Education and Economic Growth: Is There a Link?

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Abstract

This paper attempts to reconcile the mismatch between theoretical models and empirical results in addressing the issue of education and economic growth. Development theorists have made numerous attempts to explain the contribution of education to economic growth. Over the years, numerous endogenous growth models have emerged to incorporate human capital and they have been subject to rigorous econometric techniques. However, these models have yielded inconclusive results. This paper begins by looking at the history of the development of endogenous growth theories and the various econometric specifications which were estimated. This paper also concludes by identifying the main themes that have emerged in the academic debate on education's role in economic growth.

Introduction

In the mid 1980s, endogenous growth theories identified several factors which contributed to economic growth. These studies relied on a number of distinct conceptual rationales for the inclusion of human capital in models of economic growth (Loening, 2005). In this regard, the approaches to modeling the role of human capital in economic growth can be succinctly divided into the following two categories: (1) Solow theories and (2) new growth theories (Sianesi & van Reenen, 2003). Other studies (Benhabib, & Spiegel, 1994; Acemoglu & Zilibotti, 1999; Barro, 1999; and Bils & Klenow, 2000) have examined the role of education and learning in understanding technological innovation and long-run economic growth. Generally, results of the quantitative investigations for the last two decades indicated a positive correlation between economic growth and education. Some of the more robust findings have even indicated that higher levels of education exerted a stronger effect on economic growth, especially true for developed countries where research and development are pivotal.

The early models were designed to empirically measure the effect of changes in macro-economic variables and their effect on economic growth and development and usually appeared in the form of a logical representation of the real world highlighting key relationships by making some simplifying assumptions. The approaches used in such models represented a shift from the earlier neoclassical theories of economic growth which emphasized the exogenous demographic factors which affected the growth rate of countries where factors such as population growth, labor force composition, technological change, and mortality rates were assumed to determine long-run equilibrium growth rates. In addition to these factors, there was a large part of the measured growth output which remained unexplained in the neoclassical models. This phenomenon was later formalized within the Solow framework and is commonly known as Solow's residual (Snowden & Vane, 1997), an occurrence due primarily due to technological progress.

One of the main determinants of a nation's wealth is the amount of human capital accumulated via education. Frederick Harbison once said 'a country which is unable to develop the skills and knowledge of its people and to utilize them effectively in the national economy will be unable to develop anything else.' This paper discusses the development and treatment of schooling and human capital formation in economic modeling.

The rich intellectual heritage on human capital accumulation set precedence for the contemporary paradigm of long-run economic growth, which depends on a set of economic decisions and incentives, among which, education has acquired a central role. Specifically, when skills acquired via education are explicitly embedded into theoretical constructs, there are observable changes in aggregate output. These changes are as a result of growth in the stock of knowledge and skills embodied in each employee which can then be efficiently combined with stocks of physical capital in order to increase output levels. While this concept only gained attention in the late 1960s, earlier growth theories ascribed varying levels of importance to the human factor in examining economic activities. Consequently, to place this discussion into perspective, earlier economic growth theories provide the natural point of departure.

Early Theories of Economic Growth

In examining earlier growth theories, it is palpable that these constructs are evolutionary in nature. Specifically, early theories of economic behavior relied on the basic observations of human beings and the market place, which were later formalized by analyzing historical data using sophisticated econometric modeling. The emergence of human capital as an economic phenomenon was an underlying theme of many of the earlier growth theories. Beginning with Adam Smith's writings, human capital was introduced as the 'fund' which supplies all necessities and conveniences for consumption and this central theme resonated throughout the subsequent writings of Malthus, Marx, Harrod, and Domar, later forming the basis for formalization of human capital in contemporaneous economic growth theories.

Adam Smith (1776) was optimistic in his assessment of human progress. His writing echoed the belief that economic growth could continue indefinitely if there were no obstacles to specialization and the division of labor such as mercantilism, which he felt impeded the development of competitive markets and limited the process of division of labor. Adam Smith's opening sentence in *The Wealth of Nations, Introduction and Plan*, proved to be significant of his whole position: 'The annual labour of every nation is the fund which originally supplies it with all the necessities and conveniences of life which it annually consumes.' Thus, Adam Smith saw the source of all wealth in labor. 'He saw society on its economic side working automatically through competition and self interest, the whole being knit together by division of labour and the multiplex process of exchange resulting there from.'[1] Smith's early writings and his implicit inclusion of human capital, referred to as labor, could be considered the genesis of the discussion.

Thomas Malthus (1798), the second of the trinity who laid the foundations of classical English Political Economics, summarized his position in three celebrated propositions:

1. Population is necessarily limited by the means of subsistence.
2. Population invariably increases where the means of subsistence, unless prevented by some powerful and obvious check increases.
3. These checks, and the checks which represses the superior power of population, and keeps its effects on a level with the means of subsistence, are all resolvable into moral restraint, vice and misery.[2]

In these propositions, the development of human beings was stymied by the availability of resources. Coalescing Smith's concept of human beings as the 'fund' which supplies necessities with Malthus's propositions enables us to understand that the availability of the fund, in this case human capital, limits the level of economic activity that can occur. Moreover, paralleling this paradigm to more recently formalized studies, we can state that economic development occurs at a rate commensurate with resources, inclusive of, but not limited to human capital.

Marx (1878) shared the classical view that the extension of the market was critical for economic development. He introduced the 'mode of production' which is the existence of the collective conditions consisting of the social, political, and economic

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[1] Gray, Alexander. 1936. *The Development of Economic Doctrine*. London. Longmans, Green and Company. pp. 151.

[2] *Essay on Population*, Book I, chap. 2, pp. 18 - 19 in Vol. I of Everyman edition.

aspects of life. As productive forces changed, new social relations developed, new political organizations emerged, and changes were made in the mode(s) of production, a derivative of technical progress, which ultimately promoted economic growth. Simply put in Marx's model

$$\Pi = s(1-q) \qquad (1)$$

where q is the organic composition of capital $\frac{c}{c+v}$ and Π is the rate of profit $\frac{s}{c+v}$ and s is the rate of surplus value $\frac{s}{v}$. The greater the surplus value s and the lower the organic composition of capital q, the greater the rate of surplus value which leads to capital accumulation and economic growth. In contemporaneous economic literature, the accumulation of human capital occurs through education and is the equivalent of a collective condition which changes the mode(s) of production in the form of technical progress with the educated labor force as the primary sector involved in the research and development activity which enhances technical progress thereby fueling economic growth.

Interestingly, during the first half of the twentieth century, when mainstream economics focused on resource allocation, one economist stood out for his anti-neoclassical view of economics. Joseph Schumpeter (1934) was classified as a radical economist. Neo-classicists viewed the market system as inherently stable, always moving towards some stationary equilibrium. Schumpeter on the other hand, saw the capitalist system as an evolutionary process that never reverts to stationary equilibrium. Central to this process was the creative destruction of the entrepreneur, the one who saw opportunities to create and grow his company and the one who values the economic potential of innovation. While Schumpeter seemed to have radical views, his philosophy was based on the amassing of new knowledge, as discussed in chapter I of this study, and remains the basic tenet of the research and development activity which takes place in an economy commonly called Schumpeterian growth. Thus, Schumpeter's radical views captured the important feature of knowledge in economic growth.

