Stockholm School of Economics
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THE ROLE OF EDUCATION IN CHILE'S ECONOMIC GROWTH

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ABSTRACT

This thesis examines empirically whether there is a link between education and economic growth in Chile during the period 1973-2005. This is done through the adoption of time-series analysis and co-integration techniques. Based on economic theory and empirical findings, potential implications for Chilean educational policy are then discussed.

This thesis provides further evidence to the theory that education is linked to economic growth via the technology parameter, roughly approximated by total factor productivity, and that Chile constitutes no exception in this area. Consequently, these results give reason to believe that education may be an important influencer of Chile's long-term economic growth and thereby a relevant topic for Chilean economic policy. However, while recent cross-country evidence from World Bank studies suggest that it is the *quality* rather than the *quantity* of education that has the largest impact on economic growth, Chile's greatest educational achievements have actually been in terms of quantity rather than quality. This is most evident in the fact that Chile has received international acclaim for its accomplishment in raising the country's average level of schooling, while also receiving significant criticism for its modest improvements in student performance, despite consistent and substantial increases in educational funding. These findings offer several notable insights. Firstly, if the results from these World Bank studies apply to the specific case of Chile, it would appear that Chilean educational policy could be significantly more successful, seen from an economic perspective, than it currently is. Secondly, the fact that consistent and substantial increases in educational expenditure have only been reciprocated by modest progress in student performance, gives reason to believe that there may be some in-built inefficiencies in the very design of Chile's educational system.

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LIST OF ABBREVIATIONS

CEA	Centre of Applied Economics
GDP	Gross Domestic Product
IMF	International Monetary Fund
LOCE	Organic Constitutional Law on Teaching (Ley Organica Constitucional de Enseñanza)
OLS	Ordinary Least Squares
SIMCE	National Assessment System of Learning Outcomes
TFP	Total Factor Productivity
UNESCO	United Nations Economic and Social Committee
VAR	Vector Autoregression

1 INTRODUCTION

In terms of economic growth, Chile is arguably considered the biggest Latin American success story of modern times.

Since the late 1980's, Chile has gone from success to success in reducing inflation, implementing fiscal discipline, opening up to the world economy and strengthening its institutions - all of which are considered important fundamentals for achieving strong economic growth. Chile is still viewed, however, to be underperforming in the development of its human capital, and the country's total factor productivity (which is considered an important source of long-term growth) continues to only contribute modestly to economic growth, relative to many other countries. (Gregorio 2004)

The topic of education, being an important element of a country's human capital, has consequently received great attention in political and public debates in Chile. This topic has in recent years become even more relevant as the country's impressive growth (averaging around 7% per year since the mid-1980's) came to a halt in the late 1990's. (Beyer and Vergara 2002) While the Chilean economy is still doing relatively well, (the country has since experienced growth rates averaging around 4%) it is yet to return to its former high growth rates (Schmidt-Hebbel 2006).

Seen from a wider perspective, few people would disagree with the logic that a better educated labor force is likely to be more productive, and thereby contribute more to a country's overall economic growth. However, while "new" economic growth theory acknowledges this relationship between human capital and economic growth, the results from empirical studies have been surprisingly weak, leaving no clear-cut evidence as to whether education actually has bearing on economic growth. Recent studies on the topic suggest that the inconsistency in results is largely due to two contributing factors. Firstly, it has been identified that many studies use inadequate econometric estimation methods which invariably lead to spurious regressions. Secondly, the vast majority of the studies to-date has been conducted on a cross-country basis. This does not only mean that results are likely to differ based on what countries are included in the respective samples, it also means that the these studies ignore the unique relationship between education and economic growth experienced in a particular country. (Wilson and Biscoe 2004)

1. 1 Purpose of study

In recognition of the above-outlined inadequacies of previous empirical studies, this thesis examines the role of education in Chile's economic growth by adopting a *country-specific* approach where co-integration techniques are used in order to avoid spurious regressions. The purpose of this study is two-fold. Firstly, this thesis aims to empirically examine whether a link between education and Chile's economic growth can be found during the time period 1973-2005 by adopting Johansen's co-integration test. Secondly, this paper aims to analyze some of the potential implications for Chilean economic and educational policy based on general economic theory, the econometric results, and other empirical findings presented in this thesis.

The time period of this study is interesting to analyze for several reasons. Firstly, 1973 marks the beginning of Augusto Pinochet's 17-years long dictatorship – a period of dramatic restructuring of the very foundation of Chile's educational system. Secondly, while the institutional design of Chile's educational system has remained virtually the same after the country's return to democracy in 1990, the Chilean government has thereafter undertaken substantial measures to improve educational standards. These efforts have been reflected in the extension of the mandatory period of education from eight to 12 years and the tripling of government funds allocated to the

education sector. (Cox 2004) Hence, this study aims to shed light on whether these measures to raise educational standards actually seem to be linked to Chile's total factor productivity, and thereby to the country's overall economic growth. Based on economic growth theory and empirical findings, potential implications for Chilean policy-makers are then discussed.

1.2 Delimitations and contributions to the literature

In attempting to reflect Chile's efforts to improve its own educational standards, this thesis has limited its empirical examination to two key aspects of formal education: educational quantity and educational quality. Thereby, this study does not aim to assess *all* aspects of education that may be linked to Chile's economic growth. This thesis also limits its empirical examination to investigating whether a link can be found between education and economic growth *via the technology parameter*, which means that this thesis assesses only one of potentially several ways that education could be linked to Chile's economic growth.

This thesis contributes to the literature on human capital and economic growth, being one of the few *country-specific* studies conducted in this area, and being the only identified study that econometrically investigates the link between education and economic growth specifically for Chile. From an academic research perspective, this study is relevant as it is one of the few - but growing number of - papers that recognize the short-comings of using conventional regression techniques for non-stationary time-series, and alternatively adopts co-integration techniques to investigate the relationship between education and economic growth. In addition to contributing to the academic literature on the topic, this paper has been written with the intention to provide *practical* relevance seen from an economic policy-perspective. While this work has been developed to analyze the specific case of Chile, the objective has also been to provide a framework that can be used as a wider reference, applicable to other countries as well. Finally, it has been the author's aspiration to make the content of this thesis accessible to a wide range of readers who have an interest or influence in Chile's economic development, not only to those who have a strong background in the fields of economics or econometrics.

1.3 Outline of thesis

The remainder of this thesis is organized as follows: chapter two offers a theoretical framework for the role of education as a determinant of economic growth. Chapter three provides a contextual and empirical background to Chile's recent economic history and the relatively unique features of the country's educational system. In chapter four, the methodology used in this study is described. Chapter five presents the statistical results. In chapter six, these results are analyzed further and potential policy implications are discussed in light of economic theory and empirical findings. Chapter seven concludes and provides some suggestions for further research.

2 THEORETICAL FRAMEWORK

2.1 Introduction

Various conceptual approaches have been used to explore the links between education and economic performance. While these links can be assessed at many different levels, such as the individual, the company, the sector or the economy as a whole, the focus of this paper is on the latter, in that it aims to investigate the links between education and economic performance at a macro-economic level. A macro-economic approach typically explores the quantitative relationship between aggregated investments in human capital and the level or growth of total factor productivity (TFP) or per capita GDP (Wilson and Biscoe 2004). There is a large number of theoretical studies on this topic, beginning with the classical growth models first developed in the 1950's, through to the new, so-called endogenous growth models.

In order to provide a theoretical foundation to how (and why) human capital, and education in particular, have come to play an increasingly important role in explaining economic growth, a brief outline of the developments in economic growth theory is given. This outline is followed by a presentation on some recent empirical evidence on the links between education and economic growth. Finally, this chapter reviews some of the identified issues with empirical tests of this relationship.

2.2 Developments in economic growth theory

Why are some countries rich and others poor? This has been one of the grand questions in economic research over the last five decades. The question was explicitly asked when many former colonies became independent after World War II. These newly independent countries tried to develop policies that were intended to promote an economic development that would bring them at par with Western countries. With this in mind it was not more than natural that researchers started a quest for factors of economic growth. (Easterlin 2001)

2.2.1 Neoclassical growth models

One of the first economists to come up with a quantifiable growth model was Robert Solow who established the world-famous Solow's (neoclassical) growth model. At its most basic level the model follows:

$$Y/L = F(K/L, 1) \qquad [2\text{-}1]$$

where Y represents total output, L is the number of workers, and K is the capital stock. Y/L thereby represents output per worker (and therefore income per worker) and K/L represents (physical) capital per worker. (Perkins et al 2001)

The equation in [2-1] tells us that capital per worker is fundamental to the growth process and consequently the core policy implication from this model is to focus on generating more (physical) capital in the economy. (Perkins et al 2001)

While Solow's model received enormous recognition at the time and still does today, an unsettling conclusion of this basic model is that once the economy reaches its long-run potential level of income, economic growth will simply match population growth, with no chance for sustained increases in average income. Now, as history can confirm, a large number of countries across the world have experienced steady growth in average incomes since the 1820's. This led economists to believe that Solow's basic model could not possibly incorporate all factors determining economic growth. (Wilson and Briscoe 2004)

Solow's response to this identified short-coming was to introduce a factor of technological change into the model. A modified version of Solow's basic model was launched where output was now not only contingent on capital and labor but also on the "quality" of the labor. Solow argued that the reason why high-income countries had been able to sustain their income growth over very long periods of time was that the technological progress that these countries had experienced, had allowed output per worker to continue to grow. The new, modified version of Solow's model is specified in the following equation:

$$Y = F(K, T \times L) \qquad [2\text{-}2]$$

where Y represents total output (and therefore total income), K is the capital stock, L is the labor supply and T represents technological progress. In this specification, technology is introduced in such a way that it directly enhances the input of labor. (Perkins et al 2001)

However, while the modified neoclassical model of Solow allowed for countries to continue to grow over long periods of time (which proved to be more realistic), it still did not answer the question as to what causes this technological progress in the first place? According to Solow's model, technological change is exogenous, that is, determined independently of all the variables and parameters specified in the model. In this sense, technological change can be likened to "manna from heaven" and the implication of this assumption is that countries cannot really affect their technological progress through strategic economic policy. Consequently, countries can neither really influence their rate of long-term growth. This assumption does not only raise some objections from a theoretical point of view, it also limits the practical applicability of the model as a foundation for economic policy decisions. (Perkins et al 2001)

Due to the above shortcomings, it started to become clear that in order to find the answers to *why* some economies experience higher levels of growth and *how* less developed countries can progress and catch up with the more advanced ones, further research was required. This realization was what came to pave the way for the more recent endogenous growth theories. (Wilson and Briscoe 2004)

2.2.2 Endogenous growth models

The increasing awareness that other factors, beside physical capital, could be important determinants of economic growth also gave rise to the question of whether factors such as consumption, life expectancy, health and human capital could affect the potential for economic growth. As a result of this line of thinking, international organizations such as the International Monetary Fund (IMF) and United Nations Economic and Social Committee (UNESCO) started collecting more data on these factors from their member states. This in turn gave economic researchers a better foundation for conducting empirical analyses including a broader set of explanatory variables of economic growth. (Wilson and Briscoe 2004)

It was especially in the 1980's when large cross-section datasets had become available that more and more economists started to look at how the determinants of growth could be determined *within* the model rather than being exogenously determined as in the neoclassical (Solow) growth model. This period hence came to feature the development of "endogenous-growth" models. In contrast to neoclassical models, the new, endogenous growth models explicitly incorporate technology and recognize that technological change is not at all "manna from heaven", but is very much dependent on economic decisions in the same way as (physical) capital accumulation is. (Perkins et al 2001)

Economists Robert Lucas and David Romer came to pioneer this work on making technological advances explainable within the model framework and a large number of endogenous growth specifications have been put forward (Wilson and Briscoe 2004). One of the most typical specifications is the one by Robert Barro (1997):

$$\Delta y = f(y, y^*) \text{ and} \qquad [2\text{-}3a]$$

$$y^* = f(Z) \qquad [2\text{-}3b]$$

where Δy is the growth rate of per capita output, y is the current level of per capita output and y^* is the long-term or steady state level of per capita output.

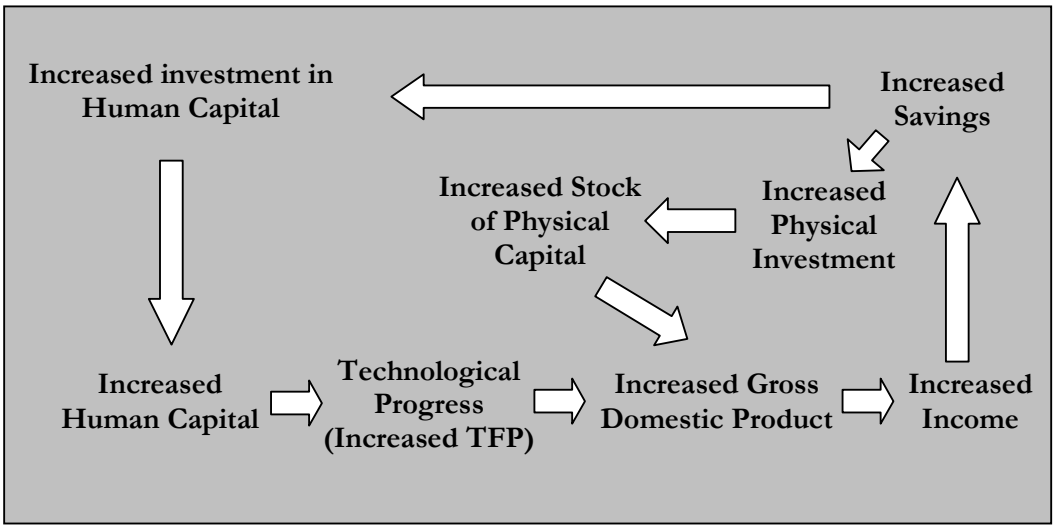
For a given value of y, the growth rate rises with y^*, which is determined by a wide set of economic, policy and environmental variables. These variables differ between studies, but typically Z in equation [2-3b] contains variables measuring population (fertility and life expectancy), labor supply, government expenditure and investment, terms of trade, inflation, and, most significant for present purposes, different variables of human capital. Barro (1997) argues that any increase in the steady-state level y^* will raise the per capita growth rate, y, over a transition interval. As technological advances now are assumed to be a factor that can be determined within the model, endogenous growth models can be more easily applied to practical work, such as developing government policies. If, for example, the government adopted an economic policy that improved the business climate or raised educational standards, this is likely to increase the steady state level of per capita output (y^*) and in turn raise the current level of output per capita (y). (Barro 1997)

In sum, while Solow's neoclassical model and the endogenous growth models make different assumptions on *how* technological advances come about, both approaches agree on the fact that differences in technological progress and total factor productivity constitute a key reason to why countries differ in national income. The fact that total factor productivity constitutes an important source of economic growth has received support from a large amount of empirical studies. Although different studies have obtained different results on whether capital accumulation or TFP growth is the most significant contributor to economic growth (it seems to depend on what region the study focuses on), there is strong consensus on the fact that TFP is a major contributor to economic growth, and even more so for the higher per-capita income countries. (Perkins et al 2001)

2.3 The role of human capital in economic growth theory

As outlined above, the endogenous growth models give special tribute to the role of human capital. These models argue that human capital contributes to the development of technology and thereby to economic growth. The conceptual flow of this reasoning is illustrated below.

Figure 2.1 Conceptual flow of the role of human capital in economic growth



There are however, several aspects that the conceptual flow in figure 2.1 does not shed any light on. First, a substantial controversy has emerged in the economics literature about whether it is the *level* of human capital or the *change* in human capital that is the most important influencer of economic growth (Wilson and Briscoe 2004). Second, the figure above does not really tell us what needs to happen at the very beginning for human capital to increase. While there is still no consensus on the answer to the first question, this paper approaches the second question by specifying what is actually meant by human capital.

2.4 Defining human capital

Defining human capital is not as straight-forward as one might think. Different researchers have different views on what should be included in this factor. Human capital is hence a broad concept, and it is commonly taken to include people's knowledge and skills, acquired partly through formal education and partly through informal education or workplace training; but it can also include people's strength and fertility, which are dependent on their health and nutrition. (Wilson and Biscoe 2004) Although human capital in its wider sense includes a range of different aspects, this thesis uses a more narrow definition of the term by solely focusing on the aspect of formal education. In the remainder of this thesis, human capital formation is hence used analogously to (formal) education.

2.5 Empirical evidence on education and economic growth

Today, there is extensive and detailed literature on the rates of return on education, based on human capital theory. Both data sets and econometric modeling techniques have developed extensively in recent years leading to an array of model specifications that have been proposed and empirically tested. However, while there is strong theoretical support for human capital formation (in the form of education) as a significant and positive influencer of economic growth, the question of just how to proxy for this variable remains an unresolved empirical issue. (Hanushek and Kimko 2000)

In addition to these specifications problems, this area of economic research has also been troubled by a series of estimation problems due to inadequacies and inaccuracies in econometric techniques and empirical data. As a consequence, and in contrast to microeconomic studies (that generally suggest that education yields a significant positive return on individual earnings), results on the macro level have been far from clear-cut and often surprisingly weak. (Jones and Schneider 2006)

The vast majority of macro-economic, empirical research on the links between education and economic growth has been conducted using cross-comparative data, either averaged across a sample of years, or taken over several years in panel data format. So far, there are relatively few - albeit a growing number of - studies that, like this one, attempt time series analysis of an individual country (Loening 2002).

