The number of elementary school education escalated from 4,353,048 for the period (1959-1990) to 6,598,051 for the period (1991-2002) or growing by 51.5%. The elementary population ratio dropped from 12% for the (1959-1990) period to 11% for the reform period. The elementary labor ratio also dropped from 33% to 29% for the same two periods mentioned before. The classroom density improved from close to 42 students per classroom to 35 students per classroom for the periods (1959-1990) and (1991-2002), respectively. The elementary enrollment male-to-female ratio improved from 1:5 for the period (1959-1990) to 1:1 for the period (1991-2002).

The number of students in primary school education increased from 1,394,967 for the period (1959-1990) to 4,122,852 for the period (1991-2002), growing by 1.95%. The primary enrollment population ratio jumped from 3% for the (1959-1990) period to 7% for the reform period. The primary enrollment labor ratio also increased from 9% to 18% for the same two periods mentioned before. The classroom density worsened from 38 students per classroom to 42 students per classroom for the periods (1959-1990) and (1991-2002), respectively. The primary enrollment male-to-female ratio improved from 1:9 for the period (1959-1990) to 1:1 for the period (1991-2002).

Egypt has three different types of high school education. One is called the "general high school", the second is the "Al-Azhar High School", and the third is the "technical high school"; it should be mentioned that, for a period of time, Egypt utilized a fourth type of high school education called the "teacher's high school," but it was discontinued. The first type, the second, and the fourth were added up to give some insights about the high school education in Egypt. However, the technical high school education is going to be handled separately.

The number of students in high school education increased 473,160 on average for the period (1959-1990) to 848,715 on average for the period (1991-2002), growing by 79%. The high school enrollment population ratio jumped from 1% for the (1959-1990) period to 2% for the reform period. The high school enrollment labor ratio also increased from 3% to 5% for the same two periods mentioned before. The classroom density worsened from 37 students per classroom to 42 students per classroom for the periods (1959-

1990) and (1991-2002), respectively. The high school enrollment male female ratio improved from 1.8 for the period (1959-1990) to .95 for the period (1991-2002).

The number of students in the technical high school education system increased from 442,689 on average for the period (1959-1990) to 1,786,174 on average for the period (1991-2002), growing by 300%. The technical high school enrollment population ratio jumped from 1% for the (1959-1990) period to 3% for the reform period. The technical high school enrollment labor ratio also increased from 3% to 8% for the same two periods mentioned before. The classroom density worsened from 33 students per classroom to 37 students per classroom for the periods (1959-1990) and (1991-2002), respectively. The technical high school enrollment male-to-female ratio improved from 2.5 for the period (1959-1990) to 1.2 for the period (1991-2002).

The number of students in college education jumped from 245,360 in average for the period (1959-1990) to 821,243 in average for the period (1991-2002), growing by 230%. The college enrollment population ratio stayed the same for both periods around 1%. The college enrollment labor ratio also rose from 2% to 4% for the same two periods mentioned before. The college enrollment male-to-female ratio improved from 2.5 for the period (1959-1990) to 1.35 for the period (1991-2002).

C.3) Number of Schools and Classrooms

The number of elementary schools increased from 10,699 for the period (1959-1990) to 18,008 for the period (1991-2002), growing by 68%. The number of primary schools jumped from 2,795 for the (1959-1990) period to 8,515 or grew by 203% for the reform period. The number of high schools increased from 608 schools to 1,502. They grew by a figure close to 200% for the same two periods mentioned before. The technical high schools escalated from 565 for the period (1959-1990) to 1,612 for the period (1991-2002), growing by a figure close to 280%.

The number of elementary classrooms increased 105,019 for the period (1959-1990) to 188,038 for the period (1991-2002), growing by 79%. The Primary classrooms jumped from 34,829 for the (1959-1990) period to 98,568 growing by 183%. The number of high school classrooms jumped from 9,636 to 23,042, growing by 139% for the same two periods mentioned before. The technical high schools classrooms escalated from 12,872 for the period (1959-1990) to 48,208 for the period (1991-2002), growing by 275%.

D) Time Trends and Data Sets on Human Capital

Next we show the time trends and data sets on the human capital variables hat where used in our computations.