In 1956, Solow introduced the neo-classical growth model in the simplest form. Solow proposed that economists should study economic growth by assuming a standard neo-classical production function with decreasing returns to the factors of production. In such a form, the production of a good required two factors, capital and labor, and was based on a constant returns to scale production function. In his model, Solow made simple predictions about how population growth, savings and per-capita income influenced the steady-state level of national income. The Solow model predicted that an economy would eventually tend towards steady-state equilibrium, where there is no growth in output or capital stock. This model also necessitated that when an economy moved away from the steady state to another, medium-term growth in per capita income and the per capita stock would occur, and, the transition from one steady state to another generated only medium term growth rather than permanent growth. In Solow's model, the source of growth was identified as exogenous technical progress. Thus, the choices of agents, with respect to education, exerted no impact on the long-term growth of output. Endogenous models contested this traditional vision arguing that long term economic growth was based on the existence of non-decreasing returns to scale for accumulated factors such as human and or physical capital.

These earlier growth theories, which focused on identifying sources of economic growth, provided invaluable insight for other pioneers in the field of economic development. Theodore W. Schultz was on of such pioneers. In Schultz's work of 1960, 1961, & 1962, he began to emphasize the role of investment in 'man' as a vehicle to increase total factor productivity, which Solow referred to as the residual. Schultz's work was based on the earlier endogenous growth theories, which has been developed as a response to the neoclassical growth theories.

Later on in the 1960s, seminal works (Becker, 1962 & 1964; Schultz, 1961; & Denison, 1962) incorporated the role of education in human capital accumulation for economic growth. In these models, human capital contributed to the enhanced productivity of the labor force, and subsequent growth in national income. The contribution of education to economic growth was presumed to occur through a number of distinct yet interacting functions. It was presumed that more efficient allocation of resources could be achieved by utilization of more advanced methods of production. However, in order to advanced production techniques, more education would have been required.

From this point in the debate, it was thought that education contributed to economic growth in at least two ways: 1) serving to heighten peoples interest in improved equipment, more aware of the availability of technology, and more capable of using it; and 2) training people in science and technology expanded their capacity for research and development work needed to invent, develop, adapt, and install new machines (Machlup, 1970). However, it was not until the mid 1980s that this concept was considered more formally in the theoretical framework of endogenous growth models.

In 1957, one model that gained popularity among planners was the Harrod-Domar[3] growth model. This model made a series of assumptions common to many growth models: Productive investment is always equal to savings and that financial markets work efficiently (savings are really invested). Assuming an economy's output (Y) consists of two categories of commodities, consumption goods (C) and investment goods (I). That is,

$$Y = C + I \tag{2}$$

then,

$$Y = C + \Delta K \tag{3}$$

Further assuming a constant capital output ratio, we get

$$\frac{K}{Y} = \gamma \tag{4}$$

where γ is constant and by moving Y and γ to opposite sides of the equal sign, it becomes clear that output is proportional to the stock of capital

$$Y = \left[\frac{1}{\gamma}\right]K = AK \tag{5}$$

where A is defined as $\left[\frac{1}{\gamma}\right]$.

In the Harrod-Domar model, the growth rate of output is directly proportional to the rate

[3] Van den Berg, Hendrik. 2001. Economic Growth and Development. Lincoln. University of Nebraska. pp. 106 - 107.

of savings. That is,

$$\Delta Y = \left[\frac{1}{\gamma}\right]\Delta K = A\Delta K \quad (6)$$

Given the dynamics of these variables, for the economy to invest capital, savings must occur. Thus, if people save a fraction of their income σ, then the change in capital stock is expressed as

$$\Delta K = I = S = \sigma Y \quad (7)$$

and combining equations 6 and 7, we get

$$\Delta Y = A\sigma Y = \left[\frac{\sigma}{\gamma}\right]Y \quad (8)$$

$$\frac{\Delta Y}{Y} = g_y = \frac{\sigma}{\gamma} \quad (9)$$

where g_y is the rate of growth of Y. This model facilitated the forecasting of the rate at which the economy grew, that is, growth was constant and was determined by the economy's rate of savings σ and the technical capital output ratio γ. While this model did not include human capital, the level of sophistication used pointed to the fact that economic modeling had begun to form the basis for policy recommendations to stimulate economic growth and development by using sophisticated theoretical constructs.

Endogenous growth models are based on the fact that returns to an accumulated growth factor, namely, human and physical capital, are not decreasing, whereas the neo-classical models are based on more rapidly decreasing returns to scale. While endogenous growth theories stressed the importance of human capital in growth dynamics, another set of studies rehabilitated the neo-classical Solow growth model, extending it to include human capital, which remained an accumulated factor of production. One of the main contributions to these type studies was that of Lucas (1988) at a point in time when economists had renewed their interest in economic growth theories.

The importance of human capital in economic growth was highlighted in much of the new growth theories which came to prominence in the late 1980s and the early 1990s. The neo-classical growth models, formalized at least three decades earlier, had focused on the accumulation of machinery and equipment and emphasized the feature of diminishing returns thereby implying that such investment would not be able to promote long run economic growth. The new generation of studies however, switched the attention of economist's to accumulation of human capital and the possibility that returns to investment in education, training, and research may not necessarily suffer from diminishing returns (Dowrick, 2003).

Robert Lucas (1988) developed an endogenous growth model where he specified education as the critical force that generated technical progress in an economy. Lucas' model showed that education and the creation of human capital could be responsible for both the differences in labor productivity and the overall level of technological progress in an economy. Lucas designed what he called the 'mechanics' suitable for studying economic development. He designed a system of equations where the solutions imitated the features of economic behavior observed in the real world. Central to Lucas' model was a system with a given rate of population growth which was 'acted on by no other exogenous forces. Further, the model assumed two kinds of capital: 1) physical capital

that was accumulated and utilized in the production process; and 2) human capital enhanced the productivity of both labor and physical capital. Lucas' model emphasized the notion that the comparative advantages, which dictated a country's production mix and introduction of new goods, would be intensified over time by human capital accumulation. Thus, in the long run, growth could only be sustained if the growth of human capital was without limit.

From the precursory work of Solow, Denison, and Lucas, human capital investments can be considered to be similar to physical capital investments. This similarity is embedded in the treatment of these factors of production in explaining economic growth. Both human and physical capital requires that current consumption be forgone in order to increase future productivity and consumption (Storesletten & Zilibotti, 2000). By definition, investments in physical capital require that certain resources, which are available to society for consumption, be set aside and used for the production of capital goods. The mechanism for human capital accumulation is similar: a share of the population of working age is withdrawn from the labor force and placed in the educational system, in order to increase future labor productivity. This theoretical concept embodies the importance of education in the promotion of economic growth theories which highlighted the externalities of higher educational attainment.

More recently, Gregory Mankiw, David Romer and David Weil (1990) developed an augmented Solow growth model, which included human capital, with educational attainment as the proxy, as an additional independent/explanatory variable in a series of cross-country regressions. They evaluated the empirical implications of the Solow model and concluded that, 'education too was a major factor in the process of economic growth'. In 1992, Mankiw, Romer, and Weil presented additional findings which indicated that the Solow framework of 1956 extended to include human capital provided a good explanation for economic growth. Moreover, their findings also led them to reject the findings of Romer (1990) which attributed growth to externalities in the accumulation of physical capital and concluded that a model without externalities, but with savings expanded to include investment in human capital, provided a superlative framework to analyze economic growth.