The following sections provide a brief overview of the results of some of the most recognized empirical studies conducted on both cross-country and country-specific basis, followed by a discussion on the advantages and disadvantages of these two approaches respectively.

2.5.1 Cross-country evidence

As outlined above, most empirical studies on the role of human capital in economic growth have so far used a cross-country approach. This means that data from a large group of countries, both developed and developing, have been combined in order to test for statistically significant and robust relationships between various factors (the Z variables in equation [2-3b]) and economic growth.

One of the most comprehensive works based on cross-section regression comes from Barro and Sala-I-Martin (1995). They find that the level of educational attainment among males has a significant, positive growth effect. Across a wide ranging sample of countries they find that higher levels of education has especially large effects; increasing average male secondary schooling by 0.68 years raises annual growth by 1.1 percentage points per year while a mere 0.09 year increase in average tertiary education raises annual growth by as much as 0.5 percentage points. An unexpected finding from this study is however that female education (both secondary and tertiary) appears to be inversely related to growth. According to Wilson and Briscoe (2004), this somewhat surprising result may be due to deficiencies in the construction of the data set; Barro and Sala-I-Martin proxies the labor force as all men and women aged over 25. This proxy may be relevant for some countries in the sample, but not for countries where a significant share of the female population is educated but not part of the labor force.

Using an educational attainment index, Benhabib and Spiegel (1994) investigate a simple growth accounting or 'sources of growth' equation, for samples of developed and developing countries. In this study, the neoclassical model yields insignificant and generally negative coefficients for the human capital stock variable, a result which holds when other regressors are added into the model and alternative proxies for human capital are applied. In contrast, Benhabib and Spiegel find a highly significant impact when using the level of human capital to explain the growth of total factor productivity.

In seeking to explain productivity growth, Nehru and Dhareshwar (1994) calculate TFP growth indices over 1960-1987 for a wide range of countries using econometric methods. Using indices of average years of schooling to explain TFP growth, Nehru and Dhareshwar find a particularly important role for human capital. Their study concludes that human capital accumulation is three to four times as important as raw labor in explaining output growth, and that its contribution is larger than estimated in previous studies.

While most cross-country studies in the above sample provide evidence for a positive relationship between education and economic growth, the results are far from clear-cut and the fact that many of the studies contradict each other indicates that these regression studies suffer from numerous methodological drawbacks. Critics of this approach argue that the main problem with cross-country studies is that they ignore the unique impact education has for the individual country because of its distinct background and economic situation. It is claimed that the marginal return on education in one country may be very different to another based on factors such as how developed the country is, its previous levels of education, the design of the educational system in place, etc. As cross-country studies typically calculate an average estimate from a large (often heterogeneous) sample of countries, these estimates may be valid for the sample as a whole, but very limited in its applicability to the individual countries in the sample. (Wilson and Briscoe 2004)

2.5.2 Country-specific evidence

To date there are relatively few studies that investigate educational effects on income levels or growth of an individual country. One of the most acknowledged studies is the one of Jenkins (1995) who explores the links between education and economic performance for the UK in the period 1971-92. While Jenkins' study gives further evidence to a significant, positive impact of education on TFP, the limited time period for this study suggests the need for caution in interpreting these results (Wilson and Briscoe 2004).

A more recent study is the one of Fortuna and Teixeira (2003) that assesses the role of human capital and innovation capability for Portugal's economic growth during 1960-2001. By using various co-integration techniques, Fortuna and Teixeira show that human capital, proxied by average years of schooling, is an important source of TFP growth.

Babatunde and Adefabi (2005) use a similar methodology to the one of Fortuna and Teixeira (2003) in order to investigate the long-run relationship between education and economic growth in Nigeria between 1970 and 2003. Using average years of schooling as a proxy for education, their results suggest that a well-educated labor force is linked to economic growth both as a separate factor in the production function (as the augmented neo-classical approach suggests) and through total factor productivity (as the endogenous approach suggests).

Francis and Iyare (2006) also use co-integration techniques to analyze the causal relationship between education and economic growth in Barbados, Jamaica, and Trinidad and Tobago during the time period 1964 to 1998. Expenditure on education per capita is used as a proxy for education, while gross national income (GNI) per capita is the proxy for economic growth. Their empirical results provide some evidence of bi-directional causality in Jamaica, but no evidence of causation in Barbados and Trinidad and Tobago.

In recent years, there has been an increase in the general consensus that evidence from annual time series of individual (or groups of) countries are probably more reliable in estimating the impact of human capital for the particular country in focus, not least because it avoids some of the above questionable assumptions in much cross-country work. However, the major problem with the time series approach is obtaining adequately long series on consistent bases; particularly in

developing countries and for the variables proxying for education. Therefore, the use of time-series methods (and their sophistication) has been restricted in practice, even though the ones conducted generally produce stronger and more consistent results. Due to recent developments in econometric techniques and the fact that with time, longer and more consistent time series will be made available, the amount of time-series evidence is expected to grow significantly. (Wilson and Biscoe 2004)

2.6 Identified issues in empirical research

Apart from the already identified pros and cons of different methodological approaches, there is a number of issues that have further complicated the empirical testing of the relationship between education and economic growth. This section highlights some of these general issues.

2.6.1 How to best proxy for education?

Because human capital in its broader sense may encompass a range of characteristics such as education, work experience and health, it is extremely difficult to practically measure human capital. Even when a more narrow definition of human capital is used, (such as formal education), there is still a lot of debate as to which type of proxies best capture this variable. (Hanushek and Kimko 2000) "The ability to solve problems, to think creatively, to read facts and to reinterpret those facts in the light of changing circumstances"; these are some of the key elements that economists seem to view as critical components of educational outcome that are likely to affect total factor productivity and thereby economic growth. (Jones and Schneider 2006)

2.6.1.1 Proxies reflecting educational quantity

So far, measures reflecting the *quantity* of education - the most popular ones being literacy rates, average years of schooling and enrolment rates - have by far been the most frequently used proxies in empirical research (Wößmann 2000). However, as outlined below, there are several pros and cons of using these proxies respectively.

Statistics on literacy rates has for a long time served as a measure of human capital. However, as more recent studies have found, the applicability of this proxy is quite limited as it only reflects the most basic level of education obtained. Consequently, measures such as average years of schooling and enrolment rates have become acknowledged as more nuanced proxies for human capital. (Barro and Lee 1996) However, these measures also have both strengths and weaknesses.

The advantage of using schooling enrolment rates is that data for this proxy is typically available in most countries, even in the less developed ones (Barro, 1991; Levine and Renelt, 1992; Barro and Sala-I-Martin, 1995). The main drawback of using this proxy is however that it only reflects the *current* flows of education and not the actual stock of human capital built up over time. (Barro and Lee 1996)

Dissatisfied with the above proxies, authors, such as Psacharopoulos and Arriagada (1986), Kyriacou (1991) and Barro and Lee (1996), have constructed more elaborate ways to measure educational quantity. One of the most acknowledged attempts to quantify the stock of human capital among workers is that of Barro and Lee (1996), who estimate the average years of schooling for the population aged 25 years or older for a wide range of countries. While this proxy comes closer at estimating the level of human capital built up over time, the drawback of defining human capital by average years of schooling is that it implicitly gives the same weight to any year of schooling acquired. This hence disregards microeconomic findings indicating that the marginal financial return for the individual (the marginal wage) typically decreases with the acquisition of additional schooling (Psacharopoulos 1994).

Regardless which proxy is used of the above, the overall results from empirical studies have been surprisingly weak and inconsistent. This has lead to an increased focus and debate on which proxies are most appropriate for estimating a country's human capital. (Altinok 2007) Pritchett (1995) argues that one of the main explanations for the difficulty in empirically finding a significant, positive relationship between education and economic growth is that the vast majority of studies only reflects the *quantity* of education and does not even partially take the *quality* of education into consideration.

The argument above receives support from an extensive study recently published by the World Bank (Hanushek and Wöβmann 2007). The report provides evidence that it is not the years of schooling, but what skills students actually acquire during their schooling, that mainly determines how productive they will be when part of the labor force. According to this study, educational quality is likely to differ greatly between countries and therefore the impact of one additional year of schooling is likely to differ as well. Therefore, it is highly unlikely that the average student in a country such as Ghana or Peru would gain the same amount of knowledge in any year of schooling as the average student in Finland or say South Korea.

2.6.1.2 Proxies reflecting educational quality

While empirical studies have shown indications that the qualitative aspect of education may be even more relevant than the quantitative aspect when proxying for human capital, it has proven far more difficult to find suitable proxies for the former than for the latter (Hanushek and Kimko 2000).

One way to account for differences in educational quality is to use proxies for the quality of educational *inputs*. Barro (1991) uses student-teacher ratios as a crude proxy for the quality of schooling in his analysis and Barro and Sala-I-Martin (1995) use the ratio of government spending on education to GDP. In one of the larger studies in this area, Barro and Lee (1996) collect data on educational expenditure per student, student-teacher ratios, teacher salaries, and length of the school year to proxy for the quality of educational inputs. Sylwester (2000) also uses educational expenditure as a proxy and his study provides evidence that educational expenditure has a significant and positive impact on economic growth, but that there is a significant time lag in this causal relationship that has to be taken into consideration.

The results of the above-mentioned studies have been mixed, and the consensus seem to be that measures of educational inputs are not always strongly and consistently linked to the cognitive skills actually acquired, rendering them limited proxies for educational quality (Hanushek 1996). According to Wöβmann (2003), measures based on input disregard the huge differences in effectiveness and efficiency with which inputs are put to use in different education systems, and are therefore not always reliable.

Another way – and perhaps the more promising one in theory – is to use direct measures of educational *output,* such as student skills reflected in tests on cognitive achievement (Gundlach 2002). Hanushek and Kimko (2000) use data from a series of standardized, international student achievements tests in the fields of mathematics and natural sciences to build a measure of educational quality during the period 1960-1990. This study finds a significant positive effect of the quality of education on economic growth that significantly surpasses their estimated association between the quantity of education and growth.

Although the theory behind Hanushek and Kimko's results has received a lot of support from other economists, the number of empirical studies using this output-based proxy is low (Neri 2001). There are several reasons for this. Researchers using a cross-country approach are finding it difficult to find test results that are comparable across a large sample of countries. The alternative

of using a time-series approach (where the focus is on an individual country) has also proven challenging. This is due to the difficulty in finding test results that can be observed for sufficiently long time periods and that are comparable from one year to another. (Wilson and Biscoe 2004)

2.6.2 The influence of data quality on results

The issue of data quality is a common theme in many of the studies referred to in this chapter; both Sianesi and Van Reenen (2000) and Temple (2000) raise the issue of data quality in these types of studies and suggest that empirical relationships between human capital and growth may be compromised by measurement errors. There are several examples of when data adjustments have led to a significant increase in the estimated relationship between education and economic growth. When De La Fuente and Domenech (2000) revise the educational attainment data for a selected number of countries in a study of Barro and Lee (1996), the estimated coefficient of human capital changed significantly. By using more detailed statistics from national sources, De La Fuente and Domenech find an appreciable improvement over the original estimate.

2.6.3 Possible endogeneity and simultaneity bias

Sianesi and Van Reenen (2000) identify possible problems of reverse causality in the links between education and economic growth (i.e. growth stimulates education and not the other way around). This issue of reverse or bi-directional causality implies that empirical estimates could overstate the impact of education on economic growth. Confusion about causality can also arise from a simple omitted variable problem. To the extent that other aspects of a country influence both various education measures and the success of the economy, the measures of human capital may simply be proxying for the true influences. (Hanushek and Kimko 2000)

2.6.4 Spill-over, external effects and non-economic benefits

Some authors, such as Osberg and Sharpe (2000) argue that GDP per capita is an inadequate indicator of the overall economic well-being of a nation and they maintain that the link between human or social capital and economic well-being is much stronger than is often implied when simple GDP measures are used in growth models. Such analyses lean towards the literature that links investment in human capital, and education in particular, to externalities in economic growth. Higher levels of education are typically associated with better environment, higher levels of public health and greater social cohesion, all of which are expected to feed back into faster economic growth measured in the wider sense. According to this line of theory, current empirical studies may therefore underestimate the true benefits of education as the estimated effect is likely to be significantly larger seen from a wider, socio-economic perspective. (Wilson and Briscoe 2004)

3 EMPIRICAL BACKGROUND

This chapter offers a contextual background to the study. The reader is first provided with a brief overview of Chile's recent economic history and the main sources of the economic growth experienced. The chapter then presents some facts about Chile's educational system, the major reforms undertaken in this area and how Chilean student performance has progressed over time and relative to other countries.

3.1 Chile's economic history – an overview

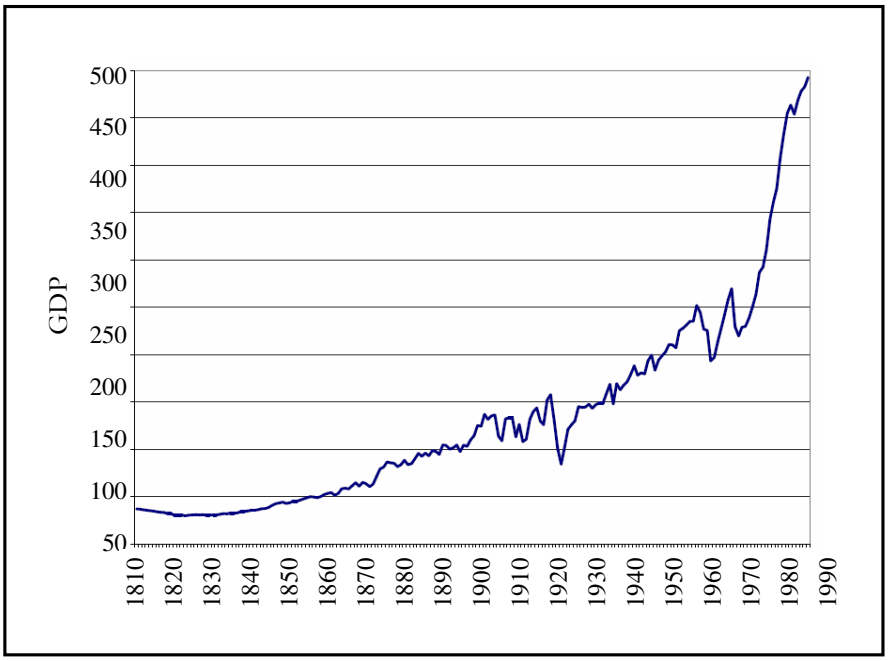
When it comes to economic growth, Chile is often referred to as Latin America's greatest success story of modern times. After a deep recession in the beginning of the decade, Chile's rapid economic growth began in the mid 1980's, and the rates recorded for the next 15 years (averaging an impressive 7% per year) were high not only by Chile's own historical standards, but also by international comparisons. (Beyer and Vergara 2002) During this period, Chile reduced inflation, implemented fiscal discipline, opened up to the world economy and strengthened its institutions – all of which are important fundamentals for achieving strong economic growth (Gallego and Loayza 2002). Despite these efforts, Chile's remarkable growth came to a halt with the global financial turmoil in the late 1990s. While many other economies quickly recovered fully from this crisis, Chile has since experienced sound but more modest growth rates, averaging around 4%. (Schmidt-Hebbel 2006)

The above sequence of events has led to a number of questions; what were the causes of this exceptional growth in the first place and what were the reasons for this growth later tapering off? Was the so-called "golden period" only a temporary phenomenon or does Chile have the potential to return to the high level of growth previously experienced? In fact, concern over how to restore growth to a rate closer to that of the golden period has been one of the most important topics in Chilean policy discussions in recent years (Gregorio 2004). In order to approach at least some of these questions, the following section presents some facts and statistics about Chile's economic growth and its main identified sources.

3.1.1 Sources of Chile's economic growth

Rapid economic growth is a relatively new phenomenon for Chile. Before growth took off in the mid-1980s, Chile had experienced occasional periods of rapid increase in per-capita GDP, but the rate of growth in those episodes was much lower than in the country's more recent experience, and not very different from the contemporaneous development in the world economy as a whole. (Schmidt-Hebbel 2006) Figure 3.1 illustrates this economic development, showing how GDP per capita has evolved from 1810-2003 and the dramatic growth take-off in the late 1980's.

Figure 3.1 Chile's economic growth



Note: Chile's GDP per capita index 1819-2003:1900 = 100
Source: Gregorio (2004)

The sharp increase in GDP per capita experienced since the mid 1980's gives rise to the question of what caused this strong economic growth in the first place? Table 3.1 provides some answers to this question by showing the sources of economic growth during the period 1970 – 2004.

