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**Essays on Economic Growth:  
Convergence, Financial Development, Education  
and Uncertainty**

A Ph.D thesis presented

by

Dimitrios Asteriou

to

The Department of Economics

in partial fulfillment of the requirements

for the degree of

Doctor of Philosophy

in the subject of

Economics

City University

London, U.K.

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# Abstract

This dissertation deals with the issue of economic growth, specifically with the examination of the determinants of economic growth, from both a theoretical and empirical perspective. The first chapter introduces the issue and summarizes the main results. The dissertation is divided into three parts. The first part comprises of two chapters (chapters 2 and 3) considering the issue of per capita income convergence. The first chapter presents the theoretical background and re-examines the convergence debate among the neoclassical and endogenous growth models while the second chapter examines empirically the convergence hypothesis using both cross-sectional and time series econometric techniques for the case of Greek regions. The second part comprises of three chapters examining the unexplained factors affecting economic growth. The two first chapters (chapters 4 and 5) of this part deal with the neglected role of finance and financial intermediation in the process of economic growth of a country. One chapter presents the theoretical literature on this subject. Most of the empirical studies on the determinants of economic growth use cross-country analysis. Such an analysis, however, ignores dynamic information that can explain part of the variation in growth rates. In our empirical analysis, which is conducted in the fifth chapter, we employ time series techniques for the examination of the relationship among financial development and economic growth, using UK data. The third chapter of the second part (chapter 6) examines empirically the role of education, for the case of the greek economy. Finally, the

last part examined the role of uncertainty on economic growth. Specifically, chapter 7 deals with the role of uncertainty stemming from political instability on UK's economic growth using time series data and techniques while chapter 8, considers the role of uncertainty on investments and economic growth examining empirically its effects for a panel of 59 developed and developing countries.

*To Julia*  
*for all her*  
*love,*  
*support*  
*and pain*  
*that so abundantly gave me*

## Aknowledgements

For many of my friends, this will be the only page of my dissertation that they will read. For others, it probably will not be read at all. However, this is my opportunity to express myself freely and to say a huge thanks to all those who helped me during this crucial period of my life, so here it goes.

Firstly, I would like to express my gratitude to my principal supervisor, Professor Simon Price. I am especially grateful for the considerable time and guidance Professor Price provided during this entire undertaking. He always made time to provide assistance and direction while accommodating my rather erratic schedule. He not only advised me in writing this dissertation but throughout my stay at City University he always guided me on the other aspects of academic life that a Ph.D. student faces. He was always willing to help and discuss any question I might have. I am really grateful for his help and kindness.

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<sup>1</sup>A version of this chapter has been published on *Regional Studies* , Vol. 32(6), pp. 537-546, (1998) with co-author Professor Costas Siriopoulos.



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<sup>3</sup>A version of this chapter has been accepted for publication on the *Journal of Policy Modeling* (forthcoming) with co-author Dr G. M. Agiomirgianakis.

<sup>4</sup>A version of this chapter has been accepted for publication on the *Scottish Journal of Political Economy* (forthcoming) with co-author Professor Simon Price.

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# Chapter 1

## Introduction

In this dissertation 'growth' refers to growth in real per capita income. Growth has long been recognised as a central concern for economists and other social scientists. Without much controversy one can say that poverty has been and continue to be one of the greatest sources of human misery the world over. A direct means by which to allay poverty is through economic growth. While growth may inflict costs and raises other challenges it nonetheless corrects number of problems.

Early economists, most notably Adam Smith and David Ricardo, provided much of the current framework for analysing the process and underlying the determinants of economic growth. Smith looked to the division of labour and the resulting increase in productivity as an engine of growth. He was also in favour of reducing trade restrictions since an open economy would permit a nation to enjoy increased rates of economic growth. Ricardo provided the notion of diminishing returns and he argued that increased investment tended to yield less than proportionate increments to output concluding that eventually

growth would cease. This could only be delayed through free trade. The first contemporarily recognizable approach to theorizing on the determinants of economic growth was undertaken by Alfred Marshall. Marshall, unlike his major contemporaries, focused upon growth. In his work Marshall sets out a number of propositions which focus on the determinants both of income growth and its distribution. His aggregate growth model is set out below:

$$g = f_1(n, e, w, F, A, S) \quad (1.1)$$

Here  $g$  is real income of a country,  $n$  is the number and  $e$  the average efficiency of its labour force,  $w$  is amount of wealth (capital),  $F$  the fertility of its natural resources,  $A$  the state of productive arts (technology) and  $S$  the state of public security.

The second equation in his growth model is:

$$s = g - T - nf_2(e) \quad (1.2)$$

This investment function is described as stemming from savings,  $s$  equals net incomes available for saving,  $f_2(e)$  the average necessities of a population whose average efficiency is  $e$ , and  $T$  taxes.

Marshall then postulates:

$$\frac{dw}{dt} = f_3(s, D, A', i) \quad (1.3)$$

Thus the determinants of savings are broader in that they deal with issues of cultural and social variation and their effect on the savings rate, here,  $dw/dt$  is the rate of saving,  $D$  is the rate at which people discount future consumption,  $A'$  is a measure of 'family

affections', and  $i$  is the rate of interest. To equation (1.3) Marshall then adds a variable  $E$  which measures the evenness of distribution incomes, which today would be recognized as a Gini coefficient:

$$\frac{dn}{dt} = f_4(n, e, g, E, A', D) \quad (1.4)$$

$$\frac{de}{dt} = f_5(n, e, g, E, A', D) \quad (1.5)$$

The variable  $E$  was viewed as 'measured by the ratio which the aggregate of the incomes bears to the sum of the differences between each individual income and the mean income'.

Not explicit in this summary of the Marshallian system is the treatment of capital and technology. The central issue was whether the productivity of each factor of production increased or decreased with volume of work. The second focus of Marshall was to consider the effect on growth of the phenomenon of increasing returns to inputs experienced by business, firms and industries.

The newest developments on the questions surrounding the phenomenon of economic growth have been presented by a host of thinkers ranging from Robert Solow and Trevor Swan to Paul Romer and Robert Lucas. Their inquiries examining the determinants and the process of economic growth introduced new bodies of theory and new research methods to help determine whether incomes converge or diverge during the process of growth. Two main theoretical approaches are now utilized to explain income changes during the process of economic growth: neoclassical growth theory and endogenous growth theory. Neoclassical growth theorists argue that capital accumulation is the engine of economic



growth; technological process occurs outside the model and thus is exogenous. Endogenous growth theory ascribes to technological innovation the role of engine of economic growth, via the existence of a positive feedback mechanism that permits increasing returns to scale. Both theoretical approaches have found varying levels of empirical support.

This dissertation consists of eight essays on the determinants of economic growth. The first two essays deal with the issue of convergence. The focus of the next two essays is the role of financial development on economic growth, while the last two essays consider the effects of education and political instability on economic growth respectively. These topics have attracted great deal of attention in growth literature. Accordingly, an empirical literature exploring the validity of relevant theories has developed. In this dissertation, these hypothesis are examined by utilising recent econometric techniques from the time series (integration, cointegration and GARCH models) literature.

Recently, in economics there has been a major revival of interest on economic growth, and especially in the evidence for long-run convergence in per capita incomes and output among countries (or economies in general). While for more than thirty years after Solow's (1956) influential paper the economic growth theory was dominated by the neoclassical explanation of the growth process, the empirical debate and the new developments on economic growth theory has promoted the endogenous growth theory, which seeks to move beyond conventional neoclassical theory by treating as endogenous those factors that the neoclassical growth model relegates as exogenous, in particular technological change and human capital. It is interesting to note that the endogenous growth theory no longer supported the convergence hypothesis. This led to the emergence of the 'convergence' debate

which is mainly the subject of the second chapter of this dissertation.

In chapter 3, the convergence hypothesis is tested for the case of Greek regions. A large body of empirical work on growth and convergence has used cross-sectional techniques, utilizing long-term averages of relevant variables. A negative relationship between initial incomes and average growth rates in these studies is interpreted as evidence of convergence and support for neoclassical growth models. Developments in standard time series techniques such as cointegration, provided researchers with additional tools to study convergence. These studies usually define convergence as temporary deviations of incomes from identical long-term trends. These techniques have the advantage over the cross-sectional methodology in using dynamic data to explain a dynamic process. Chapter 3 utilises both cross-sectional and time series techniques to test the convergence hypothesis for the Greek regions. The main results suggest absence of convergence which is in line with the endogenous growth theory predictions.

The fourth and the fifth chapters of this dissertation evaluate the neglected role of finance and financial intermediation in the process of economic growth of a nation. In keeping with the conclusions of endogenous growth literature, the research reveals a direct correlation, in the form of a positive relationship, between financial development and economic growth. Financial intermediaries are shown to influence the development of the real sector. By promoting efficiency, reducing transaction costs, increasing liquidity and lowering risks the financial sector is shown to influence the growth rate of countries. Also, the importance of stock markets which comes from their ability to reduce liquidity and productivity shocks, and expand the information set at the disposal of the financial sector,

is equally examined and it found to influence output and its growth. These conclusions are based on an empirical study for the case of U.K. using an array of newly developed financial and stock market development indicators in Granger-causality tests and cointegration techniques.

Chapter 6 contributes to the study of the role of human capital in economic growth. The endogenous growth theory, motivated by the work of Paul Romer and Robert Lucas has identified human capital as one of the key factors in explaining the growth process. Endogenous growth theory endogenised technological change by suggesting that technological change comes from what people actually do and hence, emphasized the role of human capital. Indeed an increase in the stock of human capital has positive effect on the production of goods. Moreover, since investment in human capital is taking place through training and education, endogenous growth theory provides a strong rationale in favour of government intervention. More specifically, government policies intended to affect publicly-provided education and training will determine the process of growth of the whole economy. Three alternative theoretical models are presented and analysed, while the role of human capital is empirically examined for the case of the Greek economic growth. The results suggest that human capital (proxied by enrollments in various levels of formal education and by government expenditures on educational purposes) affects positively economic growth.

Finally, the aim of chapters 7 and 8 is to assess the impact uncertainty on economic growth. Chapter 7 examines the role of uncertainty stemming from political instability. An extensive number of theoretical and empirical articles argues that political instability hinders economic growth. Specifically, it has been argued that political instability increases policy



uncertainty, which has negative effects on productive economic decisions such as investment and saving. Most of the empirical studies conducted on this subject use cross-country data. In this chapter we test the effects of political instability to economic growth, constructing indices of socio-political instability based on time-series data, considering only the case of the UK economy. The empirical results suggest the existence of a negative effect of political instability on economic growth. The evidence of a negative effect of political uncertainty on GDP growth from simple OLS regressions, is followed by evidence first from GARCH models including political instability proxies in the growth equation and second from GARCH-M specifications including political instability proxies both in the growth and in the variance equation. In the first specification we have evidence of negative effects on GDP growth and in the second it is clear that political uncertainty increases uncertainty in the growth rate of GDP. The results also suggest that uncertainty of GDP growth itself does not cause or affect the growth of GDP. Chapter 8, examines the role of uncertainty on the outcome of an investment plan and how does this affect economic growth. Uncertainty proxies are obtained from the variance of GARCH models for GDP per capita for 59 industrial and developing countries between 1966 and 1992, we estimate, using dynamic panel techniques, reduced form equations to explore the possible effects of uncertainty on investment and economic growth. Overall, we find that uncertainty reduces both investment and growth.

## Part I

# Convergence

## Chapter 2

# Endogenous versus Neoclassical Growth Theories and the Convergence Debate

### 2.1 Introduction

Although formal definitions of convergence might vary, they generally imply a tendency of poor countries to grow faster than rich ones and eventual narrowing of per capita incomes across countries. The neoclassical growth theory suggests that countries with a similar physical environment and access to the same technology should not exhibit wide and persistent disparities in growth rates, and income level of all countries would tend to converge over time. In other words, given a sufficiently long time period, the income level of a country would be independent of its starting value. There are three major reasons that

one might expect such a tendency (see Romer, 1996). First, according to the Solow (1956) model, economies converge to their balanced growth paths where each aggregate variable of the model grows at a constant rate. Hence, to the extent that differences are from economies being at different points relative to their balanced growth paths one would expect income disparities to vanish over time. Second, since the Solow (1956) model implies decreasing returns to capital, there are incentives for capital to move from rich countries where marginal product of capital is low to poor countries where it is high, implying convergence in the rate of return on capital and incomes. Finally, lags in the diffusion of technology might create temporary income differences, as some of the countries are yet to employ the current state of the art technology. However, such differences would tend to dampen as poor countries gain access to the best available technology. In short, given the features of the neoclassical growth model one must either perceive income discrepancies as transitory or must assume dramatic differences in microeconomic characteristics such as production functions or preferences (see Bernard and Jones, 1996a and 1996b).

However, observed failure of income disparities to shrink across countries and failure of poorer countries to grow faster than rich ones have raised doubts on the predictions of the neoclassical model and stimulated theoretical research in new growth models. Starting with the seminal papers of Romer (1986) and Lucas (1988) new growth theories have illustrated that observed persistence of income disparities can be generated by non-decreasing returns to scale to a broad definition of capital. Parallel to the renewed research in growth theories, an empirical literature focusing on convergence has unfolded. While findings of convergence have generally been conceived as support for neoclassical growth models, lack

of convergence has been viewed as supportive of new endogenous growth models. The controversy that started on this matter has given rise to the concept of conditional convergence, meaning convergence after controlling for differences in the steady state levels across countries. On the other hand, convergence of per capita incomes without controlling for the differences in the physical and institutional environments has been known as absolute or unconditional convergence. The empirical evidence for lack of absolute convergence has been less controversial since disparities in growth rates and income levels partly reflect different levels of saving and investment rates as well as government policies. However, evidence on conditional convergence has been far more controversial.

The aim of this chapter is to present critically the various theoretical approaches on the subject of the convergence debate. In the next two sections we present and evaluate the neoclassical and the newly developed endogenous growth theories, while in the final section we present the major empirical studies and their basic results.

## 2.2 Neoclassical growth theory

Neoclassical growth theory took its modern form in the 1950's with the work of Robert Solow (1956) and Trevor Swan (1956). Their models embody the assumption of an economy under the conditions of perfect competition. The output of this economy grows in response to larger inputs of capital and labour, and obeys the rules of diminishing returns. These assumptions results in two features of capital inputs. As the stock of capital expands, growth slows and eventually comes to a halt. For growth to continue, the economy must experience technological progress, for which the model provides no explanation:

growth-inducing technological progress occurs outside of the model and is thus exogenous. The second feature is that because poor economies (countries, regions or cities) start off with less capital, they receive higher returns from initial investment, but as they grow returns diminish. This tendency reflects the diminishing marginal productivity of capital. Ultimately, as all areas reach the same high levels of development, their growth rates will converge. The Solow-Swan growth model is expressed mathematically in a relationship illustrating the properties described above via a Cobb-Douglas type production function, which has the following form:

$$Y = AK^aL^{1-a} \quad (2.1)$$

where  $Y$  is output;  $K$  is capital;  $L$  is labour;  $A > 0$  is the level of technology and  $a$  is a constant with  $0 < a < 1$ .

In this formulation, the assumption that the coefficients on capital and labour sum to one implies that returns to inputs follow the Cobb-Douglas specification of constant returns to scale.

This can be shown by:

$$Y = f(K, L) = L F(K/L, 1) = l f(k) \quad (2.2)$$

In intensive form this becomes:

$$y = f(k) \quad (2.3)$$

Here,  $k = K/L$  is the capital over labour ratio,  $y = Y/L$  is per capita output and



the function  $f(k)$  is defined to equal to  $F(k, 1)$ .

The condition that  $Y = L f(k)$  can be used and in turn can be differentiated with respect to  $K$ , for fixed  $L$ , and then with respect to  $L$  for fixed  $K$ , to verify that the marginal products of the factor inputs are given:

$$\frac{\partial Y}{\partial K} = f'(k), \quad \frac{\partial Y}{\partial L} = [f(k) - k f'(k)] \quad (2.4)$$

and

$$\frac{\partial Y}{\partial L} = f'(l), \quad \frac{\partial Y}{\partial K} = [f(l) - l f'(l)] \quad (2.5)$$

In the model each of the inputs is essential for production, thus:

$$F(0, L) = F(k, 0) = f(0) = 0 \quad (2.6)$$

The Solow-Swan model assumes that growth stems from capital accumulation.

The steady state of the capital over labour ratio can be expressed by:

$$\frac{dk}{dt} = s f(k) - (n + g + \delta)k \quad (2.7)$$

where  $s$  is the saving rate,  $n$  is the rate of growth of population,  $g$  is the rate of technological progress, and  $\delta$  is the rate of capital depreciation, with  $s$ ,  $n$  and  $\delta$  exogenous. The steady state is given by  $dy/dt = 0$ . This condition indicates that the approach to a steady state is a function of time. Conceptually, the steady state is defined as the case in which quantities grow at constant rates. Importantly, as the steady state is reached, an economy's output

will grow at a rate equal that of population growth, and per capita growth in output reverts to 0. This can be expressed by:

$$\frac{dy}{dt} = \frac{df(k)}{dk} \frac{dk}{dt} = 0 \quad (2.8)$$

The consequence of this model is that income levels of poor areas (countries, states, regions, cities) and those of rich ones converge. When economies with lower capital per person grow more rapidly than richer ones with higher capital per person, absolute  $\beta$  convergence is said to take place. As most nations and regions exhibit widely varying patterns of savings and population growth rates, the foregoing is highly restrictive. However, conditional convergence is said to occur when there is evidence for convergence provided that saving and population growth rates and other types of national variance are controlled. A third type of convergence is  $\sigma$  convergence, which refers to the tendency of the dispersion of real per capita income levels to decrease over time. This can be seen in the case where  $\sigma_{t+T} < \sigma_t$ , where  $\sigma_t$  is the standard deviation over time of income across the particular observations.

Empirically  $\beta$  convergence is usually estimated by running a cross section 'growth regression' of the form:

$$(1/T) \log(y_{i,t+T}/y_{i,t}) = a - \beta \log(y_{i,t}) + e_{i,t} \quad (2.9)$$

where  $y_{i,t} = Y_{i,t}/Y_t$  is per capita GDP in the  $i$ -th economy relative to the average for the sample of economies under investigation,  $(1/T) \log(y_{i,t+T}/y_{i,t})$  is the annualised rate of growth of (relative) per capita GDP in the  $i$ -th economy over the study period between  $t$



and  $t + T$ , and  $\log(y_{it})$  is the logarithm of relative per capita GDP in the  $i$ -th economy in the base year  $t$ . If  $0 < \beta < 1$ , the data set is said to exhibit absolute  $\beta$  convergence. Also, the value of  $\beta$  measures the speed of the convergence.

The concept of  $\beta$  convergence can easily be shown to be closely related to that of absolute  $\beta$  convergence by rewriting the basic growth regression in discrete time, corresponding for example to annual data, as:

$$\log(y_{i,t}) = a - (1 - \beta) \log(y_{i,t-1}) + e_{i,t} \quad (2.10)$$

and taking the variance of both sides, so that:

$$\sigma_{y_{t+T}}^2 = (1 - \beta)^2 \sigma_{y_t}^2 + \sigma_e^2 \quad (2.11)$$

Finally this shows that  $\beta$  convergence is a necessary but not sufficient condition for  $\sigma$  convergence. In other words  $\beta$  convergence is required for  $\sigma$  convergence to exist, but can be had without  $\sigma$  convergence present.

### 2.3 Endogenous growth theories

The neoclassical growth model provides important insights about growth, but it also has some serious limitations. The model's basic proposition is that the rate of growth of an economy over the long run is equal to the rate of technological improvement. However, it says nothing about the factors that drive technological improvement itself. Technological improvement is not explained by the model and, in this sense, growth is exogenous. This gave rise to a new body of theories that extended the neoclassical growth theory to incorporate

market-driven innovation and henceforth to allow for endogenously driven growth.

The term 'endogenous growth' refers to a body of economic models which emerged during the 1980's, through the pioneering works of Romer (1986, 1987, 1990), together with the influential contributions of Lucas (1988), Aghion and Howitt (1992) and Grossman and Helpman (1991). The main part of these new theories, was a critical response to the shortcomings of the conventional exogenous neoclassical growth model.

In general, endogenous growth models postulate that investment and increasing returns to scale are important to the process of economic growth. Of course, the idea of endogenous technological improvement and self-perpetuating growth is not new. To a great degree, the new endogenous growth theory is based on the Schumpeterian notion of innovations under monopolistic competition and on the relax of the neoclassical assumption of decreasing returns by Arrow (1962) in order to allow for externalities in production. However, the endogenous growth theories differs from the former in that it extends further both ideas and that it develops more sophisticated growth models which are comparable to the neoclassical alternatives.

The essence of many endogenous growth theories is reflected through the 'AK model' (Lucas, 1988; Romer, 1986; Rebelo, 1991). Specifically, through the equation:

$$Y = AK \tag{2.12}$$

where,  $Y$  denotes output,  $A$  represents factors that affect technology while  $K$  includes both human and physical capital. In this case there are no diminishing returns to capital and this is achieved by invoking some externality that offsets any propensity to diminishing

returns. In this sense, any increase in the rate of investment, either in human capital by an individual or in physical capital by a firm, leads to an increase in productivity that exceeds the private gain.