Unlike Lucas (1988), Mankiw, Romer, and Weil (1992) considered human capital depreciation. Specifically, they assumed that human capital depreciated at the same rate as physical capital, that its growth rate was determined by the same accumulation function, and that returns to scale fro enlarged capital are decreasing. These assumptions can be considered appropriate if we apply the definition of Storesletten & Zilibotti (2000) to human capital. Within this framework, Mankiw, Romer, and Weil found that on the long term equilibrium growth path, the level of output per capital depends on the rate of investment in physical and human capital, or equivalently, in the savings rate and the long-term equilibrium level of human capital. Further, on the equilibrium growth path, the growth rate of production per capita depends on accumulation of education over the period. In the absence of technological progress, to maintain positive growth in the long run, the educational attainment of the population must increase continuously. The Mankiw, Romer, and Weil model was presented in an influential paper which presented conclusive results on the impact of educational attainment on economic growth (Angevin & Laib, 2005).

These influential empirical studies since the 1980s, which extended growth

models to include human capital and scale economies, leave little room for doubt that education is a factor that fuels growth in national income and in many cases, an important engine of growth in any economy. The literature on investment in human capital, over the years, attempted to prove the positive impact of human capital on economic growth, which should not be ignored in identifying sources of growth. Whilst economists have agreed that human capital is important in the process of economic growth and development, it has also been argued that human capital is a failure for economic strategy (Thurow, 1982).

The following section presents a discussion of more recent empirical investigations, which have yielded conflicting results, on investigations of the contribution of education to human capital accumulation and subsequent economic growth. In some of the studies discussed, educational variables frequently turned out to be insignificant, or tended to have the 'wrong' sign in growth regressions, particularly when these are estimated using first differenced or panel specifications (Fuente and Domenech, 2000).

Education and Economic Growth

Capital formation by education is neither small nor a neat constant in relation to the formation of capital that is non-human (Schultz, 1960). Whether education actually contributes to economic growth depends firstly on the extent to which educational levels improve over time and secondly, the impact of education on economic productivity. Insofar as schooling improved general human capabilities, it has to be viewed as having a universal impact irrespective of context. In a two part study, Rosenzweig (1995 & 1999) noted that the general influence of education on individual productivity depends on the complexity of the situation. He noted for instance that for performing agricultural tasks, involving physical exertion, there was no evidence that education levels made a difference on per worker productivity. However, the jobs requiring more complex allocative decisions are affected by the educational levels of the individuals involved.

On the macro level, the effect of education can be seen in the changing sectoral composition of the economy. It is common to suggest that the service and manufacturing sector has more functional uses for educated labor than the agricultural sector and hence, the shift from agriculture to industry will lead to greater use of educated labor and in turn requires more educated labor forces. However, there is no unanimous theoretical or empirical basis that agriculture makes use of less educated labor than other sectors of the economy. In fact, literacy rates have been high among farmers and there are more functional uses for education in agriculture in keeping accounts and keeping up with technological developments in farming practices.

Nonetheless, economists commonly claim that education yields benefits to society over and above the impact on labor market productivity perceived by the person receiving the education. These benefits include impacts on economic productivity and technological advances. McMahon (2002), in his assessment of the social benefits from education includes not only direct effects on economic productivity but also impacts on population growth rates, the environment, poverty reduction, crime and drug use, and labor force participation. While these effects involve primarily non-market activity which are not reflected in growth rates, factors such as political stability resulting from a better educated populace has obvious consequences on long term growth prospects.

In the 1960s, numerous studies attempted to estimate the effect of education in human capital accumulation and on economic growth. A central goal of these studies was to estimate the externalities to education on input over and above the private returns estimated from private data. The results have been conflicting and have often been attributed to problems in measurement and specification of human capital and its impact on economic growth.

Shortly after the early 1990s, there was a substantial increase in empirical estimation of growth models using cross-country and cross-regional data. This empirical work was largely inspired by the excitement of endogenous growth theories of the 1950s, 1960s, and 1980s (Solow, 1956; Koopmans; 1965; et al) with extensions that emphasized government policies, institutional arrangements, and the accumulation of human capital. The extended neo-classical framework enabled economists to study the factors that contributed to economic growth in countries across the world. As such, the older theories are more complementary than competitive with more recent endogenous growth models.

In expanding these theoretical constructs to include government policies and human capital, growth theories emphasized technological progress, which is determined within the model. Thus, long run economic growth can be affected by government policies instead of being driven by exogenous technological change. With respect to human capital, proxied by educational attainment, the endogenous approach argues that there should be an additional effect over and above the static effect on the level of output (Loening, 2005). These models attribute growth to the existing stock of human capital. A second category of this modeling is the Lucas (1988) type modeling. This concept broadens the definition of capital and suggests that human capital accumulation is an engine of growth due to the spillover effects that negate the diminishing returns in production.

In developing countries, one way of characterizing the role of human capital is the consideration that technology transfers from innovation countries can generate higher level of output and economic growth. As early as 1966, Nelson and Phelps suggested that education facilitated the absorption and implementation of new technologies of the innovating countries. For instance, as they suggested, that countries with lagging technological capacity may be most able to catch up if they have a large stock of human capital. In this instance, the level of human capital generates growth by facilitating improvements in productivity. Additionally, Lucas' (1990) study conjectures that physical capital does not flow from developed to developing countries because of a relatively low stock of complementary human capital.

A seminal study by Benhabib and Spiegel (1994) proposed an empirical growth model in which human capital was considered with advances in education and in new physical capital via the importation of technology. The results in this study suggested that human capital impacted economic growth in two ways. Firstly, human capital influenced the rate of domestic production, similar to the Romer (1990) study. And secondly, the human capital stock affected the rate of adoption of technology from innovating economies. This validated the Nelson and Phelps (1966) study where education played a pivotal role in economic growth.

The endogenous growth theories suggested, and still suggest, a strong causal link between education and economic growth. However, the empirical evidence has not been unanimous. For instance, Pritchett (1996) found a large and significant negative impact

of human capital accumulation on productivity growth. Subsequently, Pritchett offered three possible explanations: '1. schooling creates no human capital; 2. the marginal returns to education are falling rapidly where demand for educated labor is stagnant; and 3. perverse institutional environments have misdirected educated labor to activities that reduce economic growth'.

Subsequent to Pritchett's 1996 work, he presented another convincing argument in 2001 that the findings of only a level effect of human capital on economic growth is rather 'puzzling'. He further noted that in the framework of endogenous growth, spillover effects of knowledge should be in addition to, rather than instead of, the production effects of human capital. Leoning (2005) interpreted Pritchett's analysis of his findings to mean that 'finding only the spillover effects of human capital may be inconsistent with the micro evidence on the returns to education'.

Pritchett's claim that the 'effects are puzzling' can be validated by other past studies (Benhabib & Spiegel, 1994; Islam, 1995 & Caselli et al, 1996) which also failed to detect any significant relationship between the rate of increases in human capital and the rate of economic growth. These studies suggested that the positive findings of other cross-section studies were due to errors related to variable omission and failure to control for country specific effects. The accumulation of such negative results in the literature fueled some skepticism concerning the role of schooling in the growth process, and has since led some scholars (notably Pritchett) to consider possible reasons why the contribution of educational investment to productivity growth may actually be negative. Pritchett (2001) also argued that poor policies and institutions hampered growth in less developed economies, directing skilled labor into relative unproductive activities, thereby disrupting the statistical relationship between education and growth in samples that included less developed economies.