Table 3.1 Sources of Chile's economic growth, 1970-2004

Time Period	Output Growth	Contribution of		
		Capital	Labor	TFP
1970 – 74	0.93	1.16	0.27	-0.49
1975 – 79	3.02	0.32	0.89	1.79
1980 – 84	0.39	0.78	0.96	-1.34
1985 – 89	6.37	1.19	3.24	1.82
1990 – 94	7.29	2.70	1.75	2.67
1995 – 99	5.35	3.44	0.53	1.32
2000 – 04	3.69	2.04	0.81	0.79

Source: Gregorio (2004) Calculations based on official national accounts. Assumptions: Labor share equal to 0.6 and depreciation of capital equal 6%. *Figures are geometric averages of yearly data and may not sum the total. Author's note: To assess the robustness of these estimates, the results in table 4.1 have been compared with estimates from other studies such as Beyer and Vergara (2002) and Gallego and Loayza (2002) and these studies show similar estimates to the one presented in the above table.

Table 3.1 illustrates the strong contribution of labor to output growth in the late 1980's. This reflects Chile's recovery from recession in 1982, where unemployment declined from 30% to single digits toward the end of the decade. In contrast to the second half of the 1980's, almost half of the impressive average growth rate during the 1990's was accounted for by the accumulation of capital, sustained by record investment rates (gross fixed capital formation in real terms). Total

factor productivity (TFP) was the main source of growth in the late 1970's but has since played a more modest role and showing clear signs of decline since 1990. (Gregorio 2004)

3.2 Chile's educational system

The topic of education has, since the return to democracy in 1990, occupied a prominent place in Chile's political debate as this area is generally considered the Achilles' heel of the country's economy (Cox 2004). To give the reader a background to this debate, the following sections provide a summary of the development of Chile's educational sector. Some basic facts about Chile's educational system are first presented, followed by an outline of some of its major system and policy reforms. Some relevant statistics on how Chile's student performance has progressed over time and relative to other countries are then presented.

3.2.1 Basic facts

The education system in Chile encompasses public and private institutions, and includes the following school levels:

- Primary/Elementary school (educacion basica), which consists of eight grades.
- Secondary/High school (educacion media), which consists of four grades.
- Higher education (educacion superior), which is received at universities, professional institutes, or technical centers.

With its diversity of public and private schools and institutions, the Chilean education is currently managed through a combined system, in which the government has a conducting role; there is a decentralized public education and a strong private participation in the school system. (Mizala and Romaguera 2000)

Until recently, only primary education was mandatory in Chile. In 2003, former president Ricardo Lagos however, issued a law making secondary education compulsory as well, giving the state responsibility for its completion by all Chileans under 18 years old. (Cox 2004) Despite the fact that education has been a central topic on Chile's policy agenda, the general attitude towards Chile's educational system has been one of disappointment and frustration. This dissatisfaction became increasingly evident in 2006, when Chile experienced a major student demonstration, also known as the Penguin's Revolution or The March of the Penguins, because of the students' uniform. What started as a series of voice protests carried out by high school students escalated to its peak on May 30th in 2006 when approximately 790,000 students adhered to strikes and marches throughout the country. This sequence of events did not only turn this student demonstration into the largest one in Chile of the past three decades, it also resulted in the first political crisis of President Michelle Bachelet's administration. Amongst the students' short-term demands were free bus fare and the waiving of fees to sit the university admissions tests. The more long-term demands raised included: the abolition of the Organic Constitutional Law on Teaching (LOCE) which is a law that ensures low barriers of entry for anyone who wants to open up and operate a school; the end to municipalization of subsidized education; increased quality of education and increased equality among students from different socio-economic groups. (McEwan et al 2007)

3.2.2 The evolution of Chile's educational system in the period 1973-2005

In order to understand the background to some of the above-outlined criticisms, the following sections outline a number of unique features and events that came to lay the foundation for Chile's educational system today. First, some of the major reforms made by Augosto Pinochet's military regime, which came to re-define the very foundation of Chile's educational system, are presented. Some of the second wave reforms that came into place after Chile's return to democracy in 1990 are then outlined.

3.2.2.1 Creating a Darwinistic demand-based educational system

As Pinochet came to power in his military coup in 1973, a radical restructuring of the education system started taking place. The military regime was inspired by economic neoliberalism and the reforms implemented consequently fostered competition between schools for students and resources. The formally stated objective was to increase choice, promote efficiency and improve educational standards. This view was to a large extent based on the arguments of economist Milton Friedman who argued that potential inefficiencies could be found in the public school sector. Friedman suggested that the use of vouchers based on student attendance would result in greater achievement per dollar as an efficient private sector would grow and increased competition would force public schools to raise their productivity. In such a scheme, the role of the State would be the one of (partly) financing education and producing information to inform market decisions. Perhaps no country has taken this idea more seriously than Chile, which in the early 1980's began implementing a decentralization process of the education administration and a voucher scheme not far from Friedman's vision. (McEwan et al 2007)

Prior to the reforms outlined above taking place, three types of schools existed in Chile: i) *fiscal or public schools* that were managed by the national Ministry of Education, and accounted for about 80% of enrolments; ii) *unsubsidized private schools* that did not receive public funding, catered primarily to upper income households, and accounted for about 6 percent of enrolments; and iii) *subsidized private schools* that did not charge tuition, received limited lump sum public subsidies and accounted for roughly 14 percent of enrolment. (Matear 2007)

As part of the decentralization process, the Ministry now transferred fiscal school management to more than 300 communes (henceforth municipalities), which began to receive a per-student subsidy (voucher) for every child attending their schools. These schools retained their role as "suppliers of last resort" in the sense that they were not allowed to charge tuition and could not turn away students unless oversubscribed. (Mizala and Romaguera 2000)

In order to increase competition between schools, the government decided to facilitate the entry of private educational providers by offering them the same per-student subsidy (voucher) offered to the public schools. To this end, a new category of subsidized private schools was created. Schools in this diverse sector received public funding through the voucher system but were privately financed (and typically operating for profit) and administered individually or part of a consortium. Unlike municipal schools, they had wide latitude regarding student selection, and as of 1994, were allowed to charge fees. As of the reforms of the 1980's it is hence only the unsubsidized, tuition-charging private schools that have continued to operate without public funding. (Mizala and Romaguera 2000)

While there may also have been *political* reasons behind this reform, the underlying *economic* reasoning behind the student attendance-based voucher scheme seems to have been exactly that of neoliberal economist Friedman. Chile's school system was to be improved following a Darwinistic selection process where each school would have an incentive to improve its quality and resource efficiency in order to attract more students. The higher quality schools (or those adapting faster to the demands of students and their families) would then grow, and those that did not perform as well, would lose students, see their income reduced, and tend to disappear. (Gonzalez 2002)

The introduction of the voucher system came to have strong effects on the distribution of students between the three different types of schools (Aedo 1998). Following the reform introducing the voucher system, the subsidized private sector rapidly expanded its coverage to 33% of total school enrolment by 1989. In contrast, the municipal sector's share shrunk to 60% by the same year. This development has continued and in 2003, private institutions accounted for 62

percent of all urban schools, of which subsidized private schools alone accounted for about 48 percent. (Roberts 2007)

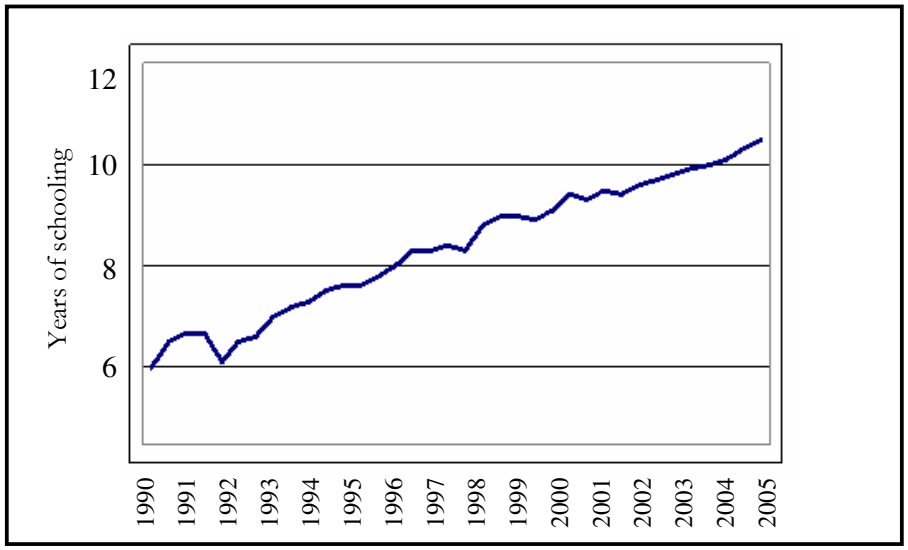
One of the most controversial events in Chile's educational history came to take place on March 10th in 1990, when General Pinochet, on the last day of his seventeen-year dictatorship, changed the Constitution with a law (LOCE) that would guarantee that the neoliberal structure of competition and deregulation even after the end of military rule. Despite being widely criticized by both students and teachers since, this highly controversial law still remains largely unmodified. It is first after Chile's major student demonstration in 2006 that the Chilean government has agreed to re-evaluate this law at a political level. (Roberts 2007)

3.2.2.2 Promoting educational attainment

In the last decades, Chile has experienced two types of reforms. During the first wave, outlined above, the military government introduced one of the most aggressive school choice initiatives in history. Since 1990, successive democratically-elected center-left administrations have, arguably due to political reasons, not changed the Constitution and thereby left the existing school types and management paradigms fundamentally unchanged. (Mizala and Romaguera 2000) The government has instead focused on its ongoing goal of raising educational standards of which increasing the coverage of primary and secondary education has continued to be a key objective (McEwan et al 2007). An important milestone on Chile's road to improvement was the Constitutional reform in May 2003 guaranteeing 12 (rather than eight) years of free, obligatory education. The new level of mandatory, free education makes Chile a special case within Latin America and the coverage of basic and high school education runs high: 99.7% of children aged 5-13 years go to primary school, and 87.7% of all 13-17 year-olds study in high school. (Cox 2004)

Figure 3.2 illustrates Chile's progress in increasing the average years of schooling of its labor force. The graph illustrates that the average level of schooling among the population aged 25 and older has steadily and significantly gone up throughout the entire time period of this study. In just the last three decades, Chile has gone from very modest educational levels to levels almost at par with Western countries.

Figure 3.2 Development of average years of schooling among Chile's labor force

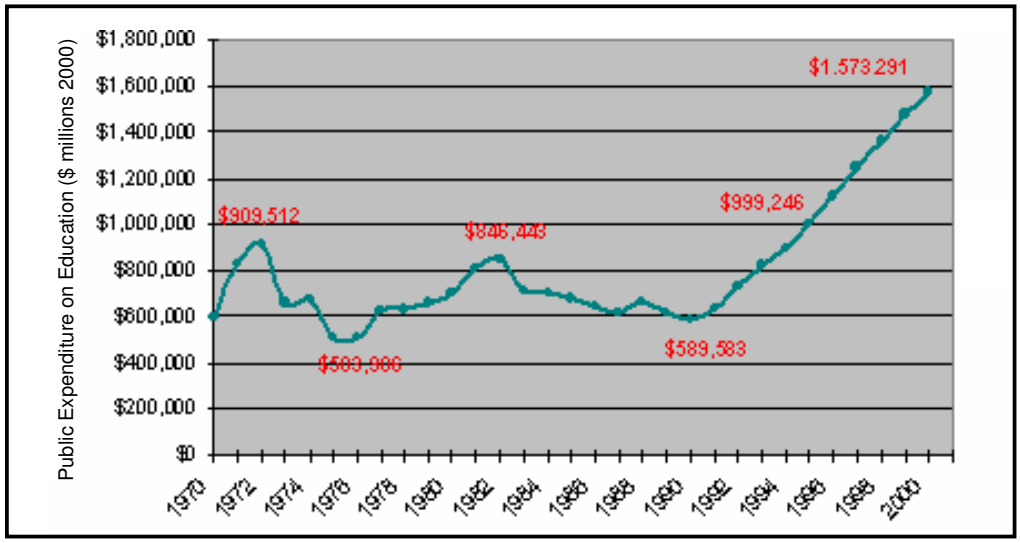


Note: Fuentes et al base these figures on a report conducted by University of Chile
Source: Fuentes et al 2006.

3.2.2.3 Promoting educational quality

Another strong focus of Chilean educational policy, particularly from 1990 onwards, has been to promote educational quality through heavily increasing government expenditure on education (Arrellano 2000). The graph in figure 3.3 shows how public spending on education has evolved over the time period of this study.

Figure 3.3 Development of public expenditure on education, 1970-2000

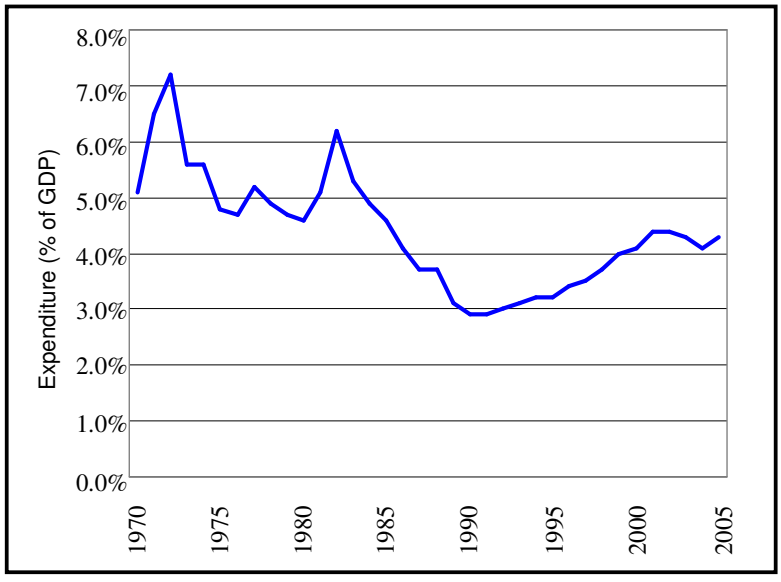


Note: Public expenditure given in millones Chilean pesos. In order to adjust for potential inflation, the public expenditure is given in year 2000's peso value.
Source: Ministry of Education 2002

To further nuance the development of public funding of education, figure 3.4 a and b illustrate the development of Chile's public expenditure as a percentage of GDP and Chile's public expenditure per student during the time period of this study.

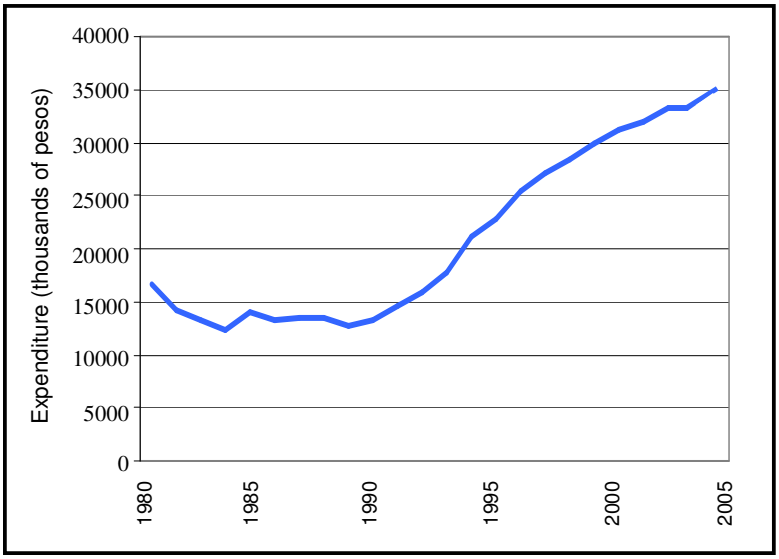
Figure 3.4 Development of Chile's public expenditure on education

3.4 (a) Development of Chile's public expenditure on education as a percentage of GDP



Note: The graph illustrates total public expenditure on education as a percentage of GDP.

3.4 (b) Development of Chile's public expenditure on education per student (primary education)



Note: Public expenditure per student given in thousands of Chilean pesos. In order to adjust for potential inflation, the public expenditure is given in year 2000's peso value. The graph illustrates expenditure per student in Chile's primary education.
Source: Ministry of Education 2005

Figure 3.4a illustrates how Chile took a deep plunge from relatively high figures during the years of recession in the beginning of the 1980's but from 1990 onwards have allocated an increasingly larger share of its GDP to the educational sector.

