

T.C.  
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SOSYAL BİLİMLER ENSTİTÜSÜ  
İKTİSAT ANA BİLİM DALI  
İKTİSAT (İNGİLİZCE) BİLİM DALI

**HUMAN CAPITAL IN TURKEY WITHIN THE  
CONTEXT OF ENDOGENOUS GROWTH  
MODELS**

Yüksek Lisans Tezi

BİLGE ERİŞ

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Danışman: Yrd. Doç. Dr. M. Nedim Süalp

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Marmara Üniversitesi  
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## **ABSTRACT**

*Endogenous growth theories those have been discussed in the growth literature since the early 1980s differ from the previous growth models in terms of the variables they determine as the engine of growth. Whereas exogenous technical progress is considered to be the driving force of the long run growth, endogenous growth models focus on factors such as research and development sector improvements, human capital and the public policies as the engine of the growth.*

*In this study, endogenous growth models that accept human capital as the driving force behind the long run growth are taken into account. On the basis of basic assumptions of these models, three models are tested for the Turkish sectors. In the first model, Cobb-Douglas type production function, in which human capital is incorporated, is estimated for Turkish manufacturing sector by using the data for the period 1974-2001. Second model makes a similar analysis with the first model for Turkish manufacturing sector for the period 1978-2001. The last model estimates five different production functions for five sectors; manufacturing, agriculture, mining, energy and transportation, and compares the results with each other. According to the results of the models using wage ratios and educational achievement data as proxy for human capital, there is not a significant relationship between the sectoral growth and effective labor augmented by human capital in Turkey.*

Keywords: Endogenous growth models, human capital, Turkey.

## ÖZET

*1980’li yılların başlarından itibaren büyüme literatüründe sıkça bahsedilen içsel büyüme teorileri, büyümenin motor gücü olarak vurgu yaptıkları belirleyiciler bakımından diğer teorilerden ayrılır. Neoklasik büyüme teorisinde büyümenin itici gücü dışsal olarak belirlenen teknolojik gelişme iken; içsel büyüme modelleri Araştırma Geliştirme sektöründeki gelişmeler, beşeri sermaye ve devlet politikaları faktörlerinde üzerinde yoğunlaşmışlardır.*

*Bu çalışmada; beşeri sermayenin uzun dönemde büyümeyi sağlayacak itici güç olarak kabul edildiği içsel büyüme modelleri ele alınmıştır. Bu modellerin temel varsayımlarından yola çıkarak Türkiye’deki sektörler için üç farklı model test edilmiştir. Birinci modelde; Türk İmalat Sanayisi için 1974-2001 dönemi verileri kullanılarak; Cobb-Douglas tipi üretim fonksiyonu, beşeri sermaye değişkeni dahil edilerek tahmin edilmiştir. İkinci grup modelde, Türk İmalat Sanayisi için 1978-2001 verileri kullanılarak, birinci modeldekine benzer bir analiz yapılmıştır. Son grupta ise; imalat, tarım ve hayvancılık, madencilik, enerji ve ulaştırma olmak üzere, beş sektör için, 1988-2003 verileri kullanılarak farklı tahminlerde bulunulmuş ve elde edilen bulgular birbiri ile mukayese edilmiştir. Beşeri sermaye değişkeni olarak, ücret oranları ve mezun oldukları eğitim kademesine göre çalışan kişi sayısının kullanıldığı çalışmanın bulguları; sektörlerdeki büyüme ve beşeri sermaye ile etkinleştirilmiş işgücü arasında anlamlı bir ilişki bulunmadığı yönündedir.*

Anahtar Kelimeler: İçsel büyüme teorisi, beşeri sermaye, Türkiye.

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## LIST OF ABBREVIATIONS

<b>GDP</b>	: Gross Domestic Product
<b>TR</b>	: Turkey
<b>USA</b>	: United States of America
<b>R&amp;D</b>	: Research and Development
<b>PS</b>	: Primary school
<b>SS</b>	: Secondary school
<b>PE</b>	: Primary education
<b>HS</b>	: High school
<b>VATS</b>	: Vocational and technical school
<b>HEI</b>	: Higher Education Institutions
<b>Y</b>	: Output
<b>K</b>	: Physical capital stock
<b>L</b>	: Labor
<b>H</b>	: Human capital
<b>HL</b>	: Effective labor
<b>E</b>	: Education related variable
<b>I</b>	: Investment
<b>pc</b>	: Per capita
<b>D()</b>	: Difference
<b>L ( )</b>	: Logarithm
<b>DW</b>	: Durbin-Watson
<b>OLS</b>	: Ordinary Least Squares
<b>TFP</b>	: Total Factor Productivity
<b>CRS</b>	: Constant returns to scale
<b>PCS</b>	: Physical Capital Stock
<b>GFI</b>	: Gross Fixed Investment

## 1. INTRODUCTION

After the Second World War, with the widening gap between the technological progress of developing and developed countries, neoclassical growth theories started to be inadequate to explain the dynamics of economic growth. Human capital became an important concept at the beginning of the 1960s in explaining the residual which were to be the unexplained part of the growth by neoclassical theories. Endogenous growth theories, which have been discussed in the growth literature since the early 1980s, determined human capital, research and development sector improvements and public sector policies as the engine of the growth, whereas exogenous technical progress was considered to be the driving force of the long run growth by neoclassical growth theories.

In this study, endogenous growth models that accept human capital as the driving force behind the long run growth are taken into account. The reason for evaluating the relationship between human capital and economic growth from the endogenous growth perspective is the common usage of the perspective in the literature. The importance of human capital is emphasized mostly by the endogenous growth theories and the studies constructed for the last fifty years were established within this framework.

Following the basic assumptions and features of the endogenous growth models, three basic models are constructed for Turkish sectors within this study. In the first model, Cobb-Douglas type production function in which human capital is incorporated is estimated for Turkish manufacturing sector by using the data for the period 1974-2001. Second model makes a similar analysis with the first model by using

different variables for Turkish manufacturing sector for the period 1978-2001. The last model estimates five different production functions for five Turkish sectors; manufacturing, agriculture, mining, energy and transportation, and compares the results with each other.

This study differs from the other studies existing in the literature in three respects. The first difference lies in studying with a single country, Turkey. The large proportion of empirical studies on the effect of human capital on growth are the ones that use data on a cross section of countries. Differently from the majority of the literature, this study relies on a single case study of Turkey. The reasons and advantages of studying with a single country can be summarized as the following: There is an opportunity to examine the historical and institutional characteristics of the given country. The most qualified and appropriate data can be used without any constraints to sustain the data consistency among the other countries. The comments on the results of the study fit only for the country being studied and policy implications are country specific which are more potential of being effective. Moreover, there are several studies concerning the relationship between human capital and growth in the developed countries, however only a few for developing countries. This study serves as an investigation for a developing country, Turkey.

The second difference and contribution of this study is that it constructs a comparative basis for five sectors; manufacturing, agriculture, mining, energy and transportation, in Turkey incorporating human capital to the growth process. A study concerning sectoral differences is crucial for Turkey in terms of defining the sector in which the human capital contributes to growth at most. Since human capital is not allocated equally to all sectors and the properties and the sectoral share of the

production in total GDP is different from each other; defining the sector specific results is important for evaluating the policy implications individually. The sectors are chosen by taking the availability of the data and the importance of the sector within the country into account.

The third characteristic feature of the study is the human capital proxy constructed for the manufacturing industry. The ratio of average wages to minimum wages is used as the human capital proxy, being inspired from Sala-i Martin and Mulligan (1997). The superiority of this variable comes from its capacity to measure the current value of human capital rather than its historical price. Alike efficiency of calculating the current market value of physical capital rather than its historical price, calculating the current value of human capital is more conceivable. The main reason of using wage ratio as the human capital proxy is the belief that it provides more accurate results than any other proxy used. Wage ratio has the capability of capturing many aspects of human capital and labor market conditions. The human capital proxy used for comparing five sectors is the number of people graduated from different levels of education in each sector. Educational achievement data is used in the literature frequently. Moreover this data is the only data to construct sectoral models. Wage ratio data is available only for the manufacturing industry. The reason of using educational achievement data for sectoral comparison is the limitations on the data for these sectors.

The study is set up as the following: Chapter 2 briefly examines the neoclassical and endogenous growth theories, comparing the main assumptions and the features of the theories. The similarities of the theories are also taken into account. In the subsections of this chapter, endogenous growth theories evaluating human capital as the engine of growth are examined in detail and the concept of human capital is put

forward with the channels it contributes to economic growth. Chapter 3 provides empirical background for the models investigating the relationship between human capital and economic growth both for Turkey and the other developing countries. For the purpose of the study, only single country studies are examined, the results of the cross country studies are given only in summary.<sup>1</sup> The main assumptions and the derivation of human capital proxies are explained briefly. In chapter 4, on the basis of basic assumptions of endogenous growth theories, three basic models with different variables are tested for Turkish sectors. The results of the estimation analysis are put forward and compared with each other. Chapter 5 presents the conclusion evaluating all results within the framework of the study.

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<sup>1</sup> The results of cross country studies are available in AppendixA.

## **2. HUMAN CAPITAL AND THEORETICAL LITERATURE**

### **REVIEW ON NEOCLASSICAL AND ENDOGENOUS GROWTH THEORIES**

Growth theories have investigated many aspects of economic growth. Most important aspects of economic growth are to be mentioned as the engine and dynamics of growth. The definition of the term economic growth takes its roots at the last decade of the 14th century . The sequence of the periods concerning economic growth continued through the Mercantilist period. Activities related with trade were the focus of this period's growth understanding and trade policies were to bear vital importance and the concepts of factories, monopolies drew attention. With the introduction of the classical growth theory, the focus switched to the discipline of modern political economy. Comparative advantage theory constructed the basis to support free trade which can be regarded as the core component of economic growth. Following the classical growth theory, neoclassical growth theory presented by R. M. Solow (1956), highly influenced the ongoing period until the 1970s. The focus of the economics literature throughout the period until the mid 1980s switched from growth to micro basis of economics and short term fluctuations. After a long period of quiescence, growth economics in the late 1980s and the early 1990s turned to an extremely active area of research-both theoretically and empirically (Mccallum, 1997:41). Endogenous growth theories were introduced to the literature mainly focusing on the physical and human capital, research and development sector, externalities and public policies.

Excluding the growth theories arising at the early periods, two of the most important theories are still exposed to controversial issues: Neoclassical growth theory and new growth theories, namely endogenous growth theory. These two theories are both complementary of and opposing to each other. The comparison of the main

features of the two theories is important in terms of understanding the differences of the dynamics of growth. Before turning to the comparison of the theories, next section presents the theories briefly to construct the theoretical comparative basis.

## **2.1 Neoclassical growth theory**

Neoclassical growth theories mainly refer to the Solow's model and Ramsey, Cass, Koopmans' model. Putting forward the main features and implications of Solow's model is adequate in terms of presenting the basis of the neoclassical model. For the purpose of constructing a comparative basis for the two theories; stating the assumptions and the main implications of neoclassical theory rather than explaining the models in mathematical detail serves as an important tool. The model developed by R. M. Solow (1956) contributed to the growth literature highly by influencing the theories developed later. The basis of this growth model is the production function that is assumed to exhibit constant returns to scale. The key assumption behind the construction of the production function is that all factor markets are perfect, in the sense that individuals can buy or sell as much as they they want at a given market price.(Banerjee and Duflo,2005:2). Another important feature of the production function is that the factors of production exhibit diminishing returns. This production function is unified with the constant saving rate assumption to construct a simplified general equilibrium model (Ates,1998:9). Following the diminishing returns assumption, the implications of this model offer that countries with initially low gross domestic production experience higher growth rates. To put the implication differently, countries with lower capital per unit of labor have higher capital returns and hence higher growth rates. This chain of reasoning make the income level of these countries

converge to the income level of developed countries. This process of convergence is named as absolute convergence, since steady state levels of capital per labor and production depend upon saving rate, population growth rate and the production function. Technology is assumed to be endowed to the whole economy. Another implication of the neoclassical growth theory is that growth will slow down unless technological progress is continual. In Solow's model, the economy converges to its steady state value in the long run regardless of the initial conditions. Steady state growth rate of income per capita is dependent upon only exogenously given technological progress.

The main criticisms pointed to the neoclassical growth theory arise from its assumption that all countries' production technologies are the same. Cross country differences are not taken into account while determining the steady state growth rates. Another criticism of the neoclassical growth is that the actual capital returns within GDP are higher than the neoclassical theory puts forward. The main point of the criticisms to neoclassical growth theory is the key role of physical capital in GDP.

Throughout the 1960s, the basic neoclassical theory attempted to endogenize the technology with learning by doing and vintage models. Arrow's (1962) model is essential for these sort of models and this model does not consider technology as a rival good. The adjustments made to construct the model make it inevitable to change the structure of the neoclassical theory. Until P. M. Romer (1986) clarified the basis of the new growth theories, the questions arising from the introduction of new assumptions to explain the growth have remained unanswered.

Neo-classical growth theory does not provide a satisfactory answer to the central question about economic growth. This conclusion stems from the implications of

the models that differences in physical capital cannot account for differences in growth across countries. While the model assumes the drivers of differences in growth across countries is effectiveness of labor, the model treats this variable as a ‘black-box’, a mystery. In addition, its exact meaning and nature is neither specified nor modeled explicitly.

## **2.2 Endogenous growth theory**

Endogenous growth theories have started to investigate the importance of physical and human capital, research and development, externalities and public policies with the workings of P. M. Romer (1986), R. E. Lucas (1988), S. Rebelo (1991), P. Aghion and P. Howitt (1992), E. Helpmann and G. M. Grossman (1991) from 1980 on. These theories endogenize technology with research and development and human capital channels. The main argument of the new growth theories that is controversial with the neoclassical growth arises from their rejection of considering technology as an endowment. Endogenous growth models do not consider technology as endowed, rather take it as endogenized within the human capital accumulation and research and development investments. The effect of human capital on economic growth was not accorded recognition until recently. Classical economic growth including the neoclassical growth model of Solow placed large emphasis on physical capital accumulation as the basis for growth. However, the emergence of new growth theories or endogenous growth theories has radically changed this line of thinking by emphasizing the role of human capital, especially knowledge or education in the growth process (Ogunleye and Eris, 2007: 344). This new thinking see growth as emanating from the creation and implementation of new ideas through research and development,

learning-by-doing. Moreover, these theories allow policies to effect long run growth, which again differ them from the neoclassical theory. One of the most important features of endogenous growth models is that the marginal productivities of factor inputs do not decline.

The weakness of the neoclassical growth about explaining the sources of economic growth is corrected by the New Growth Theory. The differences between the neoclassical growth and endogenous growth can be categorized according to the main assumptions of the models. Endogenous growth theories mainly differ from the neoclassical growth model by the assumptions they make. There are two groups those can be compared with neoclassical theory: First group of endogenous growth theories only differ from the Solow model by the assumption about the diminishing returns to accumulated factors of production. Jones and Manuelli (1990) and Rebelo (1991) are the main models which can be sorted within this type of endogenous growth. The constant returns to scale and the exogenous technology assumption are hold as the Solow model. The only difference comes from the assumption concerning returns to factors of production. Solow assumed diminishing returns to the factors of production; however, these models assume marginal productivities are constant or increasing. The second group of endogenous growth models changes three assumptions of the neoclassical growth model. Endogenous (Neoclassical) growth models assume endogenous (exogenous) technological progress, increasing (constant) returns to scale and increasing (diminishing) returns to accumulated factors of production. The main models of this second group are; Romer (1986, 1989), Lucas (1988) and Becker et al. (1990).

The differences between the neoclassical growth and endogenous growth can be put forward also in terms of their interpretation of capital accumulation: First models

agree with the Solow model on the ground that capital accumulation is not central to growth. They however, disagree with Solow model on the interpretation of the variable, effectiveness of labor. The new growth theory interprets the effectiveness of labor as knowledge and models its evolution over time. Secondly, contrary to Solow model, capital is central to growth. This conclusion relies on the extension of capital to include not only physical capital but also human capital. Hence, capital accumulation, especially human capital via knowledge accumulation and education could have a substantial impact on growth.

*In fact, human capital plays a key role in versions of both neoclassical and endogenous growth models. The critical difference is that in the first group, economic growth is ultimately driven by exogenous technical progress, whereas in the second, no additional explanation is needed and human capital is much more important (Abbas,2001:3).*

The focus of Abbas (2001) is the endogenous growth models those dismissing all the three assumptions of neoclassical growth model. These models differ from each other by the factor they determine as the engine of the growth. These factors are spillover effects emanating from research and development, human capital investment and the fiscal technological infrastructure investment. Fundamental models assessing research and development as the engine of growth are Romer (1990), Grossman and Helpmann (1989) and Howitt (1992). Human capital investment is regarded as the most important component of growth by Romer (1986), Lucas (1988), Becker et.al (1990), Stokey (1988, 1990) and Young (1991). Finally, Barro (1991) stresses the importance of fiscal technological infrastructure investment to experience sustainable growth.

Next section presents the endogenous growth models that emphasize the importance of human capital and human capital investment. The theories are presented

to build the theoretical basis to construct the model for Turkey to investigate the relationship between human capital and various growth measures at sectoral level.

## **2.3 Human capital and its effects on economic growth**

### **2.3.1 The concept of human capital**

Before putting forward the essentials of the endogenous growth evaluating human capital as the engine of growth, it is important to present the basic concepts of human capital, one of the most important pillars of endogenous growth, mainly presenting the framework that it is considered within. The existing and widening gap on the growth rates across economies and regions can be explained by a number of factors, prominent among which are the differences in the quality of human capital. There is consensus in the literature that investing in health and education is essential to maintaining a healthy population and workforce, which in turn are necessary ingredients for sustainable economic growth. Human resources can be defined as the knowledge, skills, attitudes required to manipulate capital, technology, and land among other things, to produce goods and services for human consumption. The implication of this definition is that human resources encompasses the totality of people and their potentials which include, but not limited to attitude, energy, vigor, knowledge, technology, and know-how inherent in the human resources of any economy. Conceptually there has not been a clear-cut definition on how human capital should be presented (Cohen, 2007: 52). The two most important means of acquiring human capital is through acquisition of education or knowledge and health improvement.