In general the endogenous growth theories can be classified into two different strands which envisage different sorts of increasing returns: endogenous broad capital models and endogenous innovation models (Martin and Sunley, 1996). The first strand can be further separated into two sets, one which simply show capital investment as generating externalities in the production and a different set which puts emphasis on the role of human capital and relates technological change to 'learning-by-doing' and 'knowledge spillovers'. The second strand, has been labeled Schumpeterian because it puts emphasis on the returns to technological improvements that arise from intentional innovation by the producers.

The most influential study related to the first strand is Romer's (1986) influential 'learning-by-doing' model. Romer (1986) assumes that the production function for each firm exhibits constant returns to scale in capital and labour, and adds as a third input in the production function knowledge, which is exogenous to the firms but endogenously determined in an aggregate, economy-wide scale. Thus, this third factor makes the production function to exhibit increasing returns to scale for the three factors considered together.

Another model that belongs in the first strand comes from the Lucas (1988) paper, where human capital is introduced in the production function. The introduction of the idea of technological advances due to human capital accumulation, makes knowledge a rival good, so that endogenous growth can occur without the need of externalities. However, Lucas (1988) interprets human capital accumulation in a wider sense, so that the increase

of worker's skills and knowledge has both an internal and external effect, the latter being the increase in productivity of all factors of production.

In the second strand of the endogenous growth models, purposive and profit-seeking improvements in technology are the main force behind rising standards of living. This strand tries to take into account existing market imperfections (e.g. monopolistic conditions) that provide an incentive for firms to undertake research and development (R&D) in the possibility that new products may earn temporary profits. Models of this type have been developed by Romer (1990), Grossman and Helpman (1991) Aghion and Howitt (1994), Barro and Sala-i-Martin (1990 and 1994) and Jones (1995) among others. According to these models, the existence of imperfect competition allows firms to capture sufficient profits to cover the costs of future R&D. By developing a new product which is slightly of a better quality, firms can capture profits previously enjoyed by the producers of the previous generations of the product. These innovations subsequently become the intermediate inputs for other producers so that they determine the overall growth rate of the economy. Overall, the implication of these models, is that subsidies and tax relief to promote R&D, effective patent systems, trade liberalisation (to help technology transfer) and attempts to divert skilled labour into R&D may all lead to higher growth rates.

## **2.4 The empirics of convergence**

In recent years, much of the empirical growth literature has attempted to evaluate growth theories by fitting regressions that relate the average growth rate of per capita income over some period for a sample of countries to initial per capita income and country



characteristics, and then applying standard methods of inference to the estimated coefficients (Kormendi and Meguire, 1985; Baumol, 1986; De Long, 1988; Barro, 1991; De Long and Summers, 1991; Barro and Sala-i-Martin, 1992; Mankiw et al., 1992; Chatterji, 1992; King and Levine, 1993; De Gregorio, 1993; Easterly, 1993; Alesina and Rodrick, 1994; and Persson and Tabellini, 1994; Canova and Marcet, 1995; de la Fuente, 1995; Galor, 1996; Barro and Sala-i-Martin, 1995; Sala-i-Martin, 1996, Temple, 1999 among many others). A negative relationship between initial incomes and average growth rates in these studies were interpreted as evidence of convergence and support for neoclassical growth models.

The empirical research developed in growth convergence theory using cross-sectional techniques can be classified on the following four concepts. First, there is research on what is named as unconditional convergence (Baumol, 1986; De Long, 1988). If countries in general failed to converge, this absence is then explained through institutions (Abramovitz, 1986; Alam, 1992). Secondly, there is research on conditional convergence which is examined by incorporating additional variables in various economic growth models (Dorwick and Nguyen, 1989; Barro and Sala-i-Martin, 1991, 1992; Mankiw et al., 1992, Barro et al., 1995). Some research on this concept has focused on interregional differences within a single country (a far from exhaustive list includes Mauro and Podrecca, 1994 for Italy; Mallick and Carayannis, 1994 for Mexico; Chatterji and Dewhurst, 1996 for Great Britain; Birnie and Hitchens, 1998 for Ireland; Kangasharju, 1998 for Finland; Siriopoulos and Asteriou, 1998 for Greece;) while a large part has focused on industry differences (Dollar and Wolff, 1988; Alam, 1992; Jasinowski, 1992; Costello, 1993). Thirdly, some studies have attempted to determine empirically the forces underlying sigma convergence (Vohra, 1996); while finally

there is literature on endogenous growth models, where in general convergence is absent.

A typical work in these kind of studies stems from the Mankiw, Romer and Weil (1992) paper. The key equation for testing convergence is given by<sup>1</sup>:

$$\ln y_t - \ln y_0 = (1 - e^{-\lambda t}) \frac{a}{1-a-\beta} \ln s_K + (1 - e^{-\lambda t}) \frac{\beta}{1-a-\beta} \ln s_H - (1 - e^{-\lambda t}) \frac{a + \beta}{1 - a - \beta} \ln(n + g + \delta) \ln y_0 \quad (2.13)$$

where  $y_t$  is the income per effective worker at time  $t$ ;  $n$  is the growth rate of working age population;  $g$  is the rate of technological progress;  $\delta$  is the rate of depreciation;  $a$  and  $\beta$  are the output elasticities of physical and human capital;  $s_K$  and  $s_H$  are investment rates in physical and human capital. Finally the speed of convergence term,  $\lambda$  is:

$$\lambda = (n + g + \delta)(1 - a - \beta) \quad (2.14)$$

Equation (2.13) suggests a regression of the scaled growth rate on initial income and the control variables,  $n$ ,  $s_K$  and  $s_H$ . Mankiw, Romer and Weil (1992) estimate this equation, using log differences of GDP per working age person between 1960 and 1985 and the respective averages of other variables over the same period for three different samples of countries<sup>2</sup>. Their findings support conditional convergence for all three samples and unconditional convergence for the OECD countries. Thus, their general conclusion is that the predictions of the Solow-Swan model regarding convergence are correct once the differences in the levels of human capital as well as of physical capital are accounted for.

<sup>1</sup>See equation (16) in Mankiw, Romer and Weil (1992).

<sup>2</sup>The largest sample consists of all but the oil producing countries, for which data are available; the second sample excludes countries with low population (less than one million for 1960) and with low quality data; while, finally, the third sample contains only the OECD countries.

However, the severe shortcomings of cross-sectional analysis pointed out by Friedman (1992) Quah (1993) Lee, Pesaran and Smith (1995) and Evans (1996) cast doubt on those conclusions. The single cross-section regression analysis in Mankiw, Romer and Weil (1992) which is typical in many other studies and their results regarding convergence from such analysis are subject to the following criticisms.

First, it has been argued (Quah, 1992) that the averaging of growth rates suppresses dynamic information that can explain part of the variation in growth rates. They explain that viewing the time-averaged growth regressions as explaining the changes in the underlying steady-state growth rates, growth rates,  $\Delta y_{it}$ , can be expressed as steady state growth rates,  $a_i$ , plus deviations around it:

$$\Delta y_{it} = a_i + (\Delta y_{it} - a_i) \quad (2.15)$$

However, cross-section regressions can explain  $a_i$ , meaningfully only if the deviations around it are small and uncorrelated with the set of explanatory variables. If, on the other hand, growth rates show a strong dependence on initial conditions, they will never converge to a steady state.

Also, Quah (1993a) criticizes the interpretation of convergence from cross-section regressions as being subject to Galton's fallacy of regression towards the mean, while the same author (Quah, 1993b) shows that coefficients with arbitrary signs for initial incomes in such regressions are consistent with an unchanging cross-section distribution over time.

Furthermore, Evans and Karras (1996) explain that the conventional cross-country approach to convergence is valid only if the economies have identical  $AR(1)$  structures and

all cross-country permanent differences are controlled for. They indicate that application of OLS to a model like (2.13) is unlikely to be useful for inferring information about the coefficients on  $\ln y_0$ , initial income, and other variables as the error would likely be correlated with  $\ln y_0$ . Finally, Evans (1996) shows that the error term and initial conditions would be uncorrelated if and only if income differences are generated by an  $AR(1)$  process.

Developments in standard time series techniques such as cointegration, provided researchers with additional tools to study convergence. These studies usually define convergence as temporary deviations of income from identical long-term trends. These techniques have the advantage over the cross-sectional methodology in using dynamic data to explain a dynamic process. However, since the growth models look at long-term effects, one might fear that the results from these techniques would be affected by fluctuations in incomes due to business cycles. In contrast to the vast number of cross-sectional empirical studies, relatively few papers have employed time series methods to evaluate growth theories. The two best known are those of Bernard and Durlauf (1991) and Quah (1992). Unfortunately, both papers test hypotheses that a priori rule out the possibility that countries have different growth rates, and Quah's paper also rules out the possibility that countries have noncoincident, but parallel, balanced growth paths (Evans, 1998). These restrictions limit the usefulness of their inferences because many interesting endogenous growth models predict that countries have different trend growth rates, and many interesting exogenous growth models predict that countries have parallel and noncoincident growth paths. Additionally, standard time series techniques suffer from the property of low power unless time dimension of the data is quite long.<sup>3</sup>

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<sup>3</sup>For an extensive discussion of the limitations of the cross-sectional methods in comparison with the time



Panel data across countries can provide substantial improvement in power over the standard time series techniques. Also, the panel data methods eliminate the unobserved 'fixed effects' and avoid the problem of correlation that has been observed in the cross-sectional studies. Islam (1995) using panel data found rather different estimates for the rate of convergence suggesting that the fixed effects problem is an important one. Also, he found that there are systematic variations in technical efficiency across countries, which leads naturally to the assumption that the rates of technological change must also differ, as some countries catch up while others lag behind. Using the panel data framework, Evans (1998) evaluates endogenous and exogenous growth theories for samples of 13 rich countries and 27 countries with relatively well-educated populations and his findings are mainly in favour with the predictions of the neoclassical growth theory. Finally, Lopcu (1998) using panel data from the Summers and Heston (1991) World Tables, tests the convergence hypothesis by investigating the unit root properties of income differences. His findings suggest that income differences appear to be persistent for three different samples even after allowing for country specific effects. His results also indicate an unambiguous convergence only within the OECD countries, which is inconclusive in terms of comparing the two alternative views of the neoclassical and endogenous growth theories. Finally, we have to mention that panel data methods are not without their own difficulties. Results when controlling for fixed effects are often disappointingly imprecise, because the standard transformations remove much of the identifying variance in the regressors.

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series ones see Chapter 5, Section 5.1 of this dissertation.

## Chapter 3

# Growth and Convergence:

# Evidence from the Greek Regions<sup>1</sup>

### 3.1 Introduction

Throughout the last five years, few issues have proved more controversial in empirical economics than the so-called convergence hypothesis. In the bulk of this literature, convergence has been defined as a negative correlation -after controlling for some set of variables- between initial income and growth for a cross-section of countries, regions, states, or even families.

The neoclassical growth models for closed economies, as presented by Ramsey (1928), Solow (1956), Cass (1965), and Koopmans (1965), suggest that per capita growth rates tend to be inversely related to the starting level of output or income per person. In

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<sup>1</sup>A version of this chapter has been published on *Regional Studies*, Vol. 32(6), pp. 537-546, (1998) with co-author Professor Costas Siriopoulos.

particular, if economies are similar with respect to preferences and technology, then poor economies grow faster than rich ones, promoting convergence in levels of per capita product and income. Thus, the main conclusion of those models is that poor countries or regions, to catch up with the rich ones through time, implying convergence.

Baumol (1986) examines convergence from 1870 to 1979 among the 16 industrialized countries for which Maddison (1982) provides data. He argues that convergence has shown itself strongly in the growth of industrial nations since 1870. He bases this conclusion on a regression of growth from 1870 until 1979 on the initial productivity level. However De Long (1988) demonstrates that Baumol's (1986) finding, is largely spurious. He finds two problems. The first is sample selection bias. Since historical data are constructed retrospectively, the countries that have long data series are those that are more industrialized today. Thus countries which were not rich a hundred years ago could be typically in the sample only if they grew rapidly over the next hundred years. In contrast, countries that were rich a hundred years ago, are generally included even if their subsequent growth was only moderate. The second problem is measurement error. Estimates of real income per capita in 1870 are imprecise, and this measurement error creates bias towards finding convergence. The De Long (1988) analysis suggests that there are no forces pushing for convergence. Using the same line of argument, Rebelo (1991) suggests that the absence of convergence across economies throughout the world represented strong evidence against the neoclassical model and in favour of their theories of endogenous growth.

Other papers by Dowrick and Nguyen (1989), Barro and Sala-i-Martin (1990, 1991, 1992), Mankiw, Romer and Weil (1992) and Lightenberg (1992), among others, have investi-

gated the sources of growth and convergence, using explicitly formulated growth models as a framework for empirical analysis. Barro and Sala-i-Martin (1990, 1991, 1992) formulate an equation, which is in accordance with the neoclassical framework of analysis, in order to test empirically for the existence of convergence. The overall evidence of their analysis weighs heavily in favour of convergence, suggesting that the results of the neoclassical growth models are valid. Examining the growth and dispersion of personal income in the states and regions of the USA, as well as in 73 regions of seven European countries, they conclude that poor states and/or regions really tend to grow faster in terms of per capita income and product, with a rate of convergence, approximately 2% per year, for both US states and European regions (Barro and Sala-i-Martin, 1991). Also, in their study of 1994 they extend the empirical evidence on regional growth and convergence across the U.S., Japan and European nations, confirming that the estimated speeds of convergence are surprisingly similar across data sets and that all regions tend to converge again at the same speed (of approximately 2% per year). Mankiw, Romer and Weil (1992), examine the implications of the Solow (1956) model about convergence in standards of living and their evidence indicates that, holding population growth and capital accumulation constant, countries converge about at the rate predicted by the augmented Solow model. Finally, other recent studies on the subject of convergence support the theory of the neoclassical model. Specifically, Coulombe and Lee (1995) find convergence across Canadian provinces from 1961 to 1991, and Cashin (1995), suggests that there exists convergence across the seven states of Australia .

Although neoclassical economic theory predicts convergence, the empirical evidence has been the subject of debate. Indeed the findings of Barro and Sala-i-Martin (1990,



1991, 1992) have been subject to criticism by other analysts. Specifically, Mauro and Poldrecca (1994) examined the convergence hypothesis for Italian regions, using the Barro and Sala-i-Martin framework of analysis. Their findings were the opposite of those obtained by Barro and Sala-i-Martin (1991) for the same case. They suggested the rejection of the convergence hypothesis in all cases, and the existence of economic dualism between Northern and Southern Italy.

Pagano (1993), studying productivity or income convergence in the European Community countries, suggests that the process of convergence stops or even reverses with the oil shocks of 1970s. Neven and Gouyete (1994) suggest that there exists dualism between southern and northeastern regions of the European Community, and Button and Pentecost (1995) testing the convergence in the European Union regional economies find no significant convergence across those regions in the 1980s.

Finally, Bernand and Durlauf (1995), proposing a new methodology, use time series techniques to test the convergence hypothesis. In their analysis, they apply empirical tests for convergence among 15 OECD economies, and their results suggest the rejection of the convergence hypothesis.

In this chapter, we examine income convergence across the regions of Greece. We test convergence using the Barro and Sala-i-Martin type of unconditional and conditional beta-convergence equation. Our empirical results support the hypothesis of the existence of dualism across the southern and northern regions of Greece. We also test the hypothesis of conditional beta convergence implied from the neoclassical growth model following Mankiw, Romer and Weil (1992). Our findings, cast doubt on the neoclassical model of growth,

and our results suggest that conditional beta convergence regressions do not hold for the Greek case. In the next section (section 2), we present the current position of Greek regional economic policy for our sample period (1970-1996). In the third section, we present the theoretical framework and the methodology, and in the fourth section we provide the empirical results. Finally we conclude with thoughts about the economic position of Greek regions.

### **3.2 Regional disparities and Greek regional economic policy: 1971-1995**

The issue of convergence across the Greek regions has been an extremely interesting subject, about the Greek economy, and the European unification project as well. Will the levels of per capita income tend to equalize in the long run? Do poor regions within Greece grow faster than rich ones? Will the economic differences between North and South disappear? The European Union's (EU) interest is obvious, because the EU will be able to reap the benefits of cooperation and specialization only when the individual economies benefit from the integration process.

This issue bears greater importance if we consider the fact that the economic help from the EU -through the Integrated Mediterranean Programmes and the Regional and Structural Funds- for effective regional policy, which will lead the Greek regions towards convergence, will decrease gradually after the end of this century. In other words, if convergence across the Greek regions is not achieved before 2000, the latitude for implementing an effective policy, is rather restricted or even impossible.

Over the past 15 years Greece faced a process of real divergence from the European average GDP percentage growth rates. This diverging performance is more disappointing, if compared with the performance of the rest of the so-called European peripheral areas, i.e. Spain, Portugal and Ireland, all of which converged clearly with the European Union average, as can be observed in Table 3.1.

Regional disparities in terms of national income per capita in Greece are presented in Table 3.2. We observe that these disparities are narrowing through time but still remain large enough. From the summary statistics we observe that the mean, as it is expected, increases over time but its increase is very slow, while the standard deviation shows a negative trend only during the sub-period 1971-1981 (from 0.21 to 0.15) implying convergence. Until the 1991 the dispersion oscillates around a constant value with a weak positive trend implying divergence. What is more interesting is that the coefficient of variation -which is often used to measure the regional distribution of income- also rises from 1981 to 1991, suggesting that over this period the Greek regions tend to diverge rather than converge.

However, the key question is why convergence has failed to materialize in the context of the Greek economy over the past 15 years. One aspect of the answer to this question, probably rests on the framework of regional economic policy. As far the regional incentives system for industry is concerned, it has been argued that state regional policies were not, in general, successful (Labrianidis and Papamichos, 1990). From Table 3.3, it is observed that the period 1970-96 has been marked by a stagnation of investment and restructuring of production. Since 1990 the spatial distribution of investments has changed in favor of the peripheral regions of the country (Table 3.4). Athens and Central Macedonia

faced a reduction of investments while for the rest regions there was a slight increase.

However, this trend is weak, especially after the Second World War up to early 1980s there was a pattern of continuous growth of the prefecture of Athens and other developed prefectures in Central Greece, while the rest of the country was displaying trends of decline. This probably explains the popular view prevailing in Greece, that there exists great differences (or economic dualism) between the capital city (Athens) and the other part of the country, differences not only at the economic level but also at the social level. The regional implications of other state policies such as those on tourism, agriculture, infrastructure, transportation, communications, housing, and in particular industrial branches, such as nationalised industries, were characterised by the same contradictions and were equally ineffective.

Finally, the regional development projects pursued in the context of EU policies (for example the Integrated Mediterranean Programmes) failed to alter the unplanned character of the Greek economy. They were introduced simply as lists of public works rather than as programmes. Despite the fact that regional policy plays a great role in the development of a country, the period from 1974-1981 was characterized by two external factors ( 1974-1979 the two major oil crises and 1981 Greece's accession to the European Community). In addition to this we must consider some sociological and historical aspects which influenced the 'nature' of the country in a great extent, such as the two big influxes of people during the 1920's and 1950's in Athens and in Thessaloniki coupled with the big waves of immigration, either to urban areas or abroad. Only in the decade 1970-80, 1.7 million people moved to the two major urban cities (Athens and Thessaloniki) (Kanellopoulos, 1995). The



high levels of immigration caused a very uneven geographical distribution of Greek industry. The country's two main urban industrial centres account for more than 60% of the total industrial employment and establishments. Furthermore, the most important firms in terms of R&D and market shares are located within or near those areas. So, Greece appears as an agricultural region with two main industrialized cities, Athens and Thessaloniki. This, combined with the fact that the 35% of the total population of the country lives in Athens, separates the whole country into two main regions: Athens and non-Athens.

Therefore, in order to evaluate the results of Greek regional policy, it is important to test the convergence hypothesis across the Greek regions (Athens included).

### 3.3 Convergence: definitions and methodology

#### 3.3.1 Cross-sectional methodology for testing for convergence

Following the terminology first introduced in Sala-i-Martin (1990, 1994) we define  $\beta$ -convergence in a cross section of economies (countries, states, regions e.t.c.) if we find a negative relation between the growth rate of income per capita and the initial level of income. In other words we say that there is  $\beta$ -convergence if poor economies tend to grow faster than the rich ones. In order to test for this concept of convergence we use the following non-linear regression:

$$(1/T)[\ln(y_{0+T,i}) - \ln(y_{0,i})] = c - (1/T)(1 - e^{-\beta t}) \ln(y_{0,i}) + e_{0+T,i} \quad (3.1)$$

where  $\ln(y_{0+T,i}) - \ln(y_{0,i})$  is economy's growth of GDP per capita between 0 and  $T$ ,  $\ln(y_{0,i})$  is the logarithm of the economy's GDP per capita at time 0, or the initial level of per capita GDP,  $t$  is a linear time trend and  $e_{0+T,i}$  is the disturbance term. In fact, we estimate the speed of convergence  $\beta$ . If we find  $\beta > 0$ , then the data exhibits absolute  $\beta$ -convergence.

Following Barro and Sala-i-Martin (1991, 1992) and Mankiw, Romer and Weil (1992), we can also distinguish conditional from absolute  $\beta$ -convergence. A set of economies displays conditional  $\beta$ -convergence, if the partial correlation between growth and initial income is negative. In other words, if we run a cross-sectional regression of growth of initial income holding constant a number of additional variables, and we find that the coefficient of initial income level is positive, then the economies in the data display conditional  $\beta$ -convergence. If the coefficient of initial income is positive in a univariate regression-like regression (3.1)- then we say that the data set displays unconditional or absolute  $\beta$ -convergence.