According to official data from the Chilean Ministry of Education, investment by the state across all levels of education rose from 2.9% of GDP in 1990 to 4.4% of GDP in 2001, and public expenditure was paralleled by strong growth in private investment in education which increased from 1.4% to 3.3% of GDP during that same period. This means that in just over 10 years, Chile has almost doubled the relative share of GDP spent on education (Ministerio de Educacion, 2002). Chile's priority of education over other sectors of the economy is considered high not only by the country's own historical standards, but also by international comparison. For example, Chile has in recent years allocated an average of 18.7% of total government expenditures on education, which is significantly higher than the 6.2% average for OECD countries (Education International 2007).

Figure 3.5b illustrates how Chile's public expenditure on education *per student* at primary level (grade one to eight) has evolved during the same time period. The graph shows a similar development where expenditure dropped during the years of recession, but then picked up substantially upon Chile's return to democracy.

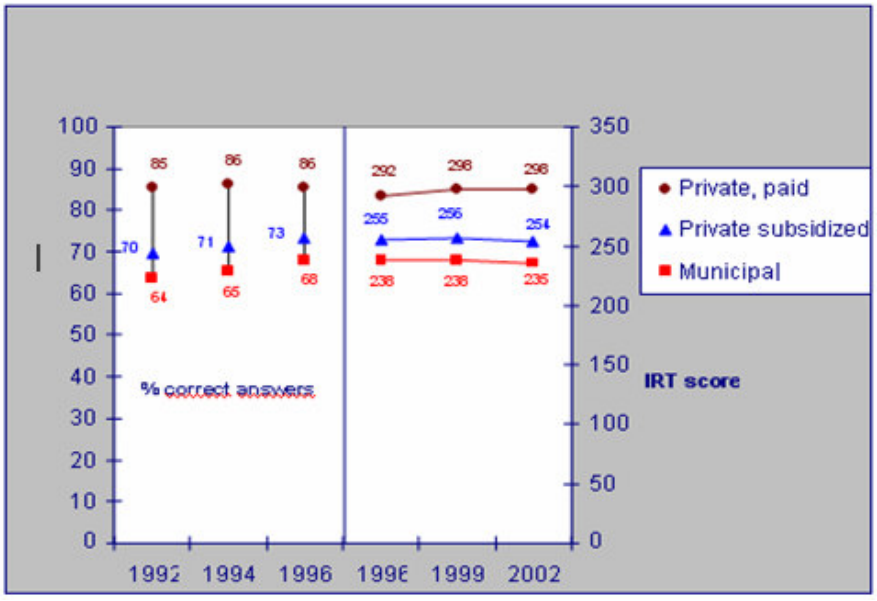
3.3 How do Chilean students perform?

Chile was one of the first countries in Latin America to introduce national student tests to monitor and improve the educational performance of schools. The fact that Chile became a regional pioneer in this area goes back to the reasoning behind Pinochet's neoliberal reform; through assessing information on different schools' performance, parents could make the best choices for their children. In 1988, The Ministry of Education (MINEDUC) hence introduced The National Assessment System of Learning Outcomes (SIMCE), which carries out census-type tests on all schools and students in the country, testing Mathematics and Spanish at fourth and eight grade in alternate years. (Mizala and Romaguera 2000)

While Chile has been proactive in the application of standardized achievement tests and the dissemination of their results (for instance, schools' unadjusted SIMCE scores have been published in Chilean newspapers since the mid-1990s), Chile - like much of Latin America - has found the task of improving learning to be a slow process (Tokman 2004). Over 60% of students do not achieve the desired learning targets by grade eight, and figure 3.5 illustrate that Chilean student performance has only improved modestly over time. Chilean students are not only performing below the country's own standards, they are also performing low by international standards. (McEwan et al 2007) Hsieh and Urquiola (2006) suggest that Chile's relative performance in international tests has not changed much since the 1970's and that Chile, as shown in figure 3.6, is still underperforming relative to countries with similar per capita GDP.

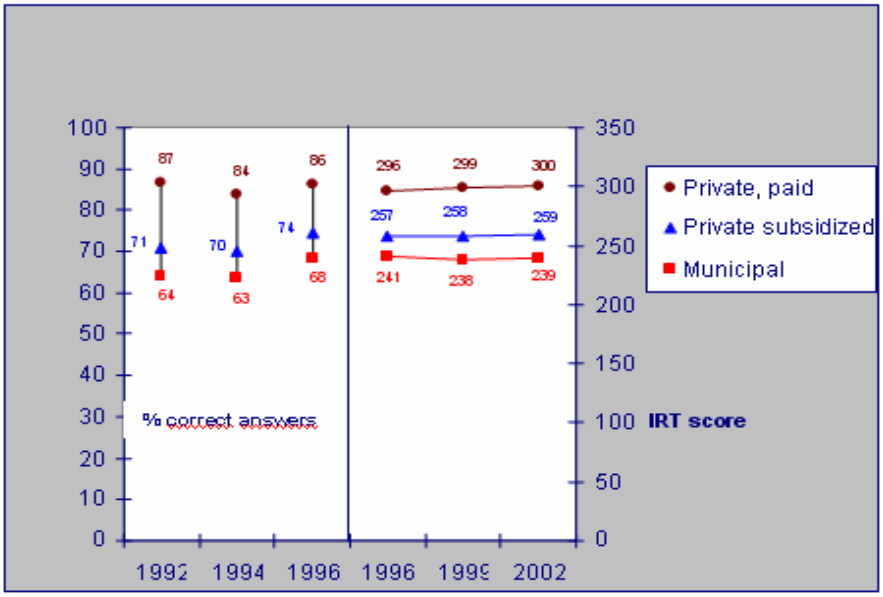
Figure 3.5 Development of Chilean student performance

3.5 (a) Fourth Grade Mathematics: Trends in SIMCE Scores, 1992-2002



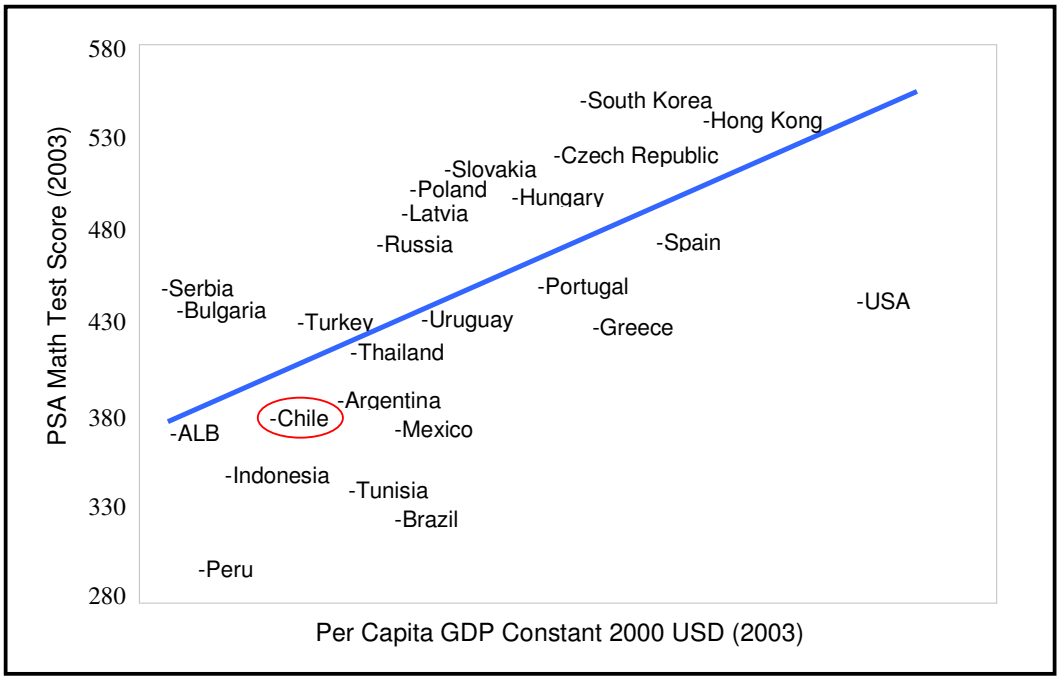
Note: During 1992-1996 series are expressed as percentages; 1996-2002 series are expressed as an IRT score.

3.5 (b) Fourth Grade Language: Trends in SIMCE Scores, 1992-2002



Note: During 1992-1996 series are expressed as percentages; 1996-2002 series are expressed as an IRT score.
Source: C. Bellei (2003), based on the Ministry of Education, SIMCE, Research and Statistics Department.

Figure 3.6 Chilean student performance by international comparison



Notes: PISA 2003 Math Scores and GDP. PISA 2000 scores were used for the countries that did not participate in 2003.
Source: Vegas and Petrow (2007) using data from OECD (2000; 2003)

4 EMPIRICAL METHODOLOGY

This chapter describes and justifies the methodology used for this study. The first part of the research work contains an econometric examination of whether a long-run relationship actually can be found between education and economic growth in the case of Chile. Based on the econometric findings, this study then uses a more eclectic approach to analyzing how Chile has performed in various dimensions of education and the potential economic and educational policy implications from these findings.

4.1 Background to study

The society of today is a global, knowledge-based society in which information holds a central position for production, economy, and society at large. It is therefore important to understand the role that "intellectual capital" or "human capital" plays for economic development.

There are several reasons to why the focus of this study is on Chile. Firstly, Chile is a country that in many respects has been successful in building an institutional framework for economic growth (Ramirez 1996). However, for some reason education is considered the country's Achilles' heel and Chilean student performance is low compared to other countries with similar GDP per capita. This makes Chile an interesting country to study, as potential benefits from educational improvements could be large. Secondly, there is, to the best knowledge of the author of this study, no prior work that empirically investigates the presence of a long-run relationship between education and economic growth specifically for Chile.

4.2 Research process

This thesis began with the reading of theory, starting with the study of a large amount of literature about human capital and economic growth. Simultaneously, the empirical model was specified, deducing the hypotheses from the theory. Since there is little country-specific information on whether education is linked to economic growth, the primary focus was to examine empirically whether or not this link could be found in the case of Chile by using an econometric approach. Based on the results of this examination, this study continued in a more eclectic way to follow up, on a theoretical and empirical basis, how Chile has performed in various aspects of education. This part of the research process involved reviewing a wide range of empirical literature on Chile, reflecting mainly on the strengths and weaknesses of the economy and on the developments and performance of its educational sector. The aim has been to focus on recent papers and to find a balance between working papers published by international organizations and reports generated by local authorities and academics that capture the current debate in Chile. Therefore, a large part of the empirical work referred to in this study has not been translated or published outside Chile. A significant number of these studies was found through the author's contact with organizations such as the Central Bank of Chile and Chile's Ministry of Education.

The remainder of this chapter outlines the methodology of this thesis in more detail, starting off by specifying the model deducing the hypotheses from the theory formulated in chapter two. The selection of variables and proxies included in the model are then presented and justified, followed by a description of the source, sampling and quality of the data used. A presentation and a discussion on the statistical methods used for testing this model are provided next. Finally, this chapter offers a discussion on the overall validity and reliability of this study.

4.3 Specification of the model

The purpose of this section is to specify a model that allows us to investigate the relationship between various educational measures and economic growth for the Chilean economy in the period 1973-2005. This model (expressed in equation [4-1] below) is deduced from the endogenous growth theory outlined in chapter two and has been specified with the guidance of Economics Professor Aurora Teixeira University of Porto, Portugal), who uses a similar model for examining the link between human capital and economic growth in Portugal (Fortuna and Teixeira 2003).

In more technical terms, the model is specified so that it allows for investigating the long run structural relations between Chile's total factor productivity, Chile's educational quantity and Chile's educational quality. These structural relations are based on a log-linear specification of the joint evolution of total factor productivity (proxy of technological progress), educational quantity (average years of schooling) and educational quality (government expenditure on education as a percentage of GDP):

$$F_t = \beta_o + \beta_1 E_t^{\text{quantity}} + \beta_2 E_{t-x}^{\text{quality}} + u_t \qquad [4\text{-}1]$$

where F_t is the (natural) logarithm of the total factor productivity (TFP) level for the year t; E_t^{quantity} is the logarithm of the average number of years of schooling (proxy for educational quantity) for the year t; E_{t-x}^{quality} is the logarithm of government expenditure allocated to the educational sector as a percentage of GDP (proxy for educational quality) for the year $t - x$. β_1 and β_2 are the TFP elasticities of educational quantity and quality respectively, and finally, u_t is a random perturbation term.

Based on the reasons outlined in the theoretical framework of chapter two, this thesis bases its model on the theory behind the endogenous growth models. This means that the model is specified in such a way that the explanatory, educational variables enter as potential influences of economic growth through the technology parameter rather than as a separate production factor as the neoclassical approach would assume. Consequently total factor productivity (TFP) - and not GDP – is assigned to be the dependent variable in this model. As TFP is considered an important source of economic growth, this model allows us to investigate whether there is a link between educational measures and economic growth in the way that the endogenous growth theory predicts (Fortuna and Teixeira 2003).

As outlined in chapter two, the underlying theory behind this model is that a more educated labor force (both in terms of the quantity and the quality of education undertaken) is the main reason behind the creation or imitation of new, more sophisticated technology. This technological progress will in turn lead to an increase in total factor productivity, which is an important source of long-term economic growth. In other words, productivity tends to increase when educational quantity (E_t^{quantity}) grows, *ceteris paribus*. Analogously, greater educational quality should over time lead to a more productive labor force. Therefore, theory suggests that productivity will be positively related to educational quantity as well as educational quality, that is $\beta_1 > 0$ and $\beta_2 > 0$.

While TFP has been selected as the best available proxy of technological progress, it is important to note that this proxy also has some limitations. As indicated by Abramovitz (1993), TFP is properly interpreted as a reflection of unmeasured sources of growth; it includes, besides technological advance, also changes in labor quality, gains from the better allocation of resources and those from the economies of scale – unless these are somehow measured. This means that educational measures may not be the only factors affecting TFP. However, as these other potential factors are not easily identified nor easily proxied for, the specification of the empirical model is

limited to incorporating educational measures, proxying for human capital and thereby the potential for innovation and imitation of new and better technology. (Fortuna and Teixeira 2003) The reason why both the quantitative and the qualitative dimensions of education are incorporated in the model is to give a more "all-encompassing" measure of education as a potential influencer of economic growth.

As specified above, this model uses the (natural) log of each variable rather than the raw levels of these time series. This is due to the frequency of so-called heteroskedasticity in economic time series (strongly trending series such as GDP, aggregate consumption and aggregate investment are likely to be associated with higher variability in absolute terms as the levels of these variables increase), which unadjusted may lead to inaccurate statistical results. (Fortuna and Teixeira 2003)

4.3.1 Choice of variables and proxies

The following sections provide a more detailed outline of the variables included in the model and the corresponding proxies selected to reflect these variables respectively.

4.3.1.1 Total factor productivity

As already outlined, this study builds on the theory behind endogenous growth models. Therefore, TFP rather than GDP is assigned to be the dependent variable in the model. This way, the model specifies human capital as a potential influencer of economic growth via the technology parameter rather than as a separate production factor.

4.3.1.2 Educational quantity

The variable of educational quantity constitutes one of the two explanatory variables in the model. This variable reflects the quantitative dimension of education, which has been a key focus of Chilean policy-makers. As outlined in chapter two, there are quite a few alternative proxies for reflecting the quantity of education, of which some of the most popular ones are literacy rates, enrolment ratios and average years of schooling. As this thesis tests for a link between education and TFP, it is crucial to find the proxy that best captures the level of education of the specific demographic group(s) that actually is in a position to determine the TFP of the economy, namely the *workers*. In order to find the proxy that best meets this requirement, each of the above proxies was evaluated before the most appropriate proxy was selected. The reasoning behind this selection is provided below.

Literacy rates provide some insight into the level of education obtained, but the problem with this measure is that it only acknowledges the first phase of human capital creation. Thus, using literacy rates as a proxy of human capital implies the implicit assumption that education beyond the most basic level does not significantly contribute to productivity. As outlined in chapter three, the last three decades of Chilean educational policy has to a large extent evolved around increasing the number of students attending secondary and tertiary levels of education rather than just making sure that graduates can read and write. This implies that literacy rates may be more applicable as a proxy for educational progress in less developed countries, than in a country like Chile that for some time has been able to take this basic skill more or less as a given for the vast majority of its population.

The second potential proxy for educational quantity is enrolment ratios. While this proxy is probably more applicable to this study than the proxy of literacy rates, it still has some significant limitations. Most importantly, this proxy does not meet the criteria of capturing the quantity of education obtained among Chile's workers as this proxy only reflects how much education today's average *student* has. As the underlying theory behind the model is that it is primarily the workers and not the students that affect TFP, this proxy is neither very applicable for this study.