Even though the difficulty of categorizing human capital investments clearly, education and health investment are accepted as the most important ones. The most important human capital investment is accepted to be education investment. Education investment include learning by doing and in-the-job training as well as formal education. All sorts of education investment increase the skill and productivity of individuals. The quality of human capital is highly related with the quality of the education system of the country. The returns to education investment takes between 8 to 11 years to mature and requires constant support.

Health investment contribute to the development of human capital by increasing the average life expectancy of people, strength of the individuals. Unhealthy individuals can not contribute to the economic growth. Health investment includes nutrition expenditures, too. Education and health investment contribute to economic growth together; however education investment is accepted to be more important than health investment in the literature.

### **2.3.2 Effects of human capital on economic growth**

The effects of human capital on economic growth emerges through 3 channels: By increasing physical capital productivity, creating employment opportunities and spillover effects through technological progress. First and foremost, human capital increases economic growth via increasing physical capital productivity. Physical capital is produced by human and becomes efficient by human labor in the production process. Human capital that provides labor skills for production and efficiency of physical capital increases productivity by positive externalities. Quantitative increases of

physical capital remain unimportant when human capital development is not taken into account.

Second channel that human capital increases economic growth is the employment opportunities created by human capital accumulation. Human capital raises the labor force both quantitatively and qualitatively and contributes to growth by effecting employment positively. High qualified labor force has higher elasticity and mobility. This situation leads qualified workers remain unemployed for shorter periods. Human capital and human capital investment play important role to increase the quality of workers in terms of technical, scientific and vocational skills.

Human capital creates technological progress and spillover effects and contributes to the economic growth. When the importance of technological progress is taken into account to close the gap among income differences across countries, human capital is very important since the technology is created by human. Besides creating technology, human beings acquire knowledge about the new technologies and better qualified workers easily adopt to the usage of new technology. Human capital helps to increase the skill of workers and thus working with high-tech capital becomes more effective.

The causality between economic growth and human capital not only runs from human capital to economic growth, but also from economic growth to human capital. Economic growth and the increase of the demand for qualified labor force increases human capital investment. Increase of human capital investment causes more accumulation of human capital and thus leads positive effects on economic growth through the channels explained above (Gumus, 2005: 56).

## **2.4 Endogenous growth models considering human capital as the engine of economic growth**

The existence of the endogenous growth models that consider human capital as the engine of economic growth takes its roots from the criticisms to neoclassical theory giving high importance to the contribution of physical capital stock to economic growth. The models expressing the importance of human capital mainly take their roots from the workings of Romer (1986) and Lucas (1988). These models are pioneer by the way they introduce human capital to the production function and main assumptions made to construct the model. Most of the models introduce human capital stock as factor of input and examine the interaction between the important variables related with the growth rate of the economy.

Next subsections present four basic endogenous growth models; Romer (1986), Lucas (1988), Stokey (1988) and Jones (1996). These models are the pioneer in the literature as the endogenous models with human capital. Presenting the main framework of these models provide the basic basis of the endogenous growth models.

### **2.4.1 First endogenous growth model considering human capital as the engine of economic growth**

Romer (1986) is known to be the first model referring to endogenous growth. This model differs from the neoclassical growth models in the way that it assumes increasing returns in capital. This assumption is the main feature of the Romer's model. However, it is important to state that the technology used to create knowledge is assumed to have decreasing returns to scale. The variable bearing increasing returns is

knowledge, which is accumulated through the physical capital accumulation and the physical capital accumulation is considered as the main engine of the economic growth. The disappearance of the diminishing returns to capital comes from the idea of combining the capital with knowledge and skill. According to Romer, tangible goods are not the only outcomes of the investment and production. New production of knowledge also occurs in this process. This way of modeling gives the opportunity to observe both growth and level effects. In the model, capital accumulation and investment expand unlimitedly and the neoclassical foresight of the convergence of income levels is not inherited. Knowledge related investment bear externalities and the equilibrium obtained from this model is a competitive externalities equilibrium.

Romer (1986) puts forward a two sector model initially and then extends it to an infinite time horizon model. Three examples to simulate the models are presented. The assumptions of the two sector model can be listed as following: Identical consumers, two periods, concave utility function, one sector, dependence of the second period good production on knowledge accumulation-physical capital-labor and the other inputs, inverse relationship between consumption and knowledge accumulation, concavity of production function in capital and other input variables, production function's being increasing in knowledge stock, profit maximization of each firm taking knowledge stock as given, common technology investments of firms. Infinite time horizon model is an extended version of the two period model. The main difference between these two models is the concavity and the convexity of the production function. The main conclusion to be drawn from these models is that knowledge and technological improvements create positive effects on the economy as a whole and provides spill over effects. Human capital in the form of creation of new knowledge is an important factor contributing to economic growth.

## **2.4.2 The model considering human capital as “formal education” and “learning by doing”**

Robert E. Lucas (1988) is one of the early economists attempting to incorporate human capital and human capital accumulation into the neoclassical growth models. Initially a review of the neoclassical growth model is presented, in which Solow’s model serves as the example of the theory. His main criticisms to Solow’s model concern the single good assumption and the high weight given to technology as explaining the economic growth and being the engine of growth. By considering technology such important, the capability of the model to explain the diversity in growth rates of different countries decline. Moreover, he argues that Solow has obtained conclusions about the determinants of growth while he was trying to explain the dynamics of USA growth rather than trying solely to construct a theory of economic growth (Lucas, 1988: 16).

After reviewing the Solow model, the historical facts that USA economy experiences are taken into account and compared with the outcomes of the model. Lucas (1988) considers neoclassical growth model inadequate to explain the diversity among countries.

Lucas (1988) argues that technology and knowledge are not the same thing in terms of human capital and neoclassical growth models considers these two concepts as if they were the same. Comparing the technology level of countries is not the same thing with comparing the human capital accumulation or knowledge stock of countries. From this point of view, identical technologies assumption of the neoclassical growth models must be criticized within the concept of human capital to explain the income level diversities among the countries. This new framework by introducing human

capital causes contradictions with the convergence argument of neoclassical statement. According to this argument, within a model with identical technological structures and capital mobility, countries with low income will catch the developed countries both in terms of income level and growth rates. Lucas (1988) argues that 18th and 19th centuries have proved this statement, however, 20th century has not. Labor mobility has declined a lot and the convergence between the countries has not actualized. His contribution to explain these facts is to construct his model by adjusting the neoclassical model.

Lucas (1988) adjusts neoclassical growth model in two ways by adding the effects of human capital accumulation. First adjustment examines the interaction between physical and human capital, keeping the position of neoclassical model with one sector. In the second adjustment, there comes a system of more than one good and the specialization of different kinds of human capital is allowed. Besides, it offers different possibilities for the interaction between development and trade.

Lucas (1988) incorporates human capital to the growth theory “as an alternative engine of growth to the technological change”. Before turning to the construction and the main conclusions of the model, it is useful to state the assumptions: Closed economy and perfect competition, rational expectations of agencies about future prices of state variables, constant returns to scale of the technology. Besides these, growth rate of labor devoted to production at time  $t$  is exogenous.

Lucas defines human capital as the general skill level of the individual. Defining human capital in this way provides the opportunity to obtain the equation

$h(t) = 2 \times \frac{1}{2} h(t)$ , where  $h(t)$  stands for the human capital level of the individual at

time  $t$ . Productivity of the individual is represented by his human capital level. Human capital theories examine the way that an individual worker allocates his time between different sorts of activities that affect his productivity. One outcome of the introduction of the human capital to the model is the change of the current production level. Through this way human capital accumulation is taken into account again.

Lucas (1988) discusses two effects of human capital: internal and external effects. Internal effects are the ones that cause changes in personal productivity and external effects are the ones changing the productivity of all other factors of production (Lucas,1988:21). After formulizing the average level of skill and introducing the external effects, new description of the technology of goods production is obtained and compared with Solow model. Next step to complete the model is combining the rate of change in human capital and effort devoted to the accumulation of human capital. According to Lucas (1988), the way that combines these two variables is at the heart of the model. Relating human capital growth to the level already attained and the effort devoted to acquire more human capital in a way that human capital accumulation has diminishing returns prohibits human capital to be considered as an engine of growth,like technology. Since there is diminishing returns to human capital accumulation in Lucas (1988), human capital is considered as a social effort. Lucas (1988) argues that the model is identical to the neoclassical growth model, if endogenous technological development is excluded. Positive externalities are the engine of growth.

As mentioned before, Lucas (1988) takes external effect of human capital into account and the use of this variable hinders the model to be constructed by the same way that Solow's model is constructed, that is competitive equilibrium and optimal paths do not coincide. Lucas (1988) followed Romer (1986) to construct the model in

the manner that he obtained two different paths and then compared them. After putting forward the main characteristics of the Lucas model, it is appropriate to state the main conclusions of the model rather than stating all of the equations. The main conclusion of the model is that, an economy beginning with low levels of human and physical capital will remain permanently below an initially better endowed economy (Lucas, 1988:25).

### **2.4.3 The model taking into account the spillover effects coming from human capital investment**

Defining growth as “producing more of the same good(s)”, Stokey (1988) considers technical change as a process, rather than innovation of goods. Stokey (1988) develops a general equilibrium model in which the sustained growth is featured by competitive equilibrium paths and the introduction of new and better goods is mandatory part of growth. The general features of the model can be summarized as follows: Potential goods are produced continuously; however a limited subset of the potential goods are produced in each period, introduction of high-quality goods lower-quality goods are excluded and, thus set of produced goods is replaced with the new one over time, economies growth continuously in the long run without any bound (Stokey,1988:702). There is no physical capital in the model, an extreme feature, and the only source of growth is the knowledge accumulation which is supplied by learning by doing. The only input is the contemporaneous labor. The standard features of the model are; inelastically supplied labor, CRS technologies and perfectly competitive markets. The model is similar with Lucas (1988) in terms of the “*sustained*” growth of per capita output generated endogenously and driven by the accumulation of knowledge which bears an externality. The main difference is the disappearance of physical capital.

Moreover, commodity space and preferences are specified differently than Lucas (1988) does.

Several assumptions are stated to construct the model,<sup>2</sup> the most important one is related with the links between the periods:

*The unit labor requirement for production of any good by any firm in any period depends on the entire economy's cumulative experience in production of all goods in all previous periods. That is, learning displays complete spillovers among firms and, in addition, may display spillovers among goods (Stokey, 1988: 705).*

This assumption is complementary to the one stating the exclusion of lower-quality goods with the introduction of higher-quality goods. The reason for the entrance of high-quality goods is greater knowledge, so with knowledge accumulation the goods set changes over time. The properties of the model make it possible to calculate the growth rate of output per capita, which is positive in each period, even though the entrance of new goods each period. There is a sector in which learning exists. Learning provides the production of some new goods.

In addition to the learning sector traditional sectors, manufacturing and agriculture, are assumed to exist where no learning takes place. For these traditional sectors, it is shown that there may be equilibrium paths displaying no growth. If there exists no experience, no goods are produced in equilibrium. This kind of sector stays stagnant permanently. If some experience is acquired, goods start to be produced and competitive equilibrium can be sustained.

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<sup>2</sup> Since the main purpose of introducing main endogenous growth models with human capital is to put forward the main features of human capital and growth, detailed assumptions, features and mathematical derivations of the models are not presented within the thesis.

The main conclusion of the model is that knowledge accumulation, which is strictly related with human capital, is the driving force behind sustained growth of the economy.

#### **2.4.4 The model incorporating technology transfer to the regression analysis**

On the basis of the previous studies, Jones (1996) constructs a model relating human capital, knowledge accumulation to economic growth and makes a regression analysis using the model constructed. The main difference of the model from the previous ones is that it incorporates technology transfer to the regression analysis.

The basic mechanism and the properties of the model can be summarized as follows: Consumption good, human capital good and new intermediate capital goods are produced in the economy. Consumption goods,  $Y$ , are produced by competitive firms using labor,  $L_Y$ , and intermediate goods,  $x_i$  (Jones, 1996:3). Any firm using average skilled workers has consumption goods production function that exhibits constant returns to scale. The aggregate production function of the economy is Cobb-Douglas type, given the production technologies of each sector.

Individuals devote their time to either working in the consumption good production sector or increasing their skills through training or leisure. The human capital accumulation of the individual is given by

$$\dot{h}(t) = \mu e^{\theta v(t)} h(t) \left( \frac{A(t)}{h(t)} \right)^\gamma$$

in which  $\nu(t), \mu, A(t)$  represents the fraction of an individual's labor endowment spent accumulating human capital, an arbitrary positive constant and technological frontier; respectively. One of the reasons of defining human capital in this way is the wage-education relation provided by microeconomic analysis (Jones,1996:4). As the education level of the individual increases, the wage he earns also goes up.

Physical capital is accumulated by the consumption foregone and is determined in consumption good units:

$$\dot{K}(t) = s_K(t)Y(t) - dK(t)$$

Where  $s_K$  and  $d$  denotes share of investment in output and depreciation rate, which is assumed to be exponential. The aggregate production function of the economy mentioned above is given by

$$Y = K^\alpha (hL_Y)^{1-\alpha}$$

The characteristic property of Jones (1996) is the length of time necessary to be devoted to training to learn new technological innovations. The steady state rates of the model are determined within the R&D sector production framework. Under some several adjustments the technological growth rate is given by

$$g_A = \frac{n}{1 - \beta - \phi}$$

where  $n$  is the population growth rate. Existing stock of ideas is represented by  $\phi$  and  $\beta$  is the elasticity coefficient. For an economy with constant population growth rate, the condition  $\beta + \phi < 1$  must be satisfied to sustain balanced growth. This condition makes the model partially endogenous. Considering the population growth as a function of time, the position that the economy reaches at the balanced growth path is given by

$$g_Y = g_K = g_h = g_A \equiv g$$

Within the framework of the model constructed, Jones (1996) makes a regression analysis to investigate the relationship between the related variables empirically. The regression equation is given by

$$\log \hat{y}(t) = \log \hat{A}(t) + \frac{1}{\gamma} \log \frac{\mu}{g} + \frac{\alpha}{1 - \alpha} \log s_k - \frac{\alpha}{1 - \alpha} \log(n + g + d) + \frac{\theta}{\gamma} \nu$$

The data used as proxy for  $\hat{y}(t)$ ,  $s_k$ ,  $\nu$  is the real GDP per labor, average investment between 1980-1990 and formal education related variables as well as training programme related variables. Educational achievement data is the proxy for

human capital and one of the most important characteristic of this model is evaluating achievement as investment rather than stock. The regression results indicate that the output elasticity of physical capital ( $\alpha$ ) is 0.344 (Jones,1996:18). The contribution of education related activities estimated to be 0.195, that is these activities increase real GDP per labor by 20% annually. The results are evaluated to be significant both statistically and economically. The main argument of the study is that less developed countries start with low levels of human capital stock and the contribution of human capital in these countries is very low when compared with developed countries and sometimes negative. Jones (1996) presents a model in which research and idea can generate successful cross-country regression.

## **2.5 Evaluation of the endogenous growth models**

The above models conclude that in the long run, sustained growth is only possible if human capital grows without bound. Several extensions have been made to relax their assumptions. These include Bills and Klenow (2000) which assume quality of education could be increasing over time. The idea is that even if education attainment is constant over time, the stock of human capital could be growing as a result of higher quality of education. Romer (1990) also posits that the steady-state growth rate partly depends on the *level* of human capital. This conclusion is based on the assumption that human capital is a key input in the production of new ideas, thus given birth to the endogenous growth theory. Acemoglu (1997) have further relaxed this assumption by examining what happens when individuals are allowed to choose their investments in education or training and firms make decisions on R&D investments.

### **3. EMPIRICAL LITERATURE REVIEW ON THE RELATIONSHIP BETWEEN HUMAN CAPITAL AND ECONOMIC GROWTH**

There are many empirical studies investigating the relationship between human capital and economic growth. These models expect to find a positive relationship between the human capital and growth to confirm the theory. However, the results of the empirical studies are not consistent with each other, that is, there are some studies finding a positive relationship between the related variables and others finding negative relationship. The human capital proxies are the main point that make these studies differ from each other. Some of the studies use a Cobb-Douglas type production function and examines the relationship between human capital and growth within an extended Solow model framework, including human capital to the production function as a determinant of growth. Constant returns to scale assumption is hold and the most important difference of these studies than the ones based on endogenous growth models is that the technological progress is exogenous. On the other hand, studies based on endogenous growth models endogenize technology where technological progress becomes dependent on R&D or human capital. Considering the fact that endogenous growth models are also neoclassical in some sense, the empirical studies are presented without classifying them like “extended Solow” or “pure endogenous”. Another point to be mentioned is that the all empirical studies presented are single country cases. The reason for presenting these empirical studies is to construct the empirical basis for the analysis to be made for Turkey.

### 3.1 Empirical studies worldwide

#### 3.1.1 Regression analysis for Taiwan

Tallman and Wang (1994) constructs a model to examine the effects of human capital on economic growth in a case study of Taiwan. This model is important in terms of studying with a single country rather than making a cross country analysis for the basis it provides to construct the model for a case study of Turkey. The aggregate production function is estimated in which human capital is incorporated to construct an effective labor input. Labor is adjusted by the degree of labor skill. This model is an extension of the neoclassical model;

*The extension from the typical Solow-Swan growth framework arises from the arguments of Lucas-Romer endogenous models that suggest that endogenously accumulated human capital has a direct impact on the productivity of labor (Tallman and Wang, 1994:111).*

The standard aggregate production theory is employed as a framework for the empirical work and the growth model used in the empirical study is

$$Y_t = A_t K_t^\alpha (H_t L_t)^\beta, \quad H = E^\delta$$

in which  $Y$  (real output) is the dependent variable and  $K$  (physical capital stock),  $L$  (raw labor input),  $H$  (level of human capital),  $E$  (measure of education level) are the independent variables and  $\delta$  (return to the education relative to raw labor input),  $A$  (exogenous knowledge and technological factor),  $\alpha$  (capital share),  $\beta$  (labor share) are the constants (Tallman and Wang, 1994:111).