The Solow growth model predicts a form of conditional convergence implied by a growth equation which derives from the transitional dynamics of the model (Mankiw, Romer and Weil 1992, Barro and Sala-i-Martin 1990). This equation is the following:

$$[\ln(y_{0+t,i}^e) - \ln(y_{0,i}^e)] = (1 - e^{-\beta t}) \ln(y_{0,i}^{e*}) - (1 - e^{-\beta t}) \ln(y_{0,i}) \quad (3.2)$$

where,  $y_{0+t,i}^e$  and  $y_{0,i}^e$ , are the output per effective worker at time  $0 + t$  and 0 respectively and  $y_{0,i}^{e*}$ , is the steady state level of output per effective worker.

Mankiw, Romer and Weil (1990), substituting for the determinants of  $y_{0,i}^{e*}$  and transforming equation (3.2) in observable variables, obtain:

$$[\ln(y_{0+t,i}) - \ln(y_{0,i})] = (1 - e^{-\beta t}) \ln A + gt$$

$$+(1 - e^{-\beta t})\left\{\left(\frac{\beta}{1 - \beta}\right) \ln s_i + \left(\frac{\beta}{1 - \beta}\right) \ln(n_i + g + d)\right\} - (1 - e^{-\beta t}) \ln(y_{0,i}) \quad (3.3)$$

where  $A$  is the technological parameter,  $g$  is the rate of technical progress,  $d$  is the rate of depreciation,  $\beta$  is the capital coefficient of a Cobb-Douglas production function with constant returns to scale,  $n_i$  is the population growth rate and  $s_i$  is the accumulation rate (in an open economy context usually proxied by the share of investment on GDP). Mankiw, Romer and Weil (1990), propose the estimation of the following linear regression:

$$[\ln(y_{0+t,i}) - \ln(y_{0,i})] = \gamma_1 + \gamma_2 \ln(s_i) + \gamma_3 \ln(n_i + g + d) + \gamma_4 \ln(y_{0,i}) \quad (3.4)$$

where  $\gamma_1 = (1 - e^{-\beta t}) \ln A + gt$ ,  $\gamma_2 = \gamma_3 = (1 - e^{-\beta t})\left(\frac{\beta}{1 - \beta}\right)$ , and  $\gamma_4 = (1 - e^{-\beta t})$ , implying  $\beta$  the parameter which reflects convergence.

Alternatively, Barro and Sala-i-Martin (1991,1992) suggest that in order to test the hypothesis of conditional convergence one must hold the steady state constant. So, they propose the estimation of the following form of equation (3.19):

$$(1/T)[\ln(y_{0+t,i}) - \ln(y_{0,i})] = c - (1 - e^{-\beta t}) \ln(y_{0,i}) + \psi X_{it} + e_{0+T,i} \quad (3.5)$$

where  $X_{it}$  is a vector of variables that proxy for, and hold the steady state constant. The only difference with (3.16), which tests for unconditional or absolute convergence, is the presence of the steady state vector  $X_{it}$ .

In our empirical analysis we estimate regressions (3.2), (3.4) and (3.5) to test for the different types of  $\beta$ -convergence across the Greek regions. All the data were taken

from a special statistical edition of the Greek Centre for Planning and Economic Research (CPER, 1993).

### 3.3.2 Times series methodology: cointegration and convergence

The issue we are interested in studying is: is there a tendency for the income of initially poor regions to become similar, on average, to the income of initially rich regions as time passes, or is it the case that the poor stay poorer than the rest? In the former case we would say that there is convergence; in the latter that there is persistence of inequality.

All our observations are collected across regions and time. The evolution of per capita income for all units is indexed by a doubly indexed stochastic process  $\{Y_t^i\}$ , where  $i$  indexes units and  $t$  indexes time. It is convenient to study (the log of) each region's per capita income relative to the aggregate. So, we define as  $y_t^i = \log(\text{share of national income per capita for region } i \text{ in period } t)$ . According to Bernard and Durlauf (1995) definition regions  $i$  and  $j$  converge if the long term forecasts of output for both regions are equal at a fixed time  $t$ . In econometric terms there is convergence if the difference  $(y_t^i - y_t^j)$  is stationary, and absence of convergence when the difference  $(y_t^i - y_t^j)$  contains a unit root. This first definition allows us to test only for pairwise convergence.

Following the second definition of Bernard and Durlauf (1995), we define convergence for a group of regions to mean that each region has identical long-run trends, either stochastic or deterministic<sup>2</sup>, while common trends allow for proportionality of the stochastic elements. This definition lead naturally to the use of cointegration techniques in testing

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<sup>2</sup>Every time serie can be expressed as:  $x_t = \text{trend} + \text{seasonal} + \text{irregular}$ , For example, GNP's sustained upward trend might be captured by a simple linear time trend, implying a deterministic long-run growth rate of the real economy, a seasonal effect if the economy is characterised by seasonality and an irregular effect (stochastic, purely random) implying some stochastic shocks, such as technological innovations.



the convergence hypothesis. For convergence, the two or more regions must be cointegrated with cointegrating vector  $[1, -1]$ . The above definition -in contrast with the cross sectional methods- allows us to test whether the regions have a common trend<sup>3</sup> in their output series. For common trends, the two or more regions must be cointegrated with cointegrating vector  $[1, -a]$ .<sup>4</sup>

In order to test for convergence and common trends, we employ multivariate techniques developed by Johansen (1988). The starting point for the empirical work is the finding that the output vectors of each region ( $Y_t^i$ ) are integrated of order one. Then we assume that a finite-vector autoregressive representation exists<sup>5</sup> and we can rewrite the output vector processes as:

$$\Delta Y_t^i = \Gamma(L)\Delta Y_t^i + \Pi Y_t^i + \mu + \varepsilon_t \quad (3.6)$$

where

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<sup>3</sup>The existence or not of one or more common trends is examined by the number of cointegrating vectors, and indicates that there are some regions in the sample that are converging between them, despite that all regions are not converging each other.

<sup>4</sup>At this point, we have to add that this notion of cointegration does not necessarily means existence of convergence. Cointegration between two series suggests that they may not diverge without bound, but not that they always converge. A more preferable testing strategy would have been to test whether the parameters of the cointegrating vector are changing over time. However, data restrictions due to the small sample space do not allow us to test for that.

<sup>5</sup>The Johansen procedure is nothing more than a multivariate generalization of the Dickey-Fuller test. In the univariate case, it is possible to view the stationarity of  $\{y_t\}$  as being dependent on the magnitude  $(a_1 - 1)$ , that is:

$$y_t = a_1 y_{t-1} + e_t$$

or

$$\Delta y_t = (a_1 - 1)y_{t-1} + e_t.$$

Now consider a simple generalization to  $n$  variables:

$$Y_t = A_1 Y_{t-1} + e_t, \text{ so that}$$

$$\Delta Y_t = A_1 Y_{t-1} - Y_{t-1} + e_t = (A_1 - I)Y_{t-1} + e_t = \Pi Y_{t-1} + e_t$$

where  $Y_t$  and  $e_t$  are  $(n \times 1)$  vectors,  $A_1$  = an  $(n \times n)$  matrix of parameters,  $I$  = an  $(n \times n)$  identity matrix and  $\Pi = (A_1 - I)$ .



$$\Gamma_i = -(A_{i+1} + \dots - A_k), (i = 1, \dots, k - 1) \quad (3.7)$$

and

$$\Pi = -(I - A_i - \dots - A_k) \quad (3.8)$$

$\Pi$  represents the long-run relationship of the individual series, while  $\Gamma(L)$  traces out the short-run impact of shocks to the system. The Johansen test estimates the rank of the cointegrating matrix  $\Pi$ , which can be written as:

$$\Pi = a\beta' \quad (3.9)$$

with  $a$  and  $\beta$ , are  $(p \times r)$  matrices of rank  $r \leq p$ .

If the rank of  $\Pi$  equals  $p$ , then each  $Y_t^i$  is a stationary process. If the rank of  $\Pi$  is  $0 < r < p$ , there are  $r$  cointegrating vectors for the individual series in  $Y_t^i$  and hence the group of time series is being driven by  $(p - r)$  common shocks. If the rank of  $\Pi$  equals zero, there are  $p$  stochastic trends and the long-run output levels are not related across regions. In particular, in order to have regional convergence there must be  $(p - 1)$  cointegrating vectors of the form  $(1, -1)$  or one common long-run trend. In our empirical analysis we apply both tests in order to test the convergence hypothesis and the presence or not of common trends, using time series data (of per capita output in constant prices) for the Greek regions and especially for the period from 1971 to 1996.

## 3.4 Empirical results

### 3.4.1 Testing for unconditional $\beta$ -convergence

As a first step, we investigate whether there exists the ‘Barro and Sala-i-Martin type’ of unconditional  $\beta$ -convergence across Greek regions. For this purpose we estimate using non-linear least squares, the regression equation (3.2).

The estimates of regression (3.2) are presented in table 3.5. We estimated this regression for the sub periods: 1971-1981, before the entry of Greece to the European Community (EC), 1981-1996, after the entry of Greece to the EC, and for the whole period 1971-1996.

At first glance the results do not support the hypothesis of unconditional  $\beta$ -convergence across the Greek regions, over any of the three sub-periods considered. The  $\beta$  coefficient, although positive, is never statistically significant different from zero. In the same table we present the results of the estimation of the same basic equation (3.2) with the addition of two explanatory variables, the shares of GDP in the manufacturing and industrial sector for each region ( $met_i$  and  $ind_i$  respectively). These two explanatory variables are used on the grounds that this should help to stabilize the  $\beta$  coefficient across the different sub periods, by holding constant the shocks which might affect groups of regions in common, or those correlated with initial per capita income. Barro and Sala-i-Martin (1991), include similar variables in their regression analysis for European regions<sup>6</sup>. In our estimation the inclusion of these additional variables does not improve our estimates and

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<sup>6</sup>In our empirical analysis we used also other structural variables as explanatory variables, such as the share of the agricultural sector on GDP and the growth rate of employment for each region. Our results are not sensitive to the inclusion of these variables. Results and tables available on request to the authors.

thus does not appear to play a significant role.

As we have mentioned before, a popular view prevailing in Greece, is that there exists economic dualism between northern and southern Greece. Therefore, it is tempting to test whether this view is true or not. The results of table 3.5 support this view, because we do not find existence of convergence. However, we want to test this more thoroughly. So, we re-estimate regression (3.2), this time including an additional north/south dummy variable ( $N/S$ ) on the right hand side. This dummy variable takes the values of 1 for Southern regions and 0 for Northern regions. Using this dummy we test the possibility that absolute  $\beta$ -convergence exists across the two groups. In other words, this dummy is a proxy for different steady state values of per capita income between North and South. Thus, a positive estimate of the  $\beta$  coefficient in this case would indicate that there exist  $\beta$ -convergence within each area, rather than convergence across all Greek regions of convergence between North and South.

The results of this regression are reported in table 3.6. In the same table we present the results of the above regression including the two structural explanatory variables. The estimates show little improvement with respect to the previous results. Specifically, only the coefficients of the two structural variables are significant, indicating influence in the stabilization of  $\beta$ . The inclusion of the  $N/S$  dummy determines an increase in the explanatory power of the regressors, while the  $\beta$  coefficient is not always positive and it is less unstable across sub-periods. The results are not conclusive yet, because we do not have statistically significant estimates for the coefficient of convergence for neither of the above cases as the values of t-statistics reveal. Thus, the hypothesis of absolute  $\beta$ -convergence

across Greek regions is clearly rejected for any of the sub-periods considered.

### 3.4.2 Testing for conditional $\beta$ -convergence.

The previous results, indicating the absence of convergence across Greek regions and the persistence of economic dualism between the northern and southern Greece, are not in contradiction with the predictions of the neoclassical model of growth. This model does not imply unconditional  $\beta$ -convergence, and it is perfectly consistent with the permanent interregional differences in per capita income levels. The poor statistical performance of the regressions (tables 3.5 and 3.6) might be due to the fact that we have not explicitly controlled for cross-regional variations of the steady states towards which each region is supposed to converge. In other words we have not tested for conditional  $\beta$ -convergence.

The concept of conditional  $\beta$ -convergence defined above suggests the estimation of a multiple regression like (3.5). If the neoclassical model is correct and the vector  $X$  successfully holds constant the steady state, we should find a positive  $\beta$ . The key, therefore, is to find the variables that proxy for the steady state and economic theory should guide our search for such variables. Different versions of the neoclassical model suggest different variables. Following Barro (1991), a large literature has estimated equations like (3.5). In this literature more than 50 variables<sup>7</sup> have been used in this type of analysis, and have been found to be significant in at least one regression. (Mankiw, Romer and Weil, 1992; Levine and Renelt, 1992; and Barro and Sala-i-Martin, 1995: chapter 12).

In our empirical analysis we initially use the share of investment in GDP as a

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<sup>7</sup>Baumol and Wolff (1988), Dowrick and Nguyen (1989), Levine and Renelt (1992) among many others showed that convergence at world level may exist by including in the regression additional explanatory variables, for example government spending, the initial level of schooling, and so on.



steady state proxy variable. This is the most important factor that can lead the Greek regions to convergence. We then add the structural variables as well as the *N/S* dummy variable. The results of these regressions are presented in tables 3.7 and 3.8.

From the results, we can conclude that our proxy variable for the steady state is a suitable one, because in most cases it is statistically significant and affects the estimates of our model and it increases the explanatory power of our regressors. The coefficient of convergence  $\beta$  is always positive as the neoclassical theory predicts but it is never significantly different from zero, with the exception of the last case and specifically for the period after Greece joined the EC (1981-1996). The latter result implies conditional convergence within the Northern and the Southern part of Greece separately (because of the use of the *N/S* dummy variable as an explanatory variable in this regression). This finding is in favour with the popular view prevailing in Greece about the economic dualism between North and South. In fact this finding states that the Northern (Southern) regions of Greece are converging only with themselves and not with the regions of Southern (Northern) Greece. Here we must notice that the finding of convergence between the two separate Greek parts, is again quite insignificant, considering the speed of convergence which is 0.4 %. Barro and Sala-i-Martin (1991 and 1992) have found a speed of convergence approximately to 2 % so that 50% of the distance between an economy's initial level of income and its steady state disappears in about 35 years, and that 75% per cent of this difference vanishes only after 70 years. Or, in other words, one-fourth of the original income differences predicted, remain after a period of 70 years. Furthermore, it is important to notice that the existence of conditional  $\hat{\alpha}$ -convergence does not mean that poor regions grow faster than the rich



ones. This evidence suggests that regions seem to approach some long-run level of income which is captured by the vector of variables  $X$ , and the growth rate falls as the economy approaches this level.

Thus, our results do not support the predictions of the neoclassical growth model. However, in order to complete our analysis we perform cross-sectional linear regressions following the model of regression (3.4) as proposed by Mankiw, Romer and Weil (1992). In those regressions we hold constant the determinants of each region's steady state which now are the share of investment on GDP ( $s_i$ ) and the population growth rate ( $n_i$ ), augmented by the rate of technical progress ( $g$ ) and the depreciation rate ( $d$ )<sup>8</sup>. The estimated coefficients are presented in Table 3.9.

The results are the same with the previous non-linear model. To be more specific, the coefficient on initial income, and therefore the implied convergence coefficient  $\beta$ , always takes the right sign but it is never significantly different from zero. Similarly, the population growth rate does not seem to matter at all, as the corresponding coefficient is never statistically significant, and even takes a positive sign in the period 1971-1981 which is in conflict with the theory. Finally, maybe the most important thing to note is that the coefficient of the share of investment on GDP is negative in both models (the non linear model of Barro and Sala-i-Martin 1991 and 1992, and the linear model of Mankiw, Romer and Weil 1992), probably implying ineffective investment planning for Greece.

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<sup>8</sup>In our analysis ( $g$ ) and ( $d$ ) are supposed to be the same for all regions as in Mankiw, Romer and Weil (1992). Specifically,  $g + d$  is supposed to be equal to 0.08. Reasonable changes of this value do not alter the nature of the results.

### 3.4.3 Testing for convergence using time series techniques

The results of the first direct test of the convergence hypothesis, are presented in table 3.10. The evidence on convergence is quite striking. It is clear that both series ( $X_1$  and  $X_2$ ) contain unit roots which indicates the absence of convergence among southern Greece and Northern Greece and among (Attica) Athens and Central Macedonia (Thessaloniki). This finding supports the popular view prevailing in Greece about the persistence of inequality that exists among the Northern and the Southern part of the country.

Having failed to find evidence for real convergence, we turn to the test for the number of common trends in the regional output series. In order to test for common trends, we first test for the presence of stochastic trends in each of our 13 output series. Table 3.11 presents the results for the Augmented Dickey-Fuller tests. None of the 13 regions reject the null hypothesis of a unit root. Then we test for cointegration applying the Johansen technique in three separate groupings of regions: a group of 10 regions (we exclude the regions Northern Aegean Southern Aegean and Ionian Islands), a group which contains only the southern regions and a group for the northern regions only.

The multivariate results from the Johansen trace and maximum eigenvalue statistics on convergence and cointegration are presented in Table 3.12, for a lag length of 1. The lag length was chosen using the BIC criterion. The two statistics in the first case (according to the critical values obtained by Ostervald and Lenum, 1992) give different estimates of the cointegrating vectors. The Johansen trace statistic rejects 4 or fewer cointegrating vectors at the 5% level for the entire ten-region sample. This implies that there are 6 or 7 shocking forces for this group. The maximum eigenvalue statistic rejects for 6 or fewer cointegrating

vectors, which suggests that there are 4 or 5 shocking forces. Taking the five Southern and the five Northern regions separately, the two statistics give the same results. For the five Southern regions both statistics reject for 2 or more trends at the 5%, while for the five Northern regions the results reject the null hypothesis that there are 5 distinct trends and cannot reject the null that there is at least 1 trend, again with both statistics. These results suggest that there are only 1 or 2 long-run processes driving output in the Greek regions.

the presence of common trends in the output series means a converging performance, while in the opposite case, the presence of shocking forces means divergence.

### 3.5 Summary and conclusions

This paper tests the convergence hypothesis for the Greek economy following the theoretical basis of the neoclassical model of economic growth and using both cross-sectional and time series analysis. Two issues are being considered. Firstly, whether there is a regional convergence in the Greek economy. Secondly, given the interest in the possibility of a north-south divide in Greece, whether there is convergence between Southern and Northern Greece. The first considers whether the Greek economy exhibits the properties and the results hypothesized by the neoclassical growth model. The second issue refers to a hypothesis that is currently popular. After the collapse of the Eastern block and the liberalisation of the other Balkan economies it has been voiced from many sides that there has been a structural change in the Greek economy. Before, the South -mainly represented by the Athens area- was the economic heartland of the country. The northern areas were basically dedicated to agriculture. Now -the argument maintains- after the crisis of the '70s

the economic and industrial basis of the South has become aged and deindustrialisation (because of the crisis) is taking its toll. On the other hand, the northern areas - boosted also by opportunities in the newly-opened northern neighboring countries- tend to become the new economic centre.

Our empirical results are not in accordance with the neoclassical model but does support the popular view prevalent in Greece on existence of economic dualism across the southern and northern regions of the country. A possible explanation for this -excluding the problems of immigration and the other sociological and historical explanations- may be the lack of experience that poor countries (like Greece) have had in comparison with the rich ones. The rich countries have the combined ability to educate themselves as they grow rich and the endogenous ability to accumulate the knowledge upon which these efforts are made. The same argument can be used as an explanation for the regional differences -the fact that poor regions do not have previous experience and knowledge for making efficient investments. Another well-documented reason is state's infamous overcentralisation. Economic activities closer to the seat of government enjoyed better relations with the state machine. Additionally, regional policies towards a more even spatial distribution of economic activities proved to be ineffective. Their incentives system was characterised by innate weaknesses and contradictions (related to vested interests) (Labrianidis and Papamichos, 1990). The regional implications of other state policies such as those on tourism, agriculture, infrastructure, transportation, communications, housing, and in particular industrial branches, such as nationalised industries, were characterised by the same contradictions and were equally ineffective. Finally, the regional development projects pursued in the context of EU policies



(for example the Integrated Mediterranean Programmes) were introduced simply as lists of public works rather than as programmes and failed to alter the unplanned character of the Greek economy.

Referring to the issue of investment, our results reveal signs of ineffective investment planning from Greek regional policy. The technological performance gap between Greece and its European counterparts appears to have become wider by the end of the 1990s, contrary to the trend of the previous two decades. If one examines the level as well as the composition of investment in Greece during the 1980s it becomes clear that investment as a percentage of GDP declined by 6.8 percentage points. If one takes investment for rationalization as a proxy of modernization and application of new techniques in the production process, again it becomes clear that Greece lags behind Europe as a whole in this regard.

Given the fact that the quantity of funds from the EU is sufficiently large, the divergent path that the Greek economy follows can only be explained, in terms of the allocation of funding to various projects of questionable importance from a development point of view. Of course the importance of the Integrated Mediterranean Programmes and Regional Structural Funds needs to be considered in conjunction with the macroeconomic environment and the microeconomic foundations (production, technological progress, competition). Unless a shift away from quantitative and in favor of qualitative priorities takes place, it is highly likely that the absorption of EU funds will never lead Greek regions to convergence, and may even reinforce the divergence dynamics of the Greek economy.