Barro and Lee's (2000) introduction of using average years of schooling of the population aged 25 years or older as a proxy for educational quantity come closer to what this study tries to capture (namely educational quantity among Chile's labor force). However, this measure also has its inadequacies, stemming from the fact that a significant share of Chile's 25+ population consists of older people that are no longer part of the active workforce. As educational attainment among Chileans was relatively low just a few decades ago, the older, retired people in this demographic group are likely to represent lower averages of schooling, bringing down the overall average of schooling of the population aged 25+. This means that this proxy may underestimate the average level of education among currently active workers. A proxy that directly measures the average level of schooling among Chile's *labor force* would therefore be more desirable for the purpose of this thesis. After some research, data for this proxy was found in a work by Fuentes et al (2006) where the average level of schooling among Chilean workers is estimated based on a report developed by University of Chile. As expected, these averages are slightly higher than the averages reflecting educational attainment for the entire 25+ population. Consequently, the proxy of average years of schooling among Chile's workers was used for this study. There are theoretical findings indicating that this measure could be further refined by using a *weighted* average, reflecting potential diminishing marginal returns from additional years of education (Wößmann 2000). This is however, a relatively new notion that so far has only been used in a small number of empirical studies. Based on the limited literature on how to best calculate this weighted average, this study therefore uses unadjusted averages.

4.3.1.3 Educational quality

As outlined in the theoretical framework of chapter two, it is not just the *quantity* of education, but also the *quality* of education, that seem to matter for economic growth. Therefore, the model expressed in equation [4-1] also includes the variable educational quality in order to incorporate the *qualitative* dimension of education and its potential link to TFP.

As for educational quantity, there are several alternative proxies for educational quality in the empirical literature, ranging from input-based to output-based measures. While more output-based measures, such as student test results on cognitive skills, is generally considered the better measure (as it directly measures what skills students actually have obtained), there is currently not enough data in Chile to compose sufficiently long time series for econometric testing. Therefore, this particular proxy was simply not available for the econometric examination of this study. In this thesis, an input-based proxy is hence used due to the above-outlined restrictions of available data, but the author also realizes the limitations of using this type of proxy.

This study uses government expenditure on education as a percentage of GDP as a proxy for educational quality. This is partly due to the fact that out of the input-based proxies, this proxy has received significant support from other empirical studies (Mizala and Romaguera 2000; Teles and Andrade 2004). The reasoning goes that the government is typically directly responsible for the majority of the investments in basic education. It is hence possible to relate the accumulation of human capital to government spending. Another reason to why this proxy was used, stems from the simple reason that it was one of the few proxies for which data is actually available for the given time period of this study. This proxy reflects *government* expenditure rather than *total* expenditure as the former is more directly linked to Chilean *policy* decisions. In addition, the former figures are easier to verify than the latter. The reason why the proxy selected measures government expenditure in percentage form rather than in absolute figures is in order to reduce the risk of reverse causality. (Economic growth may lead to increased government expenditure in absolute figures across all sectors while the relative expenditure rather reflects the level of priority of education relative to other sectors regardless of economic growth). (Sianesi and Van Reenen 2000)

As this study attempts to investigate the link between educational measures and TFP, this study has to the extent possible attempted to capture the quality of the education received among Chilean *workers*. The variable of educational quality has therefore been lagged four years and six years respectively relative to the TFP variable in order to allow for the average student (who received a certain quality of education) to move into the labor force and consequently have a larger potential impact on TFP. The key reference for the choice of lag length was the paper "Public Education Expenditures and State Economic Growth: Northeast and Sunbelt Regions" (Quan and Beck 1987).

4.4 Data - sources, sample and basic facts

For the calculation of the dependent variable, time series index of TFP developed by Fuentes, Larrain and Hebbel (2006) has been used. Data for all the observations of the explanatory variables have been collected from publicly available sources and based on data published in reports produced by Ministry of Education and University of Chile.

The selected time period for our model is 1973-2005. Based on guidance from Economic Professor Aurora Teixeira (University of Porto, Portugal) and Statistical Dr. Kenan Matawie (University of Western Sydney, Australia), this time period was selected on the *economic* basis that it marks the beginning of the current structures in Chile's educational system and on the *statistical* basis that each of the time series should consist of at least 30 consecutive observations in order to generate justifiable results from an econometric point of view.

4.5 Testing the model

The following sections provide an account of the econometric techniques used for testing the model in [4-1].

4.5.1 Using a time-series approach

For the reasons outlined in chapter two, this paper acknowledges that a country's potential for educational and economic performance is unique. Therefore, the most appropriate method for testing whether a link between education and economic growth can be found in the particular country of Chile is to conduct a country-specific study rather than relying on cross-country results as many previous studies have done. The research approach of this study has therefore been to use time-series analysis.

As time-series analysis requires some further statistical considerations before determining the specific method of testing the model, the following sections give an account of some of these considerations.

4.5.2 Concept of nonstationarity, integration and unit roots

It is only in relatively recent years that economic papers have acknowledged the additional statistical considerations required for obtaining reliable results from time-series analysis. It has now become widely recognized that when dealing with economic time series, the use of classical regression methods are often limited. The nature of the time series must first be considered from a statistical point of view before the most appropriate method for estimating the given time-series can be established. (Hargreaves 1994)

In order to form confirm the nature of the time-series, the variables should first be checked as to whether they can be considered stationary or non-stationary; whether they contain unit root(s) and at which order the time series are considered to be integrated (Perman 2006). Since these terms and underlying concepts may be unfamiliar to some of the readers, a brief outline is provided on

what is meant by these terms so that these general concepts later can be applied to the examination of this thesis.

4.5.2.1 Nonstationarity

A time-series is considered stationary if its mean, variance and auto-covariance remain constant over time. In contrast, a series where these values are likely to change over time is typically nonstationary. Time series of macro-economic variables such as GDP per capita or government expenditure are typically nonstationary as they are likely to exhibit trends in their means over time. (Perman 2006)

Stationarity is of particular importance to the empirical researcher because, in general, the classical methods of estimating economic models, such as the Ordinary Least Squares (OLS), assume that the variables of concern are stationary (Österholm 2003). This implies that if we are interested in estimating parameters or testing hypotheses of a model where at least one of our variables is nonstationary, standard techniques are largely invalid and may well produce "spurious" results, deprived of any economic meaning (Granger and Newbold 1974).

4.5.2.2 Integration

A non-stationary series which by differencing *d* times transfers to a stationary one, is called integrated of order d and denoted as I(d). For example, when a series y_t is integrated of order 1, it means that it is not itself stationary, but that its first differences are stationary. A series that is stationary from the very beginning, so that differencing is not required, is said to be integrated of order zero, denoted I(0). (Charemza and Deadman, 1997)

4.5.2.3 Unit root(s)

In the case that a time series of a certain variable is nonstationary but becomes stationary when the first difference is taken of the series, the series in question is said to possess a single "unit root". If a series does not become stationary until it has been differenced more than once, the series is said to have multiple unit roots. (Perman 2006)

4.5.3 Testing for unit root(s) in time series

Formal statistical tests that check for unit roots in time series are typically used in order to determine whether the relevant time series is nonstationary, and if so, at which order the series is integrated. To a large extent, the results from this statistical test in turn determine the appropriate method for estimating the parameters or testing the hypothesis of the specified model. If the series is found to be stationary, it does not contain any unit root(s) and conventional regression methods can therefore be used. If however, the series turn out to be nonstationary and unit root(s) are found, alternative methods need to be applied to avoid spurious regressions. (Dickey and Fuller 1981)

This means that in order for this study to establish the most appropriate method for testing the specific model in [4-1], the time series selected for this study must first be tested for nonstationarity and unit roots. This study adopts the Augmented Dickey Fuller test (ADF-test) for this purpose.

The ADF (Augmented Dickey-Fuller) test is the *t*-statistic on φ in the following regression:

$$\Delta y_t = \mu_t + \varphi y_{t-1} + \sum_{i=1}^{p} \gamma_i \Delta y_{t-i} + \epsilon_t \qquad [4\text{-}2]$$

This test statistic is probably the best-known and most widely used unit root test. It is a one-sided test whose null hypothesis is $\varphi = 0$ versus the alternative $\varphi < 0$. Under the null, the variable y_t must

be differenced at least once to achieve stationarity; under the alternative, the variable y_t is already stationary and no differencing is required. Hence, large negative values of the test statistic lead to the rejection of the null. (Dickey and Fuller 1981) The corresponding p-values (statistical measures of how much evidence we have against the null hypothesis) are calculated by means of the algorithm developed in MacKinnon (1996). Simply put, the smaller the p-value, the more evidence we have against the null hypothesis (Dickey and Fuller 1981).

A benefit with adopting the *Augmented* Dickey-Fuller test, is that it uses varying lag orders to correct for serial correlation, which otherwise may distort the size of critical values for the test statistics used. By including p number of lags of the dependent variable (y_t), these lags can "soak up" any dynamic structure present in the dependent variable, to ensure that the residual (ε_t) in equation [4-2] is not auto-correlated. Since this is a practical problem that needs to be taken into consideration, particularly in small samples such as the one of this examination, this extended version of Dickey-Fuller's test was adopted for this study. (Dickey-Fuller 1981)

The number of lags (p in equation [4-2]) should be chosen as to ensure that the regression in [4-2] is a parametrization flexible enough to represent adequately the short-run persistence of Δy_t. Setting p too low results in size distortions in the test, whereas setting p too high would lead to low power of the test. (Perman 2006) As a convenience to the user, the statistical software application used for this study (Gretl 1.65) gives the option to automatically determine the parameter p by testing down from maximum lag order. Consequently, the lag orders used in the ADF-tests conducted for this thesis were automatically calculated by the statistical program itself.

4.5.4 Testing for co-integration

As the following chapter confirms, all the variables in the model expressed in equation [4-1] are considered non-stationary, but they become stationary at first difference. This implies that these log series contain single unit roots and are integrated at first order. This consequently means that classical regression methods such as OLS are not appropriate for estimating this model. However, in order to still be able to examine whether there is a link between our dependent and explanatory variables, these variables can be tested for co-integration. (Johansen 1991) This method, first introduced by Engle and Granger (1991), means that if there exists a linear combination of two or more nonstationary series integrated of order one (I(1)) that is stationary, these series are considered co-integrated series. Co-integration analysis is hence concerned with testing for long run (economic) relationships among non-stationary, integrated variables. (Onay 2006)

In this study, the presence of co-integration in the model in [4-1], would imply that there is a long-run relationship between Chile's educational variables and the country's TFP. In other words, the presence of co-integration would provide empirical evidence that educational aspects such as educational quantity and educational quality are linked to economic growth in Chile during the given time period of this study.

Two basic methodologies are available for testing for co-integration; Engle-Granger and Johansen methodologies. While the Engle-Granger is most suitable for bivariate settings, Johansen's (1991) methodology is a maximum likelihood approach for testing co-integration in multivariate models. Since the model in [4-1] contains three different variables and the number of potential co-integration vectors is unknown, this study adopts the methodology developed by Johansen (Fortuna and Teixeira 2003).

4.5.4.1 Johansen's co-integration test

The following section provides a relatively technical outline for Johansen's co-integration test and the underlying mathematical concepts from which this test is derived. This part of the paper is written for readers who want a more in-depth explanation of Johansen's methodology. The

remaining chapters of this thesis are composed in such a way that an understanding of the below is not required for appreciating the analysis of this study.

The starting point for understanding the methodology behind Johansen's co-integration test is to consider a vector autoregression (VAR) of order p with a deterministic part given by μ_t (typically, a polynomial in time). It is then possible to write the n-variate process y_t as

$$y_t = \mu_t + A_1 y_{t-1} + A_2 y_{t-2} + \cdots + A_p y_{t-p} + \epsilon_t; \qquad [4\text{-}3]$$

However, this model can be re-cast in a form more suitable to analyze the phenomenon of co-integration. Since $y_t = y_{t-1} - \Delta y_t$ and $y_{t-i} = y_{t-1} - (\Delta y_{t-1} + \Delta y_{t-2} + \ldots + \Delta y_{t-i+1})$, the *Vector Error Correction* form of the previous model is given by

$$\Delta y_t = \mu_t + \Pi y_{t-1} + \sum_{i=1}^{p} \Gamma_i \Delta y_{t-i} + \epsilon_t, \qquad [4\text{-}4]$$

where $\Pi = \sum_{i=1}^{p} A_i$ and $\Gamma_k = -\sum_{i=k}^{p} A_i$.

The rank of Π reflects the number of stationary combinations (or co-integrating vectors) of the variables included in the model. If the rank of Π equals zero, the processes are all I(1); if the rank of Π is full, the processes are all I(0); in between, Π can be written as αβ' and you have co-integration. (Johansen 1991)

The rank of Π is investigated by computing the eigenvalues of a closely related matrix (call it *M*) whose rank is the same as Π: however, *M* is by construction symmetric and positive semidefinite. (Gretl User Guide 2007)

As a consequence, all its eigenvalues are real and non-negative; tests on the rank of Π can therefore be carried out by testing how many eigenvalues of *M* are 0. If all the eigenvalues are significantly different from 0, then all the processes are stationary. If, on the contrary, there is at least one zero eigenvalue, then the y_t process is integrated, although some linear combination $\beta' y_t$ might be stationary. On the other extreme, if no eigenvalues are significantly different from 0, then not only the process y_t is non-stationary, but the same holds for any linear combination $\beta' y_t$; in other words, no co-integration occurs. Johansen's methodology consists of two tests: the "λ-max" test, for hypotheses on individual eigenvalues, and the "trace" test, for joint hypotheses. The corresponding p-values are computed via the approximations by Doornik (1998). (Gretl User Guide 2007)

In this study, the vector y_t in equation [4-4] comprises the three variables, TFP, HQA and HQE and the number of lags has been selected to one based on Schwartz Bayesian criterion (BIC). If both the trace and λ-max accept the null hypothesis that the smallest eigenvalue is in fact 0, we may conclude that the series are in fact non-stationary. However, some linear combination may be I(0), as indicated by the rejection of the λ -max or trace of the hypothesis that the rank of Π is 0. The Johansen test for co-integration is used to establish the rank of β; in other words, how many co-integration vectors the system has. If co-integration is present, there is a long-run relationship among our series. (Gretl User Guide 2007)

4.6 The quality of the study

Two important general criteria to be satisfied in any research are the ones of validity and reliability (Bulmer and Warwick 1983). In order to evaluate the quality of this study, the following sections evaluate how well this study fits the criteria of scientific research.

4.6.1 Validity of study

The validity of the study refers to how well a study measures what it attempts to measure. As outlined in the introduction of this thesis, the objective of this thesis is to empirically investigate whether there seems to be a long-run relationship between education and economic growth in Chile during the time period 1973-2005, and if so, discuss potential implications for Chilean economic and educational policy based on economic theory and empirical findings. Since both educational quantity and educational quality are relatively broad concepts and there are no perfect proxies of these explanatory variables (especially not for the latter), this thesis can only approach the above question by investigating if a relationship can be found between some of the *measures* taken to improve educational standards and economic growth. While there is an array of educational measures and aspects that may be linked to economic growth (which in turn can be broken down to even more detailed and specific measures), this thesis focuses on two main aspects, being the quantity and quality of education. This delimitation should hence be taken into account when analyzing empirical findings of this study in a wider perspective.

The framework of this thesis is mainly based on the new, endogenous economic growth theory where education is assumed to be linked to economic growth via the technology parameter. However, Chile's education could potentially also be linked to the country's economic growth as a separate production factor, like the neoclassical approach assumes. It is therefore important to acknowledge that the empirical findings presented in this thesis are mainly analyzed in the light of endogenous growth theory. This does however not imply that this is the *only* channel through which Chile's education may be linked to Chile's economic growth.

As outlined in chapter two, potential problems of omitted variables and reverse or bi-directional causality have been identified in empirical studies on education and economic growth. Due to these econometric contingencies, this thesis avoids providing specific policy recommendations based solely on the statistical results attained. Rather, the purpose of this thesis is to econometrically examine whether a link between education and economic growth can be found in Chile during the period 1973-2005, and if so, discuss potential policy implications based on economic theory and a wider range of empirical findings presented in this paper. This final part of the study is limited to the author's own reading and reflections of the enormous literature on education and economic growth and their relevance for Chile.

4.6.2 Reliability of study

The criterion of reliability refers to the extent to which a research study gives a consistent and reproducible result. In other words, any other researcher should be able to replicate the study and reach the same results. (Bulmer and Warwick 1983)

As this study to a large extent attempts to bridge economics and statistics, the author has consulted several experts from these respective fields in order to ensure the quality of this study. The author initially conferred with Economists who have conducted similar studies to this one for other countries. This was done in order to get a deeper understanding of the economic theory underlying these empirical studies and in order to get some guidance in the specification of the empirical model. Statistical experts with experience in using time series analysis (and co-integration techniques in particular) were then consulted in order to make sure that this study would not only

meet the economic, but also the statistical criteria of research. Parallel to this, locally based authorities and academics with an extensive knowledge about Chile's economic and educational development were consulted. Of particular assistance in this research process was Economics Professor Aurora Teixeira (University of Porto, Portugal) who shared valuable insights from her work in this area and who made herself available for discussing the specification and testing methods of the model. The author would also like to acknowledge Statistics Professor Soren Johansen (University of Copenhagen, Denmark) for his helpfulness and patience in explaining part of the relatively advanced methodology behind his tests. This thesis also benefited from the support of Statistics Professor Kenan Matawie (University of Western Sydney, Australia) who assisted in the interpretation of the statistical results and who also assisted in making sure that the econometric tests were handled correctly in Gretl, the statistical software application used for this study. Finally, the author would like to recognize the assistance of Professor Mats Lundahl (Stockholm School of Economics, Sweden) who as the tutor for this thesis work provided ongoing feed-back during the research process.