The data  $Y_t$  and  $K_t$  used in the estimation are per capita real gross domestic product and per capita real gross private and public enterprise capital stock, respectively. Capital stock measure is obtained by using an input-output survey. The raw labor input is the employment to population ratio. Level of human capital is calculated by using several stages of education variables. One of the main differences of this model from other models investigating the relationship between human capital and economic growth is that it uses education achievement data rather than enrolment measures. The construction of the human capital proxy is as follows: Educational attainment as percentage of the population over 6 years ( $E$ ) is calculated by considering the number of people completing 6, 12 and 15 or more years of schooling. Then, the educational attainment is powered by a constant  $\delta$  and multiplied by raw labor input to obtain the effective labor input. As in the typical implementation of aggregate production models, natural logs are taken to obtain the estimable form. The function is estimated both in log and difference forms.

Empirical results show that, the contribution of the effective labor increases with the augmenting level of educational achievement. For example, the contribution of effective labor augmented with primary school attainment contributes to growth with a coefficient of 0.038, whereas the effective labor augmented by higher school attainment contributes with 0.475.

The model constructs two indices<sup>3</sup> to proxy the human capital and several new variables are included to test the robustness of the model. The main conclusion to be drawn up is that, the empirical evidence supports the use of educational attainment measures as human capital proxies to augment the labor input measure in an aggregate production function (Tallman and Wang, 1994:121).

### **3.1.2 Growth accounting exercise for Spain**

Fernandez and Mauro (2000) is more comprehensive than many of the single country studies in terms of both the human capital index constructed and the projections about GDP growth for the next few years. The human capital index is superior than many other indices using educational data to proxy human capital, because not only formal education data is taken into account but also productivity increases resulting from experience, learning by doing, are included. Fernandez and Mauro (2000) differs from other case studies by the projections it makes about the future GDP growth, considering the effect of human capital accumulation on economic growth. The reason for projecting about future growth is the expectation of a higher growth rate of human capital and thus a greater effect on GDP.

Considering the features of Spanish economy and the policies put in force to increase the educational quality in the country, the authors construct a growth accounting framework for the period 1978 and 1997 to estimate the impact of human capital accumulation on economic growth. The production function is assumed to be of the standard Solow form with constant returns to scale

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<sup>3</sup> Derivation of the indices are explained in detail in Chapter 4.

$$Y = AK^{1-\alpha}L^\alpha$$

where  $A$  is total factor productivity,  $Y$  is gross domestic product proxied by GDP at market prices in billions of 1986 pesetas,  $K$  is physical capital stock proxied by nonresidential private capital stock in billions of 1986 pesetas, and  $L$  is labor where working age is between 15 and 64, and the parameter  $\alpha$  is, as usual, labor's share in national income (approximately 0.7 in Spain) (Fernandez and Mauro, 200:15). Quality of workers is weighted by different educational groups, age and gender according to their relative wages and then labor is adjusted for quality, human capital. The procedure used to construct the human capital index can be summarized as follows:

$$L = \sum_s w_s N_s$$

where  $w_s$  stands for the weight of workers of type  $s$  and  $N_s$  for the number of work hours provided by group  $s$ . For simplicity  $L$  is written as

$$L = N * h$$

in which  $N$  is the total number of hours worked in the economy and  $h$  is defined as average human capital

$$\text{[1]} \quad h = \sum_s w_s n_s$$

where  $n_s$  is the proportion of work hours provided by workers of type  $s$  (Fernandez and Mauro,2000:8). The assumption of competitive factor markets imply that respective wages of work hours undertaken by different groups of workers is the weight used to calculate the index in consideration. To put it obviously average human capital at time is computed as

$$\text{[2]} \quad h(t) = \sum_{g,i,j} w_{g,i,j} n_{g,i,j}(t)$$

where  $n_{g,i,j}(t)$  is the proportion of individuals of gender  $g$ , with schooling  $I$ , and in age group  $j$ , at time  $t$ , and  $w_{g,i,j}$  is the corresponding weight given by 1995 earnings ratios (Fernandez and Mauro,2000:10). As obvious from the above calculations, total number of people employed,  $N$ , is multiplied by human capital index. The human capital index constructed by this procedure captures the many aspects of wage differentials and for this reason has a higher explanatory power than the indices using less determinants of human capital differentials. After calculating the human capital index with the sense of weighting by relative wages, labor is adjusted with the index and the production function takes the form

$$\text{[3]} \quad Y = AK^{1-\alpha} (hN)^\alpha$$

Growth accounting analysis is applied to the above production function and the results can be summarized as follows: The contribution of human capital accumulation to GDP growth is about 30%, which is a very close percent of that physical capital stock contribution, 32%. Human capital is found to be as contributing to GDP growth as physical capital stock.

Finally, potential output growth in Spain for the period 1998 and 2003 is forecasted including human capital accumulation in the production function under several assumptions. The output growth is forecasted to be 3.6% for the related period which is higher than the growth rate experienced between 1978-1997, 2.23%. This result attracts attention in terms of policy implication, because incorporating human capital to the production process yields higher growth rates in the future. This result makes policies to increase the quality of human capital important to achieve sustainable growth at higher rates.

### **3.1.3 Time series analysis for Costa Rica**

The joint influences of fertility decline and rise in human capital investment on economic development are investigated by Perez-Brignoli (2001) for Costa Rica. The period under consideration is between 1950 and 1998, in which GDP per capita grew substantially and education system was to improved by several efforts. The improvements of the education system are represented by the gross enrollment rates in primary and secondary school. It is claimed that, throughout the interested period, Costa Rica experienced a rapid process of demographic transition and economic environment provided opportunity to invest in human capital.

The model is constructed by time series data, in which the dependent variable is income per capita measured by real GDP per working age and independent variables are several dimensions of demographic change and human capital investment. The independent variables are listed as; total fertility rate, life expectancy at birth, infant mortality rate, working age population, population density and gross enrollment rates in primary and secondary school (Perez and Brignoli, 2001:2). After taking the logarithms of the variables, two models are tested by Prais-Winsten transformed regression estimator, which is a generalized least squares estimator. First model regresses all of the independent variables on income per capita and the second model excludes demographic variables, total fertility rate, life expectancy at birth, infant mortality rate, working age population, population density, and only regresses human capital investment indicators. According to the results of the first fitted model, neither of the demographic variables have significant effect on income per capita. After observing this result, demographic variables are omitted from regression and only human capital investment indicators are regressed on income per capita. This model is named final model, and the results of the final model indicate significant relationships between primary and secondary gross enrollment rates and real GDP per working age. Since logarithmic forms are used, the coefficients are interpreted as elasticities. The final model indicates that a one percentage increase in primary school enrollment rate raises income per capita by 69%, whereas the same coefficient for secondary school enrollment rate is 20%. The estimated model can be given by

$$\boxed{4} \quad \text{Logpercapitaincome} = 2.9 + 0.69 \log \text{ primary} + 0.20 \log \text{ secondary} + u_t$$

$$\text{And } u_t = 0.51u_{t-1} + e_t$$

Perez-Brignoli (2001) serves as supportive for the positive relationship between human capital economic growth. The insignificant relationship between demographic variables and income per capita indicates that health investments have an inertia effect which affected the economy when a certain degree of improvement is experienced.

### **3.1.4 An investigation of the relationship between human capital and economic growth for Greece**

Asterio and Agiomirgianakis (2001) is an empirical study examining the relationship between human capital, proxied by educational data, and economic growth in Greece by using time series data for the period 1960-1994. The production function is obtained following Lucas (1988) as

$$Y_t = AK_t^\alpha (\nu_t h_t L_t)^{1-\alpha}$$

where  $Y_t$ ,  $A$ ,  $K_t$ ,  $\nu_t$ ,  $h_t$ ,  $L_t$  denotes output, the level of technology, the stock of physical capital, the fraction of nonleisure time households spend working, a measure of the average quality of workers and labor, respectively. Output is proxied by the growth rate of GDP per capita and human capital is proxied by enrollment rates at several educational stages. The enrollment rates are measured as the percentage of the working age population. Alternatively, public expenditures on education are used as proxy for human capital. Asterio and Agiomirgianakis (2001) states that the difference of this

model from Lucas (1988) is the family utility function. Households maximize their welfare constrained by the capital accumulation. Under the assumption that households accumulate knowledge by studying, human capital accumulation is given by

$$\text{[6]} \quad h_{t+1} - h_t = \phi h_t (1 - \nu_t) n_t - x p_x n_t$$

In which  $\phi$  is the average studying productivity parameter or the exogenous endowment (ability) of each child,  $x$  is the purchased schooling inputs and  $p_x$  is its price per unit of good  $x$  (Asterio and Agiomirgianakis, 2001:484). For simplicity,  $\phi$  is held constant. After writing the LaGrange, taking the first-order conditions and making necessary manipulations, it is found that the growth rate of human capital, physical capital and the whole economy are equal to each other. Furthermore, the growth rate of human capital, hence the other variables, is given by

$$\text{[7]} \quad \gamma_h = \frac{\phi n_t - B - 2p}{1 - 2\alpha - \sigma}$$

Equation 17 indicates that human capital production sector is really the driving force behind the economy. It is obvious that the constant  $\phi$  influences the growth rate.

The methodology used to investigate the relationship between human capital and economic growth is making a cointegration analysis initially and then applying

Granger causality tests. Applying necessary steps, positive relationship between GDP and enrolments at all levels of education is found.

Causality tests are conducted to assign the direction of the causality between the variables. For primary and secondary school enrollment rates, causality runs from educational data to GDP per capita growth. This result justifies the implementation of compulsory education at primary and secondary school. For the higher level of education, the direction of causality differs from primary and secondary enrollment rates: The increase of GDP growth raises the number of students those are enrolled at higher stages of education, that is the causality runs from GDP to higher enrollment rate. This result contradicts with the theoretical prediction. The possible reason behind this result is stated to be the unplanned character of the expansion in higher education that has taken place in Greece. In policy terms, it is suggested that a quantitative expansion of the higher education without qualitative aspects will not contribute to the general welfare of the country (Asterio and Agiomirgianakis, 2001:488). For the alternate human capital proxy, public expenditure on education, the direction of the causality is same as the primary and secondary school enrolments.

### **3.1.5 Growth accounting analysis for China**

Wang and Yao (2003) constructs a growth accounting exercise for Chinese economy for the period 1952-1999, in which the human capital stock measure is incorporated to the production function. The effect of human capital stock is estimated both for the prereform period, 1952-1977, and reform period, 1978-1999,. The superiority of the study lies in the long period it captures and the in-model constructed human capital stock variable.

The Cobb Douglas form of the production function is assumed for the Chinese economy,

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

where  $Y_t$  is output proxied by real GDP,  $A_t$  is TFP,  $K_t$  is the physical capital stock calculated by perpetual inventory approach using gross fixed capital formation at current prices,  $L_t$  is total employment and  $H_t$  is the stock of human capital proxied by the number of average effective years of schooling per person in the 14-65 age group (Wang and Yao,2003:34). Under several assumptions;  $\beta$ , labor share, is calculated to be 0.5. The logarithms of the variables are taken and both sides are differentiated to further construct the growth accounting exercise.

Human capital stock series is constructed by perpetual inventory method being inspired from Barro and Lee (2000). New school graduates are used as flow variables to calculate the percentage of population graduating from some determined level of education. Average years of schooling of the labor force is considered as the population's attainment of skills and knowledge and taken as the human capital stock (Wang and Yao,2003:40). To calculate human capital stock series, an initial level is determined under several assumptions based on schooling distributions. After determining initial level of human capital stock, current flows of adult population are constructed and added to the stocks of the previous year (Wang and Yao, 2003:41). Formulas for various levels of schooling are obtained by discounting the previous year's stock variable with current mortality rate. The years of each educational category is

known, which makes to calculate net number of graduates possible. Using the educational attainment data for the period 1952-1999, which is obtained by various levels of schooling formula, human capital stock  $H$  in year  $t$ ,  $H_t$ , is given by

$$H_t = (5H_{1t} + 8H_{2t} + 11H_{3t} + 10H_{4t} + 14.5H_{5t}) / Pop_t$$

where  $H_{jt}$  denotes the number of graduates with  $j$  the highest level of schooling attained in year  $t$ , and  $j=1$  for primary,  $j=2$  for junior secondary,  $j=3$  for senior secondary,  $j=4$  for specialized secondary and  $j=5$  for tertiary (Wang and Yao, 2003: 41).<sup>4</sup> Moreover,  $Pop_t$  is the population in the age group 15.64 in year  $t$ . Time series of human capital stock is obtained by applying perpetual inventory method.

The results of the growth accounting framework are summarized in three sub-categories: 1) The whole period, 1953-1999, 2) Prereform period (1953-1977) and 3) Reform period, 1978-1999. The results of the first sub-category indicate that the most important source of economic is physical capital by 50.9%. Throughout this period the contribution of human capital stock and labor to growth is reported as 29.8% and 19.0%, respectively. TFP between 1953 and 1999 is estimated to be 0.02%. Second subcategory assigns the same results in terms of the relative contribution of factor inputs with different weights. The contribution of physical capital stock, human capital stock and labor are 55%, 46.3% and 25.1%, respectively. Human capital stock remains the second most important source at the prereform period. Compared with the first

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<sup>4</sup> The data used for number of people graduating from various levels of schooling only captures the formal education.

subcategory, the contribution of physical capital stock nearly stays the same, whereas the contribution of human capital stock is 1.5 times of the whole period's result. TFP reaches a negative value, -1.39%, at the prereform period. Finally, last category's results provide different results than the first two categories both in terms of the arrangement of magnitude of the contributions and the values of magnitudes. The contribution of all factor inputs is at their minimum level at the reform period. Physical capital stock drives 47.7% of economic growth. Labor is the second factor input contributing to growth, that is 15.9% of growth is driven by labor. The accumulation of human capital falls from 46.3% to 11.0% at the reform period. Moreover, the contribution of labor is higher than of human capital stock. TFP, which is considered as one of the most important sources of China's economic growth at the reform period, is recorded to be positive, 2.41%. Evaluating all results together puts forward the important role of human capital stock in Chinese economy. The same growth accounting framework is constructed for different shares of factor inputs and the results are to be found robust. Wang and Yao (2003) considers the conditions and features of the economy. Taking the large population of China into account, human capital investment serves as an important policy tool.

### **3.1.6 Cointegration analysis for Taiwan**

Lin (2003) constructs a model to analyze the relationship between economic growth in Taiwan and schooling and technological progress. The period taken into account captures the years between 1965 and 2004. Considering the structure of Taiwanese economy within the related period, a Cobb Douglas production function is assumed for the economy:

$$(10) \quad Y_t = AK_t^\alpha L_t^\beta H_t^\gamma$$

where all the subscripts denote the variables as usual. It is assumed that the individuals start to invest in education at the beginning of their lives and keep on working until the end of their lives (Lin, 2003:215). The output, capital stock, labor input are proxied by GDP, gross fixed capital formation and the number of people economically active population of employment status; respectively.

The formation of human capital proxy can be summarized as follows: The opportunity of education is considered to be the foregone earnings lost by being educated instead of working. Earnings of an individual graduated from school is given by

$$(11) \quad I = wH(E)$$

in which  $I, w, H, E$  represents the earnings of an individual, wage per unit of labor, quality of labor labor and schooling; respectively. With reference to the labor literature, the estimated form of structural earnings function is specified as

$$(12) \quad \ln I = c + f(E)$$

Equating both functions to each other and solving for human capital yields

$$H = e^{f(E)}$$

Under several assumptions about the structure of the human capital function, Equation is inserted to the Cobb Douglas production function and logarithms and first differences of all variables are taken to estimate the production function. The independent variables are assumed to be uncorrelated with each other. All series are found to be I(1) according to the results of DF test. For the purpose of identifying the type of the model, the variables are tested for cointegration. Cointegrating regression DW test is performed and the results indicate that cointegration does not exist in the model.

The results of the estimation yield statistically significant relationship between all explanatory variables and output at 5% level. The effects of physical capital, labor and education on economic growth are estimated to be 13%, 63% and 15%; respectively. The variable that has the largest effect on economic growth is labor. Human capital has larger effect than physical capital; however there is not much difference between the effect of two variables. The model is tested for constant returns to scale hypothesis and the production function is found to exhibit CRS, with an explanatory power of 43%. The possible reason for the high effect of education is suspected to be the complementary between capital and education; however the results of complementarity test does not reveal any relationship. The positive effect of

education on growth in Taiwan is evaluated to be realistic, based on the sound education policies implemented in the country.

### **3.1.7 Comparison of the effect of human capital in two developing countries: Pakistan and Sri Lanka**

Abbas (2001) constructs an analysis for two developing countries, Pakistan and Sri Lanka, to determine the effect of human capital in both countries and compare the results with each other. The analysis captures the period 1970-2004. Accepting some deficiencies of schooling enrollment rates, these rates are used as proxy for human capital. Assuming a production function exhibiting constant returns to scale and increasing returns in human capital, growth accounting methodology is employed with the production function in which human capital is inserted:

$$Y_t = AK_t^\alpha L_t^\beta H_t^\gamma e_t$$

all subscripts are used in their usual notation. Gross domestic investment is used as proxy for physical capital and labor input is measured by employment. As mentioned above, human capital is proxied by gross schooling enrollment rates at three levels of education, primary, secondary and higher. Gross enrollment rate is obtained as the ratio of total enrollment in the designated grade to the total population of corresponding age group (Abbas,2001:995). Standard OLS techniques are applied to the production function with all variables in their natural logarithmic forms. Two models are estimated

for both countries. First model behaves human capital as a separate factor of input, whereas the second model inserts human capital to the production function to create effective labor input. Within each model, three sub-models are constructed for each level of schooling enrollment. That is there are twelve models estimated, totally.