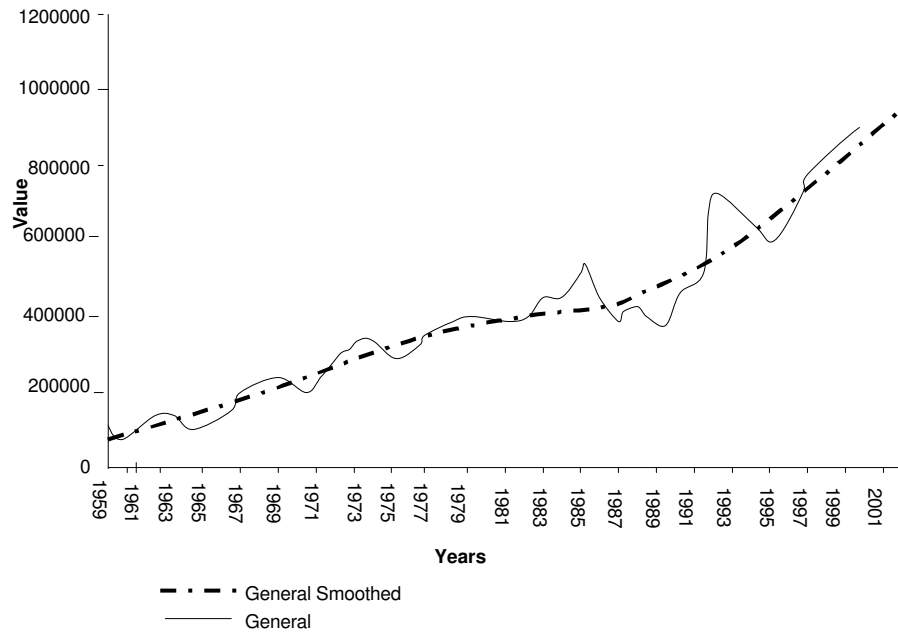## Figure D.1: General High School Human Capital, Rough and Smoothed

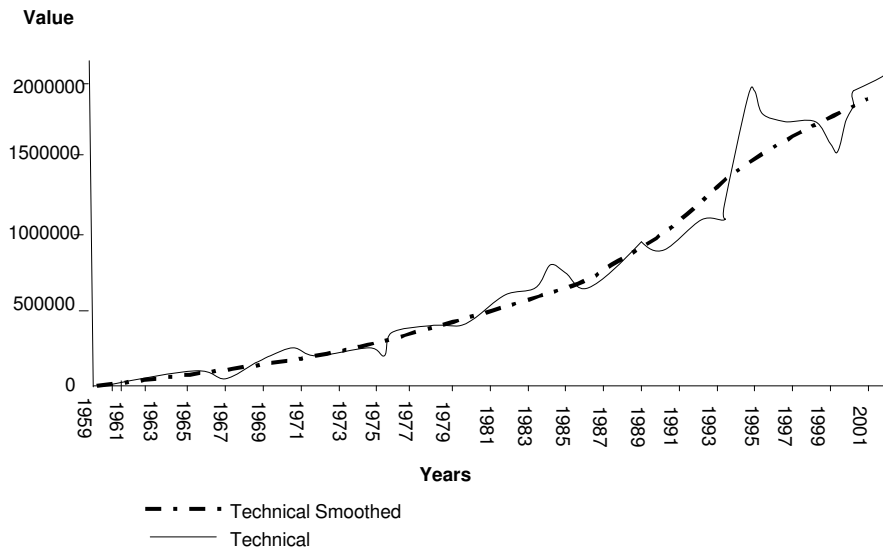**Figure D.2: Technical High School Human Capital, Rough and Smoothed**

30

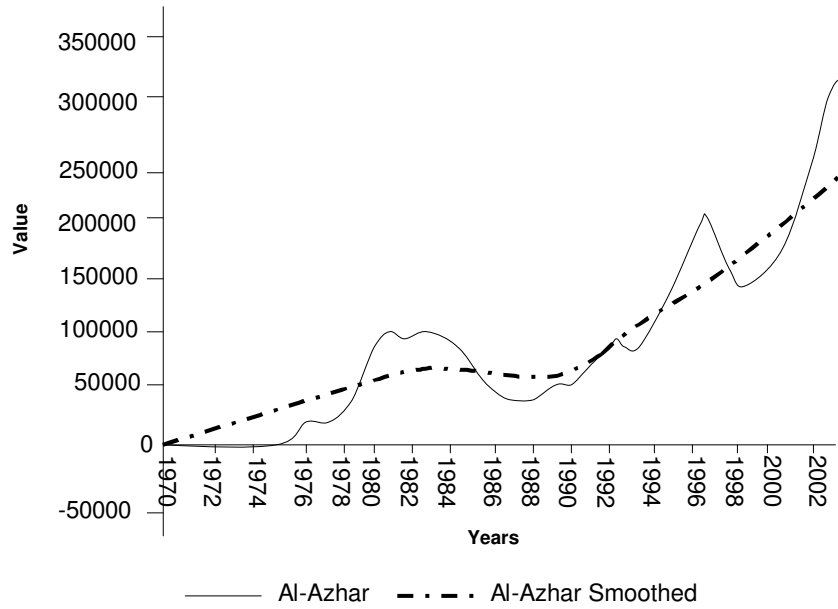**Figure D3: Al-Azhar High School Human Capital, Rough and Smoothed**