Mosino (2002) presented the argument that the limitations of the past studies on the effect of human capital accumulation through education on economic growth could be corrected for by studying the indirect impact of human capital accumulation. Thus, Mosino presented a simple regression model for estimation comprising of two linear equations. The first equation was the gross domestic product (GDP) determination taking into account the initial period. Interestingly, the principal variable of interest in determining GDP per capita was the level of labor supply.[4] The second equation was that of human capital determination, determined by government expenditure on education for 15 countries around the world for the period 1960 – 1990 (considering observations in five year periods). This study found that workers with primary education always had a positive impact on the growth rate and workers with secondary education had the same impact as the workers with primary education. However, the study found that workers with higher levels of schooling had a negative impact on economic growth.

The mismatch between the endogenous growth theories and the empirical evidence in studying the role of education in human capital accumulation and its contribution to economic growth has created an 'education puzzle'. However, according to Fuente and Domenech (2000), the mismatch between growth theories and the

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[4] The level of labor supply accounted for all educational levels (primary, secondary and higher education).

empirical evidence '[m]ay be due in part, to deficiencies in data or inadequacies of the econometric specification. Fuente and Domenech (2000) constructed a revised version of the Barro and Lee (1996) data set for a sample of Organization for Economic Cooperation and Development (OECD) countries using unexploited data sources and '[f]ollowed a heuristic approach to obtain plausible time profiles for attainment levels by removing sharp breaks in the data set that seem to reflect changes in classification criteria.' Fuente and Domenech found that the revised data performed better than the Barro and Lee (1996) or Nehru et al (1995) series in the number of growth specifications. Unlike Barro and Lee (1996), or Nehru et al (1995), Fuente and Domenech (2000) produced positive and 'theoretically plausible' results in studying the contribution of human capital to economic growth. Their study also concluded that the results obtained indicated that poor data quality provides a rational and sufficient explanation for the mismatch in recent literature between growth theories and the empirical findings rather than in the econometric specification of the models.

Another explanation offered for the mismatch is the questionable use of the empirical studies based on international comparisons, which jeopardizes the conventional development on understanding the importance of education in economic growth. According to Dessus (1999), the discrepancies in data based on international comparisons were as a result of differences in the quality of education from one country to another. Dessus also cited Lee and Barro (1993) indicating that since the '[l]abor force quality was correlated with educational infrastructures, one might think that simply introducing the latter into the neo-classical growth model would reconcile cross country and panel data series. Unfortunately, multiplying the measure of human capital with an indicator of quality to account for differences in the quality of educational systems does not significantly change the picture'. However, this alone is not sufficient evidence to reject the hypothesis that human capital accumulation through the vehicle of education has a positive impact on economic growth. At the least, it makes the results puzzling.

The differences among the neo-classical growth theories raise concern regarding the question of whether the long-run growth of the economy is an exogenous constant or whether it can be influenced by policies such as public expenditure on education. Put another way, the question is whether policies and institutions have an effect on the rate of human capital accumulation and, to what extent do these policies influence economic growth?

While some of the recent empirical studies have proven otherwise, traditional endogenous growth theories developed to explain the role of human capital accumulation in economic growth continue to be debated by economists and policy makers. Theories such as (Schultz, 1960, 1961, & 1962; Selowsky, 1969; & Lucas, 1988) provided the foundation for further empirical research and augmented models. However the negative results reported by Pritchett (1996) and Caselli (1996) et al. that human capital accumulation would exert a negative influence on growth, '[s]uffers from specification bias' (Dessus, 1999).

Subsequent to Pritchett (2001), discussed earlier in this section, Krueger and Lindahl (2001) suggested that the problem of unobserved variation in educational quality is exacerbated in panel data. Taking quality into account, Krueger and Lindahl (2001) showed that increases in the stock of schooling improved short-run economic growth. Hanushek and Kimko (2000) confirmed the belief that direct measures of labor-force

quality, from international mathematics and science test scores, are strongly related to growth. Temple (2001) found that the effects are positive, but non-linear. As such, these non-linear effects may be missed by studies that impose linearity in their specification.

In the mid 1990s, some other published studies found that there was no systematic relationship between changes in national educational attainment and changes in economic growth. However, Pritchett (2001) established that the lack of correlation (between educational attainment and economic growth) was due to a mix of factors: poor institutional performance in less developed economies, and a failure to account for the international variation in educational quality (Dorwick, 2002).

With new approaches to studying education and economic growth (Ashenfelter & Krueger, 1994; Ashenfelter & Rouse, 1997; Ashenfelter & Rouse, 1998; & Dorwick, 2002), there is renewed debate on the role of human capital accumulation, via educational efforts, on economic growth. This neo-classical revival in growth theory has had the paradoxical effect of reinforcing one of the major points of the endogenous growth revolution (Dorwick, 2002) which is that the driving force of economic growth is investment in human capital – skills and ideas – rather than investment in physical capital, since it is the inequity of human capital that reinforces innovation and development of physical capital.

Revisiting the Role of Education

In earlier neoclassical models, education was not considered a major input for production and hence was not included in growth models (Harberger, 1998). In the 1960s mounting empirical evidence stimulated the 'human investment revolution in economic thought' (Bowman, 1960). The seminal works of Schultz (1961) and Denison (1962) led to a series of growth accounting studies pointing to education's contribution to the unexplained residuals in the economic growth of western economies. Other studies looked at the impact of education on earnings or estimated private rate of returns (Becker 1964, and Mincer 1974). A 1984 survey of growth accounting studies covering 29 developing countries found estimates of education's contribution to economic growth ranging from less than 1% in Mexico to as high as 23% in Ghana (Psacharopoulos, 1984). Moreover, no country has achieved constant growth rates in output without considerable investment in the provision of education goods (Arsivi, 2001).

Educational efforts may be regarded as consumption or investment since it creates future non-pecuniary satisfaction and or future gains in productivity. Growth models evolved to embrace education as a factor fueling increases in economic activity, hence, economic growth and subsequent writings on economic growth have also tried to identify the contributions of investment in education to economic growth. The theoretical explanation postulated by economists is that education raises the market value of labor, the cost of not working increases, and in advanced economies, the chance of obtaining a job increases. The link between education and human capital goes back at least to Becker (1964) and Mincer (1974). They emphasized the fact that the education sector, by producing more human capital, raises total economic output. Earlier attempts to quantify the contribution of the education sector to economic growth usually involve running wage regressions with educational attainment on the right hand side (Kroch & Sjoblom, 1986).

In microeconomic analysis that studies the variation in wages as a function of

education, individuals' years of schooling are frequently used as an independent variable. This method has advantages in that such data are readily available in developed countries. However, it does not form the basis for, neither does it account for differences in the quality or type of education received in the countries studied. Alternatively, individuals may be classified by highest degree completed. This measure also has additional problems; for example, an individual nearly finished with college is counted as a high school graduate (Dahlin, 2002).

In macroeconomic analysis, economists' often included a variable for human capital. The reason for this inclusion stemmed from the reasoning that human capital encompassed a range of characteristics such as education, work experience, and health. Thus, it is difficult to measure human capital. Any measure of human capital must have the following attributes: 1) it must be comparable across countries; 2) it must address the broad range of criteria that compromise human capital; and 3) it must include elements of human capital for which data are available, or in the least, estimable. While techniques used to measure the education of an individual and the aggregate human capital of an economy are imperfect, disagreement among researchers as to the best measure of education and human capital made it more difficult to compare the findings of empirical studies in an attempt to determine the true impact of education on an individuals' income, and economies growth rates. These '[d]isagreements (limitations) in studying the role of education in economic development needed to be corrected for' (Wolff & Gittleman, 1993).