The results of the first model for two countries can be summarized as follows: For Pakistan, the only variable that has negative impact on economic growth is the primary school enrollment rate. The effect of secondary schooling rate, 0.061, is greater than the effect of higher schooling rate, 0.042; however the difference is very small so that it can be ignored. All human capital variables are statistically significant at 5% level, for Pakistan. The effect of human capital on economic growth is much smaller than the effect of physical capital and labor. The estimation results of different models with primary, secondary and higher schooling enrollment yield the coefficients 0.453, 0.425 and 0.440 gross fixed investment; respectively. Moreover, the same models estimate the contribution of labor to be 0.554, 0.526 and 0.59 for Pakistan. The input that has the greatest effect on Pakistan's economic growth is labor, followed by physical capital stock and human capital. For Sri Lanka, like Pakistan, primary schooling enrollment rate has a significant and negative impact on economic growth. The potential reason for this result is stated to be sending out children to work rather than school due to poverty (Abbas,2001:998). The dissimilar result for Sri Lanka is about the input which has the greatest effect on growth: Physical capital stock contributes to growth much more than the labor does in Sri Lanka. The effect of secondary and higher schooling enrollment rates are 0.248 and 0.032; respectively. The contribution of secondary schooling enrollment in Sri Lanka is approximately three times greater than of in Pakistan; however the contribution of higher schooling enrollment rate is very close in both countries.

The second model, inserting human capital as effective labor to production function, estimates statistically significant results for effective labor augmented by primary and secondary schooling rate; however there does not exist any significant relationship between higher schooling enrollment rate. For Sri Lanka the only human capital indicator that has a significant effect on growth is secondary schooling enrollment rate, with the coefficient 0.253. In both countries, augmenting labor with human capital yields greater effects on growth than the case of inserting human capital as a factor of input.

The main conclusion of the study is that the effective labor proxy yields more significant results than the simple enrollment data for both countries. The only variable that has significant and positive effect on growth in the second model is effective labor augmented by secondary level of education for both countries.

### **3.2 Empirical studies for Turkey**

#### **3.2.1 Studies using education related data as human capital proxy**

Çakmak and Gümüş (2005) analyzes the long run relationship between human capital and economic growth econometrically for Turkey for the period 1960-2002 via cointegration analysis. The data set used for the analysis is; GNP, labor force, physical capital, education related variables, human capital index, CPI and time series of the mid-year variables.

The human capital index is constructed following Tallman and Wang (1994), assigning weights 1,2,4 to the number of students graduated from primary, secondary and higher education stages, respectively. The increasing weights assigned to education

level indicate the efficiency increase of the higher education levels. Other variables are all in real and per capita terms.

The hypothesis used in the study is “There is long run relationship between human capital and economic growth” (Çakmak and Gümüş, 2005:65).

The methodology used in the study is applying Engle-Granger cointegration technique initially and then running Johansen cointegration test. Before running the regressions, each variable is tested for stationarity and all series are found to be I(1). Then, using the logarithmic forms of all the variables, four regression equations, interchanging the variables such that each variable is once the dependent variable, are estimated and then the residuals of the four equations are tested for stationarity. The test results for the residuals indicate that the variables are cointegrated of order (1,1) and there exists a long run relationship between the variables. This part of the analysis refers to the Engle-Granger cointegration technique.

After capturing the long run relationship between the variables, the relationship between GNP and physical capital, human capital and labor force is tested by Johansen cointegration test.<sup>5</sup> According to the results of the test, there exists a positive relationship between GNP and physical and human capital, however negative relationship between GNP and labor force. The cointegration equation is given by

$$\log Y = 1.610 \log K - 1.430 \log L + 0.145 \log E$$

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<sup>5</sup> For detailed information about Johansen cointegration test, see Johansen (1988).

It is observed that the contribution of physical capital to growth is higher than that of human capital. The potential reason for this situation is guessed to be the unplanned characteristic of the enlargement of the education system in Turkey. Even though the increase of the number of students, the quality of the students did not followed the same path. It is possible to expect a better qualified system of education is more potential to contribute to growth in the long run than a system expanding quantitatively only.

The human capital proxy used in Çakmak and Gümüş (2005) makes it possible to study with a longer period. Rather than health or education investment data as human capital proxy, this index generates more solid results. Because it takes into account the contribution of each level of education. The contribution of primary school graduates is less than the contribution of the graduates of higher levels of education. This difference is reflected via the construction of the human capital index with the assumption that the increase in education level increases the skills of the individuals. Investment data is capable of only reflecting the degree of importance given to education or health; however the quality and the contribution of human capital to growth is a matter of not only the importance attached to it, but also the quality it bears. Cakmak and Gumus (2005) is one of the best studies reflecting the main mechanism of the effect of human capital on economic growth. Besides choosing a well defined proxy for human capital, the technique used for the analysis is very common for empirical studies for Turkey. This property retains the study from being original in terms of its technique. Moreover, the negative contribution of labor force to growth is open to debate and necessities to be explored clearly with the possible explanations.

Masatçı and Serel (2005), constructs an econometric analysis to investigate the relationship between human capital and economic growth in Turkey for the period 1950-2000 on the basis of the assumption that educated labor force has a positive contribution to the production process. Cointegration technique is applied to test the long run relationship between human capital and economic growth.

Taking Lucas (1988) as a basic framework, the production function is assumed to take the form

$$Y_t = AK_t^\beta (u_t h_t N_t)^{1-\beta} H_t^\gamma$$

where  $Y_t$  (production represented by GNP),  $A$  (level of technology),  $K_t$  (physical capital stock represented by the gross fixed investments),  $u_t$  (time disposed to working by households),  $h_t$  (average skill level of the workers, assumed to accumulate as MRW (1992) offers),  $N_t$  (labor, represented by total employment),  $H_t$  (the exogenous effect of human capital represented by secondary school enrollment rates)<sup>6</sup> are the relevant variables and constants used in the analysis.

Due to the inclusion of the exogenous human capital factor, the production function differs from the Cobb Douglas type production. Instead of constant returns to scale, the production function determined in this way exhibits increasing returns to scale. The human capital variable is assumed to evaluate as the way that MRW (1992) model puts forward:

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<sup>6</sup> Logarithmic forms of the series are used to perform the cointegration analysis, as conventionally is done.

$$(7) \quad \Delta h_t = s_h y_t - (n + \delta)h_t$$

In which  $\Delta h_t$  is the change of human capital level,  $y_t$  is income,  $s_h$  is the saving disposed to human capital,  $n$  population growth rate and  $\delta$  is the disappeared part of human capital. The disappeared part of human capital may occur due to deaths or disease, which shows the depreciation of human capital. According to this relationship, for human capital stock to increase, saving must be disposed to education in some degree.

To perform the cointegration analysis, unit root tests to each variable is applied as the first step. After detecting that all series are I(1), Johansen cointegration test is performed for the purpose of the analysis. The results of the Johansen test indicate that there is a long run relationship between the variables given by the equation

$$(8) \quad LY = 1.09 LN + 0.287 LK + 0.175 LH$$

The results indicate that 1% increase of labor, physical capital and human capital increases the income by 1.09%, 0.287% and 0.175 in the long run, respectively. There is a positive relationship between income and all explanatory variables. After detecting that the variables are cointegrated, VECM model is constructed to investigate the short run relationship. According to the VECM model, the equilibrium which is sustained in the long run can not be sustained in the short run and the 15.6% of the

imbalances occurring in the short run are corrected each year ( Masatçı and Serel, 2005: 57).

As the final step, Granger Causality tests are performed and it is observed that there is one way relationship running from income to human capital.<sup>7</sup> The increase in income raises the human capital investment in the next period and the increase in the human capital accumulation contributes positively to economic growth in the long run.

Using secondary school enrollment rates is very common in the literature; however this proxy is incapable of capturing the situation for Turkey. In developed countries, the number of students graduated from different levels are distributed more equally than in developing countries. The number of primary school graduates may be higher than the number of graduates of other levels; however in developing countries there is a wide gap between the numbers of mentioned categories. Moreover, enrollment rate is not a good proxy for human capital since it does not provide any idea about the number of people completing the school. Masatçı and Serel (2005) constructs the model not only with cointegration analysis but also with VECM and Granger causality. This is important in terms of commenting on the long run equilibrium equations.

Özsoy (2007) is another study investigating the relationship between GDP and the number of students at selected levels of education for Turkey for the period 1923-2005. The study is organized as applying unit root tests, detecting the long run relationship between the variables by applying Johansen cointegration tests, observing the direction of the causality (if exists) and estimating VAR models within the

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<sup>7</sup> This result lowers the accuracy of the results given above. Because the effect of human capital on growth is to be analyzed. However, Granger Causality test indicates no causality running from human capital to income, which is an unexpected result considered with the whole results of cointegration analysis. The explanation for this situation can be that the returns to human capital investment are obtained in the long run.

framework of VECM. The variables used in the model are GDP with 1987 prices, number of students at primary, secondary, technical and tertiary levels of education and logarithmic level of all variables are used within the study (Özsoy, 2007:2117).

ADF unit root test results indicate that the variables are not stationary at level; however they are stationary at their first difference, which denotes that the series are I(1). From Johansen cointegration tests, it is concluded that there is one cointegrating vector at 5% critical level. This conclusion displays that there is a stationary long run relationship between the variables and the series are cointegrated (Özsoy, 2007:2118). Since there is at least one cointegrating vector, VEC model is estimated for applying Granger causality tests. The causality test includes the error correction term obtained from the cointegration vector and test results can be summarized as follows: There is a dual causality between the number of students at primary school and GDP. The causality runs from GDP to the number of students at secondary school and from the number of students at technical school to GDP. The final result from Granger causality test is that there is not any causality between the number of students as tertiary education and GDP. Evaluating all results together allows ranking human capital indicators according to their effect on economic growth. The ranking of human capital indicators according to their effect on growth from maximum to minimum is primary, secondary, technical and tertiary education.

As the final step of the study, VECM is constructed to calculate the impulse response functions and variance decomposition method to calculate the magnitude of the impact of education on growth. According to the results of the impulse response functions, the numbers of students at all levels give responses to GDP shock from the first period (Özsoy, 2007:2121). The impact of the explanatory variables on GDP is

tested for a ten year period by variance decomposition method. Changes of GDP at the first period are affected only from itself, that is the factors that affect GDP except the number of students cause GDP to change. From the second period on, the education related data start to affect GDP with an increasing magnitude. The number of students at primary school is the variable that affects GDP at most initially and as the time passes the impact of the number of students at secondary school becomes larger than the effect of those in primary school. When a ten year period is considered, the impact of the number of students at secondary, technical, primary and tertiary education on GDP is recorded to be 28%, 18%, 7% and 6.5%; respectively. The results of the study indicate a positive relationship between education and economic growth in Turkey.

Özsoy (2007) is wider than the other studies constructed for Turkey, in terms of the techniques it uses; however, the complaining for the other studies remains the same. The variables which are capable of being proxy for human capital are incorporated to the cointegration analysis separately and human capital is not represented by a sole variable. The direction of causality between variables may run from growth to human capital; which is an unexpected result when trying to explain the effect of human capital on growth. Positive long run relationship between education and growth is observed; however dual causalities prevent from observing the positive effect of human capital on growth as endogenous growth models claim.

### 3.2.2 Studies using investment variable as proxy for human capital

Canpolat (2000) investigates the relationship between economic growth and human capital accumulation in Turkey for the period 1950-1990. The most important contribution of Canpolat (2000) is that it constructs human capital stock series, which can be used as a factor of input in Cobb Douglas production function where the other major input is the physical capital stock, for Turkish economy. The opportunity cost approach is used to construct the human capital stock series. The main argument behind using this approach is that the opportunity cost of the time disposed to education is the investment made to human capital (Canpolat,2000:269). Individuals at working age do not participate to labor force and prefer to be educated more with the expectation of earning more wage.<sup>8</sup> Because, the human capital stock embodied in the individuals is the main factor determining the wage income earned at labor market. Individuals prefer to receive training to increase their human capital stock sacrificing the potential income they can earn. As a conclusion of this decision, the aggregate potential production loss due to the nonparticipation of the individuals at working age is the human capital investment.

Canpolat (2000) calculates the human capital stock series with the opportunity cost approach mentioned above, however there are potential problems of using this approach. First of all, calculating human capital stock in this way has the capability of compassing only some part of the actual human capital investment (Canpolat,2000: 271). The expenditures detached to primary school students by government and in-the-job expenditures could be included while calculating the stock series. The second problem is related with decreasing returns:

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<sup>8</sup> To justify this expectation, improved skills with higher stages of accumulation should be demanded at market. In other words the returns to higher human capital equipment should be high.

*Given the physical capital stock and the technology level, due to the decreasing returns, every individual starting to participate in the production process will decrease the output per worker. For this reason, the approach exaggerates the opportunity cost of education (Canpolat,2000:271).*

Another problem related with the opportunity cost approach is the linear relationship it attaches to the number of students and human capital. Because it is not only the number of students but also the quality of the education that determines the human capital. The increase in the number of students is considered as human capital investment; however it is realistic to expect the returns to investment to decrease with the low quality levels of education. The model used in the study is:

$$Y_t = A_t K_t^\alpha H_t^\gamma L_t^\beta, \quad 0 < \alpha < 1, 0 < \beta < 1, 0 < \gamma < 1$$

In which Y, A, K, L, H represents production level, technology index (or total factor productivity), physical capital stock, labor stock, human capital stock; respectively.

Before turning to the estimation results of the study, acknowledging about the data and the nature of the human capital stock series is crucial. It is assumed that the evolution of the stock series in a country is determined by

$$H_t = H_{t-1} + E_t$$

$H_t$  In the above representation stands for the human capital stock at time t and  $E_t$  is the net education investment at time t, calculated by the opportunity cost approach. For the above relation to operate, an initial level for the human capital stock should be chosen. The initial level for the human capital stock is given by

$$\text{1} \quad H_0 = \frac{E_0}{\bar{\eta}}.$$

Here,  $E_0$  stands for the education investment at time 0 (1940) and  $\bar{\eta}$  is the average growth rate of the labor force. Calculating the initial human capital stock is widespread approach used in literature and this proxy performs well if the human capital stock is at the steady state level, a strong assumption (Canpolat,2000:272). After calculating the initial level of human capital stock, calculating education investment in terms of social opportunity cost to obtain the evolution of human capital stock is the next step. Net education investment contributing to the human capital stock is

$$\text{2} \quad E_t = w_t [s_t - (1 + \eta_t)s_{t-1}]$$

In the above equation,  $w_t$  stands for the production per worker,  $s_t$  for the number of students those are at high school and faculty,  $\eta_t$  for the growth rate of labor force, respectively. In the light of these equations, human capital stock is calculated and

used as an input of the production function. Including other variables in the production function and dividing them with employment, per worker value of each variable is calculated. Under the assumption of constant returns to scale, logarithm of each variable is taken and the production function to be estimated is obtained. Finally a dummy variable, 1 for the years when a decrease occurs for production per worker and 0 for the years when an increase occurs, is added and the production function is estimated by using OLS technique.

According to the results of the estimation, all coefficients are statistically significant. The model has an explanatory power of 37%. The contribution of physical capital stock, human capital stock and labor force to economic growth are 53%, 39% and 8%, respectively. There is positive relationship between all the inputs of production function and growth. Due to the constant returns to scale assumption, this model seems to bear a neoclassical nature. The low contribution of employment to economic growth seems to be supportive of endogenous growth models which argue the basic inputs determining growth are technological improvement and human capital (Canpolat,2000:277). Incorporating the human capital stock to the production function causes labor force's contribution to decrease and Canpolat (2000) has a conclusion that the returns to human capital accumulation are high, approximately 40%. Another conclusion of the study is that although the number of students at high school and faculty has substantially increased, there has not occurred an improvement at the per capita physical capital stock.

Canpolat (2000) is categorized within the studies estimating statistically significant and positive relationship between growth and human capital in Turkey. It is superior than the other empirical studies constructed for Turkey for estimating human

capital stock series and considering a longer period than most of the other studies. Incorporating human capital stock as an independent factor input supplies to consider more definite conclusions on the effect of human capital.

Consistent with many of the empirical studies to investigate the relationship between human capital and growth in Turkey, Çoban (2003) constructs a cointegration analysis for the period 1980-1997. Besides the cointegration analysis, Granger causality tests and ADF tests are performed to determine the direction of the relationship and the stationarity of the variables. The variables used to construct the model are, GDP per capita, schooling rates at primary, secondary, high and tertiary level, share of public education expenditures in total expenditures (Çoban,2003:136). The production function used in the model is the same as Lucas' (1988) and the evolution of the human capital accumulation is the same as Asteriou and Agiomirgianakis (2001).<sup>9</sup>

As the first step, ADF tests are performed to determine the stationarity of the variables. According to the ADF tests, all variables are found to have unit root, that is all series are I(1). The second step consists of applying Johansen cointegration test to observe whether long run relationship between the variables exist or not. The lag interval for all variables are determined to be 1. The cointegration test results indicate that there is a long run relationship between primary, secondary, high and tertiary schooling rates, education expenditure and economic growth (Çoban,2003:138). After observing the long run relationship between the variables, Granger causality tests are performed to detect the direction of the causality between the variables. Results of causality tests can be summarized as follows: The causality runs from primary schooling rate to economic growth, from economic growth to high schooling rate, from tertiary schooling rate to high schooling rate and from education expenditures to high

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<sup>9</sup> See subsection 3.1.4 for detailed explanations of the related equations.

schooling rate. According to the results, it can be concluded that the increase of the schooling rate of primary level is the cause of economic growth and economic growth is the cause of the increase of the schooling rate at high level. Moreover, increase of secondary schooling rate causes schooling rate at tertiary level to increase and rise of education expenditures causes schooling rate at high level. The direction of the causalities is justified within the interaction chain; however, Çoban (2003) does not serve as a model explaining the relationship between human capital and economic growth. Human capital determinants are decomposed to several parts rather than being used to construct an index. The effect of human capital is difficult to observe, because many variables are used as proxy for human capital and the direction of causality from human capital proxies to economic growth does not follow the same path. A long run relationship between the variables is detected; however, this detection is not enough to conclude on the basic effect of human capital on economic growth.