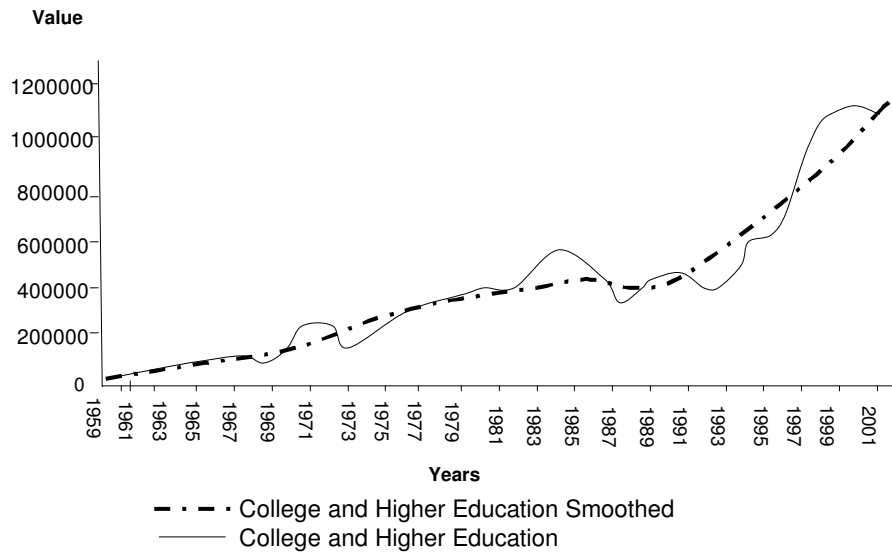**Figure D.4: College and Higher Education Human Capital, Rough and Smoothed**
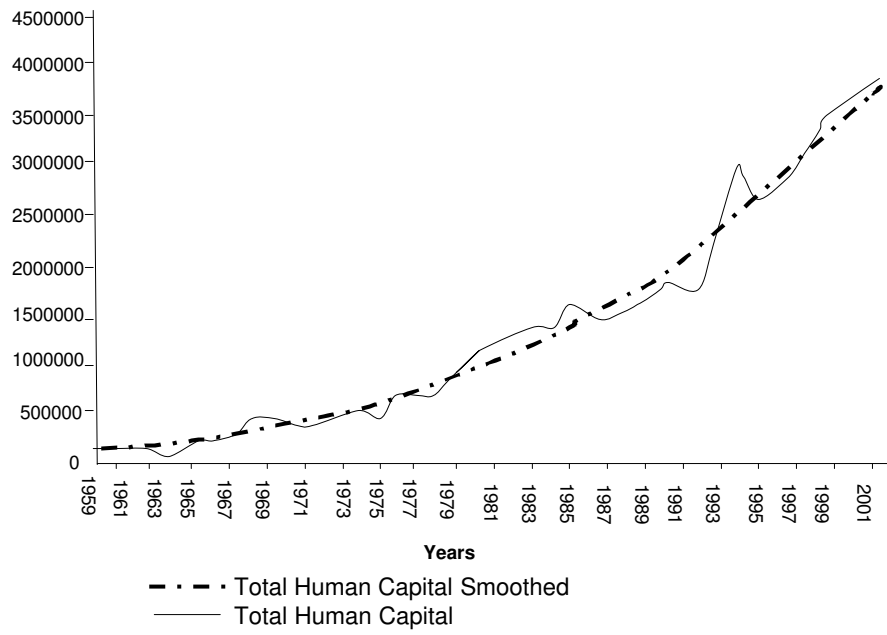
Figure D.5: Egyptian Human Capital, Total, Rough and Smoothed

References

[1] Aghion, P. and P. Howitt (1998), "Endogenous Growth Theory". Cambridge: MIT Press.