The existence of regional divergence across Greece has important economic im-



plications for the European Union. The convergence of economic regions is an important factor which influences the sustainability of a monetary union once it has been formed. Taking into consideration the fact that we have strong evidence of the existence of regional divergence for other EU members (Mauro and Podrecca, 1994; Chatterji and Dewhurst, 1996) the whole issue of convergence becomes more complicated, and leaves the agenda open for further research.

Table 3.1: Comparative Economic Performance: Greece, Portugal, Spain and EU(12)					
	Mean Annual Percentage Change of GDP				
Period	Greece	Portugal	Spain	Ireland	EU(12)
1961-1970	7.6	6.4	7.3	4.2	4.8
1971-1980	4.7	4.9	3.5	4.7	3.0
1981-1990	1.4	2.7	2.9	3.7	2.4
1991	3.2	2.1	2.2	2.9	1.6
1992	0.8	1.1	0.7	5.0	1.0
1993	-0.5	-1.2	-1.1	4.1	-0.6
1994	1.5	1.2	2.0	6.0	2.7
1995	1.9	2.9	3.0	5.8	3.0
1996	2.3	3.2	3.2	5.0	2.9

Source: OECD

Table 3.2: Development of Greek Regional Per Capita GDP (in million drachmas)						
Regions	1971		1981		1991	
	GDP per capita	% of the 'richest'	GDP per capita	% of the 'richest'	GDP per capita	% of the 'richest'
Eastern Macedonia and Thrace	20,499	50.14	35,947	65.34	50031	86.20
Central Macedonia	29,897	73.13	40,347	73.34	46562	80.22
Western Macedonia	25,428	62.20	38,824	70.57	51986	89.56
Hipiros	19,447	47.57	31,802	57.81	36977	63.71
Thessalia	24,188	59.17	38,812	70.55	42314	72.90
Ionian Islands	23,053	56.39	36,388	66.14	44989	77.51
Western Greece	25,340	61.98	36,717	66.74	38601	66.50
Stereia	35,880	87.77	55,015	100.00	55872	96.22
Attica (Athens)	40,881	100.00	46,043	83.69	50707	87.36
Peloponisos	26,151	63.97	43,098	78.34	44579	76.80
Northern Egean	20,489	50.12	29,569	53.75	34014	58.60
Southern Egean	24,610	60.20	40,278	73.21	58043	100.00
Crete	24,266	59.63	34,996	63.61	47076	81.11
Summary Measures of Dispersion of Regional Per Capita GDP						
Mean of (log) of GDP		10.144		10.554		10.73
Standard dev. of (log) of GDP		0.213		0.157		0.168
Coefficient of Variation		0.021		0.013		0.014

Year	Investments	% of GDP
1966	49.0	25.6
1971	80.5	28.9
1976	79.7	22.1
1981	85.7	21.2
1986	75.3	17.6
1991	91.9	19.0
1992	93.0	19.3
1993	92.5	19.2
1994	95.8	19.0

Source: Centre for Planning and Economic Research

Regions	1981	%	1991	%
Eastern Macedonia and Thrace	882.1	8.3	1,705.5	9.6
Central Macedonia	1,654.4	16.7	2,180.0	12.2
Western Macedonia	288.8	2.9	607.7	3.4
Hipiros	661.2	6.7	1,054.5	6.0
Thessalia	621.1	6.3	1,114.3	6.2
Ionian Islands	211.3	2.1	393.9	2.3
Western Greece	621.7	6.3	1,185.4	6.6
Stereia	573.8	5.8	1,561.1	8.7
Attica (Athens)	2,539.8	25.9	4,138.2	23.2
Peloponnisos	600.9	6.0	1,076.2	6.1
Northern Aegean	297.2	3.0	642.8	3.6
Southern Aegean	268.4	2.8	732.1	4.1
Crete	695.2	7.1	1,426.4	8.0

Source: Centre for Planning and Economic Research

period	Basic Equation		Basic Equation with Structural Variables			
	$\beta$	$R^2$	$\beta$	<i>met</i>	<i>ind</i>	$R^2$
1971-81	0.0006 (0.8)	0.05	0.0002 (0.5)	-0.02 (-2.8)	0.001 (0.09)	0.51
1981-96	0.0006 (0.5)	0.02	0.001 (1.3)	-0.02 (-4.6)	-0.02 (-3.7)	0.76
1971-96	0.001 (0.7)	0.05 (0.8)	0.001	-0.04 (-3.18)	-0.02 (-1.12)	0.55

Values of t-statistics in parenthesis

Convergence requires a statistically significant negative  $\beta$  coefficient

*met*: the share of GDP in the manufacturing sector for each region

*ind*: the share of GDP in the industrial sector for each region

period	Basic Equation			Basic Equation with Structural Variables				
	$\beta$	<i>N/S</i>	$R^2$	$\beta$	<i>N/S</i>	<i>met</i>	<i>ind</i>	$R^2$
1971-81	-0.0006 (-0.4)	0.009 (0.9)	0.12	0.0002 (0.19)	-0.02 (-3.57)	-0.02 (-3.4)	0.00 (0.00)	0.76
1981-96	-0.002 (-0.9)	0.02 (1.35)	0.17	0.001 (0.54)	-0.02 (-2.28)	0.001 (0.09)	0.00 (0.00)	0.51
1971-96	-0.003 (-0.92)	0.02 (1.45)	0.21	0.0007 (0.18)	-0.04 (-2.3)	-0.02 (-1.0)	0.003 (0.14)	0.55

Values of t-statistics in parenthesis

Convergence requires a statistically significant negative  $\beta$  coefficient

*met*: the share of GDP in the manufacturing sector for each region

*ind*: the share of GDP in the industrial sector for each region

*N/S*: dummy variable taking the values 1 for Southern regions and 0 for Northern regions



period	Basic Equation			Basic Equation with Structural Variables				
	$\beta$	$s_i$	$R^2$	$\beta$	$s_i$	<i>met</i>	<i>ind</i>	$R^2$
1971-81	0.0007 (0.82)	-0.0002 (-0.6)	0.09	0.0002 (0.41)	-0.001 (-0.41)	-0.01 (-2.9)	-0.02 (-3.0)	0.76
1981-96	0.0008 (0.86)	-0.001 (-2.8)	0.46	0.0009 (0.96)	-0.008 (-1.63)	-0.01 (-1.7)	-0.01 (-0.7)	0.63
1971-96	0.001 (1.08)	-0.001 (-2.1)	0.35	0.0006 (0.48)	-0.001 (-1.8)	-0.02 (-1.3)	0.046 (-2.1)	0.68

Values of t-statistics in parenthesis

Convergence requires a statistically significant negative  $\beta$  coefficient

*met*: the share of GDP in the manufacturing sector for each region

*ind*: the share of GDP in the industrial sector for each region

$s_i$  : the share of investment on GDP for each region

period	Basic Equation with Structural Variables and with N/S dummy					
	$\beta$	$s_i$	<i>N/S</i>	<i>met</i>	<i>ind</i>	$R^2$
1971-81	0.0005 (0.35)	-0.0002 (-0.49)	-0.01 (-2.7)	-0.02 (-2.8)	-0.002 (-0.2)	0.77
1981-96	0.004 (1.65)	-0.001 (-2.22)	-0.01 (-2.14)	-0.01 (-1.18)	-0.022 (-1.41)	0.63
1971-96	0.0033 (0.91)	-0.001 (-1.9)	-0.02 (-1.4)	0.048 (-2.1)	-0.017 (-0.8)	0.68

Values of t-statistics in parenthesis

Convergence requires a statistically significant negative  $\beta$  coefficient

*met*: the share of GDP in the manufacturing sector for each region

*ind*: the share of GDP in the industrial sector for each region

*N/S*: dummy variable taking the values 1 for Southern regions and 0 for Northern regions

$s_i$  : the share of investment on GDP for each region

period	$\ln(n + g + d)$	$\ln(s_i)$	$\ln(\gamma_{0,i})$	$R^2$	implied $\beta$
1971-81	0.01 (1.05)	0.07 (0.7)	-0.4 (-1.15)	0.54	0.4 (1.15)
1981-96	-0.05 (-0.5)	-0.3 (-2.36)	-0.08 (-0.28)	0.48	0.08 (0.28)
1971-96	-0.007 (-0.2)	-0.27 (-1.3)	-0.5 (-0.9)	0.57	0.5 (0.9)

Values of t-statistics in parenthesis

$\ln(s_i)$  : the share of investment on GDP for each region

$n$ : the population growth rate,  $g$ : the rate of technical progress,  $d$ : the depreciation rate

for each region

Unit root test of the variable	
$X1 = \ln\left(\frac{Y_{\text{southern greece}}}{Y_{\text{greece total}}}\right) - \ln\left(\frac{Y_{\text{northern greece}}}{Y_{\text{greece total}}}\right)$	-0.18073 (-2.9850)
Unit root test of the variable	
$X1 = \ln\left(\frac{Y_{\text{athens}}}{Y_{\text{greece total}}}\right) - \ln\left(\frac{Y_{\text{macedonia total}}}{Y_{\text{greece total}}}\right)$	-0.55609 (-2.9850)

Convergence requires rejection of the unit root test hypothesis

Table 3.11: Unit Root tests		
Regions	Log real per capita output	First differences of per capita output
Eastern Macedonia and Thrace	-0,2578 (-2.9850)	-3,1807 (-2,9907)
Central Macedonia	-1,789 (-2.9850)	-4,0374 (-2,9907)
Western Macedonia	-1,0947 (-2.9850)	-4,0190 (-2,9907)
Hipiros	-1,9643 (-2.9850)	-4,7938 (-2,9907)
Thessalia	-1,4738 (-2.9850)	-4,1656 (-2,9907)
Peloponisos	-1,4134 (-2.9850)	-4,0737 (-2,9907)
Western Greece	-2,0582 (-2.9850)	-3,8067 (-2,9907)
Northern Aegean	-1,1567 (-2,9850)	-5,7866 (-2,9907)
Southern Aegean	-1,2497 (-2,9850)	-4,6799 (-2,9907)
Ionian Islands	-1,9345 (-2,9850)	-5,1956 (-2,9907)
Stereia	-1,8889 (-2.9850)	-4,1509 (-2,9907)
Athens	-2,1034 (-2.9850)	-3,2714 (-2,9907)
Crete	-1,2734 (-2.9850)	-7,4929 (-2,9907)

\* 95% Critical Values in parentheses

Describing the procedure of the test, we can say that in the first column we present the results of the test for existence or not, of unit root in the log levels of our variables. The statistical values are smaller than the critical for all cases and so we cannot reject the null hypothesis of existence of unit root. Similarly, in the second column, we present the results of the same test but this time in the first differences of our variables. This time, the statistical values are greater than the critical values rejecting the null hypothesis of unit root in the first differences. Therefore, all our variables are integrated of order one  $I(1)$ .

All Regions			Southern Regions			Northern Regions		
Trends	Trace	Max	Trends	Trace	Max	Trends	Trace	Max
>9	425,9	114,1	>4	95,3	36,4	>4	*99,4	*46,9
>8	311,7	76,0	>3	*58,9	*28,8	>3	52,5	27,5
>7	235,7	67,2	>2	30,0	14,1	>2	25,0	15,3
>6	168,5	*50,6	>1	15,9	12,2	>1	9,7	5,8
>5	117,8	39,6	>0	3,6	3,6	>0	3,9	3,9
>4	*78,1	27,0						
>3	51,1	20,8						
>2	30,3	15,2						
>1	15,0	11,5						
>0	3,5	3,5						

\* rejects at 5% (Critical Values from Osterwald and Lenum)

10 regions: Eastern Macedonia and Thrace, Central Macedonia, Western Macedonia, Hippiros, Thessalia, Western Greece, Sterea, Attica (Athens), Peloponisos, Crete.

Southern Regions: Western Greece, Sterea, Attica (Athens), Peloponnisos, Crete.

Northern Regions: Eastern Macedonia and Thrace, Central Macedonia, Western Macedonia, Hippiros, Thessalia.

## Part II

# Unexplained Factors



## Chapter 4

# Financial Development and Economic Growth: The Theoretical Background

### 4.1 Introduction

In the past, broadly speaking, we could distinguish between only two different schools of thought with somewhat different policy prescriptions on the subject of financial development and economic growth. The first was the 'financial structuralist' school (Goldsmith, 1969) which was suggesting that a widespread network of financial institutions and a diversified array of financial instruments will have a beneficial effect on the saving investments process and hence, will promote economic growth. The other was the 'financial repressionist' school (McKinnon, 1973; Shaw, 1973) which considered low real interest rates

-caused by arbitrarily set ceiling on nominal interest rates and high inflation rates- as being the major impediments to financial deepening, capital formation and thus, growth. According to this school, economic growth can be achieved by abolishing institutional interest rate barriers, by abandoning selective or directed credit programmes, and in general, by ensuring that the financial system operates competitively under conditions of free entry.

However, unfortunately, the theoretical insights provided by the works of the above mentioned schools and, in fact, from subsequent work in this area<sup>1</sup>, have not been sufficient to provide a single theoretical foundation to the role of finance in the process of economic growth of developing countries.

During the past decade, there has been a revival of interest in the literature of finance and especially on its role to economic growth. This came from the new strand of endogenous growth theories and models, which incorporated both endogenous growth and exogenous financial institutions constituting a new set of more complex financial growth models<sup>2</sup>. Thus, the research on the relationship between financial development and growth has received a new source of inspiration from the rapidly expanding endogenous growth literature. By focusing on cases where the marginal product of capital outlays remain positive, this literature provides a natural framework in which financial markets affect long-run and not just transitional growth. Most of these, theoretical and empirical, studies tend to emphasise the role of financial intermediation by improving the efficiency of investment rather than its volume, and hence affecting positively the growth process. However, while

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<sup>1</sup>Fry (1980), Galbis (1997), among others.

<sup>2</sup>The new strand of financial endogenous growth models, which was based mainly on the pioneering contributions of Lucas (1988) and Romer (1986, 1990) includes, among others, Bencivenga and Smith (1991, 1992, 1993), Greenwood and Jovanovic (1990), Greenwood and Smith (1997), DeGregorio (1992), King and Levine (1993a, 1993b), Pagano (1993), Roubini and Sala-i-Martin (1992), and Saint-Paul (1992).

this positive association has been well documented years ago by Goldsmith (1969), the new strand of endogenous growth models puts also emphasis on the investigation of the various mechanisms through which financial intermediation can improve the allocation of capital and through this to accelerate the rate of economic growth.

These mechanisms, in simple terms, involve the possibility of choosing more productive investments (a) by improving managing liquidity risks (see Bencivenga and Smith, 1991); (b) by more efficiently diversifying investors' portfolios and therefore productivity risks (see Levine, 1996 and Saint-Paul, 1991); and finally, (c) by collecting information on the efficiency of various investment projects and investors abilities (see Greenwood and Jovanovic, 1990). This factor is then integrated in an endogenous growth model, where conclude that an increase in capital productivity has a positive effect on the long-run growth rate of the economy.

However, despite the important implications and conclusions of these models, they suffer from the shortcoming that they fail to be implicitly introduced in case study contexts with viable policy recommendations<sup>3</sup>. A first obvious criticism, is that none of these endogenous growth models attempts to combine short run-stabilization with long-run growth. All financial development endogenous growth models, ignore the dynamic process of financial liberalisation or stabilization which is the essence and the key issue of the financial policies in developing countries. They definitely suffer from the absence of a simple theoretical mechanism which should describe, step by step, the procedure that the governments of developing countries have to follow in order to establish the 'efficient'<sup>4</sup> financial market

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<sup>3</sup>So far only cross-country empirical studies have been used in order to prove the positive relationship between financial development and economic growth and provide evidence about the overall validity of those models.

<sup>4</sup>Here, the term 'efficient' should not be misinterpreted with the 'efficient market hypothesis'. The term

which, according to those models, will lead to economic growth.

The purpose of this chapter is to review critically the literature of the financial development endogenous growth models and to provide an alternative view about the consideration of the role of financial development to the economic growth of developing countries at the early stages of the establishment of the efficient financial market.

## 4.2 Endogenous growth models of financial development and economic growth

This section aims to provide a critical analysis of the financial development endogenous growth models. This is accomplished through an examination of the existing literature on the subject. Our main aim is to offer our own views on the key issues that are found in the literature concerning the role of financial development on economic growth.

To organise the discussion it is useful to start with the simplest form of the endogenous growth models, the 'AK' model, where for simplicity, is assumed that production depends only on the stock of capital. So aggregate output is simply a linear function of aggregate capital stock:

$$Y_t = f(K_t) = AK_t \quad (4.1)$$

where  $Y_t$  and  $K_t$  denote output and the stock of capital at time  $t$ , respectively and  $A$  is defined as the level of technology.

By totally differentiating equation (4.1) we have:

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is used mainly to include constitutional and operational efficiency.



$$\frac{dY}{Y} = A \frac{dK}{Y} \frac{dK}{K} \quad (4.2)$$

or

$$\tilde{y} = A s_t \varphi_t \quad (4.3)$$

where  $\tilde{y}$  denotes the rate of growth of output,  $s_t$  is the savings rate and  $\varphi_t$  is the marginal productivity of capital.

Equation (4.3) says that the rate of output growth is the product of the savings rate, the marginal productivity of capital and the level of technology and reveals how financial development can affect growth<sup>5</sup>. First, it can raise the marginal productivity of capital (improving the allocation of capital), second it can increase the proportion of private savings channelled to investments and third it may affect the level of technology.

The first effect was first emphasised by Goldsmith (1969). McKinnon (1993) and Shaw (1973) extended Goldsmith's (1969) argument by noting that financial deepening implies not only higher productivity of capital but also higher savings rate, and therefore, a higher volume of investment. But, McKinnon (1973) and Shaw (1973) analysed the effects of public policy regarding financial markets on savings and investment and not the endogeneity of financial development and growth process. According to the new endogenous growth models the increase in the marginal productivity of capital will result from the

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<sup>5</sup>Here, it is important to notice that, in the traditional literature on growth, emphasis has been placed on the dynamic process that would lead the economy to a steady-state level, where (per capita) output growth would eventually stop (assuming decreasing marginal productivity of capital). The endogenous growth literature, in contrast, assumes that the marginal productivity of capital does not converge to zero as capital grows continuously. Therefore, emphasis has been placed on cases where it is possible for (per capita) real output to grow indigenously, even in the absence of exogenous productivity growth.



improvement of the allocation of funds to projects with higher marginal product of capital, and not from the financial liberalisation (as McKinnon (1973) and Shaw (1973) suggested).

An important way improving the productivity of capital is the informational role of the financial intermediation. Intermediaries provide information about the alternative investment projects and evaluate these projects, thus, improve the allocation of funds. Greenwood and Jovanovic (1990) were the first who related productivity growth with information. According to their analysis, the role of financial institutions is to collect and analyse information to channel investible funds to the activities with the highest return. In their framework, capital can be alternatively invested by individuals either in a safe, but low-yield technology or in a risky, high-yield one. But, the return of the risky technology contains two random terms for the individual investors; an aggregate productivity shock and a project-specific shock. From the other side, financial institutions can avoid the aggregate productivity shock (because of their large portfolios, according to the law of large numbers) and choose the most appropriate technology. Thus, investments channelled through financial intermediaries are more efficient and lead to higher productivity of capital, which in turn, will lead to higher growth rates. Also, since the activity performed by financial intermediaries involves costs, Greenwood and Jovanovic (1990) show that there may be a positive two-way causal relationship between the development of financial system and economic growth. On the one hand, growth stimulates higher participation in financial markets and this helps to the creation of new financial institutions and to the expansion of the old ones. On the other hand, financial institutions by collecting and analysing information, allow investment projects to be undertaken more efficiently, and hence stimulate

growth as we described before.

Thus, financial intermediaries enable investors to invest in riskier but more productive technologies, through risk sharing. Bencivenga and Smith (1991) present a model in which individuals face uncertainty about their future liquidity needs. They can choose to invest in a liquid asset (which is safe but has low productivity) and/or an illiquid asset (which is riskier but has high productivity). In the absence of financial intermediaries, individuals choose to invest in assets that can be promptly liquidated, thus frequently foregoing investments that are more productive but illiquid. In this framework, the presence of financial intermediation increases economic growth by channelling savings into the activity with the highest productivity, while allowing individuals to reduce the risk associated with their illiquid needs. Also, in the absence of financial intermediaries, individuals may be forced to liquidate their investments when liquidity needs arise, while the presence of financial intermediation (by exploiting the law of large numbers) reduces the investment waste of premature liquidation.

In the same line, Levine (1996) suggests that the various types of financial intermediation (stock markets, banks, mutual funds e.t.c.) enhance growth by promoting the efficient allocation of investment through various channels (allowing agents to reduce the risk by portfolio diversification).

The second effect (an increase in the proportion of private savings channelled to firms) was first analysed by DeGregorio (1992) and Jappelli and Pagano (1994). They concentrate attention on the effect of the inability of individuals to borrow freely (borrowing constraints) on economic growth. Thus, this analysis shifts the focus from the effects of

financial markets on the production side of the economy to their effects on household behaviour. A result common to both studies is that the full or partial inability of individuals to borrow against future income, induces them to increase savings. The reason is that when individuals are unable to borrow, they must build up financial wealth by increasing their savings. Thus, these studies suggest that the financial deepening (which relaxes the borrowing constraints) is unlikely to stimulate savings. But this implication does not suggest that the financial deepening will result in lower growth. The relationship between borrowing constraints and growth will ultimately depend on the importance of the effect of borrowing constraints on the marginal productivity of capital relative to the effect on the volume of savings. In particular, DeGregorio (1992) shows that a relaxation of borrowing constraints leads to an increase in the accumulation of human capital. This is likely to increase the marginal productivity of capital and hence may lead to higher growth despite the reduction in savings.