### **3.2.3 Studies using both education and health related variables as human capital proxy**

Kar and Ağır (2006) constructs an empirical analysis for Turkey for the period 1926-1994. The methodology used in the study is organized as follows: Initially performing unit root tests to human capital and growth variables, than investigating the long run relationship between the variables via Johansen cointegration tests and finally detecting the direction of the causality between the variables by applying Granger causality tests. The human capital indicators used in the study are the share of health and education expenditures in GDP.

The unit root test results indicate that the series are nonstationary and become stationary when first differences are taken. In other words, the series are I(1). Since all series are I(1), cointegration tests can be applied to observe the long run relationship between human capital indicators and economic growth. Johansen cointegration test results indicate that all pairs of variables are cointegrated with each other, that is there is a long run relationship between the variables. The cointegration equations are given by

$$\text{3} \quad PY = 6.86 + 0.588ED \text{ and}$$

$$PY = 7.65 + 0.98HE$$

where PY, ED and HE represents GDP per capita, share of education expenditures in GDP and share of health expenditures in GDP, respectively. It is obvious from the equations that there is a positive relationship between economic growth and both indicators of human capital (Kar and Agir,2006:10).

The causality tests indicate that the education expenditures cause economic growth and economic growth causes health expenditures to increase in the short run. The conclusion from these results is that the relationship between economic growth and human capital is sensitive to the human capital indicator chosen. The reason for the direction of causality between health expenditures and growth is suspected to be the low share of health expenditures in GDP (Kar and Agir,2006:12).

As Kar and Agır (2006) states the sensitivity of the model to the human capital indicator used, this model does not provide a certain conclusion on the effect of human capital. Moreover, the share of health and education expenditure in GDP does not serve as a good proxy for human capital in Turkey; because Turkey could not sustain qualitatively improvement in health and education services. Only quantitative and monetary increases in terms of investment were actualized; however this situation is not enough to capture the nature of human capital in the country.

Atik (2007) constructs logarithmic models to examine the relationship between human capital and economic development in Turkey for the period 1965-2005. Economic development is proxied by the variables GNP, the share of agricultural production in GNP, the share of industrial production in GNP, the share of services production in GNP and electricity consumption per capita. Human capital is proxied by school enrollment rates at primary, secondary and tertiary level, average life expectation at birth and per capita purchasing power parity (Atik,2007:2124). The difference of Atik (2007) from many of the studies constructed for Turkey is examining economic development rather than economic growth.

The study consists of 25 different models and each model is constructed by changing the dependent variable and including human capital indicators each time. Education related human capital is included initially, then other human capital variables are added. Moreover, the models are estimated for the logarithmic forms of the variables. Among 25 models, the best models are chosen according to some criteria including  $R^2$ , adjusted  $R^2$ , Akaike Schwarz values, Durbin Watson statistic and t-statistic values. 5 models using the original form of the variables among 25 models are

chosen and 5 models using the logarithmic form of the variables among 25 models chosen. Each of the five models uses a different dependent variable.

The results of 5 models using the original form of the variables can be summarized as follows: The model using GNP as the dependent variable includes all human capital indicators as explanatory variable and indicates a positive relationship between GNP and all human capital indicators. In the second model, the share of agricultural production in GDP is the dependent variable and independent variable is only the enrollment rate. There is a negative relationship between the share of agricultural production in GDP and school enrollment rates. The share of industrial production in GNP is affected from all human capital proxies positively, whereas the share of services in GNP is affected only from the average life expectancy at birth. Electricity consumption per capita is dependent on all factors of human capital. All of the coefficients of these models are statistically significant at 5% level. Enrollment rates and life expectancy seem to have impact on economic development whatever variable is used as proxy for economic development.

Models using the logarithmic forms of the variables indicate significant relationships between all human capital indicators and GNP, the share of agriculture and services in GNP and electricity consumption per capita. On the other hand, the share of industrial production is affected from only the enrollment rate.

Evaluating the results of 10 models as a whole, human capital is important in terms of economic development in Turkey. The most important component of human capital is enrollment rates, which affect many of the variables used as proxy for the development of the economy.

Atik (2007) differs from the other studies in terms of constructing models as much as possible and choosing among them according to some determined criteria. Moreover economic development is taken into account, rather than economic growth. Human capital is found to be important for economic development in Turkey. Atik (2007) performs better than other studies in terms of finding the best proxy for human capital and development. On the other side; the variables which are used as proxy for human capital are inadequate of capturing the effect of human capital as a whole. Positive relationship between human capital and economic development may not be the real case in Turkey.

## **4. EVOLUTION OF HUMAN CAPITAL INDICATORS IN TURKEY**

It is important to observe the evolution of the variables, which are accepted as human capital indicators, in terms of evaluating the results of empirical models. There are many variables accepted as indicators of human capital, which the most important ones are education, R&D and health related variables. In this chapter, the available variables for Turkish economy is subdivided into three categories; education, R&D and health, and general conclusions about the evolution of these indicators are drawn up.

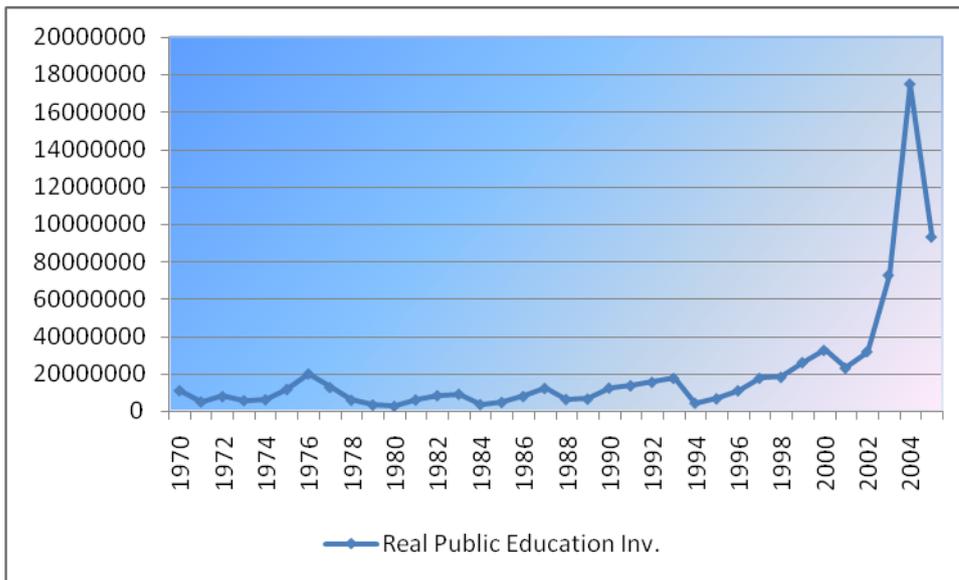
### **4.1 Education indicators**

In literature, education is accepted as the most important component of human capital. The assumption behind the acceptance is that educated labor force contributes to the production process more efficiently. Education refers to formal education; however in-the-job training and learning by doing are as important as education in terms of increasing the productivity of the workers. For Turkey; real public investment, primary school enrollment, secondary school enrollment, number of students per teacher and literacy rate are examined as long as the data are available.

In Figure 4.1, the movement of real public education investment is observed. The data is obtained from the website of Ministry of Labor and Social Security of Republic of Turkey. The real investment data gives more concrete information than nominal data, especially for a country experiencing high inflation rates like Turkey. Between the years 1970 and 2006, investment fluctuates within a narrow band and reaches its maximum in 2003. A steady increase or decrease is not experienced within the related period. There occurs a jump between 2003 and 2005, in 2006 there exists a

decrease. It is concluded that an increasing trend for real public education investment is not observed, which is not a good result in terms of human capital development.

**Figure.4 1: Real Public Education Investment**



Source: T.R Prime Ministry State Planning Organization

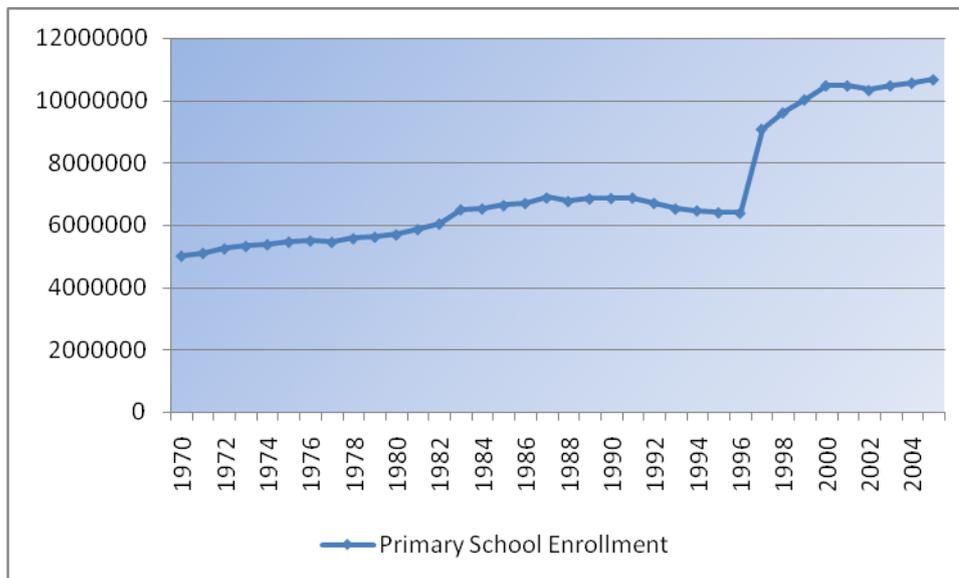
a) Y-axis is in dollars.

Primary and secondary school enrollment rates are given in Figure 4.2 and Figure 4.3. As the number of students enrolling at basic stages of education increase, the illiteracy rate declines and this contributes positively to the productivity of the labor force.<sup>10</sup> Both primary and secondary school enrollments increase during the years 1970 and 1998. In 1998 there occurs a decline and the number of students at both level reach

<sup>10</sup> This situation holds under strict assumptions such that, many of the students participate in labor force, education quality stays the same or does not decline as the number of students increase, which necessitates education investment to increase. All of the indicators are strongly related with each other.

their maximum in 2005. Primary school enrollment increases approximately more than two times; whereas secondary school enrollment is five times larger than its value in 1970. The growth rate of secondary school enrollment is larger than of primary's. The number of students at primary and secondary level in Turkey increased between 1970 and 2005. This situation is evaluated positive in terms of human capital development; however this evaluation does not fit with the facts of Turkey. In Turkey, there is a quantitative increase in education sector; however qualitatively increase does not take place. Interpreting the increase in enrollment as positive in terms of human capital development causes inadequate conclusions.

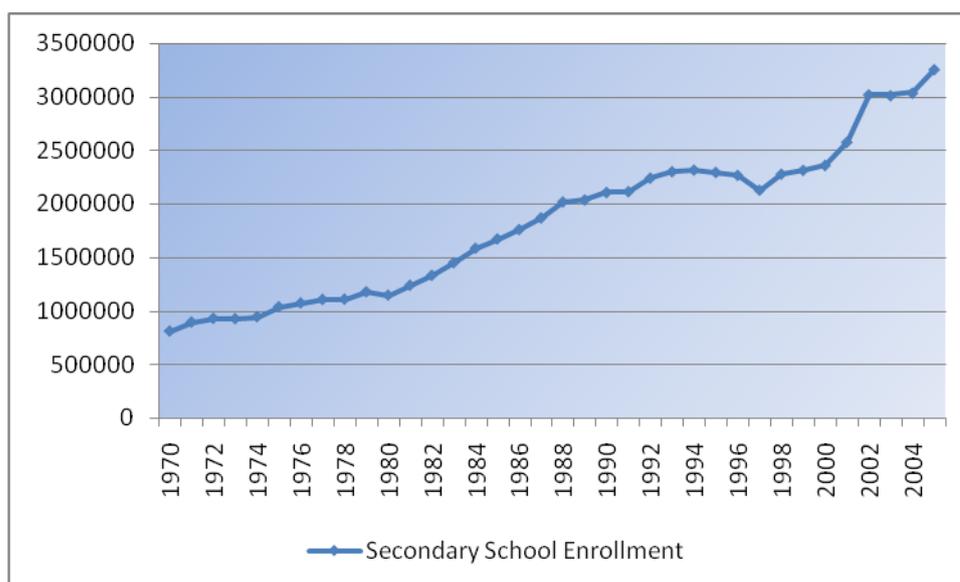
**Figure.4 2: Primary School Enrollment**



Source: WDI Software, 2006

a) Y- axis is the number of students enrolled in primary stage.

**Figure.4 3: Secondary School Enrollment**



**Source: WDI Software, 2006**

a) Y- axis is the number of students enrolled in secondary stage.

Parallel with the increase of enrollment rates; literacy rate, that can be observed from Table 4.1, recorded a considerable increase from 1935 on. The total literate rate which was 19.25% in 1935 increased more than three times and reached 87.32% in 2000. Throughout the whole period, total literate declined once in 1960. Except the decline in 1960, total literate rate increased continuously. The same observation holds for both male and female literate rate; that is both literate rates increased steadily between 1935 and 2005 except 1960. One important point about the male and female literacy rate is the gap between the literacy rates of the sexes. Male literacy rate is higher than the female literacy rate for all years.

**Table.4 1: Literate rate (population six years age and over) in Turkey between 1935-2000 with 5-year periods**

	<b>Total</b>	<b>Male</b>	<b>Female</b>
<b>1935(a)</b>	19.25	29.35	9.81
<b>1940</b>	24.55	36.2	12.92
<b>1945</b>	30.22	43.67	16.84
<b>1950</b>	32.51	45.52	19.45
<b>1955</b>	40.99	55.94	25.61
<b>1960</b>	39.51	53.63	24.84
<b>1965</b>	48.76	64.1	32.84
<b>1970</b>	56.21	70.31	41.8
<b>1975</b>	63.72	76.21	50.51
<b>1980</b>	67.48	79.98	54.67
<b>1985</b>	77.45	86.52	68.16
<b>1990</b>	80.49	88.81	71.98
<b>2000</b>	87.32	93.86	80.64

Source: Turkish Statistical Institute

a) Five year periods are available due to the census years.

Among the education component of human capital indicators, number of students per teacher is important because it gives some information about the quality of education, which is mentioned to be more crucial than quantitative educational developments. If the number of teachers does not increase with the same speed as the number of students does, access to education of good quality becomes difficult, which does not contribute to the development of human capital. From Table 4.2,<sup>11</sup> it is observed that the number of students per teacher at different education levels recorded different patterns.

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<sup>11</sup> It has been undergone 8 years compulsory education since 1997/ '98 education year.

**Table.4 2: Number of students per teacher**

	<b>PS</b>	<b>SS</b>	<b>PE</b>	<b>HS</b>	<b>VATS</b>	<b>HEI</b>
1970/ ' 71	38	36	—	25	16	19
1971/ ' 72	36	40	—	24	17	15
1972/ ' 73	34	36	—	24	17	15
1973/ ' 74	34	35	—	23	17	15
1974/ ' 75	34	37	—	13	16	21
1975/ ' 76	32	37	—	14	18	22
1976/ ' 77	30	36	—	15	19	22
1977/ ' 78	30	35	—	15	19	20
1978/ ' 79	30	36	—	14	19	16
1979/ ' 80	28	38	—	15	18	13
1980/ ' 81	26	32	—	13	15	11
1981/ ' 82	28	33	—	13	15	11
1982/ ' 83	29	32	—	11	14	13
1983/ ' 84	31	34	—	11	14	16
1984/ ' 85	31	37	—	12	14	18
1985/ ' 86	31	39	—	12	14	20
1986/ ' 87	31	42	—	12	15	20
1987/ ' 88	31	44	—	12	15	19
1988/ ' 89	31	46	—	12	16	19
1989/ ' 90	30	45	—	12	17	20
1990/ ' 91	30	45	—	12	17	20
1991/ ' 92	29	42	—	13	17	22
1992/ ' 93	28	40	—	14	17	22
1993/ ' 94	27	37	—	15	17	25
1994/ ' 95	28	36	—	17	18	25
1995/ ' 96	28	33	—	17	18	23
1996/ ' 97	29	32	—	16	18	23
1997/ ' 98	—	—	30	17	13	24
1998/ ' 99	—	—	30	18	13	23
1999/ ' 00	—	—	30	16	12	22
2000/ ' 01	—	—	30	19	12	22
2001/ ' 02	—	—	28	23	13	22
2002/ ' 03	—	—	28	26	16	24
2003/ ' 04	—	—	27	24	16	23
2004/ ' 05	—	—	26	21	15	24
2005/ ' 06	—	—	27	20	14	28
2006/ ' 07	—	—	26	18	14	27

Source: Turkish Statistical Institute

For primary school, number of students per teacher declines between 1970 and 1997. There occurs some increases; however considering the period as a whole presents positive development in terms of primary school quality. Secondary school ratios

experiences decline between 1970 and 1997, like primary school ratio; however the decline is not much larger than primary school's. Throughout the period, increases are also experienced and the secondary school student/teacher ratio reached its maximum, 46, in 1988/ '99 education year. The period 1986-1993 can be considered as negative for the secondary school quality development, because the highest ratios were recorded within this period. The case for primary education can be summarized as continuously declining student/teacher ratio for 10 education periods. The number students per teacher at primary education was 30 in 1997/ '98 education year and declined to 26 in 2006/ '07 education year. This situation is positive; however compared with the developed countries, the ratio is still above the ratio that is recorded in those countries. The case for high school and vocational and technical school is similar with each other. The ratio for both levels of education decreased within the 36 years period, experiencing some fluctuations. The education category experiencing a different path than the other categories is the higher educational institutions. The number of students per teacher at higher education institutions increased from 19 in 1970/ '71 education year to 27 in 2006/ '07 education year. This increase is important to pay attention, because higher levels of education is considered as the most important component of human capital that leads to productivity rise. Turkey experiences some qualitatively decrease in terms of higher education, when the number of students per teacher is considered. That is, the most important component of human capital in terms of education does not display positive evolution, which stays very important for policy implications to promote human capital.