Selowsky (1969) provided a natural point of departure for discussions on the pitfalls of earlier studies. Selowsky pointed out that '[p]ast studies dealt with the effect of increases in the educational level of the labor force, neglecting the contribution of education that stems from maintaining the average level of schooling of the labor force, thereby underestimating the total contribution of education to economic growth'. Selowsky subsequently developed and tested a model to analyze the contribution of education to economic growth, correcting for the shortcomings of earlier studies. He found that the contribution of the maintenance factor underestimated the effect of education on economic growth in developing countries by a greater percent than it did for developed countries.

Investment in education and its effect on economic growth continued to intrigue economists' which meant a relentless pursuit of a model that would fully assess the effect of investment in human capital and its contribution to economic growth. From causal empiricism, we observe that investment in human capital has two components. Individuals directly acquire educational goods and services in the market, which enables them to improve the efficiency of their labor. Therefore, human capital accumulation has a direct cost (given by the market price of educational goods). This direct component of investment in human capital (through education) is a perfect substitute for investment in physical capital.

Secondly, individuals spend part of their own resources, such as time, in manipulating educational goods at home to increase their labor productivity. The cost of this activity is the opportunity cost given by the market returns to these resources allocated to human capital accumulation. Thus, the indirect component of investment in human capital is not a perfect substitute for physical capital accumulation. However, both components are empirically relevant for studying the effect of education and human

capital accumulation on economic growth. These observations form the basis for most of the studies cited in this section.

In a neoclassical life-cycle model, Sheng Cheng Hu (1976) presented a continuous general equilibrium model allowing for investment not only in tangible capital, but in education as well. The basic assumption within this model was that individuals lived for two periods, devoting a fraction of time to schooling in the first period and working full time in the second. Each person had a utility function dependent on education as well as present and future consumption, choosing the amount of schooling and the rate of saving so as to maximize utility. Hu empirically evaluated the importance of education in multiple long run equilibria, concluding that investment in education is a critical factor in moving an economy towards a steady state. The welfare implication for this model is that where the education level is exogenous, then the interest rate must be equated to the population growth rate to move the economy towards a steady state.

The aggregative analyses of Denison (1962), Bowman & Anderson (1963), and Schultz (1963) have estimated the contribution of education expenditures to national income. According to Denison's study, the contribution of human inputs to national income may depend on years of schooling S of employed persons and on the quality of the schooling. The quality of education provided was affected by dollars spent on public education per pupil E, as well as by quality obtained from a dollar as influenced by cost considerations. The discussion suggested that income can be explained by a production function containing human and non-human capital $Y = y (H, K, U, N, u)$. Human capital is determined by years of schooling and the quality of schooling, $H = h (S, Q)$. Assuming linear logarithmic functions, Tolley and Olson (1971) derived the expression*

$$Y = a + bE + cU + dD + eN + fS + gK + u \qquad (10)$$

Table 3.1
Symbols for Logarithm in the Tolley and Olson Study

*Symbol for Logarithm	***Definition**[5]
a	Constant
Y	Personal income per employed person
E	Expenditure in level on education per pupil in attendance
U	Percentage of Population in Urban areas
D	Population per square mile
N	Percentage of non-white
S	School years per employed person
K	Privately owned real property
u	Error term
b, c, d, e, f, g	Estimation parameters

Based on the regression analysis for the logarithmic function that Tolley and

[5] U.S. Bureau of Census (1962, Chapters A, B and C) adopted in the Tolley and Olson study.

Olson developed, a simple correlation between the variables of .956 indicated that government expenditure on education had a significant impact on national income growth. They concluded that the strategy of human capital development is one of the imperatives of any program for accelerated economic growth and development. Human capital development has three key elements: the building of appropriate incentives, the promotion of effective training of employed manpower, and the rational development of formal education. These three parts are interdependent and must be reflected in governmental plans in order to promote economic growth (Barro & Sala-i-Martin, 1999).

Easterly and Rebelo (1993) conducted a similar study and established that the relationship between government spending and economic growth only held true for some of the models specified while Levine and Renelt (1992) concluded that government education expenditures are not necessarily correlated to robust growth rates. However, more recently, Krueger and Lindhal (2001) concluded that there is sufficient evidence in favor of private returns to years of school rather than a relationship between economic growth and changes in the levels of schooling.

Blankenau and Simpson (2004) in an article entitled 'Public Education Expenditures and Growth' explored the relationship between government spending on education and its impact on economic growth within the context of an endogenous growth model with overlapping generations,[6] in which private and public investment are inputs to human capital accumulation. They concluded that '[n]o clear empirical validation of this link exists'.

The approach used in the Blankenau and Simpson study was consistent with other empirical investigations, which yielded discouraging results. Again, reference is made to an earlier study, Dessus (1999). If we apply Dessus' reasoning, as presented earlier in this chapter, we see that Blankenau and Simpson's approach to studying educational attainment and its effect on economic growth suffers from 'specification bias'. Further, if we apply the approach of Fuente and Domenech (2000) to evaluate the Blankenau and Simpson approach, we can see that their model also suffers from 'deficiencies in the data or inadequacies of the econometric specification'.

Policy makers can influence the formation of human capital, mainly through schooling. However, the latter concept (schooling) cannot be easily grasped in numbers, due to its qualitative nature. Quality differences between schooling systems are often hard to measure. Different countries may have school days of unequal length, class sizes may vary, teacher qualifications may vary, and the curriculum varies. Despite these limitations, one of the main determinants of a country's wealth is the quality and quantity of human capital accumulated (Ho & Jorgenson, 1999). Frederick Harbison once said that: '[A] country which is unable to develop the skills and knowledge of its people and to utilize them effectively in the national economy will be unable to develop anything else'.

Earlier, Easterlin (1981) formulated the hypothesis that under-development in some countries is as a result of late arrival of mass primary education, which delayed the technology transfer. Easterlin based his study on a small number of developing countries in the western world and argued that the reason for slow economic growth in these

[6] The economy consisted of three-period-lived homogenous agents, a representative firm producing a single good, a government, and a technology for producing human capital.

countries is because of limited geographical diffusion of technology. This limitation is in turn linked to the quality and quantity of educational systems. Since technology transfer is linked to the educational process, Easterlin viewed schooling as a crucial variable in attaining economic growth.

Hanson (1989) later conducted a test of Easterlin's hypothesis[7]. Hanson's study of 37 former colonies of European countries found that schooling in these countries were determined by socio-cultural and political factors. The socio-cultural factors Hanson presented were primarily the societal norms of the roles of men and women and, the political factor stemmed from the fact that in ex-colonies, the governments were responsible for covering the cost of schooling up to a certain level. Hanson regressed several economic indicators of economic development, of technology, and of income on the adult literacy rate showing that all coefficients for the literacy rate were statistically significant. In particular, increased literacy rates had a positive impact on income, and on the reduction of the share of agriculture in national product. Hanson's results provided '[e]vidence that primary education substantially contributed to economic growth of national economies in the post-War II period'.

On the other hand, studies relating to the impact of tertiary education on economic growth (Graff, 2001; & Wolff & Gittleman, 1993) have mixed results. The plurality of conclusions is explained by a variety of factors, among which: the fact that studies rely on different variables (enrollment rates as opposed to literacy rates of the working population); the non-uniformity in the definition of educational levels across countries; and the linear form of the models used conceals the effects of structural breaks and critical values (Andreosso-O' Callaghan, 2002).