As outlined in chapter two, the issue of data quality (or lack of) is a common theme in many of the studies conducted on the topic of education and economic growth. In order to minimize the extent of this problem in this particular study, a number of measures have been taken. First, all data and information on Chile (both the data used for the econometric examination and the empirical background provided and analyzed in conjunction with this examination) have been collected from published reports from a selection of recognized, official entities, such as Chile's Ministry of Education and the World Bank. While this is typically a good indication of reliability, its accurateness could be questioned on the basis of the critique that data from developing countries are particularly prone to inaccuracies due to corruption and inexperience in statistical handling of data (Bulmer and Warwick 1983). This study has however aimed to reduce this risk by carefully discussing the accuracy of this data with experts at the Centre of Applied Economics (CEA) in Chile. In addition, different sources of data have been compared to verify the recorded values of the variables included in the econometric examination and to confirm the reliability of other empirical findings presented in this thesis. In sum, this problem has been approached as thoroughly as possible in order to minimize the data reliability constraint. Nevertheless this constraint should be kept in mind when interpreting the results of this study.

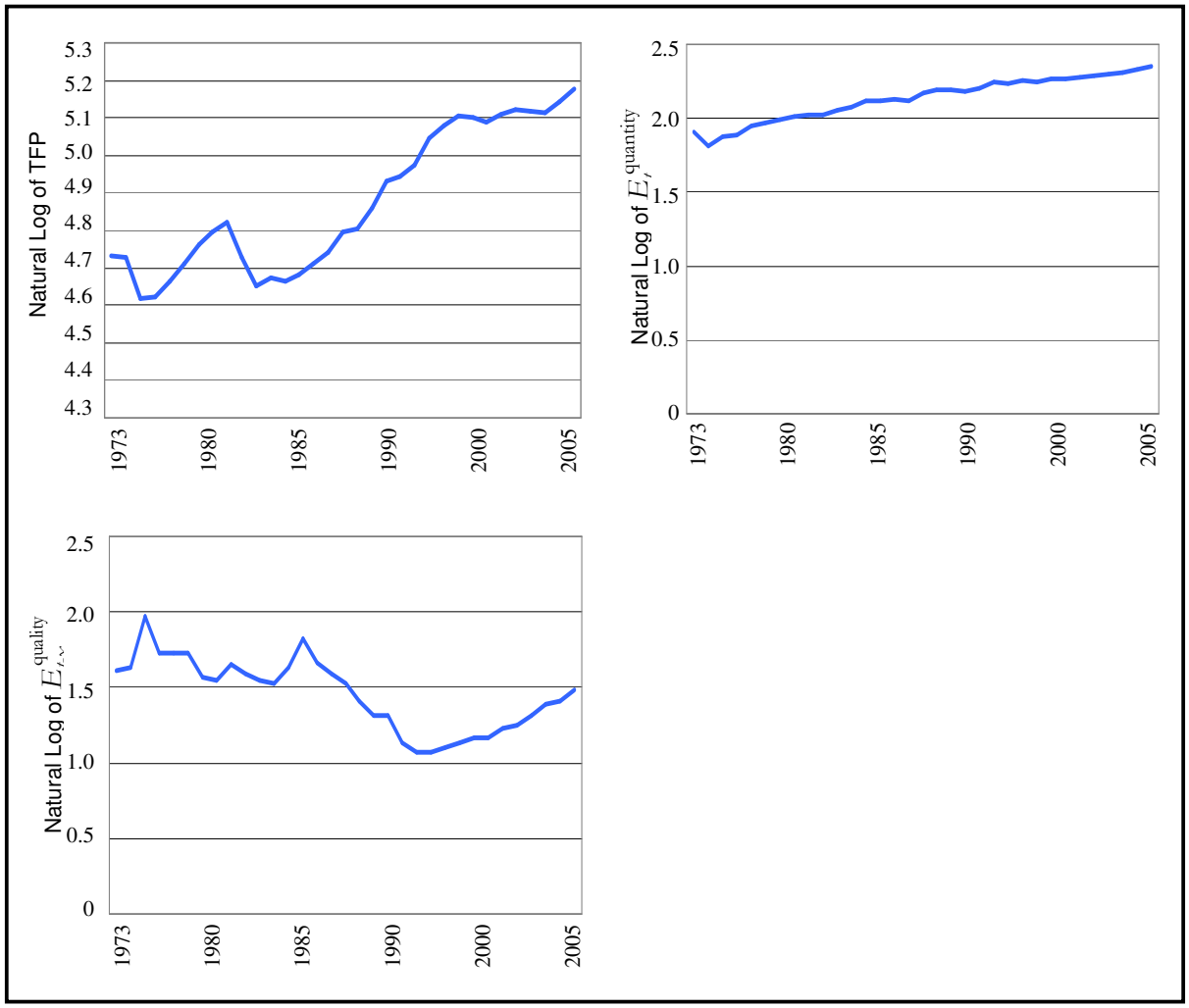
Another potential problem in time-series analysis is that the relevant time series are not sufficiently long to ensure reliable results. The time-period of this study is limited to 1973-2005 due to lack of available data from previous years as well as the problem of including time periods with many *structural* changes in the areas investigated, in this case, the educational system. While this study meets the general statistical criterion of having at least 30 consecutive observations in each time-series, the time-period of this study is still relatively short. In light of the fact that longer time-series are generally considered to give more reliable results, this aspect should hence be taken into account.

5 STATISTICAL RESULTS

5.1 Time plot of variables

The starting point of the econometric examination is to establish whether the time series are stationary or not, so that the appropriate method for testing the model in [4-1] can be established. In many cases, particularly with macroeconomic data, it is quite possible to conclude, on the basis of theory and by looking at a plot of data against time, whether a variable is stationary or not. Figure 5.1 below shows the evolution of our logged variables, being educational quantity (E_t^{quantity}), educational quality ($E_{t\text{-}x}^{\text{quality}}$) and total factor productivity (TFP).

Figure 5.1 Evolution of Chile's TFP, Years of schooling and Public educational expenditure



The graphs show that TFP and E_t^{quantity} seem to exhibit some strong positive trends over time, while $E_{t\text{-}x}^{\text{quality}}$ shows more of a quadratic trend displaying a negative trend from the year of economic recession in 1985 until 1990 when its starts displaying an upward trend again. The fact that all variables seem to exhibit strong trends, gives reason to think that these variables may indeed be nonstationary. However, while the graphs above may give some preliminary insight, this is primarily a matter to be decided empirically. The reason behind this argument is that one cannot be sure of whether these series are stationary but exhibit deterministic trends, or whether they

indeed exhibit a stochastic trend and therefore contain unit roots (Perman 2006). In order to establish this, formal statistical unit-root tests are required. For the reasons outlined in chapter three, this study adopts the Augmented Dickey Fuller (ADF) test for this purpose.

5.2 ADF-tests for nonstationarity or unit roots

Table 5.1 ADF unit root test results (variables in levels)

Series	Constant		Constant & Trend		Constant & Quadratic Trend	
	t-statistic (lags)	p-value	t-statistic (lags)	p-value	test-statistic (lags)	p-value
TFP	-0.313603 (1)	0.9206	-2.81136 (1)	0.193	-2.61512 (1)	0.5028
E_t^{quantity}	-3.01305 (1)**	0.03371	-2.5714 (0)	0.2947	-6.74933 (0)***	8.604e-005
$E_{t\text{-}x}^{\text{quantity}}$	-1.59948 (0)	0.4713	-1.108 (0)	0.9119	-1.68038 (0)	0.8908

Notes: For these series a model is specified with a) constant only; b) constant and time trend; and c) constant and quadratic time trend. MacKinnon (1996) critical values for rejection of hypothesis of a unit root, that is *nonstationarity* at * 1%, ** 5% and *** 10%.
Legend: TFP*:* natural logarithm of Chile's TFP index 1973-2005; E_t^{quantity}: natural logarithm of the index of average years of schooling of Chile's labor force 1973-2005; $E_{t\text{-}x}^{\text{quality}}$: natural logarithm of the public expenditure on education as a percentage of GDP per capita in Chile 1973-2005.

Table 5.1 reports the t-statistic and p-value for each ADF test of the variables. Simply put, the way these values can be interpreted is that if the p-value is sufficiently low (0.1 or below) or analogously, if the negative value of the t-statistic is very large, the null hypothesis of a unit root can be rejected. The lower the p-value of the test is (or the greater the negative value of our t-statistic is), the more stationary is the series. If the p-value is lower than 0.10 it is considered significant at the level of 10% whilst a p-value equal or lower than 0.01 is even more significant as it is so at the level of 1%.

In order to nuance the results further, the ADF-tests have been conducted in such a way that they allow for three different underlying specifications of the model; a) with constant only; b) with constant and time trend; and c) with constant and quadratic trend. As can be seen from the results reported in table 5.1, the null hypothesis of a unit root can *not* be rejected for TFP or $E_{t\text{-}x}^{\text{quality}}$ no matter what the underlying specifications of these series are. The results on E_t^{quantity} imply that the series is stationary if the model is specified with a constant only or with a constant and a quadratic trend (a) or c)). If the model however is specified with a constant and trend, the null hypothesis of a unit root can not be rejected for this variable either. As the plot for E_t^{quantity} in figure 5.1 clearly indicates the presence of a strong upward trend for virtually the entire time period of the series, there is support for the specification of constant and trend (b)) being the most relevant one for this series. As the null hypothesis of a unit root can not be rejected with this specification, the overall results from the ADF-test at level variable is that all our time series can be considered nonstationary and that further ADF-tests are required in order to establish at which order these time series are integrated (in other words, at which order our time series become stationary). This is done by taking first difference of our variables and then conducting the ADF-tests again for these variables respectively.

Table 5.2 ADF unit root test results (variables in first difference)

Variables	Constant		Constant and Trend		Constant and Quadratic Trend	
	t-statistic (lags)	p-value	t-statistic (lags)	p-value	t-statistic (lags)	p-value
TFP	-3.68633*** (0)	0.009415	-3.75038** (0)	0.03356	-3.87577* (0)	0.06902
E_t^{quantity}	-10.6641*** (0)	8.173e-009	-11.6144***(0)	1.006e-023	-11.7016***(0)	2.918e-008
$E_{t-x}^{\text{quantity}}$	-4.301***(0)	0.001991	-4.41819***(0)	0.007282	-4.32975**(0)	0.02751

Notes: For these series the model is specified with a) constant only; b) constant and time trend; and c) constant and quadratic time trend. MacKinnon (1996) critical values for rejection of hypothesis of a unit root, that is *nonstationarity* at * 1%, ** 5% and *** 10%.
Legend: TFP*:* natural logarithm of Chile's TFP index 1973-2005; E_t^{quantity}: natural logarithm of the index of average years of schooling of Chile's labor force 1973-2005; E_{t-x}^{quality} : natural logarithm of the public expenditure on education as a percentage of GDP per capita in Chile 1973-2005.

Table 5.2 reports the t-statistics and p-values for the ADF-tests of our variables in first difference. The results from this test show that the null hypothesis of a unit root *can* be rejected at the 10% level for all specifications of our series and in most cases even at the 1% level. These results confirm that all three variables can be considered nonstationary at level variable, but that they all become stationary at first difference, meaning they are all integrated at first order (I(1)).

5.3 Johansen's co-integration test

As the results from our ADF-tests confirm that the time series contain unit roots, conventional regression techniques can not be used as they are bound to yield spurious regression results (Granger and Newbold 1974). Alternative methods, such as co-integration tests, can however be used in order to investigate whether a long-run relationship can be found between the three variables in the system. As the results from the second round of ADF-tests, reported in table 5.2, confirm that none of our three series is integrated at an order higher than the first order, the series meet the criterion for Johansen's co-integration test (Fortuna and Teixeira 2003). The results from this test are reported in table 5.3a (where educational expenditure is assumed to take four years to have an effect on Chile's labor force) and 5.3b (where educational expenditure is assumed to take six years to have an effect on Chile's labor force).

Table 5.3a Johansen co-integration test results

Rank	Eigenvalue	Trace test	p-value of Trace test	Lmax test	p-value of λ max test
0	0.50372	34.511	0.0569	22.420	0.0861
1	0.23988	12.091	0.3079	8.7770	0.5263
2	0.098394	3.3145	0.0687	3.32145	0.0687

Note: The values of E_{t-x}^{quality} lagged four years relative to TFP and E_t^{quantity}
Lag order 1. Observations 1974-2005. T = 32; Case 5: Unrestricted trend and constant

Table 5.3b Johansen co-integration test results

Rank	Eigenvalue	Trace test	p-value of Trace test	λ max test	p-value of λ max test
0	0.52636	33.334	0.0758	22.419	0.0861
1	0.25591	10.915	0.4037	8.8679	0.5168
2	0.065959	2.0470	0.1525	2.0470	0.1525

Note: The values of $E_{t\text{-}x}^{\text{quality}}$ lagged six years relative to TFP and E_t^{quantity}
Lag order 1. Observations 1976-2005. T = 30; Case 5: Unrestricted trend and constant

In a multivariate system consisting in this case of TFP, E_t^{quantity} and $E_{t\text{-}x}^{\text{quality}}$, the maximum number of co-integrating vectors are n-1 = 2 (where n is the number of variables in the system). The low p-values for the trace and λ -max test at rank 0 confirms that the null hypothesis of no co-integration relationship at 10% significance level can be rejected. The p-values for the trace and λ -max test at rank 1 confirm that the null hypothesis of one co-integration relationship can *not* be rejected, suggesting that these variables are indeed co-integrated. As shown in figure 5.3 a and b, these results hold both when the values of $E_{t\text{-}x}^{\text{quality}}$ is lagged four years and six years respectively relative to the other variables. This means that no matter if is assumed to take students (enrolled in a system that receives a certain amount of government expenditure in any one year) four or six years before they are part of the labor force, a long-run relationship between the three variables in the system is still found.

6 ANALYSIS

This chapter reflects on the econometric findings as well as the other empirical findings presented in this thesis. The starting point of the analysis is to assess whether education seems to be linked to Chile's economic growth and whether the econometric results attained are in line with economic theory and similar empirical studies. This chapter then takes the analysis one step further by discussing possible implications for Chilean educational policy at both theoretical and empirical grounds.

The framework of this thesis is based on four key questions that all build on one another. The first question, and probably the most fundamental one of them all, is whether the results of the time-series analysis indicate a presence of a long-run relationship between education and Chile's economic growth? Based on the answer to this first question, the relevance of education as a strategic topic for Chilean economic policy is then discussed in conjunction with the question as to how successful Chile's educational policy has been. Thirdly, possible implications from these empirical findings are discussed, and in particular, the question as to why significant increases in public expenditure on education have not been matched by similar increases in student performance is addressed. Finally, this paper takes a forward-looking approach by addressing some of the aspects of Chile's current educational system that may need to be addressed in the country's strive to adopt a more effective educational policy.

6.1 Is there a link between education and economic growth in Chile?

This question is an important one. If the econometric examination of this thesis had given no indication of co-integration between Chile's educational variables and the country's TFP, this would have implied that factors such as educational quantity and quality are of little or no relevance for Chile's TFP and thereby long-term economic growth (at least during the time period of this study). Consequently, this thesis would not have been able to provide any preliminary empirical evidence for the argument that education is an important topic for Chilean economic policy.

However, the results of Johansen's test, presented in 5.3a and 5.3b, suggest that Chile's educational variables and the country's TFP seem to exhibit some form of co-integration during the time-period of this study. This means that there indeed seems to be a long-run relationship between these variables, indicating that Chile's education is somehow linked to the country's economic growth through the channel of total factor productivity.

While further econometric analysis is required to confirm the *nature* of this relationship, the results from Johansen's co-integration test confirm that these variables indeed seem to be related to one another, which is consistent with the presumptions of the endogenous growth theory. As there is no other known country-specific study for Chile that empirically tests for the relationship between education and economic growth, this study cannot compare the results attained with other, similar studies on Chile. However, the indications of co-integration from Johansen's co-integration test is in line with a series of similar studies conducted for a range of other countries (Fortuna and Teixeira 2003; Babatunde and Adefabi 2005; Francis and Iyare 2006) that also find some form of co-integration between these variables.

The fact that the econometric findings of this study confirm the presence of a long-run relationship between education and total factor productivity does not only give further support to the endogenous growth theory. If developments in the areas of education and economic growth are somehow related, these findings also provide preliminary empirical evidence for the argument that education may constitute an important topic for Chilean economic policy. In other words, the

current debate on how to improve Chile's educational policy may prove relevant not only from a social point of view, but also from a purely economic perspective.