Neither of the education indicators are used separately in the empirical analysis for Turkey within the study. The reason for not using these variables as proxy for human capital is evaluating the variables as being inadequate to reflect the nature of

human capital in Turkey. Investment reflects the quantitative development. Enrollment data only shows the number of students entering to school; however does not present any information about how many of them graduated from the level they entered. Literacy rate only puts forward demographic structure of the country and does not involve the quality of the actual working population. Number of students per teacher is important in terms of defining the quality of the education system; however the data should be combined with other education related data to construct an index for human capital. Besides the nature of all data, sector specific models are built in this study and none of the above variables is available for the sectors in use.

#### **4.2 Research and development indicators**

Research and development is also an important topic that endogenous growth theories deal with. Romer (1990), Aghion and Howitt (1992) and Grossman and Helpman (2001) claim that R&D sector has growth effects in the long run. These models include the interaction between R&D activities and the human capital employed in this sector. In the literature, R&D variables are accepted as important components of human capital. Three basic R&D indicators are presented in Table 4.3.

**Table.4 3: R&D Indicators**

	a)R&D Expenditure/GDP (%)	b)R&D Expenditure per capita (Respect to Purchasing Power Parity - USD)	c)Number of the R&D Personnel (Full time equivalent)
<b>1990</b>	0.33	17.75	16246
<b>1991</b>	0.54	25.9	14969
<b>1992</b>	0.5	25.9	15701
<b>1993</b>	0.44	24.6	16087
<b>1994</b>	0.36	19.1	16899
<b>1995</b>	0.38	21.1	18498
<b>1996</b>	0.45	27.4	21983
<b>1997</b>	0.49	32.2	23432
<b>1998</b>	0.5	32.5	22892
<b>1999</b>	0.63	39.8	24267
<b>2000</b>	0.64	40.5	27003
<b>2001</b>	0.72	43.8	27698
<b>2002</b>	0.67	42.8	28964
<b>2003</b>	0.61	41.6	38308
<b>2004</b>	0.67	51.4	39960

Source: T.R Prime Ministry State Planning Organization

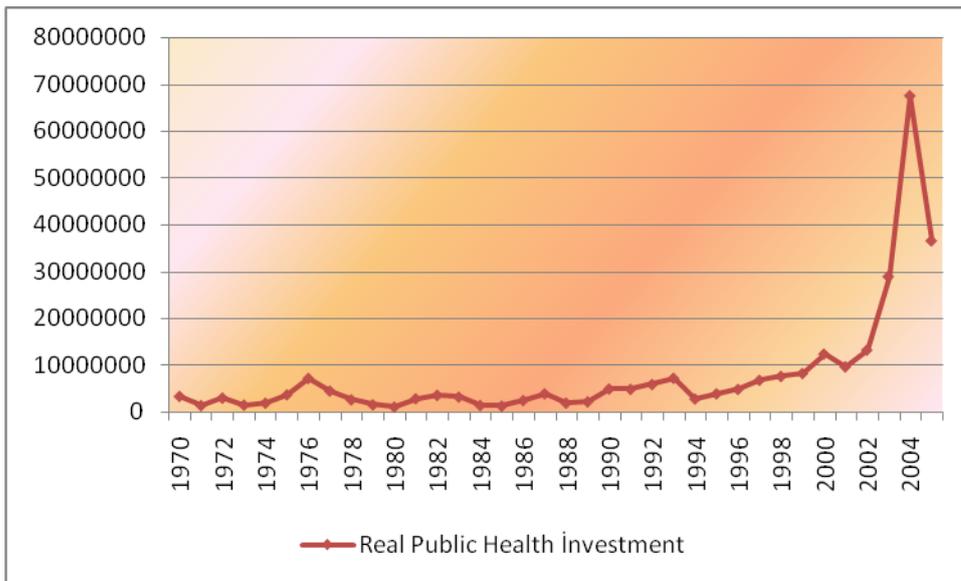
Turkey's R&D sector is less qualified than the R&D sector of developed countries; however Table 4.3 indicates positive evolution. All variables related with R&D development can be attributed to have increasing patterns between 1990 and 2004. The share of R&D expenditure in GDP doubles in 2004 with respect to its value in 1990, however is still very low when compared with other countries. R&D expenditure per capita approximately triples, increases to \$51.4 in 2004 from \$17.75 in 1990, throughout the period. Finally, the number of R&D personnel also increases and this increase is more stable than of the share of expenditure in GDP and expenditure per capita. All variables indicate positive development of R&D sector in Turkey and this trend should keep for R&D sector to have positive long run growth effects in Turkish economy.

R&D variables at sector basis are not available for Turkish economy. It is known that R&D improvements in Turkey are much behind of the developed countries. It is obvious that R&D variables are not good proxies for human capital in Turkey. In the long run, if improvements take place, R&D may start to contribute growth in Turkey and may be good proxy for human capital to augment labor.

### **4.3 Health indicators**

The quality of health services within a country is accepted an important human capital indicator. The reasoning behind the importance of health is that the ineffectiveness of labor force, whatever the degree of education is, without healthy individuals. In this section; real public health investment, life expectancy at birth and infant mortality rate are observed for Turkey to get idea about the health indicators of human capital. Initially the evolution of real public health investment can be observed from Figure 4.4.

**Figure.4 4: Real Public Health Investment**



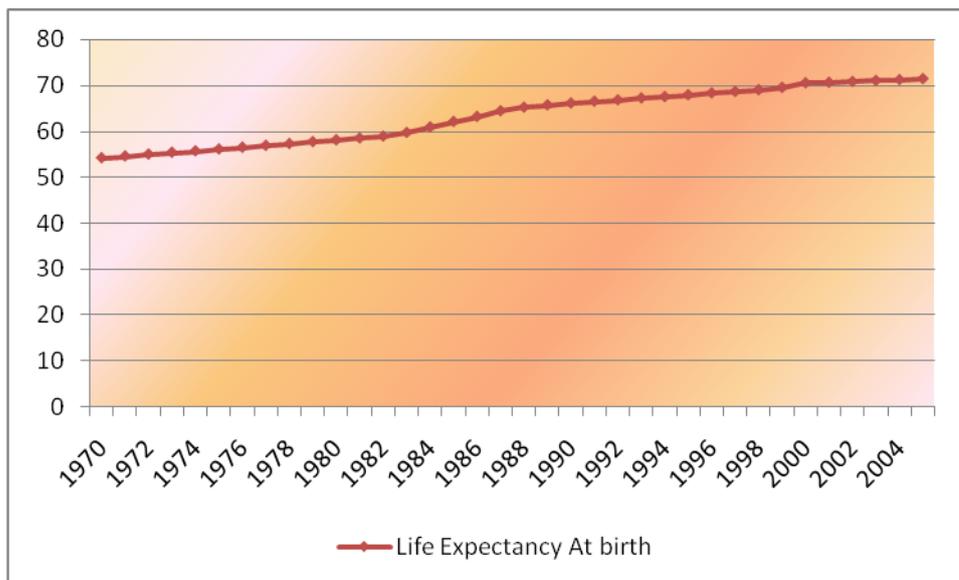
**Source: T.R Prime Ministry State Planning Organization**

a) Y-axis in in dollars.

Figure 4.4 puts forward that real public health investment fluctuates within a narrow band between 1970 and 2003. There occurs a jump in 2004 and 2005; however evaluation of the whole period does not present positive developments in terms of human capital. The level of investment for 24 years increases very low. The expected trend to get positive implications in terms of human capital is an increasing trend of real investment throughout the related period. The growth rate of real public health investment is 0 or negative for many years between 1970 and 2003.

Other health indicators are accepted to be life expectancy at birth and infant mortality rate in the literature. Both indicators present positive developments in terms of human capital, which can be observed from Figure 4.5 and Figure 4.6.

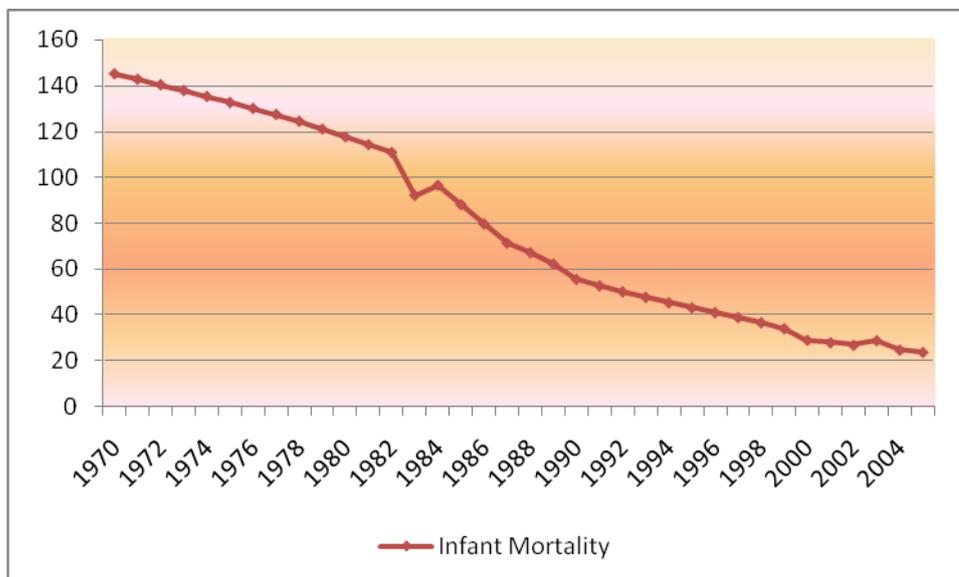
**Figure.4 5: Life Expectancy at Birth**



Source: WDI Software, 2006

a) Y-axis represents number of years.

**Figure.4 6: Infant Mortality**



Source: WDI Software, 2006

a) Y-axis is the number of mortal infants each year.

Life expectancy increases to 72 years in 2004 from 54 years in 1970 and infant mortality decreases to 23 in 2004 from 142 in 1970.

Health indicators do not lead to common conclusions about human capital development. Real public health investment indicates negative evolution, whereas life expectancy at birth and infant mortality rate indicate positive evolution. It is important to state that life expectancy and infant mortality do not indicate as accurate results as real public investment, because observing that life expectancy and infant mortality in developing countries puts forward similar results with Turkey, which may cause inconclusive results about human capital development.

Health related variables are as available as the education related variables in Turkey. Using life expectancy at birth or infant mortality rate captures only a small part of what is defined as human capital. A health index must be constructed to determine human capital. Moreover these variables are not available at sector basis, so it is impossible to use them to construct the models within the study.

## 5. EMPIRICAL ANALYSIS FOR TURKEY

The large proportion of empirical evidence on the effect of human capital on growth are the studies that use data on a cross section of countries and try to link some initial level of human capital with subsequent real output growth performance (Tallman and Wang, 104). Differently from the majority of the literature, this study relies on a single case study of Turkey. There are many reasons for studying with a single country rather than making cross section analysis with various countries. First and foremost, cross section analysis is dependent on the same sort of data for all countries in use to get comparable results. This dependency puts limitations on the available data to run regressions for a single country. The effort to construct same datasets not only prevents the author to use all the available data but also puts time limitations to determine the period to study through.

Second reason for studying with a single country comes from the disadvantage of the cross country studies that they have little space to take into consideration of the main situations of the single countries. As Abbas (2001) states, cross-country studies may fail to capture important country specific characteristics that may be crucial to their economic development. Cross country studies draw up results which may be inconclusive due to the conflicting evidence they put forward.

The reasons and advantages of studying with a single country can be summarized as the following: There is opportunity to examine the historical and institutional characteristics of the given country. The most qualified and appropriate data can be used without any constraints to sustain the data consistency among the other countries. The comments on the results of the study fit only for the country being

studied and policy implications are country specific which are potential of being more effective.

Finally, there are many studies concerning the relationship between human capital and growth in the developed countries, however for developing countries there is a few. This study is important for two reasons: First, it serves as an investigation for a developing country, Turkey. In the literature it is common that the technological progress is the most important component of growth in the developed countries. The contribution of human capital to the growth process in developed countries comes from the skills of high qualified workers. In developing countries, the effect of human capital on growth is ambiguous that is, some empirical evidence indicates significant relationship whereas some indicates insignificant relationship between human capital and growth. Second important contribution of this study is that it constructs a comparative basis for 5 sectors; manufacturing, agriculture, mining, energy and transportation, in Turkey incorporating human capital to the growth process. A study concerning sectoral differentials is crucial for Turkey in terms of defining the sector in which the human capital contributes to growth at most. The properties and the share of the production of each sector in total GDP is different from each other, so defining the sector specific results is important for evaluating the policy implications individually. The sectors are chosen taking into account the availability of the data and the importance of the sector within the country. Manufacturing sector is the leading sector of the Turkish economy, since the biggest share, approximately 25% in average throughout the related periods, in GDP belongs to this sector. Agriculture sector follows manufacturing sector with a share of 16% in average. It is common fact that agricultural production has been very important for Turkish economy since the formation of Turkish Republic; however with the industrial transformation, the share of agricultural

production has decreased. Compared with other developing countries, agriculture sector is still very important for Turkey both for providing raw material for industrial production and contributing to export directly. The importance of mining sector increases gradually for Turkey, since the industrial transformation necessities the the production of qualified raw material and Turkish mining sector has the potential of providing the raw material both geopolitically and efficiently. Mining sector has been prominent sector in most of the developed countries, so determining the driving forces of this sector is important. Again with the industrial transformation, energy sector plays an important role in contributing to the growth of the economy. The energy used in Turkey is mainly imported from the producer countries. Turkey should produce its own energy used in the industrial activities and the future of this sector is important. In the pre-accession period to EU, transportation sector is one of the key elements in assisting the integration between countries. The determinants of growth of this sector are important to sustain a better growth path. All of the sectors in the study are important and have the potential to be the prominent sectors of Turkish economy. Analyzing at sectoral basis provides more solid results purifying the heterogeneous structure of Turkish industry at some level. The results are evaluated at sector specific basis and conclusions are driven from sectoral perspectives.

The empirical analysis for Turkey consists of three types of models. First model investigates the relationship between physical capital stock and effective labor and growth in the Turkish manufacturing sector for the period 1974-2001. Second model examines the same relationship, with a different capital stock series for the period 1978-2001. Final model provides analysis for five sectors; energy, manufacturing, mining, agriculture and transportation, to compare the effect of human capital on growth for the period 1988-2003.

## **5.1 Manufacturing sector and wage ratios as human capital proxy for the period 1974-2001**

### **5.1.1 Data and the methodology**

In this section, the data and the methodology used to analyze the effect of human capital accumulation in the manufacturing industry of Turkey for the period 1974-2001 is briefly examined. The most important reason for choosing this period can be stated as the inadequateness of the necessary data to construct the relevant model. Minimum wages, which are to be explained in detail later, were to be determined at city basis until 30 January 1974. From 1 July 1974 on, minimum wage regulation was dispersed to country as a whole and common wages were in force in all cities. The beginning year of the period is limited by the availability of the minimum wages. The closing year 2001 is exposed to limitations coming from the annual payments made to employees at manufacturing sector. This data is available until 2001 with same units, after 2001 the way to calculate the payments has changed in method. However, the final year of the related period can not be justified only by the limitations coming from the data. The year 2001 is a turning point for the manufacturing industry which is most related with the real changes occurring after the financial crisis. To avoid including a break point for the manufacturing industry, the period is taken until 2001.

In accordance with the rest of the literature, Cobb Douglas type of production function is assumed for the manufacturing sector

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

where  $Y_t, K_t, H_t, L_t$  and  $H_t L_t$  represents output, physical capital stock, human capital, employment and effective labor; respectively. The reason for including human capital as a multiplicative of employment is to get the effective labor series. Unless the human capital stock series is calculated, human capital does not enter the production function as a separate factor of input. The human capital variable obtained in this analysis is not a stock variable, so it is regarded as increasing the productivity of labor and enters to the production function as an augmenting factor of labor.

The first variable used in the Cobb Douglas production function is the GDP of the manufacturing industry throughout the related period. The source of the data is Saygılı et.al. (2005), where the related data is put forward together with the GDP's of the other main sectors of the economy. The data is presented in billion TL and with 1990 prices, which is kept throughout this study, because this does not cause any inconsistency with the other variables used in the production function so that the remaining data expressed in prices are also used in terms of billion TL. This data enters to the function in real terms, which again keeps the consistency among the other variables.

The second data is the physical capital stock. This data, like the GDP, is taken from Saygılı et.al. (2005), which serves as a very important source for estimating the physical capital stock for the period 1972-2003, because it is difficult to access the related variable for Turkey, due to both the nature of the data itself and the limited attempts to estimate the stock variable. Although there are some existing workings to estimate the series, the one used for the analysis is the most up to date working.

The physical capital stock series, which is proxied by using the gross fixed investment stock, is constructed with the help of the methodology and in the light of the

assumptions used and made by OECD. According to the gross fixed investment stock definition of OECD, the current aggregate physical capital of countries or industries is represented by this variable. The investment series is available only for a limited period and this limitation also holds for the estimation of the capital stock series. The estimation is annual to preserve from the potential effects those may come from the seasonal fluctuations. Another reason for estimating the data annually is the difficulty to access any investment data reported in higher frequencies.

The physical capital stock series of countries is estimated by the Perpetual Inventory Model by OECD International Sectoral Database (Saygılı et.al, 2005:15). This model takes depreciation rates into account and uses the investment expenditure data belonging to the past periods.<sup>12</sup>

The third variable used in the estimation of the Cobb Douglas production function is the number of people employing in the manufacturing industry, employment variable. The source of the data is Turkish Statistical Institute, Statistical Indicators 1923-2006. The employment data of the manufacturing industry is taken among the employment variables of other main sectors which are grouped as the number of people employed by kind of economic activity and who are above the age of 15. The data is reported in thousand people, which are then converted to their real unit numbers to keep the consistency with the rest of the literature.