We live in a 'knowledge based economy' in which education is widely, although by no means universally, regarded as investment, and as a means of generating wealth and reducing unemployment. Investment in education expands and extends knowledge, leading to advances, which raise productivity and improve health. With investment in human capital and non-human capital both contributing to economic growth and welfare, and in probably an interdependent manner, more attention should be paid to the adequacy of the level of expenditure on people. But, before this can be accomplished, economists should focus on the general impact of education on economic growth.

Katharina Michaelowa (2000) of the Hamburg Institute for International Economics depicted the general impact of education on economic growth in the form of a diagram. Michaelowa (2000) examined the impact of education on economic growth both at the micro and macro levels and examined the direct and indirect effects of education. The three key assumptions used in Michaelowa's approach are as follows:

1. Education results in learning – it is not merely an indicator of worker quality;
2. Demand within the economy is sufficient to consume higher levels of output resulting from productivity gains and;
3. Monetary and fiscal policies are sufficiently responsive to meet the demands of a growing economy.

The study the illustrated the macro and micro impacts of education on the process of economic growth as shown in Figure 3.1 in which the direct effects of education such as

[7] Easterlin hypothesized that under-development in some countries were as a result of the late arrival of mass primary education which delayed the process of technology transfers.

increases in individual earnings, increased labor force participation, and higher growth all followed from the assumption that education results in learning which increases the productivity of the individual.

The Michaelowa study also examined the indirect effects of education wherein as more educated individuals made better parents and healthier individuals. While the direct impacts are crucial to economic growth, the indirect impact is a critical factor in assessing economic development since economic development encompasses improvements in the welfare of the individuals in a country.

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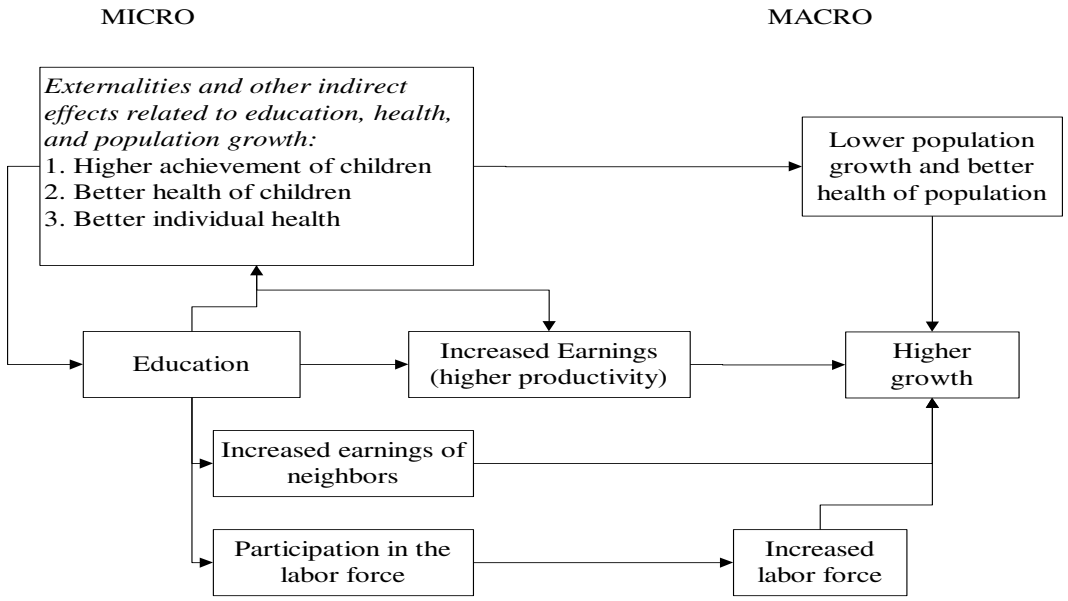

Figure 3.1. Macro and Micro Impacts of Education on Economic Growth

Despite the shortcomings in measuring educational attainment, and in studying the human capital – growth relationship: two major conclusions can be drawn from the studies presented in this chapter. The first is that educational attainment indicators are highly correlated with wealth levels of countries; in particular, mass primary education has a positive impact on economic growth. Secondly, different levels of education have different impacts on economic growth, depending on the stage of economic development reached by the various countries, and on the quality of education. The latter, in part, helped form the basis for this research undertaken to identify and measure the differential impacts of human capital accumulation (educational attainment being used as a proxy) on economic growth.

Human Capital Accumulation: Salient Points on the Debate

Human capital refers to the skills and knowledge intensity of the labor force in an economy, which are acquired through the vehicles of schooling and additional training. The relevance of human capital accumulation to the process of economic development is rooted in its potential beneficial impacts on macroeconomic productivity and on the long run distribution of incomes, once some basic conditions are met. These conditions are variegated at the minimum, multifaceted and

As growth theories continue to evolve, economists are able to isolate more and more of the factors contributing to growth and are better able to measure the effect of changes in such factors. One of the most important contributors to economic growth as revealed in some recent studies (Evans, 1997; Jorgenson & Sturoh, 2000; & Anand & Sen, 2000) is the growth rate of human capital or investment in human capital. Most notably, in these studies, the engine of growth of human capital is the level of education attainable within an economic system. The role of human capital accumulation with – specific regard to social services (particularly basic health and education) – received greater emphasis in the 1980s despite the fact that these services were viewed mainly as a means of raising the incomes of the poor.

Amartyra Sen (1977, 1984, & 1985) resented the view that human capital accumulation was an intrinsic aspect of economic growth and development and the underdevelopment was primarily due to a lack of certain basic capabilities rather than a lack of income. If these individuals were provided with the basic skills, then they would have the ability to earn better wages, Sen argued. Sen's argument can be directly linked to the seminal works of Becker (1961; 1964), Schultz (1961), and Denison (1962) in that the observations made in their studies indicated that years of schooling, as well as the quality of schooling had a positive impact on the productivity of workers thereby enabling them to earn higher wages.

Investment in people makes it possible to take advantage of the technological progress as well as to continue that progress. Improvements in health make investment in education more rewarding by extending the life expectancy of an individual. Investment in education expands and extends knowledge, leading to advances, which raises productivity and improves health. With investment in human capital and non-human capital both contributing to economic growth and welfare in an interdependent manner, more attention should be paid to the adequacy of the level of expenditure on people.

In economic literature, the concept of human capital did not receive much attention throughout the years. In the 1960s and 1970s, studies such as Schultz (1960) provided the impetus for investigating the role of human capital accumulation in economic growth. This enthusiasm for studying the role of human capital led to the exploration of various methods to measure human capital and the rate of return on investment in education in which government expenditure on education was treated as an investment rather than as a consumable good.

Some studies (Eckaus, 1964; Becker, 1967; & Johnson, 1970) centered on the issue of the rate of return to schooling. The issue of schooling and its impact on long term economic growth began to dominate the social science discourse in the 1960s and early 1970s. Eventually, the debate shifted in the 1980s to the impact of technology, combined with human capital accumulation (through schooling) on economic growth. It became clearer that technical change and technological progress could not be evaluated in isolation. Rather, technical change had to be studied together with the human capital factor. Technical change could not be independent of the human inputs that created them and utilized them.

In 1962, Weisbrod evaluated the relationship between education and investment in human capital within the benefit-cost framework focusing on the ways by which a society benefits from formal education. In his study, Weisbrod identified the benefits of education by recognizing the beneficiaries of the education process. His findings

revealed that some of the benefits of education are realized at the time that education is being received and, for others, after formal education was completed. Additionally, in Weisbrod's study, other findings suggested that benefits from education not only occur at various times, but also in various places. The benefits of education accrue to people in the area, in school districts, and the economy as a whole.