The econometric findings of this thesis become even more relevant in light of the fact that TFP has so far constituted a relatively modest source of Chile's economic growth. Reflecting on the statistics presented in Table 3.1, it becomes clear that the impressive economic growth experienced in the late 1980's and 1990's have mainly been due to employment expansion and investment booms. This hence implies that the rapid growth experienced during the golden period is explained mostly by the *accumulation* of factors, first labor and later capital, rather than the *productivity* of factors.

In a sense, these figures can have both an optimistic and a pessimistic interpretation. On the negative side, Chile's TFP has not been at the level expected or desired. Since TFP is considered an important source of long-term economic growth, Chile may therefore not be able to sustain its high growth in the future if there is not sufficient development in the productivity of the economy. On a more positive note, Chile has shown extraordinary growth figures in the last fifteen years despite lack of strong development in its TFP. This would imply that there is a lot of unrealized potential for Chile to experience future periods of high economic growth if the productivity of existing factors could be improved on. Following the reasoning behind the endogenous growth theory, technological progress is however not likely to come to Chile like "manna from heaven". Rather, it is through conscious policy efforts, designed to promote TFP, that Chile can experience a higher level of sustained economic growth. As the econometric results of this study indicate that education may constitute an important influencer of Chile's TFP, there may hence be strong, economic reasons to analyze how various aspects of education are best promoted.

6.2 How successful has Chile's educational policy been?

While Chilean authorities for some time have recognized the importance of education by actively and continuously taking a series of measures in this area, this does necessarily imply that these efforts actually have been *effective*, at least not in all respects. Admittedly, the perceived successfulness of Chile's educational policy is likely to be contingent on the specific goals of different stakeholders. This section however looks closer at how effective Chilean educational policy has been in attaining the formally stated goals of increasing the quantity and quality of education. Based on what has been achieved in these respective areas, potential implications for Chile's current and future educational and economic policy are discussed.

6.2.1 Chile's effectiveness in increasing educational attainment

During the period 1973-2005, the average level of educational attainment among Chile's labor force increased from 6.7 years to 10.5 years, making this country a stand-out in the Latin-American region. In just 30 years, Chile has gone from humble beginnings to levels approaching the ones found in the Western world. These findings alone give reason to believe that these figures could not have been achieved in such a short time had the efforts undertaken in this area not been effective.

The most evident measure taken to promote educational quantity is the new law, making high-school education mandatory. However, as this regulation was established at the tail end of the time period of this study (in year 2003), this law is more likely to affect *future* levels of education rather than the ones already experienced. It therefore seems that Chile's educational policy must have also given other incentives to send children to school. One of these incentives is likely to have been the offering of primary and secondary education free of charge. This way, more families from lower socio-economic groups have been able to afford sending their children to school for longer. Looking beyond some of these fairly obvious measures to increase educational attainment,

there is also reason to believe that policy actions taken with other motives than just promoting educational attainment may have come into play. Chile's voucher system - implemented with the aim to improve educational quality and efficiency - may for example have acted as an indirect catalyst for educational attainment. As the subsidies introduced were based on student attendance, schools were now given a strong, financial incentive to keep students enrolled for longer.

As outlined in chapter two, economic theory suggests that the link between average years of schooling among labor force and total factor productivity is typically a positive one. While further econometric analysis is required to confirm the exact nature of the long-run relationship found between educational variables and Chile's TFP, the logic behind this theory does make sense. Workers with more years of education should reasonably have more skills, making them more adept to create or imitate new technology, which in turn should increase the productivity of the economy. If this general theory applies to the specific case of Chile, this would imply that the country's success in improving the quantitative dimension of education has been advantageous for its TFP and thereby for its long-term economic growth.

However, even if further research would confirm that the influence of Chile's educational attainment on TFP has been significantly positive, this does not necessarily mean that prioritizing educational quantity has been optimal for the Chilean economy. In order to understand the true, net benefits from prioritizing the quantitative aspect of Chilean education, policy makers would need to approximate the *marginal* return from extending the average level of educational attainment and then compare this return with the marginal cost as well as the *opportunity cost* from prioritizing this area over other aspects of education. Regardless of whether these returns and costs are estimated in purely economic terms or in broader, socio-economic terms, Chilean policy makers would benefit from using this information as a foundation for planning, implementing and evaluating future educational policy efforts.

Policy-makers however face a fairly complex task when making educational policy decisions. The above-outlined returns and costs may not only be difficult to estimate, they are also likely to vary over time. This means that even if Chile's *past* economic returns from increasing educational attainment would prove to be high, Chilean policy makers can not assume that these measures will give the same returns today or in the future. Just 20-30 years ago, Chile experienced relative modest levels of schooling but today, the country is finding itself at levels almost in line with the Western world. Based on this development, one has to take into account that as the *average* level of educational attainment *increases*, the *marginal* return on schooling may actually *decrease*. It is therefore important for Chilean policy makers to continuously evaluate the marginal returns and costs of different measures and then design educational policy accordingly.

Ultimately, the economic benefits from raising Chile's educational attainment are likely to be dependent on what has been achieved in other areas parallel to these efforts. If the quality of the education provided is high, it pays to keep children in school for longer, but if additional schooling does not actually increase the actual skills of the people enrolled, the (economic) return on this investment is likely to be significantly lower. This reasoning reinforces the findings of recent World Bank studies, indicating that efforts to raise educational attainment are much more beneficial for economic development if these efforts are complemented with high educational quality.

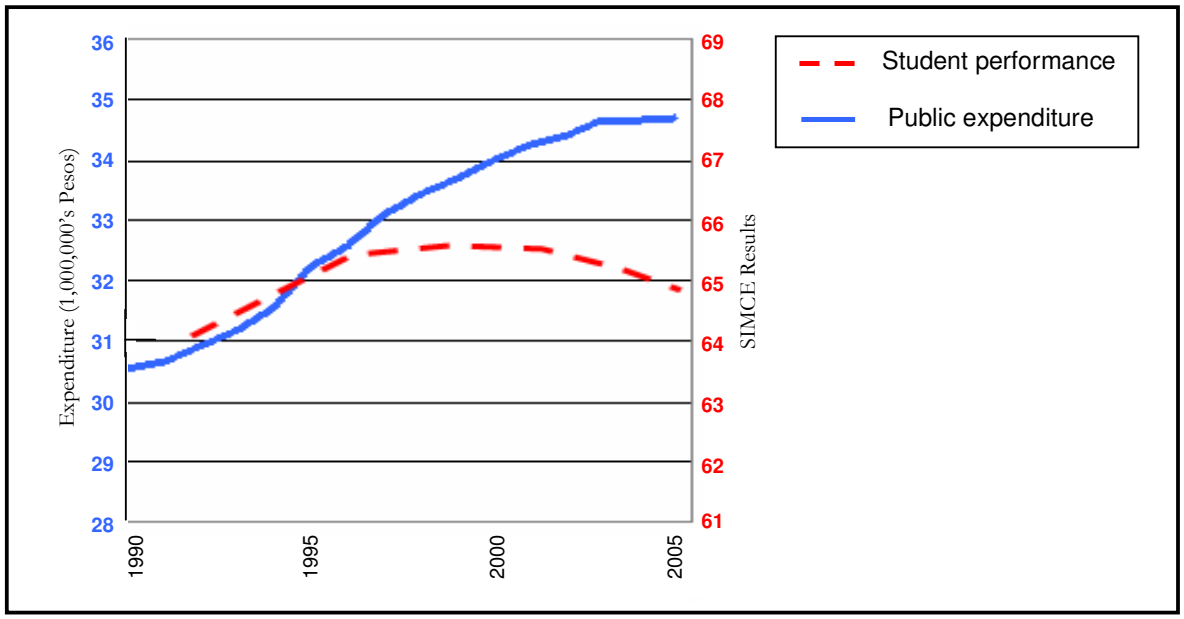
6.2.2 Chile's effectiveness in increasing educational quality

Since Chile's return to democracy, the country has expressed special commitment to improving the quality of education. The fact that government expenditure on education (in absolute figures) has increased more than 300% in just the last fifteen years is impressive, but it is not necessarily the most indicative measure of a government's *commitment* to educational progress. Chile has in

these years experienced high economic growth and it is therefore likely that a vast range of areas, including the educational sector, have benefited from additional funding. However, Chile's educational sector has in recent years also received an increased *share* of Chile's national income. This figure should reasonably constitute a more direct reflection of Chile's increased commitment to improve educational quality as it reflects an increased priority of the educational sector over other areas of the economy.

While the proxy "average years of schooling" is a fairly direct measure of educational quantity, the proxy "expenditure on education" (be it per student or as a percentage of GDP) constitutes a much more indirect measure of educational quality. In other words, while the former proxy reflects actual achievement in the quantitative dimension of education, the latter does not guarantee that Chile's educational inputs actually have turned into the output expected or desired. Due to lack of sufficiently long time-series, output-based measures of educational quality could not be incorporated in the *econometric* examination of this study. However, Chile's effectiveness in raising educational quality can still be discussed on empirical grounds. If we define educational quality to be synonymous with student performance, efforts to raise educational quality through the allocation of more government funds would be considered effective if these additional funds generated a sufficient increase in student performance. In order to approach the answer to how effective Chile's efforts to raise educational quality have been, there is hence a need to evaluate if the dramatic increase in educational expenditure has been reciprocated with a similar development in the performance results of Chilean students.

Figure 6.1 Student resources versus student performance



Note: Trend of student performance is taken from figure 3.5a showing Chile's student performance in mathematics in 4th grade (municipal school). Trend of expenditure is taken from figure 3.4b showing Chile's government expenditure on education per student in primary education.

Figure 6.1 combines figure 3.4b and 3.5a and compares the development in government expenditure per student (in primary education) with the development of student performance (in primary education) during the last 15 years. The graph hence serves as an approximate comparison between these respective trends. Figure 6.1 also illustrates the fact that student performance has stagnated even though public expenditure per student has steadily increased over the last 15 years. Based on these findings, there is strong reason to believe that Chile's educational policy, in this

particular respect, has not proven as effective as one may have hoped for. However, before drawing too simplistic (and pessimistic) of a conclusion, there are some aspects that should be taken into account.

Firstly, while the above graph illustrates a significant difference in the development of public expenditure per student and the development of student performance, it should be noted that this "gap" is significantly smaller than the gap between the development in *total* public expenditure and the development of student performance. The reason for this is that while total expenditure on education has increased dramatically over time, so has the number of students enrolled in Chile's educational system. This means that at least part of the increase in expenditure may have gone to maintaining (rather than increasing) the average level of resources per student. Consequently, Chile's great achievement in raising educational attainment may, at least partly, has come at the expense of raising educational quality. However, while public funding *per student* has not increased as much as the *total* public investment in education, figure 6.1 illustrates that the former measure has still experienced a steady and upward trend for the last 15 years. The question therefore remains as to why this development has not been reciprocated with a more similar development in student performance?

An argument that potentially could nuance the seemingly disenchanting development in student performance is that the number of Chilean students progressing to higher levels of education has increased significantly. This means that the number of low achieving students remaining in the education system is also likely to have increased (Wolff, 2002). In other words, the students most susceptible to dropping out early are now retained for longer in the system and therefore the average performance of Chilean students is likely to drop accordingly. Although this last argument makes sense in itself, further assessment of the results for students in 8th grade (where enrolment rates have gone up significantly in recent years) indicate that the development in student performance in this grade has been more or less the same as in 4th grade (where enrolment rates have been more or less the same for a long period of time) (Bellei 2003). Based on these findings, this argument does not actually seem to apply to the specific case of Chile.

The strongest argument in defense of the disappointing development in Chilean student performance seems to be that increased financial resources cannot improve educational quality overnight. If a school receives additional resources so they can afford computers for their students, it is only after some time that these computers will be bought and set up. First after an additional time lag, students are likely to start using these computers and start acquiring some computer skills. However, even when allowing for a certain time lag for these investments to generate a return, figure 6.1 clearly shows a tangible reason for questioning the effectiveness of public educational funding. The fact that Chilean students are also performing significantly lower than other countries with similar GDP reinforce the doubt that educational funds are handled in the most effective manner. The slow development in student performance is even more disappointing given the fact that figure 6.1 only reflects the increase in *public* expenditure per student and does not reflect that this development has also been matched with significant increase in *private* expenditure.

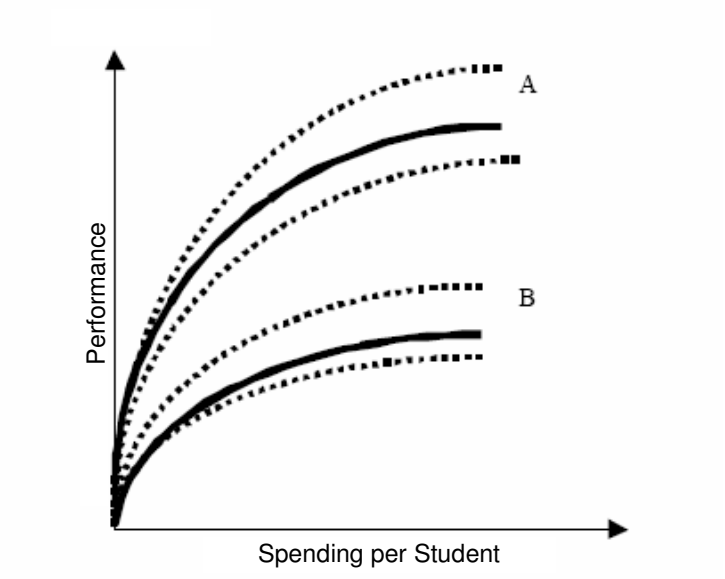
So far, the above analysis has only discussed how successful Chile has been in raising *student* performance through allocating more government funds to this sector. From an economic policy perspective, the question as to how Chile's *macroeconomic* performance may have been affected from these measures still remains. While this study can not confirm this on econometric grounds, the empirical findings discussed above give reason to believe there is significant room for improvements in this area. The reasoning behind this argument is as follows: if increases in education expenditure have only lead to modest improvements in educational quality, are these investments likely to have done much more for total factor productivity?

In sum, the reasons for the slow development in student performance are not easily isolated among the many factors involved and the inevitable time lag between the introduction of policies and their impact in the system. However, it is clear that Chilean student performance has progressed little over time and continues to be low relative to other countries with similar expenditure on education. This reinforces the importance to approach the question as to why increased resources have not lead to more significant improvements in academic performance?

6.3 More resources but what about more skills?

The original purpose of Chile's competitive demand-based system was based on Friedman's belief that the return per dollar would be greater. However, while schools in Poland and Hungary have managed to produce world-class pupils despite spending only a little more than countries like Brazil or Mexico, Chile is still underperforming by international standards So, how come Chile's consistent and substantial increases in both public and private educational expenditure have not yielded more visible results? Figure 6.2 illustrates a potential explanation to this question.

Figure 6.2 Academic performance and spending per student



Source: Beyer (2003)

Figure 6.2 illustrates a possible relationship between spending and the quality of education. It also suggests that the relationship between spending per student and academic performance is not unique. In order to illustrate this line of thought, the graph presents two curves that both relate spending to the quality of education. The curve marked A shows a high expected performance for each level of spending per student. (The dotted curves represent the confidence intervals of that technology, leaving room for countries of similar educational technology to report differences in academic performance even though their levels of spending are very similar). Curve B, on the other hand, reflects a very low academic performance for each level of spending per student. This illustrates that there can be huge differences in academic performance between different countries with similar GDP and similar expenditures on education, where the adoption of an "educational technology" such as the one described by curve A is desirable whilst one described by curve B is particularly regrettable for a country. (Beyer 2003) Figure 6.2 hence illustrates the fact that if a country finds itself on a technology curve of the latter, the effect on academic performance will be modest no matter how much the country increases its expenditure. In this case, a change from

technology B to technology A is more advantageous – rather than an increase in spending - because it will raise the academic performance of students more.

After presenting this general theory, a discussion can now be held on how Chile fits into this model. The fact that large increases in Chile's educational expenditure over the last 15 years have only resulted in modest increases in student performance, gives reason to believe that Chile may find itself on a curve more similar to B than A in figure 6.2. If this supposition is correct, increases in educational expenditure are likely to continue to yield low returns unless these funds are complemented with a change in the educational technology. According to this line of theory, the reason for the slow development in Chile's student performance could hence be due to the lack of structural improvements to the country's educational system. This would however imply that the current design of Chile's educational system – established under Pinochet's military regime – would feature some potential inefficiencies and that this would be the reason why student performance has remained more or less the same despite significant increases in resource allocation. This thesis does not postulate a definite answer to whether this is the case or not, but it does suggest that this question is critically evaluated. To link back to the model presented in figure 6.2; the final section of this analysis discusses how Chile could potentially ensure a higher return on future educational spending by moving from a hypothetical curve of B to one more similar to A?