Finally, Saint-Paul (1992) develops a model where financial markets affect technological choice (the third effect). In this model, agents can choose between two technologies. The first technology is highly flexible and allows productive diversification but yields low productivity. The second is rigid, more specialised but more productive. The economy is exposed to shocks to consumer preferences, which may result in a lack of demand for many products. Therefore, in the absence of financial markets risk-averse individuals may prefer technological flexibility rather than high productivity. Financial markets, in contrast, allow individuals to hold a diversified portfolio to insure themselves against negative demand shocks and, at the same time, to choose the more productive technology.

Roubini and Sala-i-Martin (1992) analyse the relationship between financial development and economic growth by a different perspective, emphasising the role of government policy. They develop a model, where financial repression is a tool that governments may use to broaden the base of inflation tax. Thus, financial repression yields higher seignorage to finance government expenditures. However, Roubini and Sala-i-Martin (1992) show that tax evasion induces policy makers to repress the financial system and set a high inflation rate in an attempt to generate higher revenues from the inflation tax. Since financial repression reduces the productivity of capital and lowers savings, it hampers growth.

The majority of theoretical models, use the overlapping generation model with endogenous production and capital accumulation. Specifically, most of them embed the Diamond and Dybvig (1983) model of financial intermediation in a three period overlapping generations model where young individuals work only in the first period of their lives and consume only at periods 2 and 3. However the Diamond and Dybvig (1983) model assumes (rather unrealistically) that banks are established by and deal with only one generation of individuals. The overlapping generation models make it unnecessary, and indeed impossible, for banks to hold any currency at all. Another of the most unrealistic assumptions of the Diamond and Dybvig (1983) based models is the absence of financial intermediation costs. Pagano (1993) rectifies this by introducing costly financial development into the endogenous growth model, but this is not an explanation for the other models.

Also, while the literature on financial development and endogenous growth suggests various explanations for the existence of financial intermediation (costly information, transaction costs, economies of scale in information collection and some form of uncertainty)



none of these can explain the emergence and spread of financial intermediaries during the economic development process. A new analysis is needed in order to show how rising incomes can stimulate the growth of financial markets while simultaneously the growth of financial markets can stimulate growth.

Focusing on this criticism and closing the battery of financial development endogenous growth models, Greenwood and Smith (1997) present two different models that are used to address a large number of questions on the role between financial markets development and growth. They study three market mechanisms: autarky, a pure banking system and stock markets. Under some conditions about relative rates of return, it is shown that in the autarkic regime consumers will choose to hold both, assets and capital storage. So, this regime is wasteful as the capital held by the consumers who die is simply lost. In the banking regime, it is possible for the economy to hold a diversified portfolio. However, as we have discussed before, there is no waste, as the law of large numbers allows banks to hold just the right amount of storage. Finally, equity markets, will shift the composition of capital towards productive investment raising the growth rate of the economy. But, the discussion of the market systems would be incomplete if not accompanied by an analysis of the circumstances that make those markets to emerge. To address this issue, Greenwood and Smith (1997) study a model in which there are two technologies: a backstop low productive technology that can be operated in isolation and a more productive that requires the use of many intermediate goods and so requires the formation of a supporting market. At this context market makers are allowed to charge a fee for market participation, and the process of market formation is modelled as a game between potential market makers.



However, the question that arises is: is it reasonable to use this as a model of the formation of financial markets? Does this model provide an answer to the old question about the causal direction: is the existence of a sufficiently large network of financial markets a prerequisite for growth or, to the contrary, is it economic growth that induces the creation of new markets? The next section will present two alternative models supporting contradictory views about this subject (the supply-leading and the demand following hypotheses), which shows that there is no definite answer to this question.

### **4.3 The two competing hypothesis: supply leading versus demand following**

An expanding literature argues that financial systems provide services that promote economic growth (for recent literature surveys see Arestis and Demetriades (1997) or Levine and Zervos (1996)). The financial systems may affect economic growth through three main channels.<sup>6</sup> One important way is liquidity. Bencivenga, Smith and Starr (1996) and Levine (1991) argue that stock market liquidity, or the ability to trade equity easily is very important for economic growth. Moreover Holmstrom and Tirole (1993) argue that liquid stock markets can increase incentives for investors to get information about firms and to improve corporate governance. Another important aspect through which stock market development may influence economic growth is risk diversification. Obstfeld (1994) suggests that international risk sharing through internationally integrated stock markets improves

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<sup>6</sup>At this point, we have to acknowledge that there is a constantly growing literature concerning financial crises and their possible negative effects on growth (see Bernanke and Gertler, 1989; and Aghion, Bachetta and Banerjee, 1999). However, in our analysis we focus and explore the effects of a well-performed financial system in the economy's growth without considering the detrimental effects crises.

the allocation of resources and accelerates the process of economic growth. Finally, stock markets may also impact on economic growth through changes in incentives for corporate control.

Following the most recent developments in the theory of economic growth, the causal relationship between financial development and economic growth can also be placed within the context of models of endogenous growth theory. However, the theory yields two competing predictions, such that we are confronted with the supply-leading and demand-following dichotomy. This can be clearly illustrated through the presentation of two simple models.

#### 4.3.1 A model of the demand-following hypothesis

In the first, following Wang and Yip (1992) we consider a continuous-time, representative-agent, perfect-foresight specification, where money is considered as an input and physical and human capital are both endogenously determined. The representative agent's optimization problem is to:

$$\max \Psi = \int_0^{\infty} \gamma(c) \exp(-vt) dt \quad (4.4)$$

subject to:

$$c + \dot{k} + \dot{m} = F(k, L, m) - nk - (n + p)m + g \quad (4.5)$$

where  $c$  is consumption per capita,  $m$  is real money balances per capita,  $p$  denotes the inflation rate,  $k$  and  $L$  are physical capital and effective labour inputs (or human capital

denoted by  $hl$ ) respectively,  $g$  is a lump-sum transfer from the government and  $v$  and  $n$  represent constant rates of time preferences and population growth<sup>7</sup>.

Following Lucas (1988) we can specify an equation for the evolution of human capital as follows:

$$\dot{h} = \Phi(1 - l_t)h \quad (4.6)$$

Equation (4.6) states that human capital grows at its maximal rate when all the effort is put into accumulating human capital ( $l = 0$ ). Next, we assume that consumer preferences are given by the constant intertemporal elasticity of substitution utility function:

$$u(c) = \frac{c^{1-\delta}}{1-\delta} \quad (4.7)$$

where  $\delta$  is the inverse of the elasticity of substitution parameter.

The production technology is Cobb-Douglas type so that:

$$F(k, L, m) = A(m)K^\alpha L^{1-\alpha} \quad (4.8)$$

Money is introduced via a Hicks-neutral production technology,  $A$ . The necessary restrictions are that  $A_m > 0$  and  $A_{mm} < 0$ ;  $\sigma = mA_m/A$  and  $\epsilon = -\frac{mA_{mm}}{A_m}$ . To obtain money market equilibrium, suppose that  $\gamma$  is the constant rate of monetary growth and that  $g_t = m_t$ ; thus:

$$\frac{\dot{m}}{m} = \gamma - p - n \quad (4.9)$$

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<sup>7</sup>Lower case letters denote variables expressed in per capita terms. The time index is suppressed for convenience.

The goods market equilibrium condition can be written as follows:

$$c + \dot{k} = F(k, L, m) - nk \quad (4.10)$$

When equations (4.9) and (4.10) are solved for an optimal endogenous monetary growth equilibrium, it is found that the growth rates of real macroeconomic aggregates are independent of the growth of the money supply, or in other words that financial growth does not affect real economic growth.

#### 4.3.2 A model of the supply-leading hypothesis

In the second model - firstly developed by Pagano (1993) - let aggregate output (denoted by  $Y$ ) be a linear function of the aggregate capital stock ( $K$ ). Also assume (following Romer, 1989) that the economy is a competitive one, comprising  $N$  identical firms and households so that per firm and per capita values coincide. Each firm faces a constant-returns-to-scale technology but productivity is an increasing function of capital so that each firm's output is given by:

$$y = Gk^\alpha \quad (4.11)$$

where  $y$  and  $k$  are firm-specific output and capital respectively and  $G$  is a parameter responding to the average capital stock. Thus aggregate output is given by a summation of individual firms' output:

$$Y = AK = Ny \quad (4.12)$$

We further assume that the population is stationary and that only one good is produced in this economy, which can either be consumed or invested. The gross investment ( $I$ ) is given by:

$$I_t = \dot{K} + \delta K \quad (4.13)$$

Capital market equilibrium requires that gross savings ( $S$ ) equal gross investment. However, a proportion of savings ( $1 - \phi$ ) leaks from the process of financial intermediation, so that:

$$I = \phi S \quad (4.14)$$

From equation (4.12) the growth rate of this hypothetical economy is given by:

$$\gamma = \dot{Y} - 1 = \dot{K} - 1 \quad (4.15)$$

Substituting (4.13) to (4.15) yields:

$$\gamma = \frac{I}{K} - \delta \quad (4.16)$$

Rearranging (4.12) to yield  $K = \frac{Y}{A}$ , and substituting this together with the stock market equilibrium solution of (4.14) we obtain:

$$\gamma = A\phi \frac{S}{Y} - \delta \quad (4.17)$$

Thus, this last expression predicts that financial development affects growth through three specific channels: it may increase the social productivity of capital ( $A$ ); it can influ-



ence the saving rate ( $\frac{S}{Y}$ ); or it may increase (reducing the proportion of savings  $1 - \phi$  that escape from the intermediation process). This model is a version of the 'supply-leading' hypothesis and contradicts the result obtained from the previous model.

Overall therefore, the endogenous growth theory suggests that there are two possible directions of causality between the development of the financial sector and real economic growth (clearly this is an empirical issue, not yet determined). Resolving this is the aim of the paper.

#### **4.4 Empirical studies of financial development and economic growth**

Most of the financial development endogenous growth models (presented at section 2) suggest that financial development (especially stock market development) has positive growth effects, while the causality direction among financial development and economic growth is not yet determined. Despite, the importance of the policy implications provided by the above models, there are only a few empirical studies who examine the validity of the above propositions.

One possible way of studying the growth effects of financial development on economic growth is to start with the influential paper of Mankiw, Romer and Weil (1992), which includes human capital as a third input to the common production function, simply adding a fourth input which will embody the development of financial sector. Thus, the production function will have the form:

$$Y_t = F_t^\alpha K_t^\beta H_t^\gamma (AL_t)^{1-\alpha-\beta-\gamma} \quad (4.18)$$

where we use the standard notation:  $Y$  is output,  $K$  is capital,  $L$  is labour,  $A$  is the level of technology,  $H$  is the stock of human capital and  $F$  is the level of financial intermediation.  $L$  and  $A$  are assumed to grow exogenously at rates  $n$  and  $g$ , so:

$$L_t = L_0 e^{nt} \quad (4.19)$$

and

$$A_t = A_0 e^{gt} \quad (4.20)$$

The physical capital stock and the human capital stock are augmented at the constant saving rates  $s_K$  and  $s_H$  respectively and we assume that they depreciate at the common rate  $d$ .

The evolution of physical capital is given by:

$$\frac{dK}{dt} = s_K Y_t - dK_t \quad (4.21)$$

and similarly human capital evolves according to:

$$\frac{dH}{dt} = s_H Y_t - dH_t \quad (4.22)$$

Then assuming that countries are in their steady states and following the logic used by Mankiw, Romer and Weil (1992) we obtain:

$$\ln \frac{Y_t}{L_t} = \ln A_0 + g_t - \left( \frac{\alpha + \beta + \gamma}{1 - \alpha + \beta + \gamma} \right) \ln(n + g + d) + \left( \frac{\alpha}{1 - \alpha + \beta + \gamma} \right) \ln s_F$$

$$+ \left( \frac{\beta}{1 - \alpha + \beta + \gamma} \right) \ln s_K + \left( \frac{\gamma}{1 - \alpha + \beta + \gamma} \right) \ln s_H \quad (4.23)$$

with  $\alpha$  as the financial intermediation's share of income,  $\beta$  as the physical capital's share of income and  $\gamma$  as the human capital's share of income. In order to estimate empirically equation (4.24) we must make the crucial and rather restricting assumption that the rate of technological progress,  $g$ , is the same for all countries. By this assumption,  $t$ , becomes a fixed number, and  $g_t$  enters just as a constant term in the cross-section regression. Also, the  $A_0$  term in equation (4.24) which reflects not only technology but other factors also (such as resource endowments, climate e.t.c.) must differ across countries and Mankiw, Romer and Weil (1992) assume that  $\ln A_0 = a + e$ , where  $a$  is a constant and  $e$  is country specific term (or the residual).

Incorporating these assumption in equation (4.24) we derive the following equation which can be estimated econometrically:

$$\ln \frac{Y}{L} = c - \left( \frac{\alpha + \beta + \gamma}{1 - \alpha + \beta + \gamma} \right) \ln(n + g + d) + \left( \frac{\alpha}{1 - \alpha + \beta + \gamma} \right) \ln s_F$$

$$+ \left( \frac{\beta}{1 - \alpha + \beta + \gamma} \right) \ln s_K + \left( \frac{\gamma}{1 - \alpha + \beta + \gamma} \right) \ln s_H + e \quad (4.24)$$

Atje and Jovanovic (1993) estimate the constraint version of equation (4.25) in order to measure the level effects of financial development. Their findings suggest that there are strong positive effects of financial development on the level of income. They also transform the Greenwood and Jovanovic (1990) model into an econometrically testable

equation and provide evidence (using cross-sectional analysis for 94 countries) in favour of the financial development endogenous growth models.

Ghani (1992) estimates growth equations for a sample of 50 countries following an approach used by Barro (1991). The initial level of financial development (as measured by the ratio of total assets of the financial system to GDP or the ratio of private sector credit to GDP) in 1965 yields significantly positive coefficients, while the initial level of per capita real GDP produces negative coefficient in an equation explaining average growth rates over the period 1965-89.

In a similar perspective, King and Levine (1993) present cross-country evidence (using data for 80 countries over the 1960-89 period) which is consistent with the hypothesis that the financial system promotes economic growth. In order to prove that the level of financial development is strongly associated with real per capita GDP growth, they use different measures, proxies for financial development: the ratio of liquid liabilities of the financial system to GDP, the ratio of deposit money bank domestic assets to deposit money bank domestic assets plus capital bank domestic assets, the ratio of claims on the non-financial private sector to total domestic credit and the ratio of claims of the non-financial private sector to GDP.

Levine and Zervos (1996) using cross-country growth regressions for 41 countries and for the period 1976-93, conclude that various measures of equity market activity are positively correlated with current and future rates of economic growth, capital accumulation and productivity improvement. In their analysis they include variables that capture the effects of political instability on stock market development and economic growth.

Finally, Berthelemy and Varoudakis (1995, 1996) incorporate measures of financial development into the classical Barro and Sala-i-Martin (1992) conditional convergence equation, to test the sensitivity of those variables and their effects on the process of global convergence.

However, all these studies simply provide cross-country evidence in favour of the theoretical considerations of financial development endogenous growth models, sometimes even using neo-classical (exogenous) growth models for their econometric analysis . Also, cross-country regressions suffer from wide limitations and the sensitivity of their results is acknowledged by the users of the techniques themselves (Levine and Zervos, 1996). The cross-country approach involves averaging out variables over large periods of time. Therefore, in principle the investigator is unable to estimate something else except the average influence of the determinants of economic growth. Lee, Pesaran and Smith (1995) show that convergence tests obtained from cross-country regressions are possibly misleading because the estimated coefficient on the convergence term contains asymptotic bias. Quah (1993) points out that the technique is predicated on the existence of stable growth paths and shows (using data from 118 countries), that long run growth paths are unstable. Thus, the cross-country variations in result are difficult to interpret and have nothing to say about the nature and the operation of financial institutions as well as about financial policies pursued in each country.

Recent empirical studies on the subject financial development and economic growth have shifted from cross-sectional to time series data and analysis, utilising the cointegration techniques and causality tests in specific countries contexts (Arestis and Demetriades, 1996,



1997 and Demetriades and Hussein, 1996). They seek to detect the relationship between financial development and economic growth based on whether there is a long-run equilibrium relationship between the logarithm of real GDP per capita and various financial development proxy variables (logarithm of M2 over nominal GDP, logarithm of stock market capitalisation and logarithm of stock market volatility). Their overall results suggest that there is a positive relationship between those variables, while the causal link between finance and growth in most cases differs among different economies and its sensitivity is crucially determined by the policies implemented in each country. In the next chapter we will apply the newly developed econometric techniques of integration - cointegration to macroeconomic time series data for the UK in order to test for long run relationships among economic growth and financial development as well as to determine the causality direction among them.

## Chapter 5

# Financial Development and Economic Growth: UK Time Series Evidence<sup>1</sup>

### 5.1 Introduction

This chapter investigates the effects of financial and stock market development on the process of economic growth in UK. The importance of the relationship between financial development and economic growth has been well recognised and emphasised in the field of economic development (See e.g., Gurley and Shaw (1955), Goldsmith (1969) among other studies). However, whether the financial system (with emphasis on stock markets) is important for economic growth more generally is not clear. One line of research

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<sup>1</sup>A version of this chapter has been accepted for publication on *Ekonomia*, (forthcoming) with co-author Professor Simon Price.

stresses the importance of the financial system in mobilising savings, allocating capital, exerting corporate control and easing risk management, while, in contrast, a different line of research does not mention at all the role of financial system in economic growth<sup>2</sup>.

Although recent studies on this subject seem to accept the hypothesis that the development of the financial sector plays a crucial role in successful economic growth, there is a critical question still unanswered; namely, the causal relationship that characterises the financial development and the economic growth. Real economic growth may induce the expansion of the financial system. As the real side of the economy develops, its demand for various new financial services materialise, and these are met rather passively from the financial side. This view is called 'demand-following', and is in contrast with the alternative 'supply-leading' view. According to the latter, the expansion of the financial system precedes the demand for its services. Channelling scarce resources from 'small' savers to 'large' investors, the financial sector precedes and induces real growth.

We discuss the above points and test empirically these questions for the case of the UK. The aim of the paper is to establish whether or not a cointegrating relationship among real per capita GDP and financial development proxies exists and after that to establish the causality direction that characterizes those indicators. The empirical literature on this issue utilises mainly cross-country regressions. However, the cross-country studies suffer from wide limitations<sup>3</sup> and the sensitivity of their results is acknowledged by the users of the technique themselves.<sup>4</sup> In this paper we examine the time series evidence for a

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<sup>2</sup>In a survey of development economics, Stern (1989) lists various factors that affect economic growth. Finance is not included in this list, nor in his list of omitted topics.

<sup>3</sup>The limitations of cross-country studies and their drawbacks against time-series studies are presented and documented in Arestis and Demetriades (1997).

<sup>4</sup>Quah (1993b) emphasises the non-existence of balanced growth paths, Levine and Renelt (1992) focus on omitted variable bias or mis-specification, Evans (1996) and Pesaran and Smith (1995) dwell on the

single country, the UK. Important econometric advantages are stemming from this fact. Besides being better able to address issues of causality and endogeneity, time series data and techniques are also less likely to suffer from the limitations of cross country growth regressions discussed above.

The chapter is constructed as follows. The next section reviews the interrelations between stock market development, and economic growth presenting two alternative models. The third section discuss the construction of the financial proxy variables that will be used in the empirical analysis. Next, the fourth section presents the econometric methodology and the empirical results for stationarity and cointegration while section five presents the results of the causality tests. Finally, we summarise and conclude.

## 5.2 The data: construction of the proxy variables

Following standard practice in empirical studies (e.g. Roubini and Sala-i-Martin (1992); King and Levine (1993a,b)) our indicator for economic development is real GDP per capita.

The existing literature suggests as a proxy for financial development ratios of a broad measure of money often M2, to the level of nominal GDP or GNP. This ratio directly measures the extent of monetization, rather than financial deepening. It is possible that this ratio may be increasing because of the monetization process rather than increased financial intermediation. An alternative is to deduct active currency in circulation from M2 or to use the ratio of domestic bank credit to nominal GDP. In our analysis, two alternative proxies

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heterogeneity of slope coefficients across countries while problems of causality and endogeneity are explored by Demetriades and Hussein (1996).

of financial development are employed based on two different definitions of money. The first is the currency ratio, the ratio of currency to the narrow definition of money (M0) (the sum of currency and demand deposits). The second is the monetization ratio given by a broader definition of money (M4) over nominal GDP the inverse of velocity. The first variable is a proxy for the complexity of the financial market. A decrease in the currency ratio will accompany real growth in the economy, especially in its early stages, as there exists more diversification of financial assets and liabilities and more transactions will be carried out in the form of non-currency. The monetization variable is designed to show the real size of the financial sector. We would expect to see the ratio increase (decrease) over time if the financial sector develops faster (slower) than the real sector.

A third measure of financial development is constructed in order to provide more direct information on the extent of financial intermediation. It is the ratio of bank claims on the private sector to nominal GDP (the 'claims ratio'). As it is the supply of credit to the private sector which, according to the McKinnon/Shaw inside model, is ultimately responsible for the quantity and the quality of investment and, in turn, for economic growth, this variable may be expected to exert a causal influence on real GDP per capita (Demetriades and Hussein (1996)).