In an influential paper published in 1992, 'A Contribution to the Empirics of Economic Growth', Gregory Mankiw, David Romer and David Weil (MRW) evaluated the empirical implications of the Solow model and concluded that education was indeed a major factor in the process of economic growth. Mankiw, Romer and Weil specified a simple Cobb-Douglas production function of the form

$$Y = K^{\alpha}(E.L)^{1-\alpha} \tag{10}$$

this can be written in per-effective worker terms as

$$Y^{*} = \frac{Y}{E.L} = \left[\frac{K}{E.L}\right]^{\alpha} = K^{*\alpha} \tag{11}$$

Assuming population grows at a rate n and technology grows at a rate z the Solow model establishes that a change in the ratio of capital to effective workers K^{*} was

$$\Delta K^{*} = \sigma y - (n + z + \delta)k^{*} = \sigma K^{\alpha} - (n + z + \delta)k^{*} \tag{12}$$

where σ and δ are the rates of depreciation and saving, respectively. Thus, in the steady state $\Delta K^{\alpha} = 0$ and $\sigma K^{\alpha} = (n + z + \delta)k^{*}$ deriving the expression,

$$K^{*} = \left\{\frac{\sigma}{n + z + \delta}\right\}^{\frac{1}{1-\alpha}} \tag{13}$$

Mankiw, Romer and Weil tested the Solow model and concluded that the rates of saving, population growth and depreciation do matter for growth, as does technological progress, which is dependent on investment in human capital through education. Since human capital is the knowledge acquired by workers, this endogenous growth model viewed human capital as one of the main factors fueling increases in productivity, and ultimately, output.

The MRW study examined variations in school enrollment rates, using a single cross-section of both the industrialized and less developed countries. The study concluded that schooling has a significantly positive impact on the rate or growth of real GDP. They interpreted this as evidence of changes to the short-run transitional growth paths. Similarly, Barro and Sala-i-Martin (1995) too investigated the impact of educational expenditures by governments, finding that they have a strong positive impact. Also, using instrumental variation techniques to control for simultaneous causation, their (MRW) regressions suggested that the annual rate of return on public education was in the order of 20%.

More recently, the Mamuneas, Savvides, and Stengos (2001) study posited that human capital accumulation should raise income at the macro (aggregate) level, a proposition put forward by Schultz (1960) and subsequently tested empirically. The Mamuneas, Savvides, and Stengos (2001) study remedied the deficiencies of previous studies by using annual data for 1971 – 1987 for 51 countries to calculate the 'orthodox' index of TFP (total factor productivity) growth. Then, the index was used to evaluate the impact of human capital in the growth of TFP. This was accomplished using semiparametric methods, which allowed the effect of human capital accumulation on

economic growth to be non-linear. This study found that human capital accumulation was more critical as a stimulus for economic growth in developed countries as opposed to developing countries. Wide dispersions in empirical evidence in examining the role of human capital accumulation continue to be a source of constant debate in the literature among development economists'.

Education, Human Capital Accumulation, and Economic Growth

The approaches considered thus far relate to changes in educational attainment of the labor force and to changes in worker productivity. An alternative, though not mutually exclusive, approach is to relate the level of educational attainment of an economy's labor force to its rate of economic growth. The premise for so doing is that a high but unchanging level of educational attainment should contribute to economic growth by facilitating technological innovation as well as enabling adaptation to change, particularly in developing countries. Topel (1999) argued that there may not be any fundamental difference between these two approaches in that productivity can only occur if there is advance and adaptation, which has to be reflected in ongoing changes in human capital. Nonetheless, some empirical studies based on international data for the late twentieth century have found that a country's level of educational attainment has a much stronger impact on the rate of economic growth than its rate of improvement in educational attainment (Benhabib & Spiegel, 1994).

The paucity of data on schooling attainment limited the empirical examination of the relationship between levels of human capital and economic growth prior to the twentieth century (Pritchett, 2001). However, Sandberg (1982) presented a descriptive argument of the comparison of economies in various categories and showed that countries with high levels of schooling experienced faster rates of economic growth. Others studies (O'Rourke & Williamson, 1997; and Foreman-Peck & Lains, 1999) found that high levels of schooling and literacy is what enabled the European countries to converge in the late nineteenth century and at the state level for the United States over the twentieth century.

More recently, Alonso-Carerra and Friere-Seren (2001) conducted an investigation on how the way in which individuals combine educational goods and effective time to produce new human capital, affects the equilibrium dynamics, the long-run economic growth rate, and the growth effects of alternative fiscal policy. They were interested in analyzing the technology of human capital accumulation and its ability to explain differences in growth rates. Their research was motivated by their observation that education in developed economies made superior use of intermediate goods, whereas under-developed economies were characterized by a simple process of human capital accumulation based on the use of time.

Their study specified human capital as a non-market activity that used effective human capital as a non-market activity that used effective labor and educational goods as inputs, building on Heckman (1976). They then integrated the two approaches of human capital accumulation previously used in the literature on endogenous growth. Their study presented a three-sector model of endogenous growth with physical and human capital accumulation. Human capital accumulation was defined as a home activity in which individuals combined their non-working time with intermediate market goods. Alonso-Carerra and Friere-Seren (2001) considered educational goods to be produced by a

specific, independent technology, which had only a productive value in the sector responsible for accumulation of human capital. This framework enabled them to obtain three important results concerning economic growth.

First, the study showed that the technology for accumulating human capital determined the long-run growth rate and the growth effects of fiscal policy. The study reported that Differences in the proportions at which individuals use educational goods and effective time explained the observed differences in growth patterns across countries. Secondly, the study proved that economic equilibrium is not always locally 'saddle-path' stable. Under some conditions of fiscal policy, the equilibrium was either locally indeterminate of locally unstable. Finally, Alonso-Carerra and Friere-Seren (2001) proved that governments can 'directly stimulate the accumulation of human capital by subsidizing the price of educational goods and by subsidizing the opportunity cost of the time allocated to human capital accumulation'.

Undoubtedly, there is substantial theoretical and empirical evidence in studying the human capital accumulation – growth issue. More interestingly, the mismatch between theories and empirical studies were overshadowed by the experience of the East Asian economies where significant and sustained investment in human capital enabled some of these economies to grow rapidly, and maintain relatively high levels of economic growth.

According to a recent World Bank study (2002), in nearly all rapidly growing East Asian economies, the growth and transformation of systems of education and training during the past three decades have been dramatic. The quantity of education children received increased at the same time that the quality of schooling improved. According to the statistical information reviewed, the improvement in education was a significant explanatory variable in the record rates of growth achieved by Singapore.

The World Bank reports highlighted the fact that the periods of accelerated growth in Singapore were largely due to the role of human capital which resulted in increases in the output per effective worker, which led to increases in output, thereby increasing national income. The relevance of human capital accumulation to the process economic growth in Singapore stems from its beneficial impact on macroeconomic productivity and on the long run distribution of incomes, once basic conditions are met. Additionally, sociologists highlight the fact that education is associated with the loosening of religious and traditional norms.[8] Therefore, the sequence is: schooling – modernity – economic growth. Singapore's growth in GDP was a direct result of dramatic increases in labor productivity stemming from improvements in education. Based on the Signapore/Asian experiences, it can be concluded that a substantial schooling system is a prerequisite for sustained economic growth in addition to which the quality of human capital in any country commands the ability of inward investment to add to economic growth.