6.4 Looking forward; what are the challenges ahead?

Given the universal complexity of educational policy, there is no simple answer to what makes an educational system to move to a higher curve in figure 6.2. This thesis does therefore not pretend to consider all factors that may affect student performance. Rather, this section highlights some areas that in light of economic theory and empirical findings seem critical to Chile's strive to improve educational standards and promote economic growth.

6.4.1 Setting clear goals and assigning accountability

While academic research has not provided very conclusive answers to what makes an educational system move to a higher curve, we know that an educational system would be lame if the players (students, teachers and authorities among others), felt no pressure to achieve good academic results. The entire region of Latin America has received criticism for not fulfilling this criterion and according to various Chilean economists such as Beyer (2003); Arellano (2000); Cox (2004), Chile constitutes no exception. According to Beyer (2003), the Chilean educational system is not designed to make schools feel pressure to do well as the overall focus is basically on administrative processes and very little results.

The above argument also seems justified in light of the fact that Chilean students demanded increased clarity in the setting of educational goals during the nation-wide student demonstration in 2006. Based on this, Chilean policy-makers may do wise in reviewing to which extent and in which way educational goals are set, who sets these goals and who is responsible for making sure that these goals are actually achieved?

A related question to the ones above is the burning question as to whether Chile's municipalities are actually the best parties to be in charge of managing public school? After years of controversy, the Chilean government has finally recognized that this may need to be re-evaluated at a political level (Roberts 2007). This would be an opportunity for Chilean authorities to re-evaluate with whom accountability for educational performance actually should lie. While the natural choice typically falls on schools (as those are the institutions that actually provide the education), Chile has so far not had the legislation to support this assignment of responsibility, at least not when it comes to its public schools. As Chile's public schools currently do not have the autonomy or authority to make the higher-level decisions affecting educational outcome, these schools can

consequently not be assigned sole responsibility for student performance. With the current design, it is the local mayors that have the power to make decisions regarding public schools. The critical question then becomes; can Chilean policy-makers really rest assure that these mayors actually have sufficient insight and incentive to decide on these matters effectively? Potential incentive issues aside, it is also difficult to hold the municipalities fully responsible for Chile's student performance as these institutions in turn are dependent on the schools to deliver on the decisions made. Consequently, there is a risk that the accountability for Chilean student performance falls into a "no-mans land" where neither schools nor municipalities want to take responsibility for the slow development in student performance. The critical questions for Chilean policy-makers hence become; how should educational goals be set and who should ultimately be responsible for these goals being met? In addition, what can be done to make sure that the party assigned responsibility for educational performance has both the incentive and authority to make sure that these goals are met?

6.4.2 Re-evaluating educational reforms and programs

There are several aspects of Chile's educational framework that may be appropriate for achieving the sought objective of raising educational standards, such as its diversity of actors (both public and private, profit and not-for-profit), its absence of entry barriers to the system and the existence of a national quality assessment system. At the same time, the slow progress in student performance indicates that the very same system may also have created a series of direct and indirect effects working against its original purpose. It may therefore be critical for Chilean policy-makers to review the design of Chile's educational system in order to make sure that the framework in place is actually designed to give a good return on educational funding.

If Chilean policy-makers are to re-evaluate educational designs and policies for future purposes, it is critical that relevant information on these matters is available. This reinforces the importance that Chilean authorities continue to collect, disseminate, and use information on school performance. While Chile is considered one of the strongest pioneers in Latin America as far as educational monitoring goes, more nuanced and sophisticated analysis of data would provide policy-makers with better insight to the direct effects as well as the potential indirect effects of their educational policies.

6.4.3 Increasing availability and accuracy of information

The design of Chile's education system is one of a competitive demand-based system where parents actively have to choose a school for their children. Given this design, the availability and accuracy of information on school performance becomes absolutely vital for parents ability to select the most effective schools for their children. Seen from a larger perspective, this information is crucial for ensuring an efficient student and resource allocation for the educational sector as a whole.

A striking feature of Chile's educational sector is the dramatic expansion of private schools; enrolment has increased from 20% to 60% in urban areas during the time period of this study and the number of students enrolled in privately run schools continues to grow at the expense of the municipal sector. This development seems to stem from the general perception that private schools offer better education than the municipal, public ones.

Based on the publicly reported SIMCE results in figure 3.5, it would seem like this perception is in line with reality as students in private schools perform significantly better on average than students in public schools. However, as argued by Matear (2007) in her study about equity in Chile's education, these publicly reported figures have not been adjusted for socio-economic group (children from wealthy families are more likely to enroll in private schools while children from

poor families are more like to enroll in public schools). Once adjusted for this factor, Matear concludes that it is actually the municipal schools that are performing better than the private ones.

If these results are correct, they tell us two things. First of all, there may be further reason to believe that financial investments are not handled effectively and efficiently (if so, private schools would be performing significantly better than municipal schools even after adjusted for socio-economic status as the former typically have much more resources at hands than the latter). Secondly, there may be a discrepancy between the *perception* of which schools offer the best schooling and the *reality* of which schools actually deliver the best education. If so, this would imply that the current allocation of students is not as effective as it could be. Since Chile's voucher system is based on student attendance, this would also imply further inefficiencies stemming from the less than optimal allocation of government funds to schools.

It is beyond the scope of this thesis to confirm the reliability of Matear's results. However, in light of her findings and the rapid transition from public to private schooling, it seems critical that Chilean policy makers as well as the general public move away from the simplistic assumption of private = good, public = bad, and start to investigate which factors actually determine Chilean school performance at a more deep-going level. Regardless of what further investigations find on this matter, it is critical that Chilean policy makers provide proper guidance to students and their families in their school choices. This guidance would in turn prove more helpful if the facts and statistics compiled and presented painted a more nuanced picture of Chile's various schools.

6.4.4 Correcting ineffective incentives

In any operation including various stakeholders, a key challenge is to make sure that all parties move towards the same goal, or at least that all parties have the *incentive* to move in the same direction, leading to the overall goal. Chile's educational system has a wide range of stakeholders; government, students, parents to students, school staff, municipalities, private investors etc. While nobody is likely to object to the formally stated goal of raising educational standards, different stakeholders are likely to prioritize this goal differently. With the current legislation ensuring free entry of profit-making schools, it is likely that a significant number of players on Chile's educational arena look at education as a business rather than a social investment. This is not necessarily a bad thing by any means. It does however stress the importance that the fundamental design of Chile's educational system provides enough incentive for its various stakeholders to align their individual goals with the stated overall goal of increasing educational standards for everyone.

The demand-based educational system of Chile fosters strong competition between schools, which is typically considered an important characteristic for promoting better performance among stakeholders. However, Chile's method of creating this competition may also have lead to an array of side effects that have to be considered when assessing the overall effectiveness of Chile's educational system. For example, Chile's introduction of a student voucher scheme may, in some respects, have lead to larger discrepancies between the goals of various stakeholders. The reasoning behind this argument is that the voucher system in a sense gives schools a stronger incentive to *look* good than actually fulfilling the formally stated goal of *being* good. As schools are dependent on government vouchers and/or private funds they are bound to be very conscious of the fact that next year's budget will be determined on the number of students currently enrolled. Therefore, there is an obvious incentive to prioritize *looking* good over *being* good; if a school does not appear appealing to new applicants, it will not get the funds allowing it to be good anyway.

In relation to this argument, it has been identified that many of Chile's private schools spend significant resources on screening applicants and accepting high-performing applicants while declining low-performing ones. This is done in order to ensure a higher school performance rating in the public SIMCE reports, leading to an increased number of student applications next year

round. (Matear 2007) This phenomenon offers several insights. Firstly, it offers a tell-tale sign that the goals pursued by individual schools are driven by other motives than the formally stated goal of raising Chile's student performance level nationally and across socio-economic groups. Secondly, this occurrence is also an indication of ineffective resource handling as a large amount of resources is seemingly spent on getting a larger individual share of the economic pie, rather than focusing on increasing the size of the pie so that everyone benefits. Municipal schools are not allowed to reject any applicants while private schools can act at their discretion in this area. This means that municipal schools are bound to get a lower SIMCE rating, leading to a negative, downward spiral. This phenomenon may not only lead to increased inequality and segregation among different socio-economic groups. It may also distort the incentives of private schools so that high-performing students become more important as *input* rather than *output* for school operations. This argument has even more bearing in light of the fact that many of these private schools are driven by financial profit and not necessarily by social benefits.

Another potential issue with the voucher-system is that it may create very short-sighted efforts from schools, regardless of whether they are public or private ones entitled to government subsidies. The budget of these schools are partly or completely determined on annual enrolment rates; what room is there then to undertake long-term improvement projects, such as the one of raising educational quality, where schools can afford to let results drop in the short-run for the long-term benefit? Chilean policy makers may therefore need to evaluate if potentially conflicting incentive structures in the country's educational system have jeopardized Chile's progress to see these more long-term and deep-going changes through?

As any reform, including the voucher system, has its pros and cons, this thesis will not take a stand on whether Chile's current design, all things considered, is desirable or not. However, Chilean policy-makers would probably do wise in critically assessing the various incentives that drive stakeholders in this model, perhaps the most important ones being the schools. The critical question follows; what can be done to make sure that individual stakeholders are given stronger incentives to contribute to the overall goal of raising national educational standards? One way of doing this would be to reward (extrinsically or intrinsically) the actors in the educational sector for actually *producing* better student performance, and by the same token penalize the ones that fail to do so. Identifying how various actors perform in this area would require nuanced data and analysis. Given that Chile already has an established national system for monitoring educational performance, the country's potential for finding these answers should be relatively good.

7 CONCLUSION

This thesis has examined whether a long-run relationship between education and economic growth can be found in Chile during the period 1973-2005. This examination has been done by adopting time-series analysis and co-integration techniques. Potential implications for Chilean educational policy have also been analyzed in light of economic theory, the econometric results attained and other empirical findings presented in this thesis.

The results of Johansen's co-integration test provide further evidence to the theory that education is linked to economic growth via the technology parameter, roughly approximated by total factor productivity, and that Chile constitutes no exception in this area. These results also give reason to believe that education may constitute an important strategic topic seen from an economic policy-perspective. However, while education has been a topic of priority on Chile's political agenda for quite some time now, education continues to be considered the country's Achilles' heel. This has given rise to a debate on whether efforts have actually been made in the right places. This debate has been further intensified by recent cross-country evidence from World Bank studies suggesting that it is the *quality* rather than the *quantity* of education that has the largest impact on economic growth. These results stand in sharp contrast to Chilean educational performance where the greatest educational achievement has been in terms of raising educational quantity rather than quality.

Reinforced by the fact that Chile's recent economic growth has mainly been due to the *accumulation* rather than the *productivity* of factors, there may be several reasons to look closer at the design of Chile's educational policy. Firstly, if the results from these World Bank studies apply to the specific case of Chile, it would appear that Chilean educational policy could be significantly more successful, seen from an economic perspective, than it currently is. This could in turn explain, at least partly, why Chile has experienced relatively modest growth in total factor productivity, despite achieving quite amazing results in terms of raising the average years of schooling of the country's labor force. Secondly, Chile's consistent and substantial increases in educational expenditure have only been reciprocated by modest progress in student performance. This gives reason to believe that Chile's educational system may have some in-built inefficiencies that have slowed down the development of student performance.

Given the universal difficulty in designing effective educational policy, this thesis does not offer any "silver bullet" solutions to the challenges Chile is facing. However, paying further attention to the creation of clear national educational goals and the assignment of accountability for these goals seems important. Further, this thesis suggests that Chilean policymakers critically evaluate past and current educational reforms and programs in terms of both effectiveness and inefficiency. While this work is likely to require both skill and financial resources, these evaluations (if done accurately) should disclose important lessons for future policy-making. More nuanced information on school performance also seems necessary to ensure efficient student and resource allocation. Finally, and perhaps most critical of them all, Chilean policy-makers should review the motives that drive different stakeholders - most importantly the schools - in order to assess what can be done to further align their motives with the overall, societal goal of improving national student performance.

In sum, while Chile may face some challenges in the area of education, this does not mean that the country's future is necessarily bleak. First, improving educational standards require political will and Chile has over the last decades shown strong political commitment to raising educational standards. In 2006, the current government united with all parties (including the ones in opposition) on making education a topic of priority on the political agenda and the Chilean government is today reviewing some of the laws framing the current educational system. Second,

the magnitude of the economic benefits stemming from educational improvements is typically contingent on the institutional framework of the economy as a whole. Chile has a sound macroeconomic framework with strong financial and legal institutions. This means that the potential benefits for Chile could be large once educational performance picks up. Finally, Chile's total factor productivity has so far constituted a relatively modest source of the country's economic growth, and still, Chile has shown an impressive growth pattern in the last two decades. This leaves great room of potential for Chile to sustain or even increase its economic growth well into the future if measures to improve total factor productivity are successfully implemented. In light of economic theory and the empirical findings presented in this thesis, improving educational standards may be a critical factor in this process.

7.1 Suggestions for further research

During the research process for this thesis, several topics for further research were unfolded. This study examines econometrically if there is a *long-run relationship* between measures of education and TFP in Chile, but further research is still required in order to econometrically determine the specific nature of the individual parameters in the model in [4-1]. This study originally planned to extend the econometric examination further by estimating these parameters through so-called Vector Error Correction Modeling (VECM), but decided in the end to not do so. The main reason for this decision was that VECM is a fairly advanced form of statistical modeling and is still a relatively uncharted area of economic research. Several of the statistical experts consulted for this thesis also indicated that *economic* papers using VECM have so far had a tendency to compromise the *statistical* criteria in favor of the *economic* criteria when conducting this kind of modeling.

Nevertheless, this study acknowledges that there is great relevance for further research in this area. In particular, additional work needs to be done to bridge economics and statistics so that economic models can be estimated further through the use of adequate statistical methods. In this particular study, the adoption of VECM or similar econometric methods would allow the estimation of the individual effect of educational quantity and educational quality respectively on Chile's TFP. By also testing if there are additional explanatory variables that have a significant impact on TFP, the research could be refined even further. This type of research could prove extremely valuable as the results from these studies would allow policy-makers to compare the estimated impact of different policy measures. Policy-makers could hence base their decisions on the estimated effect from different actions and select the one(s) that seems to give the highest return. This means that further research on the links between education and economic growth could ultimately provide policy-makers with a significantly stronger foundation for effective educational and economic policy.

It is important that any estimates used as a foundation for policy-decisions are precise. Researchers should therefore carefully consider the issue of reverse or bi-directional causality. If time-series analysis is used, it may also be beneficial to extend the number of observations and then experiment with time dummies reflecting structural changes in the Chilean economy. The reason for this is that longer time-series are considered to give more reliable estimates of the individual parameters in a model. Another recommendation is to refine the vector error correction modeling (VECM) based on type of school and level of schooling. This way, the effect of Chile's educational policy can be compared across school types and across school levels.

Future research in this area would also benefit from using more precise proxies of human capital. Availability of data naturally sets some boundaries to what can be achieved in this area, but to the extent possible, future studies should aim to use proxies that are *direct* reflections of the variables they approximate. In the particular case of Chile, time is likely to be the best friend for achieving this; Chile has an established framework for recording student performance, school enrolments,

teacher per student ratios and other educational measures, but still lack enough observations for some of these variables to be incorporated in time-series analysis.

Finally, education is likely to have more effects than just the purely economic ones. It would therefore be valuable to identify and estimate these non-economic, social benefits from educational improvements and then incorporate these additional aspects into the design of educational policy.

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APPENDIX

Time series used to compute the relevant variables

Year	TFP Index	Educational Quantity	Educational Quality
1973	113.522	6.70	5.60
1974	113.22	6.10	5.60
1975	101.26	6.50	4.80
1976	101.73	6.60	4.70
1977	106.17	7.00	5.20
1978	110.98	7.20	4.90
1979	116.82	7.30	4.70
1980	121.10	7.50	4.60
1981	124.17	7.60	5.10
1982	113.22	7.60	6.20
1983	104.79	7.80	5.30
1984	106.99	8.00	4.90
1985	105.99	8.30	4.60
1986	107.72	8.30	4.10
1987	111.34	8.40	3.70
1988	114.32	8.30	3.70
1989	120.85	8.80	3.10
1990	121.84	9.00	2.90
1991	128.69	9.00	2.90
1992	138.52	8.90	3.00
1993	140.28	9.10	3.10
1994	144.60	9.40	3.20
1995	155.09	9.30	3.20
1996	160.83	9.50	3.40
1997	165.05	9.40	3.50
1998	164.23	9.60	3.70
1999	162.12	9.70	4.00
2000	165.27	9.80	4.10
2001	167.58	9.90	4.40
2002	167.25	10.00	4.40
2003	166.61	10.10	4.30
2004	171.44	10.30	4.10
2005	177.36	10.50	4.10

Sources: TFP Index (1960 = 100): Fuentes et al (2006). Educational Quantity (average years of schooling among labor force): Fuentes et al (2006). Educational Quality (government expenditure on education as a percentage of GDP): Ministry of Education 2005