In order to examine the connection between growth and the stock market, we have to construct individual indicators of stock market development. One important aspect of stock market development is liquidity (see Bencivenga, Smith and Starr (1996) and Holmstrom and Tirole (1993)). Liquidity can be measured in two ways. One way is to compute the ratio of total value of trades of the Capital Market over the nominal GDP. The



second way is to compute the 'turnover ratio', defined as the value of trades of the Capital Market over the market capitalization, where market capitalization equals the total value of all listed shares in the Capital Market. There are of course, other possible indicators of financial development. Nevertheless, in a time-series context the capitalisation indicator as a ratio, has a number of advantages. Firstly it is a stock variable rather than a flow variable and secondly, at the aggregate level increased stock market capitalisation may be accompanied by an increase in the volume of bank business, if not an increase in new lending, as financial intermediaries may provide complementary services to issues of new equity such as underwriting. Thus, it is likely that at the aggregate level the development of the stock market goes hand-in-hand with the development of the banking system (see Arestis, Demetriades and Luintel, 2000).

Finally, we needed data for employment and for the stock of capital in order to construct the capital/labour ratio of an implicit Cobb-Douglas productivity function. The data for the stock of capital were available for UK only in a yearly basis. Assuming that capital depreciates with a constant annual depreciation rate of  $\delta$ , we applied the implicit annual rate to an initial value of the stock of capital for the first quarter of 1970 using the quarterly time series for gross fixed capital formation. This enabled us to simulate a quarterly time series for the stock of capital.

The data set used in estimation and testing consists of quarterly observations from the UK and the sample period spans from the first quarter of 1970 to the first quarter of 1997, with the exception of the turnover ratio which covers the period 1983:1-1997:1. The data were drawn from the UK's National Income and Expenditure Accounts and from the

Datastream (for a thorough description of the data set, see Appendix 1).

### 5.3 Econometric methodology and empirical results

#### 5.3.1 Stationarity and unit root tests

Before any sensible econometric analysis can be performed, it is essential to identify the order of integration of each variable. Therefore, the first step is to apply tests which determine the order of integration of the variables. We will apply two asymptotically equivalent tests: the Augmented Dickey-Fuller (ADF) test and the Phillips-Perron (PP) test.

A time series  $y_t$  is said to be stationary or indegated of order zero (denoted by  $I(0)$ ) if does not have a unit root. In many cases, a variable may be non stationary in its level form but stationary in its first difference form (i.e.  $I(1)$ ). In order to test for stationarity we will use the well known Augmented Dickey-Fuller (ADF) procedure (Dickey and Fuller, 1979 and 1981). However, given that ADF tests tend to be sensitive to the order of augmentation, we determine the latter following the Akaike's final prediction error (FPE) criterion.

The ADF test entails estimating the following regression equation (with an autoregressive process):

$$\Delta y_t = c_1 + by_{t-1} + c_2t + \sum_{i=1}^p d_i \Delta y_{t-i} + v_t \quad (5.1)$$

In the above equation,  $y_t$  is the relevant time series,  $\Delta$  is a first-difference operator,  $t$  is a linear time trend and  $v_t$  is the error term. The test can be performed without trend

term (by deleting the  $c_2t$  term in the above equation) or constant (i.e.  $c_1 = c_2 = 0$ ). The null hypothesis for the presence of a unit root is  $b = 0$ .

The distribution theory supporting the ADF tests assumes that the errors are statistically independent and have a constant variance. Therefore, in using this methodology, we must have uncorrelated error terms. While the ADF procedure aims to retain the validity of the tests based on white noise errors, an alternative test for a unit root, developed by Phillips and Perron (1988), acts instead to modify the statistics after estimation in order to take into account the effect that uncorrelated errors will have on the results. Asymptotically, the statistic is corrected by the appropriate amount, and so the same limiting distributions apply. Like the ADF test, the Phillips-Perron test is a test of the hypothesis  $\rho = 1$  in the equation:

$$\Delta y_t = \mu + \rho y_{t-1} + \varepsilon_t \quad (5.2)$$

Unlike the ADF test, there are no lagged difference terms. Instead, the equation is estimated by ordinary least squares (with the optional inclusion of constant and time trend) and then the  $t$ -statistic of the coefficient is corrected for serial correlation in  $\varepsilon_t$ . The main advantage of this procedure is the fact that it does not require the estimation of additional autoregressive parameters and therefore it does not consume a larger number of degrees of freedom.

We begin the ADF test procedure by examining the optimal lag length using Akaike's FPE criteria. Then we proceed to identify the probable order of stationarity. The results of the tests for all the variables and for the three alternative models are presented at

Table 5.1, first for their logarithmic levels and then (in cases where we found that the series contain a unit root) for their first differences, and so on. The results indicate that each of the series is non-stationary when the variables are defined in levels. But first-differencing the series removes the non-stationary components in all cases and the null hypothesis of non-stationarity is clearly rejected at the 5% significance level suggesting that all our variables are integrated of order one, as it was expected.

The results of the Phillips-Perron tests are reported at Table 5.2, and are not fundamentally different from the respective ADF results. Analytically the results from the tests in the levels of the variables clearly point to the presence of a unit root in all cases except the claims ratio which appears to be integrated of order zero. The results after first-differencing the series robustly reject the null hypothesis of a presence of unit root, suggesting therefore that the series are integrated of order one. The lag truncation for the Bartlett kernel were chosen according to the Newey and West (1987) suggestions.

### 5.3.2 Cointegration tests

Once the stationarity order has been established, we can move to cointegration tests. We use the Engle and Granger (1987) procedure and the multivariate method proposed by Johansen (1988). Three  $I(1)$  variables - namely  $x_t$ ,  $z_t$  and  $y_t$  - are said to be cointegrated if there exists a linear combination of them that is stationary. If the variables are cointegrated, then the OLS method gives super-consistent estimates (Engle and Granger, 1987). In econometric terms the Engle-Granger test involves testing the null hypothesis of non-cointegration between  $x_t$ ,  $z_t$  and  $y_t$  as follows:

$$H_0 : a = 1 \text{ against } H_1 : a < 1 \quad (5.3)$$

where,

$$\Delta z_t = az_{t-1} + c_1 \Delta z_{t-1} + \dots + c_n \Delta z_{t-n} + u_t \quad (5.4)$$

and  $z_t = x_t - b_1^{OLS} - b_2^{OLS} y_t$ . The degree of augmentation  $n$  is again determined by the FPE. However, there are important shortcomings of the Engle-Granger cointegration methodology. However, there are important shortcomings of the Engle-Granger methodology. One of the most important problems being that it does not give us the number of cointegrating vectors.

Therefore, we will use the Johansen cointegration methodology (see Johansen, 1988 and Johansen and Juselius, 1990 for details) which provides us with the ability to determine the number of distinct cointegrating vectors. The method can be understood as a multivariate generalization of the Dickey-Fuller test. In the univariate case, it is possible to view the stationarity of  $x_t$  as being dependent on the magnitude of  $(a_1 - 1)$  that is:

$$y_t = a_1 y_{t-1} + u_t \quad (5.5)$$

or

$$\Delta y_t = (a_1 - 1) y_{t-1} + u_t \quad (5.6)$$

Now consider a generalization to  $m$  variables:



$$Y_t = A_1 Y_{t-1} + u_t$$

$$\Delta Y_t = A_1 Y_{t-1} - Y_{t-1} + u_t$$

$$\Delta Y_t = (A_1 - I) Y_{t-1} + u_t$$

$$\Delta Y_t = \Pi Y_{t-1} + u_t \quad (5.7)$$

where  $Y_t$  and  $u_t$  are  $(m \times 1)$  vectors,  $A_1$  is an  $(m \times n)$  vector of parameters,  $I$  is an  $(m \times n)$  identity matrix and  $\Pi = (A_1 - I)$ .

The method in its basic form can be shown by the error correction representation of the VAR(p) model with Gaussian errors:

$$\Delta Y_t = a_0 + \Gamma_1 \Delta Y_{t-1} + \Gamma_2 \Delta Y_{t-2} + \dots + \Gamma_{p-1} \Delta Y_{t-p-1} + \Pi Y_{t-p} + \Theta X_t + e_t \quad (5.8)$$

where  $Y_t$  is an  $(m \times 1)$  vector of  $I(1)$  variables,  $X_t$  is an  $(s \times 1)$  vector of  $I(0)$  variables - which may be a null set -  $\Gamma_i$  and  $\Pi$  are  $(m \times m)$  matrices of unknown parameters,  $\Theta$  is an  $(m \times s)$  matrix and  $e_t \sim N(0, \sigma^2)$ .

Johansen and Juselius (1993) describe two likelihood ratio tests. For the first, the maximum likelihood method is used to estimate (5.56) subject to the hypothesis that  $\Pi$  has a reduced rank  $(r \times m)$ . The hypothesis, therefore, is as  $H(r) : \text{Rank}(\Pi) = r - 1$  against the  $H(r - 1)$ . The maximal eigenvalue test statistic is given by  $J_{ME} = -T \ln(1 - \lambda_r)$  where  $T$  is the number of observations and  $\lambda_r$  is the maximal eigenvalue. The second likelihood ratio test is based on the trace of the stochastic matrix and is defined as  $J_{TR} = -T \sum_i \ln(1 - \lambda_i)$ .

Table 5.3 reports the results from using the Engle and Granger (1987) cointegration methodology. We first regress GDP per capita to the Capital/Labour ratio and to every

financial development proxy (one at each specification). The test statistics presented in Table 5.3 are the augmented Dickey-Fuller tests relating to the hypothesis of a unit root in the cointegrating regression residuals of each specification. The results of the first method indicate that the hypothesis of existence of a bivariate cointegrating relationship between the level of GDP per capita and each of the financial development proxies is clearly rejected in all cases.

However, as is well known the Engle-Granger procedure suffers from various shortcomings. One such is that it relies on a two-step estimator. The first step is to generate the error series and the second step is to estimate a regression for this series in order to see if the series is stationary or not. Hence, any error introduced by the researcher in the first step is carried into the second step, in particular the misspecification in the short run dynamics. The Johansen (1988) maximum likelihood method circumvents the use of two-step estimators and, moreover, can estimate and test for the presence of multiple cointegrating vectors. The Johansen (1988) test also allows us to test restricted versions of the cointegrating vectors and speed of adjustment parameters.

Thus, we continue testing for cointegration with the Johansen method. First, we test for the presence of cointegrating vectors introducing in each case only one financial development proxy variable, then we proceed to include all four financial development proxies.

### Monetisation Ratio

We want to test for the existence of cointegration relations among per capita GDP and the financial development variables. The first proxy variable for financial development

is the monetisation ratio. The Johansen method is known to be sensitive to the lag length (see Banerjee et. al., 1993). We therefore estimate the VAR system comprising the monetisation ratio, the capital/labour ratio and GDP per capita for various lag lengths and we calculate the respective Akaike Information Criterion (AIC) and the Schwartz Bayesian Criterion (SBC) in order to determine the appropriate lag length for the test of cointegration. Nine alternative VAR(p),  $p=1,2,\dots,9$ , models were estimated over the same sample period namely 1972:1-1997:1 and, as to be expected the maximized values of the log-likelihood (LL) increase with p. Both criteria indicated that the optimal number of lag is two. The results presented at Table 5.4, show that the log-likelihood ratio statistics suggest VAR of order 7. By construct both the AIC and the SBC suggest the use of 2 lags. Initially, we test for cointegration using only two lags in the VAR system.

We also need to determine the appropriate restrictions on the intercept and trends in the short- and long-run models<sup>5</sup>. We use the Pantula Principle. That is, we estimate all three alternative models and moving through from the most restrictive model to the least restrictive model, comparing the trace or the maximal eigenvalue test statistic to its critical value, we stop (and therefore choose the model) only when the null hypothesis is not rejected for the first time. The results from the three estimating models are presented in Table 5.5. The first time that the null hypothesis is not rejected is for the first model (restricted intercepts, no trends in the levels of the data) and we can see that both the trace and the maximal eigenvalue test statistics suggest the existence of one cointegrating relationship.

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<sup>5</sup>In general three models can realistically be considered: (a) restricted intercept, no trends, (b) unrestricted intercept, no trends, (c) unrestricted intercept, trends (see Harris, 1997 for a clear exposition).

The results of the cointegration test are presented in Table 5.6. We observe one cointegration vector which is given in the last row of the Table. We have the expected positive signs for the monetisation ratio and the capital/labour ratio. However, the model selected suggests that there is no constant in the cointegrating vector. This may be interpreted as evidence that the technological parameter in the production function is not significant, and that all the technological innovation is driven by the monetisation ratio, but this is implausible. Also, the corresponding Vector Error Correction Model (VECM) suffers from residual serial correlation and non-normality. This suggests that the lag-length chosen may be too small and an alternative lag length might be used.

Thus, we re-estimated the model for a lag-length of seven<sup>6</sup>. The results in Table 5.7 indicate that the appropriate model this time has unrestricted intercepts and no trends, which is consistent with the economic theory predictions; namely, that there is a stochastic trend in technical progress (see Greenslade, Hall and Henry (1999)).

The results for the cointegration tests are presented in Table 5.8. Again we conclude that there exists one cointegrating relationship (as in the case with the 2 lags) which is reported in the last row of the Table. We observe a strong positive relationship between the monetisation ratio and the GDP per capita, which provides evidence in favour of the hypothesis that there is a link among financial development and economic growth.

Table 5.9 reports results from the VECMs and the basic diagnostics about the residuals of each error correction equation. The results show that the coefficients for the  $ecm_{t-1}$  component have the expected signs and are statistically significant in the equations of Y and M. The insignificance of the  $ecm$  component for the capital/labour variable indi-

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<sup>6</sup>We also include intervention dummies for residual outliers to help accept for the non-normality.



cates that this ratio is weakly exogenous to the model. The dynamic terms in most cases are significant, while the diagnostic tests which involve  $\chi^2$  tests for the hypothesis that there is no serial correlation; that the residual follow the normal distribution; that there is no heteroscedasticity; and lastly that there is no autoregressive conditional heteroscedasticity; in all equations indicate that the residuals are Gaussian as the Johansen method presupposes. Proceeding, we re-estimated the above relationship using the recursive method of estimation in order to test for existence of structural changes in the cointegrating relationship, mainly bearing in mind the events of the Big Bang and the stock market crash of 1987. The recursive trace tests confirm the existence of a stable unique cointegrating vector while the  $\beta$ 's obtained are also shown to be stable<sup>7</sup>.

### Turnover Ratio

Continuing we proceed with the next financial development proxy variable which is the turnover ratio. The results of the tests for the lag length of this model (which includes GDP per capita, turnover ratio, capital/labour ratio, intercept and various structural dummy variables) are reported in Table 5.10 and indicate a lag length of order 2. All three alternative measures of the order of lag length agree for this choice. In this case the selected model is the one with the unrestricted intercept but not trend in the levels of the data, consistent with our expectations (see Table 5.11). The results of the cointegration test are presented at Table 5.12. We observe one cointegration vector reported in the same Table with the expected signs, indicating that there exists a positive long-run relationship between GDP per capita and the turnover ratio. Again the diagnostics reported in Table

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<sup>7</sup>Specifically, after 1981 there is no evidence of  $r > 1$  and the restricted  $\beta$ 's are stable. Tables and results available from authors upon request.



5.13, show that the error terms are Gaussian. The *ecm* coefficients have the expected signs and are statistically significant different from zero. Finally, the dynamic terms are significant with the exception of the loadings for the Turnover equation. Again, as in the case of the monetisation ratio, we re-estimated the cointegrating equation using the recursive method of estimation in order to test for the existence of structural changes in the cointegrating relationship and for the stability of  $\beta$ 's; as before, there is no evidence for structural change.

### Claims and Currency Ratios

Extending our analysis to the other two financial development proxy variables (Claims and Currency Ratios) we found in both cases that the suitable model is the second one (unrestricted intercept, no trends) but there is no cointegration relationship among those variables and the GDP per capita (see Tables 5.14 and 5.15).

Thus, with the Johansen procedure we found strong evidence of cointegration between the two of the four financial development proxies (the monetisation and the turnover ratio) and GDP per capita.

### A Model with more than one Financial Development Proxy Variables

In this section we examine a specification which includes more than one financial development proxies. First we estimated a model including all four proxy variables. The selected lag length is two (see results at Table 5.16) and the appropriate model includes unrestricted intercepts but no trends in the VECMs (Table 5.17).

The results for the test of cointegration are reported in Table 5.18. This time

we have two cointegrating vectors, which is consistent with the previous findings of cointegration among monetisation and GDP per capita and turnover and GDP per capita. The results from the VECM for all those variables are reported in Table 5.19, and indicate that the claims ratio and the currency ratio should be treated as weakly exogenous variables in the cointegrating model. Therefore, we re-estimated treating those two proxies as exogenous variables. However, while the results then clearly indicated the existence of one cointegrating vector with the correct - according to the theory - signs of the coefficients for the capital/labour ratio and the financial proxies, we were in all different cases unable to accept the exogeneity test conducted after that. Thus, we finally estimated a model including the financial development proxies for which we have found that are cointegrated with per capita GDP (namely the turnover and the monetization ratio). The results of the test for cointegration of this model are presented at Table 5.20. It is clear that we have one cointegrating vector which is reported at the same Table. From these results, we observe a positive relationship among GDP per capita and the capital/labour ratio with a higher coefficient than from the previous cases and also positive relationships among the dependent variable and the two financial development ratios. We do not wish to claim too much about the results of this final specification, but it seems to capture some of the implications of the underlying economic theory and at least are consistent with the previous findings of the tests for cointegration for each variable reflecting financial development separately.<sup>8</sup> Therefore, the next step is to test for the causal direction among those variables. Causality tests are described in the next section.

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<sup>8</sup>However, this may not reflect a direct positive relationship between financial development and growth because financial sector development is promoting growth, but also because financial sector problems (crises, fragility etc) are harmful for growth.

## 5.4 Causality tests

When a set of variables is stationary or cointegrated, causality tests can be conducted (Granger, 1988). Following the work of Granger (1969) an economic time series  $x_t$  is said to 'cause' another series  $y_t$  if  $E[y_{t+1}|\Omega_t] \neq E[x_{t+1}|\bar{\Omega}_t]$  where  $\Omega_t$  is the information set containing all available information whilst  $\bar{\Omega}_t$  excludes the information in past and present  $x_t$ .

The conventional Granger causality test involves the testing of the null hypothesis 'x<sub>t</sub> does not cause y<sub>t</sub>', simply by running the following two regressions:

$$y_t = \sum_{i=1}^m a_i y_{t-i} + \sum_{j=1}^n b_j x_{t-j} + e_t \quad (5.9)$$

$$y = \sum_{i=1}^m a_i y_{t-i} + e_t \quad (5.10)$$

and testing  $b_i = 0 \forall i$ .

The testing procedure for the identification of causal directions becomes, however, more complex when, as is common in macroeconomic time series, the variables have unit roots. In such a case - after testing for the existence of cointegration - it is useful to reparametrise the model in the equivalent ECM form (see Hendry et al., 1984; Johansen, 1988) as follows:

$$\Delta y_t = \alpha_0 + \alpha_{1i} \sum_i^m \Delta x_{t-i} + \alpha_{2k} \sum_k^n \Delta z_{t-k} + \alpha_3 v_{t-1} + u_t \quad (5.11)$$

where  $v_{t-1} = y_{t-1} - \alpha_1 x_{t-1} - \alpha_2 z_{t-1}$ , is the long-run cointegrating relation not using an Engle-Granger approach.

The null hypothesis now, that  $x$  does not Granger cause  $y$ , given  $z$ , is  $H_0(\alpha_1 = \alpha_3 = 0)$ . This means that there are two sources of causation for  $y$ , either through the lagged terms  $\Delta x$  or through the lagged cointegrating vector. This latter source of causation is not detected by a standard Granger causality test. The null hypothesis can be rejected if either one or more of these sources affects  $y$  (i.e. the parameters are different from zero). The hypothesis is again tested using a standard F-test. Following Granger and Lin (1995), the conventional Granger causality test is not valid, because two integrated series cannot cause each other in the long-run unless they are cointegrated. Therefore, we test for causality among the variables that are found to be cointegrated, using the VECM representations for the cointegrated variables. Results of those causality tests are presented in Table 5.21.

Causality in the long-run exists only when the coefficient of the cointegrating vector is statistically significant different from zero (Granger and Lin, 1995). In our analysis we apply variable deletion (F-type) tests for the coefficient of the cointegrating vector and for the lagged values of the financial proxies for the GDP per capita VECM and vice versa (testing for the validity of the supply leading and demand following hypothesis respectively). The results reported in Table 5.21, show that there is strong evidence in favor of the supply leading hypothesis. In both cases (turnover ratio and monetisation ratio) the causality direction runs from the financial proxy variable to GDP per capita, while the opposite hypothesis - that GDP per capita causes financial development - is strongly rejected. Also, we observe in all cases that the coefficients of the cointegrating vectors are statistically significant, although we know this already given the earlier cointegration analysis.