The final data is human capital, which the contribution of this study mostly relies on. The human capital series is inspired from the workings of Sala-i Martin and Mulligan(1997). Sala-i Martin and Mulligan (1997) argues that, using data related with

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<sup>12</sup> For the purpose of the thesis, stating the method to estimate the capital stock series rather than giving details about is fairly enough. For detailed explanation about the Perpetual Inventory Model , see Saygılı et.al.

educational attainment is not an appropriate way of calculating human capital. This argument is best expressed by questioning the relationship between productivity growth and educational attainment:

*Can we say that such dramatic changes in the educational attainment of labor force is an important source of economic growth? Well, income and wage rates have grown along with educational attainment over the same period; therefore we could be tempted to say yes. Time spent in school has grown, but so have hours of television viewing. Can we argue that television viewing is responsible for productivity growth? (Sala-i Martin and Mulligan,1997:160).*

The human capital series constructed by Sala-i Martin and Mulligan (1997) is the ratio of total labor income per capita to the wage of a person with zero years of schooling. In other words, the method calculates human capital as the ratio of the wage of an average worker to the wage of an unskilled worker (Jeroen,1999:30). The reason behind dividing the wage of an average worker with the wage of an unskilled worker is to correct the effects of factors which increase the aggregate productivity while remaining human capital constant. Before turning to the superiority of this variable, it is very important to state the critical assumption of the study: Uneducated workers are perfect substitutes for the rest of the labor force (Sala-i Martin and Mulligan,1997:160). Another assumption is that the human capital of an uneducated person is constant over time. Under the assumption that wage differences reflect the marginal product of labor, it is possible to measure human capital differences by the differences in the wages earned by different labor force groups (Wösman,2000:4). These assumptions seem to be restrictive, however it is nearly impossible to construct a model without any assumptions. These assumptions can be accepted to some degree and considered as being the best to further study the effects of human capital. Even though some potential

problems and the inadequateness of this proxy<sup>13</sup> to calculate human capital, this ratio is considered being more reliable than not only educational attainment but also some other proxies such as literacy rates, educational spending etc. The main problem with these proxies is the limited capability to calculate the aggregate knowledge or skill of an individual. Literacy rates consider the issue only from one aspect, whereas educational spending from another, which should be combined together to see the total effects of human capital. The superiority of this variable comes from its capacity to measure the current value of human capital rather than its historical price. Alike goodness of calculating the current market value of physical capital, calculating the current value of human capital is more conceivable. The main reason of using wage ratio as human capital proxy is the belief that it provides more accurate results than any other proxy used.

Human capital series are obtained by following Sala-i Martin and Mulligan (1997) for Turkish manufacturing industry. The wage of an average worker is calculated by dividing the annual payments made to employees by the annual average number of employees at the manufacturing industry. Both data is taken from Turkish Statistical Institute, Statistical Indicators 1923-2006. The payment data is in million TL and is expressed in nominal terms. Any adjustments to the data, such as deflating with GDP deflator or converting it to some other units, are not made; because it is divided with the wage rate of an unskilled worker so that there is no need to express the data in real terms unless the denominator is in real terms. Difference of this measure with the one used by Sala-i Martin and Mulligan, total labor income per capita, is being expressed as per worker rather than per capita. Sala-i Martin and Mulligan (1997) calculated total

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<sup>13</sup> The different reasons of changes in wages and human capital are potential of being problematic in terms of using wage ratio as human capital proxy. A reason causing wages to change may not cause human capital to change, so that changes in human capital may not be measured correctly.

labor income per capita due to the nonavailability of the number of employees. As Sala-i Martin and Mulligan (1997) expresses, using annual average number of employees is a better way of calculating the wage of an average worker.

To obtain the wage ratio, the wage of a worker with zero years of schooling is represented with the minimum wages. This approach seems to capture the argument of Sala-i Martin and Mulligan (1997), because the situation of Turkish labor force reflects this fact: Workers paid minimum wages are usually with zero years of schooling or graduated from low stages of education. The minimum wage data is obtained from the website of Ministry of Labor and Social Security of Republic of Turkey. The average data is reported in daily and monthly frequencies and categorized as the workers above and under the age of 16. The monthly data for the workers above the age of 16 is used, because the employment variable stands for the number of workers above the age of 15. These data do not refer to the same working population, however the difference coming from the ages of 15 and 16 is little which does not cause much inconsistencies and can be ignored. Minimum wages are announced at nominal terms and in TL. Since this data is the denominator of the wage ratio, it should be converted to million TL which is the unit of the nominator of the ratio, average wages. Minimum wages are converted to million TL. The way used to obtain the yearly minimum wages can be summarized as follows: The data is recorded according to the dates which the wages were in force. For example, the wage 1800 TL was in force between 01.06.1976 and 31.12.1977. This wage captures six months from 1976 and all months from 1977. For a given year, minimum wages are recorded for the number of months they were in force. Then each wage is calculated with the number of months it was in force and the results are summed up to obtain the minimum wage a worker is paid through the given year.

The final step to obtain the human capital proxy is to divide the average wages by minimum wages, which both are in nominal terms and expressed in million TL.

### 5.1.2. Results

For the purpose of the analysis, natural logarithms of the all of the variables are taken to run regressions. The estimations are performed by E-views 5.1 package programme. Before estimating the linear regression model, all variables are tested for stationarity by unit root tests.<sup>14</sup> All data sets are found to be I(1) series and bearing stochastic trend. The results obtained by regressing nonstationary series are spurious. Taking into account the stochastic trend the data bear, first differences of all data are taken and the regression is estimated by OLS method with White heteroskedasticity-consistent standard errors covariance. The results of the estimation are given in Table 5.1

**Table.5 1: Estimation Results for the Manufacturing Industry for the period 1974-2001**

<b>Variable (a)</b>	<b>Coefficient</b>	<b>Probability</b>
Constant	0.0394	0.0201
D(L(K))	0.2817	0.1412
D(L(HL))	-0.0894	0.0154
<b>R-squared=0.618399</b>		<b>DW-Statistic= 2.0440</b>

a) *Dependent variable is D(L(Y))*

<sup>14</sup> Unit root test results for the series are available in the AppendixB.

As Table 5.1 indicates<sup>15</sup>, there is a significant relationship between effective labor and output; however, the sign of the relationship is the inverse of the expectations. A one unit increase of effective labor decreases output by 0.08%. This result contradicts with the large proportion of the empirical studies in the literature. On the other hand, the contribution of the physical capital stock to the growth in the manufacturing sector is insignificant. Including human capital to create effective labor input displays the conclusion that, the growth in Turkish manufacturing industry between 1974 and 2001 is not explained by endogenous growth.

Another regression is run with the same variables in their per capita terms. The results of the regression with per capita terms are available in Table 5.2. These results also display a significant, however negative relationship between effective labor and growth in manufacturing sector:

**Table.5 2: Estimation Results for the Manufacturing Industry for the period 1974-2001 with per capita variables**

<b>Variable(a)</b>	<b>Coefficient</b>	<b>Probability</b>
Constant	0.022211	0.1549
D(L(Kpc))	0.565901	0.0529
D(L(HLpc))	-0.093812	0.0124
<b>R-squared=0.408680</b>		<b>DW-Statistic= 2.1294</b>

a) *Dependent variable is D(L(Y))*

<sup>15</sup> The residual tests are performed for all the regressions in the analysis and none of the assumptions of CLRM are violated.

Estimation results with per capita variables indicate a significant relationship between physical capital stock and growth, approximately by 95% confidence interval. If physical capital stock per capita increases by 1%, GDP per capita increases by 56%. The relationship between effective labor per capita and GDP per capita exhibits similar results with the first results. Endogenous growth theory remains being incapable to explain the growth of the manufacturing sector.

## **5.2 Manufacturing sector and wage ratios as human capital proxy for the period 1978-2001**

In this section, two models are constructed for Turkish manufacturing sector for the period 1978-2001. First model is with the variables output, employment and human capital; staying the same; however, physical capital stock is augmented by capacity utilization. The reason for the period change is the limitations on the new augmenting variable, capacity utilization. Since the capacity utilization in Turkish manufacturing industry is low, it is important to see the effects of used physical capital that contributed to production. The capacity utilization data is obtained from T.R. Prime Ministry State Planning Organization website. The same conditions for the analysis between 1974 and 2001 are valid. The second model, uses gross fixed investment instead of physical capital stock, to provide accordance with the effective labor input, which is also not a stock variable. The reason for studying within this period is to present two kinds of estimations for the same period, as it is done for the period 1974 and 2001.

### 5.2.1 Results

The estimation results of the two models support the findings of the models for 1974-2001. The results of the first model with capacity utilization are given by Table 5.3.

**Table.5 3: Estimation Results for the Manufacturing Industry for the period 1978-2001 with physical capital stock variable**

<b>Variable(a)</b>	<b>Coefficient</b>	<b>Probability</b>
Constant	0.032667	0.0545
D(L(UsedK))	0.643960	0.0050
D(L(HL))	-0.066627	0.0585
<b>R-squared=0.544339</b>		<b>DW-Statistic= 1.6278</b>

a) *Dependent variable is D(L(Y))*

There is a significant relationship between the used physical capital and GDP, whereas there is an insignificant relationship between effective labor and GDP. The output elasticity of physical capital in use is 0.38, that is 1% increase in the used physical capital raises output by 38%. The insignificant and negative relationship between effective labor and output indicates that the sources of growth in Turkish manufacturing sector between 1978 and 2001 can not be explained by the dynamics of endogenous growth.

The results of the second model with gross fixed investment variable as  $K_t$  is given by Table 5.4.

**Table.5 4: Estimation Results for the Manufacturing Industry for the period 1978-2001 with gross fixed investment variable**

<b>Variable(a)</b>	<b>Coefficient</b>	<b>Probability</b>
Constant	0.045910	0.0003
D(L(I))	0.223047	0.0013
D(L(HL))	-0.086851	0.0050
<b>R-squared=0.466642</b>		<b>DW-Statistic= 1.7040</b>

a) *Dependent variable is D(L(Y))*

As obvious from Table 5.4, the model has an explanatory power of 41% with all relations between the independent variables and dependent variable are significant. The output elasticity of gross fixed investment is 22%, whereas the same coefficient is -0.08% for effective labor. There is a negative relationship between effective labor augmented by human capital and output, which is a contradictory finding with the forecasts of endogenous growth models.

### **5.3 Sectoral comparison using educational achievement as human capital proxy for the period 1988-2003**

In this section, the relationship between growth and human capital in five sectors of Turkish economy is analyzed by using OLS technique for the period 1988-2003. Accepting the main deficiencies of using a short period, it is important to state that the data in use is the only available proxy to make a comparison between the sectors. The data used in the analysis as proxy for human capital is the number of

workers according to the level of education they have graduated from, in each sector.<sup>16</sup> The education levels in consideration are primary, secondary, high, vocational and technical and higher or faculty. The production function is the same as used in section 5.1. A Cuobb Douglas type production function is assumed for the sectors:

$$Y_t = K_t^\alpha (H_t L_t)^\beta \quad \text{and} \quad H = E^\gamma$$

Except human capital proxy all of the data are the same as they were in Section 5.3 and sources of the data remain the same. The only variable different is human capital which is derived following Tallman and Wang (1994): An index is constructed for educational achievement data, under the assumption that more educated workers are more productive. The number of workers graduated from primary, secondary and higher levels of education are weighted by 1, 2 and 4; respectively.<sup>17</sup> This is the way Tallman and Wang (1994) followed and justified by the argument that this is typical scheme in the growth and education literature. After weightening the graduate variables, they are added and divided by 7 to obtain an average data for education proxy,  $E$ . The second step is combining human capital with the average education variable via the constant  $\gamma$ . The constant is defined as the number equating the growth rate of effective labor to the growth rate of physical capital stock and it is set equal to 1.07 while constructing the regression analysis.. Educational data is combined to human capital via the constant 1.07, appearing as the power of the educational data. After obtaining human capital

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<sup>16</sup> Due to the nonavailability of the wage ratio data for the sectors in the analysis, the education related data is used in accordance with the large proportion of the literature.

<sup>17</sup> The other index constructed by Tallman and Wang (1994) uses the weights 1,1.4 and 2 for the same level of education.

proxy, it is combined with the employment variable to obtain effective labor. The final step to get the regression equation is converting each variable per capita unit and taking the logarithms of all variables. Then, the model estimated for each sector is;

$$\log Y = \alpha \log k + \beta(\gamma \log E + \log L)$$

The estimation result for each sector evaluating the position and properties of each sector is given in the following sub-sections.

### **5.3.1 Manufacturing sector**

In estimating the sectoral production functions, following method is applied: The production function is estimated with the log levels of the variables. If there does not occur any serial correlation problem, the estimation results are evaluated. If there occurs any serial correlation problem, the variables are checked for stationarity and necessary technique is applied to get rid of the violation of “no serial correlation” assumption. The regression for manufacturing sector bears no serial correlation problem and the analysis is run by the log levels of the variables. Due Estimation results for manufacturing sector is given in Table 5.5.

**Table.5 5: Estimation Results for the Manufacturing Industry for the period 1988-2003**

<b>Variable(a)</b>	<b>Coefficient</b>	<b>Probability</b>
Constant	6.993943	0.5525
L(K)	0.755100	0.2885
L(HL)	1.307924	0.0088

**R-squared=0.768437    DW-Statistic= 2.0033**

*a) Dependent variable is L(Y)*

The results indicate different relationship between the variables when compared with the results of the model in which wage ratio is used as human capital proxy. The effect of human capital augmented labor on growth of the manufacture industry is statistically significant at 5% level and has a positive coefficient. 1% increase of human capital augmented labor causes 1.30% increase of the manufactural production. The effect of physical capital appears to have an insignificant effect on growth, contradicting with results of the first two models. There are two explanations of these results: The model constructed to investigate the relationship between human capital and growth is sensitive to the human capital proxy in use. The other explanation is the data deficiency which is potential for generating unexpected results. Education achievement data provides positive relationship between human capital and growth in the manufacturing industry; however this conclusion is open to debate.

### 5.3.2 Energy sector

The regression run by the log levels of the variables involves serial correlation problem. The variables are tested for stationarity with Augmented Dickey-Fuller test. All data series used for the energy sector are found to be I(1) and the model is estimated via using the first differences of the series. Table 5.6 designates the estimation results for the energy sector.

**Table.5 6: Estimation Results for Energy Sector for the period 1988- 2003**

<b>Variable(a)</b>	<b>Coefficient</b>	<b>Probability</b>
Constant	0.044698	0.0007
D(L(K))	0.113944	0.8070
D(L(HL))	0.046851	0.0248
<b>R-squared=0.475945</b>		<b>DW-Statistic= 1.7639</b>

*a) Dependent variable is D(L(Y))*

The model provides positive and statistically significant relationship for human capital augmented labor and energy sector production; however positive and statistically insignificant relationship for physical capital and production. In the energy sector educational improvement is potential to be important for contributing to the growth of the sector. The distribution of the workers in the energy sector shifted in the last ten years; that is the number of workers graduated from higher levels of education increased from 2000 to 16000 between the years 1988-2003. The number of the workers graduated from higher levels of education was one-sixth of the number of workers

graduated from primary school in 1988. In 2003 this share declined and the number of higher level graduates became more than the half of the primary school graduates. Compared with the other sectors, energy sector catches a better qualified worker profile than the other sectors. This improvement contributes to the production of the sector positively; however, education achievement data is insufficient to indicate the relationship between human capital and economic growth. Policy implication for the energy sector is to ameliorate the the education quality. This conclusion is not enough to generalize the situation for the human capital improvements of the sector.

### 5.3.3 Mining sector

The regression with the log levels does not violate the “no serial correlation” assumption, so the log levels of the variables are used for the model estimation. The model is estimated by OLS technique. The results are given in Table 5.7, providing same sort of conclusion with the first two models.

**Table.5 7: Estimation Results for the Mining Sector for the period 1988- 2003**

<b>Variable(a)</b>	<b>Coefficient</b>	<b>Probability</b>
Constant	7.648098	0.0311
L(K)	0.329776	0.0240
L(HL)	0.061244	0.5609
<b>R-squared=0.632413</b>		<b>DW-Statistic= 1.0674</b>

*a) Dependent variable is L(Y)*

The effect of effective labor is insignificant, whereas physical capital has a positive and statistically significant effect on mining sector growth. 1% increase of the physical capital causes output to growth 32%. On the other side; effective labor augmented with educational achievement data does not contribute to the growth of mining sector's growth. This conclusion is expected, because the overall education quality of the mining sector is low. The highest share in the workers belongs to the primary school graduates. In fact this situation holds for all sectors; however, the percentage of the primary school graduates in mining sector is higher than other four sectors. Human capital proxied by educational achievement does not contribute to growth. The variable contributing to growth in mining sector is physical capital, which is likely to attract more attention. Turkish mining industry is rich in raw material; however, the production process is not conducted efficiently. Engineers or graduates of other higher level fields do not participate in the mining labor force and hence the contribution of human capital remains insignificant.

#### **5.3.4 Agriculture sector**

The regression estimated by the log levels of the variables does not encompass serial correlation problem. Same procedure for such regression is applied for the estimation purposes. The estimation results are presented in Table 5.8.

**Table.5 8: Estimation Results for Agriculture Sector for the period 1988- 2003**

<b>Variable(a)</b>	<b>Coefficient</b>	<b>Probability</b>
Constant	15.95752	0.0042
L(K)	0.129875	0.0357
L(HL)	0.073503	0.5369

**R-squared=0.447280    DW-Statistic= 1.6408**

*a) Dependent variable is L(Y)*

The contribution of effective labor is insignificant and the variable contributing to agricultural growth is the physical capital. This result is expected for the agriculture sector, because the workers in the agriculture sector contribute to production by their physical skills rather than skills accumulated via education. The graduates are mainly primary school graduates and any human capital variable proxied by education related data is expected to generate same sort of results. If it were possible, the wage ratio proxy is expected to provide same conclusions, because the average wage in the agriculture sector is very close to the minimum wages. The human capital in Turkish agriculture sector is not enough developed to contribute to the growth of the sector. Since the level of technology used in agriculture sector is not very high, the demand for high qualified labor does not occur. A sector in which demand for educated labor does not occur, human capital is not expected to contribute to growth, where educational achievement data is used to proxy human capital.