[2] Ali, A. A. (2002) "Building Human Capital for Economic Development in the Arab Countries." Egyptian Center for Economic Studies 76. ¡http://www.eces.org.eg/downloads/ECESWP76.pdf¿.

[3] Barro, R.J. and X. Sala-i-Martin (1995) " Economic Growth", McGraw-Hill Book Company, New York.

[4] Barro, R. (1991) "Economic Growth in a Cross Section of Countries." Quarterly Journal of Economics 106 (2).

[5] Barro, R. J. and J.-W. Lee (1993) "International Comparisons of Educational Attainment." The World Bank .

[6] Benhabeb, and Spiegel (1994): "The Role of Human Capital in Economic Development: Evidence From Aggregate Cross-Country Data." Journal of Monetary Economics 34(2): 143-174.

[7] Bils, M. and P. Klenow (1996), "Does Schooling Cause Growth or the Other Way Around?" Chicago: University of Chicago Press.

[8] Booth, A. (1994) "Employment, Unemployment and Access of Education," University of London, Working Paper no. 39.

[9] Boucekkine, R. and R. Ruiz-Tamarit (2000): "Imbalance Effects in the Lucas Model: An Analytical Exploration." Journal of Economic Literature C61, C62, O61.

[10] Boucekkine, R. (2001)] "Knowledge, technology and economic growth". In: How to Promote Growth in the Euro Area, Dombrecht M., Smets J. ed., Edward Elgar: 98-103.

[11] Canning, D. and P. Pedroni (1999) "Infrastructure and Long Run Economic Growth." Harvard Institute for International Development CAER II Discussion Paper No. 57.

[12] Canning, D. (1999): "Infrastructure, Human Capital, and Economic Growth in Egypt." The Egyptian Center for Economic Studies (ECES) Cairo.

[13] Copeland, M. A. (1937) "Concepts of National Income," in Studies in Income and Wealth, Vol. 2, New York: National Bureau of Economic Research, pp. 3-63.

[14] Copeland, M.A. and E.M. Martin (1938) " The Correction of Wealth and Income Estimates for Price Changes," in Studies in Income and Wealth, Vol. 2, New York: National Bureau of Economic Research, 1938, pp. 85-135; including discussion by Milton Friedman.

[15] De la Croix, D. and V. Vandenberghe (2004): "Human Capital as a Factor of Growth and Employment at Regional Level". Brussels: University of Cath Louvain.

[16] Den Berg, V. H. (2000): "Economic Growth And Development". New York: McGraw-Hill.

[17] El-Baradei, M. (2000) "Toward a Pro-Poor Educational Policy for Egypt." Center for Economic and Financial Research and Studies, Cairo.

[18] El-Mattrawy, K. (2006) "Total Factor Productivity, Human Capital, Knowledge, and the Growth path of Egypt", New School University, New York, USA.

[19] Fawzy, S. (1998) "The Business Environment in Egypt". The Egyptian Center for Economic Studies Working Paper No. 34.

[20] Fawzy, S. (2002) "Investment Policies and Unemployment in Egypt." The Egyptian Center of Economic Studies (ECES).

[21] Fergany, N. (1998) Memorandum. "Human Capital and Economic Performance in Egypt".

[22] Galal, A. (2003) "Social Expenditure and the Poor in Egypt." The Egyptian Center of Economic Studies Working paper No. 89.

[23] Gallup, J., J. Sachs, and A. Mellinger (1998): "The Annual Bank Conference on Development Economics", The World Bank.

[24] Gong, G. and W. Semmler (2006), "Stochastic Dynamic Macroeconomics: Theory and Empirical Evidence", Oxford, New York, Oxford Press.

[25] Greiner, A., W. Semmler, and G. Gong (2005) "The Forces of Economic Growth: A Time Series Perspective". Princeton: Princeton University Press.

[26] Griliches, Z. (1996) "The Discovery of the Residual: A Historical Note", Journal of Economic Literature, Vol. 34, No. 3, pp. 1324-1330.

[27] Griliches, Z. (1958) "Research Cost and Social Return: Hybrid Corn and Related Innovations," Journal of Political Economy, 66(5), pp. 419-31.

[28] Grossman and Helpman (1991) "Innovation and Growth in the Global Economy", 2nd edition, MIT - Press, Cambridge, Mass.

[29] Jimenez, E. (1991) "A Review of Equity and Efficiency." World Bank Research Observer 1(1):111-29.