## 5.5 Summary and conclusions

This chapter investigated empirically two competing hypotheses regarding financial development and economic growth in terms of their causal relationships, the supply-leading and demand-following hypothesis. We test those two hypotheses for the case of UK using time series data and econometric techniques. First, we tested the series for stationarity and cointegration. It was found that the relevant variables were stationary only after differencing. Second, we found some evidence that unique cointegrating relationships exist, interpretable as long-run production relationships. However, in only one case (monetisation) was the capital share consistent with our prior expectations, and there was no separate role for technical productivity, a worrying feature. Nevertheless, the results do rule out the demand following hypothesis. We then tested for short-run Granger causality using the ECM representations. The evidence obtained from the causality tests provided no evidence for short-run demand leading effects. The causal direction runs from the development of the financial sector to the real sector development (measured by real GDP per capita).

In summary, despite our caveats about some features of the results, we do seem to have found evidence for a role of financial development in the UK's growth process. The weakness of our results may be interpreted as suggesting that the UK financial system although proves to be helpful it is not a strong promoter of economic growth, which to some extent reflects its weak links with industry, in that it is typical capital market-based system, and its international character.



Table 5.1. Augmented Dickey - Fuller Test Results				
Model: $\Delta y_t = c_1 + by_{t-1} + c_2t + \sum_{k=1}^p d_k \Delta y_{t-k} + v_t$ ; $H_0 : b = 0$ ; $H_a : b > 0$				
Unit Root Tests at Logarithmic Levels				
Variables	constant	constant and trend	none	k
GDP per capita (Y)	-0.379	-2.435	3.281*	1
Monetisation Ratio (M)	-0.063	-1.726	1.405	4
Currency Ratio (CUR)	-1.992	1.237	1.412	9
Claims Ratio (CL)	-2.829	-2.758	1.111	7
Turnover Ratio (T)	-1.160	-2.049	-1.84	2
Capital/Labour (K)	-0.705	-2.503	-2.539	2
Unit Root Tests at First Differences				
Variables	constant	constant and trend	none	k
GDP per capita ( $\Delta Y$ )	-6.493*	-6.462*	-	1
Monetisation Ratio ( $\Delta M$ )	-3.025*	-4.100*	-2.671*	4
Currency Ratio ( $\Delta CUR$ )	-3.833*	-4.582*	2.585*	5
Claims Ratio ( $\Delta CL$ )	-6.549*	-6.591*	-6.596*	3
Turnover Ratio ( $\Delta T$ )	-6.196*	-6.148*	-5.452*	2
Capital/Labour ( $\Delta K$ )	-2.908*	-3.940*	-	2

\* Denotes significance at the 5% level and the rejection of the null hypothesis of non-

stationarity.

Critical values obtained from Fuller (1976) and are -2.88, -3.45 and -1.94 for the first, second and third model respectively.

The optimal lag length k, where chosen according to the Akaiques' FPE test.

Table 5.2. Phillips - Perron Test Results			
Model: $\Delta y_t = \mu + \rho y_{t-1} + \varepsilon_t$ ; $H_0 : \rho = 0$ ; $H_a : \rho > 0$			
Unit Root Tests at Logarithmic Levels			
Variables	constant	constant and trend	k
GDP per capita (Y)	-0.524	-2.535	4
Monetisation Ratio (M)	-0.345	-1.180	4
Currency Ratio (CUR)	-2.511	-0.690	4
Claims Ratio (CL)	-4.808*	-4.968*	4
Turnover Ratio (T)	-0.550	-3.265	3
Capital/Labour (K)	-1.528	-2.130	4
Unit Root Tests at First Differences			
Variables	constant	constant and trend	k
GDP per capita ( $\Delta Y$ )	-8.649*	-8.606*	4
Monetisation Ratio ( $\Delta M$ )	-7.316*	-7.377*	4
Currency Ratio ( $\Delta CUR$ )	-11.269*	-11.886*	4
Claims Ratio ( $\Delta CL$ )	-	-	-
Turnover Ratio ( $\Delta T$ )	-11.941*	-11.875*	3
Capital/Labour ( $\Delta K$ )	-4.380*	-4.301*	4

\* Denotes significance at the 5% level and the rejection of the null hypothesis of non-

stationarity.

Critical values obtained from Fuller (1976) and are -2.88, -3.45 and -1.94 for the first, second and third model respectively.

The optimal lag length k, where chosen according to the Akaiques' FPE test.

Variables in Cointegrating Vector	ADF statistic	k	n
Y, K, M	-2.6386	4	109
Y, K, CUR	-2.1290	6	109
Y, K, CL	-2.0463	4	104
Y, K, T	-3.3999	4	85

$k$ , degree of augmentation for the ADF test, determined by the FPE test.

$n$ , number of observations used in the first step of the Engle-Granger procedure.

Order	LL	AIC	SBC	LR test	Adjusted LR test
8	1092.2	1014.2	912.1	-	-
7	1089.4	1020.4	930.1	$\chi^2(9) = 5.62[.777]$	4.17[.900]
6	1068.0	1008.0	929.5	$\chi^2(18) = 48.33[.000]$	35.89[.007]
5	1064.1	1013.1	946.3	$\chi^2(27) = 56.21[.001]$	41.74[.035]
4	1060.7	1018.7	963.7	$\chi^2(36) = 62.97[.004]$	46.76[.0108]
3	1051.1	1018.1	974.9	$\chi^2(45) = 82.15[.001]$	61.00[.056]
2	1045.1	1021.1	989.7	$\chi^2(54) = 94.13[.001]$	69.90[.072]
1	938.8	968.8	949.2	$\chi^2(63) = 216.58[.000]$	160.82[.000]
0	284.5	275.5	270.7	$\chi^2(72) = 1615.1[.000]$	1199.4[.000]

AIC=Akaike Information Criterion; SBC=Schwarz Bayesian Criterion

$H_0$	r	n-r	Model 1	Model 2	Model 3
$\lambda$ max test					
	0	3	40.68	19.96	31.21
	1	2	13.13*	4.56	13.65
	2	1	3.69	0.07	4.17
$\lambda$ trace test					
	0	3	57.50	29.60	42.03
	1	2	4.56*	4.46	17.82
	2	1	0.07	0.07	4.17

\* Denotes the first time when the null hypothesis is not rejected for the 90% significance

level.

Null Hypothesis	Alternative Hypothesis		critical values	
			95%	90%
$\lambda_{max}$ rank tests		$\lambda_{max}$ rank value		
$H_0 : r = 0$	$H_a : r > 0$	40.68*	22.04	19.86
$H_0 : r \leq 1$	$H_a : r > 1$	13.13	15.87	13.81
$H_0 : r \leq 2$	$H_a : r > 2$	3.69	9.16	7.53
$\lambda_{trace}$ rank tests		$\lambda_{trace}$ rank value		
$H_0 : r = 0$	$H_a : r = 1$	57.50*	34.87	31.39
$H_0 : r = 1$	$H_a : r = 2$	16.82	20.18	17.78
$H_0 : r = 2$	$H_a : r = 3$	3.69	9.16	7.53
Normalised ecm: $Y=0.408*K+0.286*M+8.392$				

107 obs. from 1970q3 to 1997q1.

(\*,\*\*) denote rejection of the null hypothesis for the 5% and 10% significance levels respectively.

Critical values form Ostervald-Lenum (1992).

$H_0$	r	n-r	Model 1	Model 2	Model 3
$\lambda$ max test					
	0	3	32.29	29.20	42.60
	1	2	27.27	8.76*	12.80
	2	1	8.58	0.19	8.61
$\lambda$ trace test					
	0	3	69.32	38.17	64.02
	1	2	36.35	8.96*	21.41
	2	1	8.58	0.13	8.61

\* Denotes the first time when the null hypothesis is not rejected for the 90% significance level.

Null Hypothesis	Alternative Hypothesis		critical values	
			95%	90%
$\lambda_{max}$ rank tests		$\lambda_{max}$ rank value		
$H_0 : r = 0$	$H_a : r > 0$	29.20*	21.12	19.02
$H_0 : r \leq 1$	$H_a : r > 1$	8.76	14.88	12.98
$H_0 : r \leq 2$	$H_a : r > 2$	0.19	8.07	6.50
$\lambda_{trace}$ rank tests		$\lambda_{trace}$ rank value		
$H_0 : r = 0$	$H_a : r = 1$	38.17*	31.54	28.78
$H_0 : r = 1$	$H_a : r = 2$	8.96	17.86	15.75
$H_0 : r = 2$	$H_a : r = 3$	0.19	8.07	6.50

Normalised ecm:  $Y=0.376*K+0.335*M$

102 obs. from 1971q1 to 1997q1.

(\*,\*\*) denote rejection of the null hypothesis for the 5% and 10% significance levels respectively.

Critical values form Ostervald-Lenum (1992).



Table 5.9: Results from the VECMs and Diagnostic Tests

	$\Delta Y$	$\Delta K$	$\Delta M$
constant	0.904 (4.50)*	-0.141 (-1.48)	-0.908 (-2.77)*
ecm(-1)	-0.208 (-4.49)*	0.004 (1.54)	0.280 (2.78)*
$\Delta Y_{t-1}$	0.313 (2.36)*	-0.028 (-4.70)*	0.010 (2.07)*
$\Delta Y_{t-2}$	0.056 (2.58)*	-0.147 (-3.23)*	0.163 (2.04)*
$\Delta Y_{t-3}$	-0.144 (-1.38)	0.042 (0.85)	-0.099 (-0.58)
$\Delta Y_{t-4}$	0.145 (1.31)	-0.069 (-1.32)	-0.078 (-0.43)
$\Delta Y_{t-5}$	0.206 (2.43)*	-0.103 (-2.57)*	-0.052 (-0.37)
$\Delta Y_{t-6}$	-0.189 (-2.36)*	0.014 (0.38)	0.153 (2.17)*
$\Delta K_{t-1}$	-0.65 (-2.87)*	0.54 (5.10)*	1.012 (2.73)*
$\Delta K_{t-2}$	-0.031 (-0.13)	-0.122 (-1.02)	-1.516 (-3.52)*
$\Delta K_{t-3}$	0.389 (1.96)*	0.024 (0.21)	0.534 (1.37)
$\Delta K_{t-4}$	-0.18 (-0.70)	-0.134 (-1.07)	-0.010 (-0.02)
$\Delta K_{t-5}$	-0.08 (-0.31)	0.284 (2.29)*	-0.143 (-0.33)
$\Delta K_{t-6}$	-0.24 (-1.08)	-0.107 (-2.99)*	0.356 (0.95)
$\Delta M_{t-1}$	0.15 (3.05)*	-0.059 (-2.44)*	0.33 (4.06)*
$\Delta M_{t-2}$	0.026 (2.48)*	-0.0002 (-0.01)	0.151 (2.67)*
$\Delta M_{t-3}$	-0.04 (-0.59)	0.044 (1.38)	-0.010 (-0.09)
$\Delta M_{t-4}$	0.02 (2.31)*	0.016 (2.54)*	-0.057 (-0.54)
$\Delta M_{t-5}$	0.12 (2.20)*	-0.071 (-2.59)*	-0.046 (-0.48)
$\Delta M_{t-6}$	-0.26 (-5.06)*	0.060 (2.45)*	0.272 (3.22)*
$R^2$	0.79	0.75	0.79
S.E. of Regression	0.006	0.002	0.01
$\chi^2_{S.C.}(4)$	0.639	2.748	8.195
$\chi^2_{Norm}(2)$	0.776	5.995	5.585
$\chi^2_{Het}(1)$	2.511	0.067	2.993
$\chi^2_{Arch}(4)$	1.445	4.781	3.239

\* Rejects null hypothesis at 5% significance level. t-statistics in parentheses.

Table 5.10: Test Statistics and Choice Criteria for Selecting the Order of the VAR					
Based on 77 obs. from 1978q1 to 1997q1;					
List of variables included in the unrestricted VAR: Y, K, T.					
Order	LL	AIC	SBC	LR test	Adjusted LR test
8	692.6	614.6	523.2	-	-
7	685.3	616.3	535.4	$\chi^2(9) = 14.54[.104]$	9.63[.381]
6	679.9	619.9	549.6	$\chi^2(18) = 25.24[.118]$	16.72[.542]
5	672.0	621.0	561.2	$\chi^2(27) = 41.17[.040]$	27.26[.449]
4	667.2	625.2	576.0	$\chi^2(36) = 50.80[.052]$	33.64[.581]
3	664.4	631.4	592.7	$\chi^2(45) = 56.42[.118]$	37.37[.783]
2	649.4	625.3	597.2	$\chi^2(54) = 86.55[.003]$	57.32[.353]
1	606.8	591.8	574.3	$\chi^2(63) = 171.48[.000]$	113.58[.000]
0	170.4	164.4	157.3	$\chi^2(72) = 1044.4[.000]$	691.75[.000]

AIC=Akaike Information Criterion; SBC=Schwarz Bayesian Criterion

$H_0$	$r$	$n-r$	Model 1	Model 2	Model 3
$\lambda$ max test					
	0	3	49.86	24.11	27.76
	1	2	23.74	8.67*	17.96
	2	1	7.34	0.55	0.43
$\lambda$ trace test					
	0	3	49.86	33.43	54.19
	1	2	23.74	9.23*	26.43
	2	1	7.34	0.55	8.46

\* Denotes the first time when the null hypothesis is not rejected for the 90% significance

level.

Null Hypothesis	Alternative Hypothesis		critical values	
			95%	90%
$\lambda_{max}$ rank tests		$\lambda_{max}$ rank value		
$H_0 : r = 0$	$H_a : r > 0$	24.11*	21.12	19.02
$H_0 : r \leq 1$	$H_a : r > 1$	8.67	14.88	12.98
$H_0 : r \leq 2$	$H_a : r > 2$	0.55	8.07	6.50
$\lambda_{trace}$ rank tests		$\lambda_{trace}$ rank value		
$H_0 : r = 0$	$H_a : r = 1$	33.43*	31.54	28.78
$H_0 : r = 1$	$H_a : r = 2$	9.23	17.86	15.75
$H_0 : r = 2$	$H_a : r = 3$	0.55	8.07	6.50

Normalised ecm:  $Y=0.376*K+0.335*M$

83 obs. from 1976q3 to 1997q1.

(\*,\*\*) denote rejection of the null hypothesis for the 5% and 10% significance levels respectively.

Critical values form Ostervald-Lenum (1992).

	$\Delta Y$	$\Delta K$	$\Delta T$
constant	0.795 (4.54)*	-0.239 (-2.77)*	-12.63 (-2.34)*
ecm(-1)	-0.029 (-4.29)*	0.009 (2.80)*	0.473 (2.35)*
$\Delta Y_{t-1}$	0.169 (1.75)	-0.140 (-2.95)*	2.366 (0.79)
$\Delta K_{t-1}$	-0.438 (-2.85)*	0.665 (8.74)*	1.036 (0.21)
$\Delta T_{t-1}$	-0.007 (-2.02)*	0.003 (1.99)*	-0.063 (-0.53)
$R^2$	0.59	0.77	0.42
S.E. of Regression	0.005	0.0027	0.171
$\chi^2_{S.C.}(4)$	6.48	5.56	3.03
$\chi^2_{Norm}(2)$	0.18	3.01	4.40
$\chi^2_{Het}(1)$	0.93	0.10	1.04
$\chi^2_{Arch}(4)$	3.89	11.45*	1.88

\* Rejects null hypothesis at 5% significance level. t-statistics in parentheses.

$H_0$	r	n-r	Model 1	Model 2	Model 3
$\lambda$ max test					
	0	3	39.60	13.27*	31.73
	1	2	11.04	9.60	12.88
	2	1	7.60	0.24	9.34
$\lambda$ trace test					
	0	3	58.25	23.12*	53.96
	1	2	18.65	9.58	22.22
	2	1	0.06	0.24	9.34

\* Denotes the first time when the null hypothesis is not rejected for the 90% significance

level.

H <sub>0</sub>	r	n-r	Model 1	Model 2	Model 3
$\lambda$ max test					
	0	3	39.11	11.20*	32.00
	1	2	7.70	7.51	10.87
	2	1	6.13	0.09	7.37
$\lambda$ trace test					
	0	3	52.95	18.81*	50.25
	1	2	13.84	7.60	18.25
	2	1	6.13	0.09	7.37

\* Denotes the first time when the null hypothesis is not rejected for the 90% significance

level.

Order	LL	AIC	SBC	LR test	Adjusted LR test
8	1421.4	1121.4	769.8	-	-
7	1363.1	1099.1	789.7	$\chi^2(36) = 16.67[.000]$	40.91[.264]
6	1312.6	1084.6	817.4	$\chi^2(72) = 17.67[.000]$	76.32[.341]
5	1287.0	1095.0	869.9	$\chi^2(108) = 268.94[.000]$	94.30[.823]
4	1254.7	1098.7	915.8	$\chi^2(144) = 333.54[.000]$	116.95[.952]
3	1225.3	1105.3	964.6	$\chi^2(180) = 392.33[.000]$	137.57[.992]
2	1190.3	1106.3	1007.9	$\chi^2(216) = 462.23[.000]$	162.08[.998]
1	1129.5	1081.5	1025.2	$\chi^2(252) = 583.96[.000]$	204.76[.987]
0	90.47	378.4	364.4	$\chi^2(288) = 2061.9[.000]$	723.01[.000]

AIC=Akaike Information Criterion; SBC=Schwarz Bayesian Criterion



Table 5.17: The Pantula Principle for all the Financial Dev. Ratio Proxy Variables					
$H_0$	r	n-r	Model 1	Model 2	Model 3
$\lambda$ max test					
	0	6	51.37	51.12	56.60
	1	5	41.90	34.65	47.95
	2	4	29.81	18.37*	24.86
	3	3	17.37	10.80	17.20
	4	2	7.50	5.79	10.80
	5	1	5.70	0.86	5.76
$\lambda$ trace test					
	0	6	153.68	121.99	163.23
	1	5	102.31	70.86	106.23
	2	4	60.40	36.20*	58.67
	3	3	30.58	17.46	33.80
	4	2	13.21	6.66	16.60
	5	1	5.70	0.86	5.79

\* Denotes the first time when the null hypothesis is not rejected for the 90% significance

level.

Table 5.18: Cointegration Test Based on the Johansen's Max. Likelihood Method				
Null Hypothesis	Alternative Hypothesis		critical values	
			95%	90%
$\lambda_{max}$ rank tests		$\lambda_{max}$ rank value		
$H_0 : r = 0$	$H_a : r > 0$	51.12*	39.83	36.84
$H_0 : r \leq 1$	$H_a : r > 1$	34.65*	33.64	31.02
$H_0 : r \leq 2$	$H_a : r > 2$	18.37	27.42	24.99
$H_0 : r \leq 3$	$H_a : r > 3$	10.80	21.12	19.02
$H_0 : r \leq 4$	$H_a : r > 4$	5.79	14.88	12.98
$H_0 : r \leq 5$	$H_a : r > 5$	0.86	8.07	6.50
$\lambda_{trace}$ rank tests		$\lambda_{trace}$ rank value		
$H_0 : r = 0$	$H_a : r = 1$	121.99*	95.87	91.40
$H_0 : r = 1$	$H_a : r = 2$	70.86*	70.49	66.23
$H_0 : r = 2$	$H_a : r = 3$	36.20	48.88	45.70
$H_0 : r = 3$	$H_a : r = 4$	17.46	31.54	28.78
$H_0 : r = 4$	$H_a : r = 5$	6.66	17.86	15.75
$H_0 : r = 5$	$H_a : r = 6$	0.86	8.07	6.50
Normalised ecm1: $Y=0.138*K+0.130*M+0.252*CUR+0.098*CL+0.058*T$				
Normalised ecm2: $Y=0.231*K+0.200*M+0.279*CUR+0.007*CL+0.089*T$				

83 obs. from 1976q3 to 1997q1.

(\*,\*\*) denote rejection of the null hypothesis for the 5% and 10% significance levels respectively.

Critical values form Ostervald-Lenum (1992).

	$\Delta Y$	$\Delta K$	$\Delta M$	$\Delta_{CUR}$	$\Delta_{CL}$	$\Delta_T$
constant	1.27(4.88)	-0.26(-1.93)	-0.01(-0.32)	-0.14(-0.35)	-0.01(-1.14)	-29.3(-2.57)
ecm1(-1)	0.007(1.2)	-0.007(-0.2)	0.01(1.79)	-0.01(-1.14)	-1.52(-5.91)	0.03(0.18)
ecm2(-1)	-0.03(-5.18)	0.007(2.27)	0.01(1.80)	-0.004(-0.41)	-0.33(-1.31)	0.35(1.78)
$R^2$	0.59	0.70	0.52	0.40	0.52	0.23
S.E. of Regression	0.005	0.003	0.1	0.009	0.25	0.19
$\chi^2_{S.C.}(4)$	3.95	8.69	13.95*	3.43	15.18*	22.29*
$\chi^2_{Norm}(2)$	0.52	3.32	15.53*	7.31*	69.74*	1.49
$\chi^2_{Het}(1)$	0.85	0.08	0.0001	0.62	0.004	0.64
$\chi^2_{Arch}(4)$	5.43	1.71	3.16	2.32	2.54	0.89

\* Rejects null hypothesis at 5% significance level. t-statistics in parentheses.