### 5.3.5 Transportation sector

Estimation results for the transportation sector are given in Table 5.9. Since the static regression does not comprise serial correlation problem, log levels of the variables are used in the regression function.

**Table.5 9: Estimation Results for Transportation Sector for the period 1988- 2003**

<b>Variable(a)</b>	<b>Coefficient</b>	<b>Probability</b>
Constant	5.211217	0.0044
L(K)	0.552838	0.0000
L(HL)	-0.047990	0.8758

**R-squared=0.920785    DW-Statistic= 1.1848**

*a) Dependent variable is L(Y)*

The effect of effective labor is observed to be insignificant and negative for the transportation sector. Physical capital has a statistically significant effect on growth. The output elasticity of the physical capital is approximately 55%. The contribution of physical capital in the transportation sector is the highest among the other sectors. The effect of human capital remains consistent with the majority of the other sectors' results. Human capital does not contribute to the growth of the transportation sector. The situation for the general profile of Turkish labor force holds for the transportation sector, too: The average education level of the workers is low due to the excessive number of primary school graduates. In the pre-EU integration process, the quality of the sector in terms of human capital is to be improved, because the sector is expected to become one of the most important sectors driving economic growth.

## 6. CONCLUSION

The attempts to explain the relationship between human capital and economic growth take its roots in the middle of the 20th century. Human capital contributes to economic growth in the form of skilled labor and knowledge. The accumulation of human capital occurs through education, health and migration investment. All sorts of human capital investment are related with and complementary to each other. Human capital has been an important concept for both neoclassical and endogenous growth theories. The deficiency of neoclassical theory about explaining long term sustained growth is overcome by endogenous theories. Endogenous growth theories consider human capital as a factor of input and engine of growth. Human capital increases the efficiency of labor and thus contributes to long run growth. Many of the empirical studies on the investigation of the relationship between human capital and economic growth attempted to define the sort of human capital effect. In other words; the effects of human capital on growth is suspected to be either direct or indirect. Empirical studies put forward which kind of effect human capital has on economic growth. Majority of the empirical literature on the subject consists of cross country studies. The results of these studies indicate that human capital contributes to growth in developed countries more than it does in developing countries.

Observing the human capital evolution in Turkey since 1970 indicates positive results in some degree. Literacy rate, average life expectancy, enrollment rates increase and infant mortality decreases. Real public education and health investment do not increase much until 2004. All these observations designate positive development; however, all of the indicators are much beside the ones in developed countries. The complain about the education system comes from the low quality levels. On the other

side, high skilled labor in capable of using high-tech machines is scarce. Besides education and health sector situations, the development of the R&D sector puts forward the rearwardness of Turkey.

In this study, three basic models are estimated to investigate the relationship between human capital and economic growth in basic Turkish sectors. First model uses times series data for the period 1974-2001 and estimates Cobb Douglas type production function for Turkish manufacturing sector. Two sub-models are estimated within the framework of this basic model. Before running the regression, unit root tests are performed to all variables and necessary method is applied according to the results of the tests. First submodel uses manufacturing sector GDP as dependent variable and physical capital, human capital augmented effective labor as independent variables. The ratio of average wage in manufacturing sector to the wage of minimum wage is used as proxy for human capital. The results of the first submodel indicate negative relationship between human capital augmented effective labor and growth in manufacturing sector, opposing to the theoretical expectations. Second submodel uses the per capita terms of the same variables and same conclusions hold. Effective labor does not contribute to the growth of the manufacturing sector.

Second model estimates Cobb Douglas type production function for the manufacturing industry using the data for 1978-2001. The difference of the second model from the first model is the physical capital variable used. Second model also consists of two submodels. First submodel uses used physical capital stock, that is the physical capital stock variable is multiplied by capacity utilization variable. Calculating physical capital in this way provides to capture the effect of capital stock that actually contributes to production. According to the results of the first submodel, human capital

augmented labor contributes negative to the growth of the manufacturing industry. Second submodel uses gross fixed investment data as proxy for physical capital stock. Using this proxy is common in the literature. Production function is estimated other variables remaining the same. The results overlap with the results of the first submodel: Human capital augmented effective labor does not contribute to the manufactural growth.

Third model uses data for the periods 1988-2003 and estimates five different production functions for five Turkish sectors: Manufacturing, energy, mining, agriculture and transportation. Same model is constructed for each sector and estimated separately. Estimation results are evaluated and compared with each other. The model estimates the Cobb Douglas type production function for each sector. The dependent variable is GDP of each sector. Independent variables are physical capital stock and human capital augmented effective labor. The human capital variable used in these models is different than the one used in the first two models. The proxy for human capital is the number of workers according to the level of education they have graduated from, in each sector. Using this variable an index is constructed following Tallman and Wang (1994). Number of people graduating from each category is weighted with given constants and powered by another constant. After obtaining the human capital proxy, effective labor input is obtained by multiplying the employment variable with human capital proxy. Five production functions are estimated for each sector.

The results for the manufacturing sector differ from the results of the first two models in some degree. The effect of human capital augmented effective labor on economic growth appears to be significant and positive. This results leads to conclude that estimation results are sensitive to the human capital proxy used. Energy sector

exhibits similar results with the manufacturing sector within the context of the third model. Effect of human capital augmented labor is positive and statistically significant. This results draws attention in terms of policy implication since energy sector is on the way to become one of the most important sectors for Turkish economy. Turning to the mining sector results, insignificant relationship between effective labor and mining sector production is observed. The only factor contributing positively to the production is physical capital stock. This conclusion is expected, because the overall education quality of the mining sector is low. The highest share in the workers belongs to the primary school graduates. Estimation results for the agriculture sector provide insignificant relationship between effective labor and sectoral growth. This result is expected for the agriculture sector, because the workers in the agriculture sector contribute to production by their physical skills rather than skills accumulated via education. Finally, results for the transportation sector are parallel with the results for mining and agriculture sector. Effective labor does not have any effect of GDP of the transportation sector. The situation for the general profile of Turkish labor force holds for the transportation sector, too: The average education level of the workers is low due to the excessive number of primary school graduates.

In this study three main models are estimated rather than estimating one model to be able to observe and evaluate different results. An evaluation of all results indicates that human capital augmented effective labor does not have significant effect on the growth of Turkish sectors. Only in energy and manufacturing sector a significant and positive relationship is observed. On the other hand, first two models estimate production function for manufacturing sector with a different human capital proxy and find insignificant relationship. The results are sensitive to the human capital proxy in use. Turkish sectors are not at qualified levels in terms of human capital. One of the

possible reasons for this situation is the high share of young people in the population. Number of students is increasing, whereas the education quality remains the same. The same situation holds or the health sector. Number of people benefiting from social security is increasing; however public health expenditures compose only a little share is GDP.

These results are contradictory with the theoretical expectations of endogenous models. The growth of the five Turkish sectors is not explained within the framework of endogenous growth theory. The dynamics of sectoral growth are suspected to lie in some other fields, which are potential of being subjects for further studies. If there were available data for services sector, results in accordance with the endogenous theory might have exist. Because most qualified workers are employed in services sector. The investigation of the relationship between human capital and growth in this sector is open to be examined.

## APPENDIX A

**Table.A 1: Summary conclusions of the basic cross country studies on the relationship between human capital and growth**

<b>Empirical Study</b>	<b>Human capital variable (Period)</b>	<b>Conclusion</b>
Romer (1989b)	Literacy rate(1965-85)	Indirect effect of human capital
Benhabib and Spiegel(1994)	Enrollment rates(1960-85)	Human capital effects TFP
Lee and Lee(1995)	Test grades, fertility rate(1970-89)	Human capital raises physical capital stock
Nonneman an Vanhoudt(1996)	Secondary school enrollment rate(1960-85)	R&D is more effective than human capital
Jones (1996)	Enrollment rates(1960-85)	Human capital effects technology transfer
Barro (2001)	Number of secondary school years(1960-95)	Human capital effects TFP
Lau et. al (1993)	Number of secondary school years(1991)	Physical capital is more effective
Mankiw et. al (1992)	Secondary school enrollment rate(1960-85)	Human capital positively effects production
Gemmel(1996)	Secondary school achievement(1960-85)	Primary-secondary achievement is more important in developing countries
Chow-Lin(2002)	Number of secondary school years(1952-98)	Education is more effective

Panel approach is common.

*Source:* Gümüş, 2005:150.

## APPENDIX B

### B.1: UNIT ROOT TEST RESULTS OF THE VARIABLES USED IN THE MODEL FOR MANUFACTURING SECTOR AND WAGE RATIOS AS HUMAN CAPITAL PROXY FOR THE PERIOD 1974-2001

**Table.B 1: Augmented Dickey-Fuller Test on L(Y) in level**

	t-statistic	Probability(a)
Augmented DF test statistic	-1.207923	0.6559
Test critical values:		
1% level	-3.699871	
5% level	-2.976263	
10% level	-2.627420	

(a) MacKinnon (1996) one sided p-values.

**Table.B 2: Augmented Dickey-Fuller Test on L(Y) in first difference**

	t-statistic	Probability(a)
Augmented DF test statistic	-4.611275	0.0012
Test critical values:		
1% level	-3.711457	
5% level	-2.981038	
10% level	-2.629906	

(a) MacKinnon (1996) one sided p-values.

**Table.B 3: Augmented Dickey-Fuller Test on L(K) in level**

	t-statistic	Probability(a)
Augmented DF test statistic	1.403633	0.5649
Test critical values:		
1% level	-3.711457	
5% level	-2.981038	
10% level	-2.629906	

(a) MacKinnon (1996) one sided p-values.

**Table.B 4: Augmented Dickey-Fuller Test on L(K) in first difference**

	t-statistic	Probability(a)
Augmented DF test statistic	-4.371565	0.0022
Test critical values:		
1% level	-3.724070	
5% level	-2.986225	
10% level	-2.632604	

(a) MacKinnon (1996) one sided p-values.

**Table.B 5: Augmented Dickey-Fuller Test on L(HL) in level**

	t-statistic	Probability(a)
Augmented DF test statistic	-1.940002	0.3100
Test critical values:		
1% level	-3.699871	
5% level	-2.976263	
10% level	-2.627420	

(a) MacKinnon (1996) one sided p-values.

**Table.B 6: Augmented Dickey-Fuller Test on L(HL) in first difference**  
t-statistic    Probability(a)

Augmented DF test statistic	-6.113760	0.0000
Test critical values:		
1% level	-3.711457	
5% level	-2.981038	
10% level	-2.629906	

(a) MacKinnon (1996) one sided p-values.

- According to the results of TableB.1,2,3,4,5,6; the variables GDP, Physical capital stock and human capital augmented effective labor are I(1) series.

**Table.B 7: Augmented Dickey-Fuller Test on L(Ypc) in level**

	t-statistic	Probability(a)
Augmented DF test statistic	-1.269482	0.6286
Test critical values:		
1% level	-3.699871	
5% level	-2.976263	
10% level	-2.627420	

(a) MacKinnon (1996) one sided p-values.

**Table.B 8: Augmented Dickey-Fuller Test on L(Ypc) in first difference**

	t-statistic	Probability(a)
Augmented DF test statistic	-4.544320	0.0014
Test critical values:		
1% level	-3.711457	
5% level	-2.981038	
10% level	-2.629906	

(a) MacKinnon (1996) one sided p-values.

**Table.B 9: Augmented Dickey-Fuller Test on L(Kpc) in level**

	t-statistic	Probability(a)
Augmented DF test statistic	-1.388823	0.5720
Test critical values:		
1% level	-3.711457	
5% level	-2.981038	
10% level	-2.629906	

(a) MacKinnon (1996) one sided p-values.

**Table.B 10: Augmented Dickey-Fuller Test on L(Kpc) in first difference**

	t-statistic	Probability(a)
Augmented DF test statistic	-4.275583	0.0028
Test critical values:		
1% level	-3.724070	
5% level	-2.986225	
10% level	-2.632604	

(a) MacKinnon (1996) one sided p-values.

**Table.B 11: Augmented Dickey-Fuller Test on L(HLpc) in level**

	t-statistic	Probability(a)
Augmented DF test statistic	-2.120315	0.2387
Test critical values:		
1% level	-3.699871	
5% level	-2.976263	
10% level	-2.627420	

(a) MacKinnon (1996) one sided p-values.

**Table.B 12: Augmented Dickey-Fuller Test on L(HLpc) in first difference**

	t-statistic	Probability(a)
Augmented DF test statistic	-6.147538	0.0000
Test critical values:		
1% level	-3.711457	
5% level	-2.981038	
10% level	-2.629906	

(a) MacKinnon (1996) one sided p-values

- According to the results of TableB.6,7,8,9,10,11,12; the variables GDP per capita, Physical capital stock per capita and human capital augmented effective labor per capita are I(1) series.

**B.2: UNIT ROOT TEST RESULTS OF THE VARIABLES USED IN THE MODEL FOR MANUFACTURING SECTOR AND WAGE RATIOS AS HUMAN CAPITAL PROXY FOR THE PERIOD 1978-2001**

**Table.B 13: Augmented Dickey-Fuller Test on L(Y) in level**

	t-statistic	Probability(a)
Augmented DF test statistic	-0.794198	0.8019
Test critical values:		
1% level	-3.752946	
5% level	-2.998064	
10% level	-2.638752	

(a) MacKinnon (1996) one sided p-values

**Table.B 14: Augmented Dickey-Fuller Test on L(Y) in first difference**

	t-statistic	Probability(a)
Augmented DF test statistic	-4.698872	0.0013
Test critical values:		
1% level	-3.769597	
5% level	-3.004861	
10% level	-2.642242	

(a) MacKinnon (1996) one sided p-values

**Table.B 15: Augmented Dickey-Fuller Test on L(UsedK) in level**

	t-statistic	Probability(a)
Augmented DF test statistic	-0.675031	0.8341
Test critical values:		
1% level	-3.752946	
5% level	-2.998064	
10% level	-2.638752	

(a) MacKinnon (1996) one sided p-values

**Table.B 16: Augmented Dickey-Fuller Test on L(UsedK) in first difference**

	t-statistic	Probability(a)
Augmented DF test statistic	-4.596898	0.0017
Test critical values:		
1% level	-3.788030	
5% level	-3.012363	
10% level	-2.646119	

(a) MacKinnon (1996) one sided p-values

**Table.B 17: Augmented Dickey-Fuller Test on L(HL) in level**

	t-statistic	Probability(a)
Augmented DF test statistic	-2.948602	0.0552
Test critical values:		
1% level	-3.752946	
5% level	-2.998064	
10% level	-2.638752	

(a) MacKinnon (1996) one sided p-values

**Table.B 18: Augmented Dickey-Fuller Test on L(HL) in first difference**

	t-statistic	Probability(a)
Augmented DF test statistic	-5.941429	0.0001
Test critical values:		
1% level	-3.769597	
5% level	-3.004861	
10% level	-2.642242	

(a) MacKinnon (1996) one sided p-values

**Table.B 19: Augmented Dickey-Fuller Test on L(I) in level**

	t-statistic	Probability(a)
Augmented DF test statistic	-1.629253	0.4522
Test critical values:		
1% level	-3.752946	
5% level	-2.998064	
10% level	-2.638752	

(a) MacKinnon (1996) one sided p-values

**Table.B 20: Augmented Dickey-Fuller Test on L(I) in first difference**

	t-statistic	Probability(a)
Augmented DF test statistic	-5.328414	0.0003
Test critical values:		
1% level	-3.769597	
5% level	-3.004861	
10% level	-2.642242	

(a) MacKinnon (1996) one sided p-values

- According to the results of TableB.13,14,15,16,17,18,19,20; the variables GDP, Actually used physical capital stock, human capital augmented effective labor and Gross fixed investment are I(1) series.

### B.3: UNIT ROOT TEST RESULTS OF THE VARIABLES OF THE ENERGY SECTOR IN THE SECTORAL COMPARASION MODEL

**Table.B 21: Augmented Dickey-Fuller Test on L(Y) in level**

	t-statistic	Probability(a)
Augmented DF test statistic	-2.499953	0.1348
Test critical values:		
1% level	-3.959148	
5% level	-3.081002	
10% level	-2.681330	

(a) MacKinnon (1996) one sided p-values

**Table.B 22: Augmented Dickey-Fuller Test on L(Y) in first difference**

	t-statistic	Probability(a)
Augmented DF test statistic	-4.252379	0.0064
Test critical values:		
1% level	-3.959148	
5% level	-3.081002	
10% level	-2.681330	

(a) MacKinnon (1996) one sided p-values

**Table.B 23: Augmented Dickey-Fuller Test on L(K) in level**

t-statistic    Probability(a)

Augmented DF test statistic	-3.540687	0.0230
Test critical values:		
1% level	-4.004425	
5% level	-3.098896	
10% level	-2.690439	

(a) MacKinnon (1996) one sided p-values

- According to the results of TableB.21,22,23; the variables GDP, Physical capital stock and human capital augmented effective labor per capita are I(1) series.



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OECD, Organisation for Economic Co-Operation and Development website, [www.oecd.org](http://www.oecd.org)

SPO, T. R. Prime Ministry State Planning Organization website, <http://www.dpt.gov.tr>

TCMB, Central Bank of the Republic of Turkey website, [www.tcmb.gov.tr](http://www.tcmb.gov.tr)

The World Bank website, [www.worldbank.org](http://www.worldbank.org)

TURKSTAT, Turkish Statistical Institute website, [www.tuik.gov.tr](http://www.tuik.gov.tr)

TÜSİAD, Turkish Industrialists' and Businessmen's Association, [www.tusiad.org](http://www.tusiad.org)

UNCTAD, United Nations Conference on Trade and Development website, [www.unctad.org](http://www.unctad.org)

WHO, World Health Organization website, [www.who.int](http://www.who.int)