Table 3.1 presents the estimates of total factor productivity growth in Singapore. Although the late 1960s appear to have been a period of rapid productivity growth, these

[8] Andreosso-O' Callaghan, Bernadette. 2002. *Human Capital Accumulation and Economic Growth in Asia.* National Europe Centre Paper No. 30. Prepared for the workshop on Asia-Pacific Studies in Australia and Europe: A Research Agenda for the Future, Australian National University.

In Table 3.1, we also see that weighted capital input grew at an average of 2.8% per annum faster than output and output per unit of effective worker grew at 3.0% annum. Interestingly, although the growth of capital input has slowed over time, the growth of human capital accelerated. While weighted labor input grew 3.1% slower than raw labor in the late 1960s, it rose to 3.0% faster in the 1980s due mainly to large increases in the age and educational attainment of the workforce.

Table 3.1
Total Factor Productivity Growth: Singapore

Time Period	Output	Raw Capital	Weighted Capital	Raw Labor	Weighted Labor	TFP	Labor Share
Economy:							
66 – 70	.130	.119	.134	.054	.033	.046	.503
70 – 80	.088	.122	.140	.050	.058	-.009	.517
80 – 90	.069	.091	.084	.036	.066	-.005	.506
66 – 90	.087	.108	.115	.045	.057	.002	.509
Manufacturing:							
70 - 80	0.103	0.123	0.130	0.086	0.089	-0.009	0.423
80 - 90	0.067	0.090	0.094	0.021	0.051	-0.011	0.385
70 - 90	0.085	0.107	0.112	0.054	0.070	-0.010	0.404

Source: Alwyn Young. The Tyranny of Numbers: Confronting the Statistical Realities of the East Asian Growth Experience. *The Quarterly Journal of Economics*, vol. 110, no. 3, Aug. 1995, pp. 658.

In Singapore, the increases in total factor productivity would not have been possible without significant investment in education (Young, 1995). The primary vehicle for increases in effective output per worker was investment in education at the primary and secondary levels. According to Table 3.2, for the period 1980 – 1995, the average primary school enrollment was 95% and for secondary school enrollment it was approximately 70% with a pupil-teacher ratio of 25 students per teacher in the classroom for both the primary and secondary level. Moreover, the per capita income for the same period rose steadily from 12,345 to 37,591 (Singapore Dollars) or 5,851 to 22,277 (U.S. Dollars).

Singapore's largely corruption-free government, skilled work force, and advanced and efficient infrastructure have attracted investments from more than 7,000 multinational corporations from the United States, Japan, and Europe. Foreign firms are found in almost all sectors of the economy. Multinational corporations account for more than two-thirds of manufacturing output and direct export sales, although certain services sectors remain dominated by government-linked corporations. Singapore's ability to attract large multi-national corporations is directly attributed to significant investment in human capital accumulation. This provides evidence that there is a positive link between human capital accumulation and economic growth. Investment in human capital, reflected in high enrollments in Singapore, allowed for increased productivity as workers

applied knowledge to new and existing industries. Inefficiency was low as unemployment of the educated population was kept to a minimum.

Table 3.2
School Enrollment in Singapore

Year	School Enrollment Primary (% of net)	School Enrollment Secondary (% of net)	Pupil-teacher Ratio	Exp. On Education	Per Capita GDP
1984	97	67	27	2076	14,225
1985	96	69	26	2204	15,487
1986	95	73	26	2231	17,819
1987	95	74	25	2369	19,854
1988	96	75	26	2828	22,034
1989	97	74	25	3655	23,932
1990	98	72	25	3532	25,160
1991	99	70	26	4047	28,564
1992	92	70	25	3409	31,716
1993	93	69	24	3633	34,086
1994	92	72	23	4082	35,639
1995	91	73	21	4472	37,591

Source: Alwyn Young. The Tyranny of Numbers: Confronting the Statistical Realities of the East Asian Growth Experience. *The Quarterly Journal of Economics*, vol. 110, no. 3, Aug. 1995, pp. 659.

The main emphasis in education was improvement in the quality of teachers, teaching methods and the teaching curriculum (Wong, 1974). The secondary school curriculum was tailored to provide more technical education that would allow for the pursuit of higher education or skilled technical careers. Additionally, opportunities were made available for teachers to improve their academic and professional qualifications (Wong, 1974). Through the hiring of more highly qualified teachers, the teacher-student ratio declined thus offering students more individual attention. The cornerstone of Singapore's educational policy was 'equality in education for all'.

In studying the economic performance in Singapore stemming from investment in human capital through education and additional training, it is clear that there exists a positive correlation between investment in human capital and economic growth. The acquisition of new and higher skilled labor results in increased levels of productivity, which is reflected in higher levels of output in both the manufacturing and service sectors.

Conclusion

For all economies of the world, acquiring and sustaining competitiveness implies investing in education so as to accumulate an adequate stock of human capital. By viewing schooling as in investment in man, the economists of the 1960s opened a new

avenue in the analysis of the determinants of wealth. Studies, such as the one discussed throughout this chapter, made in the ambit of the new growth theories have complemented the picture of the 1960s by treating technology and human capital as two inseparable elements in the process of generating economic growth. In most poor countries, education is considered a priority to reduce poverty, and several studies have emphasized its importance.

The relationship between education in economic can be classified into three main categories. According to Mitch (2004), the first of the three categories is stagnation in both educational attainment and output per head. The classic case of this was, arguably, in the world prior to 1750. In using the qualifier 'arguably', Mitch made inadequate allowance for the improvements in informal education. The second category is the period 1750 to 1840 when income per capita rose despite stagnating educational levels. During this period, English schooling and literacy rates rose only slightly, while per capita income rose, sometimes sharply. At that time, literacy was of little use in newly created manufacturing occupations such as cotton spinning (Nicholas & Nichholas, 1992). The third category is that of rising educational attainment corresponding with rising rates of economic growth. This is the situation which will prevail if education contributes to economic productivity and if any external shocks are insufficient to offset its influence.

The conflicting empirical evidence in calculating or evaluating the effect of educational attainment can easily be reconciled if they are interpreted to support a mix of the three situation described in the preceding paragraph. Much of the education puzzles created by economic theorists have been the result of the treatment of education and the measurement of human capital in the models (Woessmann, 2002 & 2003). However, the theoretical reconciliation of growth theories which include education and human capital was presented by Benhabib & Spiegel (1994) when they carried out an econometric estimation on various models to explain the variation in twenty year growth rates on a cross section of 78 countries. In their preferred model, technological progress is the sum of two components: and exogenous component, and a semi-endogenous component. Their study, which drew on Nelson and Phelps (1966), found that an interactive term, one between the productivity gap and the level of human capital, was statistically significant thereby supporting the idea that there is an endogenous component to technological progress. A similar attempt at reconciliation of growth theories inclusive of human capital was conducted by Dowick and Rogers (2002) and yielded similar results.

Though there is risk of oversimplification, I will attempt to convey the main findings of the research work on education and economic growth in two broad themes. Firstly, from a theoretical perspective, education plays a major role in improving productivity. The models which lend to this proposition are based on micro economic mechanisms which seem plausible and commands wide agreement among economists (Temple, 2000). And secondly, education's contribution to growth is merely a positive externality of individuals' desires to advance themselves. While the second observation is less favorably received, the argument has theoretical basis in private returns to education studies. Overall, the case for education as a contributor to economic growth has not yet been proven beyond reasonable doubt. Nonetheless, casual perusal of studies provides evidence in favor of education.

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