[30] Jorgenson, D. W. and B. M. Fraumeni (1989) "The accumulation of human and nonhuman capital, 1948-1984". In R. E. Lipsey and H. S. Tice (Eds.), The Measurement of Savings, Investment and Wealth (pp. 227-282). Chicago, I.L.: The University of Chicago Press.

[31] Jorgenson, D. W. and B.M. Fraumeni (1992) "The output of the education sector". In Z. Griliches (Ed.), Output Measurement in the Services Sector (pp. 303-338). Chicago, I.L.: The University of Chicago Press.

[32] Kendrick, J. (1976): "The Formation and Stocks of Total Capital". New York: Columbia University Press.

[33] Klenow, P. and A. Rodriguez-Clare. (1997): "The Neoclassical Revival in Growth Economics: Has It Gone Too Far?" NBER Macroeconomics annual meetings, USA.

[34] Lucas, R. (1988): "On the Mechanics of Economic Development." Journal of Monetary Economics. Vol. 22 (1): 3-42.

[35] Mankiw, G., D., and D. N. Weil (1992). "A Contribution to the Empirics of Economic Growth." Quarterly Journal of Economics Vol. 107: 407-37.

[36] Messiha, S. (1991) "Sources of Productivity Growth in the Egyptian Economy (1959-88)". Cairo: American University in Cairo Press.

[37] Mulligan and Sala-i-Martin (1993)"Some Evidence on the Links between Aggregate Income and Human Capital", University of Chicago, mimeo.

[38] Radwan, S. (2002) "Employment and Unemployment in Egypt." The Egyptian Center for Economic Studies (ECES) Cairo.

[39] Romer, D. (1986)"Increasing Returns and Long-Run Growth." Journal of Political Economy, Vol. 94: 1002-37.

[40] Romer, D. (1990) "Endogenous Technological Change." Journal of Political Economy, Vol. 98: S71-102.

[41] Ruttan, V. W. (1954) "Technological Progress in the Meatpacking Industry, 1919-47" Washington, DC., USA.

[42] Ruttan, V. W. (1956) "The Contribution of Technological Change to Farm Output, 1950-75," The Review of Economics and Statistics, 38, pp. 196- 207.

[43] Schultz, T.W. (1953) "The Economic Organization of Agriculture", New York: McGraw-Hill.

[44] Schultz, T.W. (1961) "Investment in Human Capital". American Economic Review 51 (1): 1-17.

[45] Schultz, T. (1991) "Investment in People and Agriculture Development in the Third World", 2nd ed. Baltimore: The Johns Hopkins University Press, pp: 280-89.

[46] Solow, R. (1956): "A Contribution to the Theory of Economic Growth." Quarterly Journal of Economics Vol. 70: 65-94.

[47] Stigler, G.J. (1947) "Trends in Output and employment", New York: NBER.

[48] Temple, J. (1998): "A Positive Effect of Human Capital on Growth." Working Paper.

[49] Tilak, J. (1989): "Education and Its Relationship to Economic Growth, Poverty, and Income Distribution-Past Evidence and Further Analysis." World Bank Discussion Paper, The World Bank.

[50] Turnovsky, S.J. and W.H. Fisher (1995) "The Composition of Government Expenditure and its Consequences for Macroeconomic Performance." Journal of Economic Dynamics and Control, Vol. 19: 747-787.

[51] Uzawa, H. (1965) "Optimum Technical Change in an Aggregative Model of Economic Growth." International Economic Review, Vol. 6: 18-31

[52] Young, A. (1995): "The Tyranny of Numbers: Confronting the Statistical Realities of the East Asian Growth Experience." Quarterly Journal of Economics 104.

List of Abbreviations

CAPMS: Central Agency for Public Mobilization and Statistics, Egypt; **CBE:** The Central Bank of Egypt; **CHC:** College Human Capital; **ECES:** Egyptian Center for Economic Studies, Egypt; **ERSAP:** Economic Reform and Structural Adjustment Program; **HSH:** High School Human Capital; **IDSC:** Information and Decision Support Center, Egypt; **IMF:** The International Monetary Fund; **MFHC:** Maintenance Factor of Human Capital; **MOE:** The Ministry of Economy of Egypt; **MOE:** The Ministry of Education of Egypt; **MOHE:** The Ministry of Higher Education of Egypt; **MOP:** The Ministry of Planning of Egypt; **NBE:** The National Bank of Egypt; **R&D:** Research and Development; **TIHC:** Technical Institutes Human Capital; **USAID:** United States Agency for International Development; **WB:** The World Bank; **LE:** Egyptian Pound; **LUC:** Local Currency