Null Hypothesis	Alternative Hypothesis		critical values	
			95%	90%
$\lambda_{max}$ rank tests		$\lambda_{max}$ rank value		
$H_0: r = 0$	$H_a: r > 0$	30.24*	27.42	24.99
$H_0: r \leq 1$	$H_a: r > 1$	14.29	21.12	19.02
$H_0: r \leq 2$	$H_a: r > 2$	5.07	14.88	12.98
$H_0: r \leq 3$	$H_a: r > 3$	0.02	8.07	6.50
$\lambda_{trace}$ rank tests		$\lambda_{trace}$ rank value		
$H_0: r = 0$	$H_a: r = 1$	49.63*	48.88	45.70
$H_0: r = 1$	$H_a: r = 2$	19.39	31.54	28.78
$H_0: r = 2$	$H_a: r = 3$	5.09	17.86	15.75
$H_0: r = 3$	$H_a: r = 4$	0.02	8.07	6.50

Normalised ecm:  $Y=0.122*K+0.110*M+0.073*T$   
83 obs. from 1976q3 to 1997q1.

(\*,\*\*) denote rejection of the null hypothesis for the 5% and 10% significance levels respectively.

Critical values form Ostervald-Lenum (1992).

Table 5.21: Testing for Long-run Granger Causality				
Model: $\Delta y_t = \alpha_0 + \alpha_{1i} \sum_i^m \Delta x_{t-i} + \alpha_{2k} \sum_k^n \Delta z_{t-k} + \alpha_3 v_{t-1} + u_t$				
where y=(GDP per capita); x=(Turnover, Monetisation); z=(K/L ratio)				
x-variable	F-statistic		lags	causality relationship
turnover ( $\Delta T$ )	$a_3 = 0$	F(1,71)=20.26*	1	$cv_{t-1} \rightarrow \Delta Y$
	$a_{2k} = 0$	F(1,71)=3.73*	1	$\Delta T \rightarrow \Delta Y$
monetisation ( $\Delta M$ )	$a_3 = 0$	F(1,74)=23.60*	6	$cv_{t-1} \rightarrow \Delta Y$
	$a_{2k} = 0$	F(6,74)=7.30*	6	$\Delta M \rightarrow \Delta Y$
Model: $\Delta y_t = \alpha_0 + \alpha_{1i} \sum_i^m \Delta x_{t-i} + \alpha_{2k} \sum_k^n \Delta z_{t-k} + \alpha_3 v_{t-1} + u_t$				
where y=(Turnover, Monetisation); x=(GDP per capita); z=(K/L ratio)				
y-variable	F-statistic		lags	causality relationship
turnover ( $\Delta T$ )	$a_3 = 0$	F(1,71)=5.88*	1	$cv_{t-1} \rightarrow \Delta Y$
	$a_{2k} = 0$	F(1,71)=1.07	1	$\Delta T - / \rightarrow \Delta Y$
monetisation ( $\Delta M$ )	$a_3 = 0$	F(1,74)=12.81*	6	$cv_{t-1} \rightarrow \Delta Y$
	$a_{2k} = 0$	F(6,74)=0.836*	6	$\Delta M - / \rightarrow \Delta Y$

\* Denotes the rejection of the null hypothesis of no causality.

## Chapter 6

# Human Capital and Economic Growth: Time Series Evidence for the Case of Greece<sup>1</sup>

### 6.1 Introduction

The early neoclassical theory of economic growth had placed much emphasis on exogenous demographic factors that affect the growth rate of nations. Factors such as the growth rate of population, the structure of the labour force and the rate of technological change were assumed to determine the long-run equilibrium growth rate. Indeed, in neoclassical theory, capital accumulation increases an economy's growth in the medium term but the steady state growth is constrained by the rate of growth of the labour force.

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<sup>1</sup>A version of this chapter has been accepted for publication on the *Journal of Policy Modeling* (forthcoming) with co-author Dr G. M. Agiomirgianakis.



Moreover, technical progress, which is assumed exogenous, is the main driving force of the model. However, a large part of the measured growth in output was left unexplained in the neoclassical model, the so-called Solow residual, see, e.g. Snowden and Vane (1997) Romer (1996).

In the mid 1980s, however, the endogenous growth theory, motivated by the work of Paul Romer and Robert Lucas, has identified a number of factors that determine the growth rate of an economy. Hence, factors such as increasing returns to scale, innovation, openness to trade, international R&D and human capital formation are considered key factors in explaining the growth process (see e.g. Lucas 1988 and Turnovsky 1999, for an excellent review). Endogenous Growth Theory endogenised technological change by suggesting that technological change comes from what people actually do and, hence, emphasised the role of human capital. Indeed, an increase in the stock of human capital has positive effect on the production of goods. Furthermore, since investment in human capital is taking place through training and education, endogenous growth theory provides a strong rationale in favour of government intervention. More specifically, government policies intended to affect publicly-provided education and training will, in effect, determine the process of growth of the whole economy, see e.g. Lucas (1988), Shaw (1992), Romer (1994), Barro and Sala-i-Martin (1995), Aghion and Howitt (1998), Kaganovich and Zilcha (1999) and Capolupo (1999).

The aim of this chapter is to examine the role of education in Greek economic development. It is widely accepted that the principal institutional mechanism for developing human skills and knowledge is the formal educational system. Moreover, human capital

theory advocates that investment in education could be profitable to, both, the individual and the society. Indeed it is well established in the literature that a higher investment in education, undertaken by the employees, tends to lead into higher future earnings. On the other hand, in an era of increasing globalisation in the product, labour and capital markets, as well as, of accelerating worldwide - technological advances, shortages in human skills by limiting the introduction of new technologies, competition and productivity may result in an effective constraint to the economic growth of a modern economy. However, one may ask whether further and sustainable increases in education would indeed lead to higher growth. More specifically, this raises two further questions: first, how does investment in education affect economic development and second, what is the magnitude of this effect? Answers to both of these questions are needed if a policy description is to be made regarding the use of educational investment as an instrument to growth.

Much of the empirical literature so far, has been focused on the second question (Psacharopoulos, 1973 and 1984; Dean, 1984; Mc Mahon, 1987; Lau et al., 1993), while the work related to the first question is generally descriptive in nature.

On theoretical ground, the existing literature on the role of education on economic growth usually employs standard sources-of-growth equations based on a dynamic Cobb-Douglas aggregate production function, which can easily be extended to include human capital as a determinant of the economy's growth rate. One strand of models includes those by Baumol (1986) and Barro (1991) which argue that human capital plays an important role as a facilitating factor on the international transfer of technology from innovating countries to 'imitating' ones, helping them to 'catch-up' with the developed countries. Also, Mankiw

et. al. (1992) show that an extended Solow type growth model, when solved for the steady-state per capita income level, ends up in an equation which includes physical and human capital as the basic growth determinants. Alternatively, on the endogenous growth side of models, human capital accumulation has been recognized as one of the most important engines of economic growth. Romer (1990) develops a growth model, assuming that the creation of new ideas/designs is a direct function of the human capital (which has the form of scientific knowledge). Therefore, investment in human capital, by improving research and development, entails a growth in physical capital investment which in turn results in higher real growth rates. Persistent accumulation of knowledge by human beings, either with intentional efforts (Lucas, 1988; Becker et al., 1990, Jones and Manuelli, 1992) or with learning by doing (Stokey, 1988; Azariadis and Drazen, 1990; Young, 1991), promotes the productivity of labour and capital and is the driving force of economic growth (see Kim, 1998). Finally, Wang and Yip (1999) construct a two-sector overlapping generations model of endogenous growth to study the effects of brain drain on growth, education and income distribution. Their model is an extension of the models of Uzawa (1965) and Lucas (1988) where 'education is the only channel through which human capital accumulates, and the rate of accumulation of human capital depends on, among other things, the time an agent spent on education' (Wang and Yip, 1999).

Investment in human capital is generally proxied by educational variables. Indeed, it is widely acceptable that the principal institutional mechanism for developing human skills and knowledge is the formal educational system. In the U.S.A. spending on formal public and private education is about 6.5% of GDP while physical capital formation is about

16% of GDP<sup>2</sup>. According to Denison (1985) the annual rate of growth for the USA for the period 1929-1982 was 2.9%. The contribution of education was 14% of this growth and the contribution of physical capital formation was 19%<sup>3</sup>. Moreover, in developed countries 100% of children get a primary education, 90% get a secondary education and only 38% get a higher education.

Most developing countries have been led to believe that the rapid quantitative expansion of educational opportunities is the key to their economic and national development. Recently, Greece has committed itself to the goal of an expansion of the educational opportunities in the higher education<sup>4</sup>. Until now, Greece has an equal opportunity system available free to all residents: public financed primary, secondary and higher education, while entry-examinations exist for the higher education. This system normally results in an exclusion of a great number of candidates for higher education, each year. Nowadays, however, Greek educational policymakers plan the abolition of the entry-examination system that allows free higher education virtually to each candidate.

In this chapter, we examine the potential impact of an enlarged number of highly educated people to the economic growth of Greece. More specifically, the hypothesis that we want to test is whether or not this educational expansion (by leaving free the entrance in higher education) could affect the Greek economic development.

The last two decades have witnessed voluminous empirical studies worldwide, that try to investigate quantitatively the relation between education and economic growth. The

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<sup>2</sup>See e.g. Blanchard O. (2000), page 222.

<sup>3</sup>See Denison (1985), page 15.

<sup>4</sup>This increase in the number of higher education students is either due to the establishment of new universities or due to an increase in the number of enrollments in the existing ones. Characteristically, one could say that in the last ten years at least three universities have opened: Ioannina, Aegean and Open University.



general result of these studies indicates that there is a positive correlation between economic growth and education. However, there remains a scepticism, concerning this empirical evidence: first, most of the existing studies on the relationship between education and economic growth have been carried out by employing cross sectional data and techniques, mostly from the advanced countries that had solved the most crucial problems of development by the first quarter of the 20th century. Second, it is trivial to state that educational planning and development planning are closely related, since both of these plans are considered as national frameworks of policies with a common objective: the realisation of a rapid and healthy economic development. Therefore, the fact that we must consider is the causal direction between those two variables in order to recognise which one is a precondition for what and vice versa. In order to investigate the above hypothesis, the present chapter adopts an alternative, time series based, empirical strategy: cointegration tests are followed by causality tests. Furthermore, the choice of Greece as a case study is based on several considerations: first Greece is an emerging European economy with a fast growing financial sector, that has controlled inflation and budget deficits and enjoying higher rates of GDP growth (3.5% in 1999). Secondly Greece heads towards participation in the European Monetary Union (EMU) a prospect that by many Greek policymakers<sup>5</sup> is expected to contribute to further increases in economic growth. Third, educational qualifications in Greece are considered prerequisites for a successful career either in the public or private sector (see Pirounakis, 1997, page 62, for further details).

The chapter is organized as follows. In section 6.2, we incorporate education into three alternative growth models. First, we augment a standard textbook Solow-model by

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<sup>5</sup>See e.g. Nikolaou N., 2 January 2000, Vima, page Δ2.



following Mankiw et al. (1992). Next, we assume a simple endogenous growth model in a discrete time environment where education is a parental choice variable entering the utility function. The first model allows us to determine the contribution of education to the long-run output per capita, while the second model focuses on the importance of education in determining the rate of growth of the economy. In both models we arrive to reduced form equations describing the effect of education on the growth rate of the economy. Section 6.3 describes the Greek educational system, while in section 6.4, we look at the long run relationship between educational variables (enrolments in elementary, secondary and higher education, as well as, government expenditures in education) and gross domestic product testing for the existence of cointegrated relations.

Our main results suggest that there exist cointegrating relationships among the educational variables and the GDP per capita, while the causality direction runs through educational variables to economic growth, with the exception of higher education where there exists reverse causality. The causality direction from the two first levels of education to economic growth, suggests that the more the educated persons the more rapid the development. However, the finding that the more the economic development the more the demand for higher education suggests that the expansion of formal schooling and the acquisition of higher degrees and certificates, for the case of Greece, is not necessarily associated with an improved ability to undertake productive work and hence to foster economic growth. The later result is in sharp contrast with the theoretical predictions, but it could be explained by the unplanned character of the expansion in higher education that has happened in Greece during the last ten years, and led to an always expanding pool of long-term unemployed

young people with university degrees. Finally, section 6.5 concludes the chapter.

## 6.2 Growth models with human capital

In this section we incorporate the case of education into three growth models. We first start with a neo-classical augmented model and then we move on to two endogenous growth models, one in a discrete time and an alternative in a continuous time environment.

### 6.2.1 The neoclassical augmented model

Following Mankiw et. al (1992) we augment the Solow model by including human capital. Let the production function be:

$$Y(t) = K(t)^a H(t)^\beta [A(t)L(t)]^{(1-a-\beta)} \quad (6.1)$$

where  $Y(t)$  is output,  $H(t)$  is the stock of human capital,  $K(t)$  is the stock of physical capital,  $L(t)$  is the labour force and  $A(t)$  is the level of technology.

Along the lines suggested by Tallman and Wang (1994), we assume that  $H(t) = E(t)^\phi$ . Empirical studies, see e.g. Maddison (1991), Pencavel (1991) and Tallman and Wang (1994), suggest that the value of  $\phi$  is very close to unity. Therefore, in our analysis we do not distinguish between the measure of education and the hypothesised human capital measure.

Assuming that  $L(t)$  and  $A(t)$  grow at constant and exogenous rates  $n$  and  $g$  respectively, we get:

$$L(t) = L(0)e^{nt} \quad (6.2)$$

$$A(t) = A(0)e^{gt} \quad (6.3)$$

On the other hand<sup>6</sup>,

$$\dot{K}(t) = s_K Y(t) \quad (6.4)$$

$$\dot{H}(t) = \dot{E}(t) = s_H Y(t) \quad (6.5)$$

where  $s_K$  and  $s_H$  are the fractions of output devoted to physical and human capital accumulation respectively<sup>7</sup>.

The evolution of the economy is then described by

$$\dot{k} = s_K k(t)^\alpha h(t)^\beta - (n + g)k(t) \quad (6.6)$$

$$\dot{h} = s_H k(t)^\alpha h(t)^\beta - (n + g)h(t) \quad (6.7)$$

where  $k = K/AL$ ,  $h = H/AL$ ,  $y = Y/AL$ .

Solving for the levels of  $k$  and  $y$  on the balanced growth path we get:

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<sup>6</sup>For the sake of simplicity we assume no capital accumulation.

<sup>7</sup>One may adopt the explanation of (6.64) suggested by Romer (1996) p 129, that the technology for producing human capital is similar to technology of producing good, i.e. in both case we have the combined use of physical capital human capital and raw material. Indeed assuming that

$\dot{H} = K_E^\alpha H_E^\beta [AL_E]^{(1-\alpha-\beta)}$  where  $K_E$ ,  $H_E$ ,  $L_E$  are the quantities of physical capital, human capital and labour devoted to the education and also assuming  $K_E = s_H K$ ,  $H_E = s_H H$ ,  $L_E = s_H L$ , then we derive  $\dot{H}(t) = s_H [K^\alpha H^\beta (AL)^{(1-\alpha-\beta)}]$  and hence the equation (6.64) above.

$$k^* = \left[ \frac{s_K^{(1-\beta)} s_H^\beta}{n+g} \right]^{(1/1-a-\beta)} \quad (6.8)$$

$$h^* = \left[ \frac{s_K^a s_H^{(1-a)}}{n+g} \right]^{(1/1-a-\beta)} \quad (6.9)$$

Substituting into the production function and taking logs we have:

$$\ln y^* = \frac{a}{1-a-\beta} \ln s_K + \frac{\beta}{1-a-\beta} \ln s_H - \frac{a+\beta}{1-a-\beta} \ln(n+g) \quad (6.10)$$

(6.10) describes how output per capita depends on population growth and the accumulation of human and physical capital. Clearly, an increase in the fraction of output devoted to education will increase the level of output on the balanced growth path.

This model has been estimated for a number of countries employing long-term averages of relevant variables in each country, using various measures of human capital, such as enrollment rates in primary and secondary schools, which are found to be positively associated with growth. Mankiw (1995) states clearly that incorporating human capital investment into the Solow-Swan neoclassical growth model the proportion of international variation explained by the model is raised substantially. Hence, broadening the meaning of capital to include not only physical, but human as well, can help make the assumptions concerning convergence in international output of the neoclassical growth model consistent with the international experience.

Though supportive to the Solow-Swan model, the Mankiw, Romer and Weil (1992) model has received criticism. First, it has been argued that some or all of the right hand side variables are surely exogenous (Obstfeld and Rogoff, 1996). For example, Razin and

Sadka (1995) show that there can be feedback from income to family size. Second, the use of investment as a share of GDP for a proxy for the saving rate, suffers from endogeneity (see Grossman and Helpman, 1994). Another shortcoming of the model is that it makes the assumption that education affects individuals' productivity equally on all jobs, no matter whether these jobs are already routinized or innovative.

### 6.2.2 Discrete time endogenous growth model

In this section, we lay out a simple endogenous growth model to show that the growth rate of output per capita depends on the growth rate of ideas. Romer (1993a,b) emphasized the distinction between objects and ideas, and their role in explaining the growth patterns in the world economy. According to Romer (1993a,b), economies can be faced with an object gap, an idea gap or both. An economy suffers from an object gap when it lacks physical objects (e.g. factories and roads) while an economy suffers from an idea gap which it lacks the knowledge to create value. At the same time, ideas are the most important resource for creating wealth in modern economies. Most economic activity in modern economies takes place outside factories (activities for example such as packaging, marketing, distribution, payment systems, information systems and quality controls are directly related to ideas). It is therefore very important for low-income economies that want to achieve higher rates of growth to reduce their possible idea gap, and this can be done through education and development of human capital in general.

Following Pinteris (1997), we consider an economy with three sectors, a final goods sector, an intermediate goods sector and a research sector that produces ideas. Labour is characterised as skilled ( $L_s$ ) and unskilled ( $L_u$ ). The final goods sector uses unskilled labour,



capital ( $K$ ) and the current stock of intermediate inputs ( $E$ ) to produce output ( $Y$ ). The production function of this sector is given by:

$$Y_t = E_t^\alpha L_{u,t}^\beta K_t^\gamma \quad \alpha, \beta, \gamma > 0 \quad (6.11)$$

which is a typical constant returns to scale Cobb-Douglas production function and the subscript  $t$  denotes time.

The intermediate goods sector uses skilled labour and the current stock of ideas ( $I$ ) to produce intermediate goods through the following production function:

$$E_t = I_t L_{s,t} \quad (6.12)$$

Finally, the research sector employs researchers ( $H$ ) and the stock of ideas that exist at the end of the previous period to produce new ideas. The production function of this sector is:

$$I_t = H_t^\delta I_{t-1}^\zeta \quad \delta, \zeta > 0 \quad (6.13)$$

We assume, for simplicity, that the number of unskilled and skilled workers is fixed and that the only factors which are growing (accumulated) is the number of researchers and the number of ideas. Specifically, the number of researchers is growing at a constant rate  $n^8$ . Therefore, from (6.11) we can obtain the productivity function:

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<sup>8</sup>This assumption implies that the aim of the government is to increase the number of researchers (and obviously by that the number of ideas) and in order to do this increases the expenditures for education as a proportion of the total expenditures.

$$y_t = \frac{Y_t}{L_{u,t}} = E_t^\alpha L_{u,t}^{\beta-1} K_t^\gamma \quad (6.14)$$

Given that labour and capital do not grow through time, the growth of output per worker will depend on the growth of the number of intermediate products, which, in turn, will depend on the growth of ideas. From (6.12), the rate of growth of intermediate products is given by:

$$\xi_{E,t} = \frac{E_t}{E_{t-1}} = \frac{I_t L_{st}}{I_{t-1} L_{s,t-1}} = \frac{I_t}{I_{t-1}} \quad (6.15)$$

similarly the growth rate of ideas is given by:

$$\xi_{I,t} = \frac{I_t}{I_{t-1}} = I_t = H_t^\delta I_{t-1}^{\zeta-1} \quad (6.16)$$

which shows that the current period growth rate of ideas depends on the stock of ideas during the previous period and also says that:

$$\xi_{E,t} = \xi_{I,t} \quad (6.17)$$

Now, we can take the growth rate of ideas:

$$\frac{\xi_{I,t}}{\xi_{I,t-1}} = \frac{H_t^\delta I_{t-1}^{\zeta-1}}{H_{t-1}^\delta I_{t-2}^{\zeta-1}} = n \frac{I_{t-1}^{\zeta-1}}{I_{t-2}^{\zeta-1}} = n \xi_{I,t-1}^{\zeta-1} \quad (6.18)$$

where  $n$  is the growth rate of researchers. The initial value of  $\xi_{t-1}$  is determined by the initial number of researchers and the stock of ideas that already exists in the economy. Thus, equation (6.18) determines the behaviour of the growth rate of ideas, which is related to the value of the parameter  $\zeta$  and grows according to the growth rate of researchers. Assuming

that  $\zeta > 1$ ,<sup>9</sup> the growth rate of ideas must be increasing over time and this leads and this leads to an increased rate of growth of intermediate inputs, which gives an increased rate of growth of output per capita, as well. Concluding, an economy with more researchers (and with higher values of  $n$ ; the growth of the number of researchers) or a higher initial stock of ideas will exhibit permanently higher growth rates.

### 6.2.3 Endogenous growth over time

Following Lucas (1988)<sup>10</sup> which argues that we can have constant returns to scale in inputs that can be accumulated by arguing that all inputs can be accumulated (Sala-i-Martin, 1990). Therefore, following Lucas (1988) we introduce human capital in the production function which has the following form:

$$Y_t = AK_t^a(v_t h_t L_t)^{1-a} \quad (6.19)$$

where we use the standard notation,  $Y_t$  is output,  $A$  is the level of technology,  $K_t$  is the stock of physical capital  $v_t$  denotes the fraction of non-leisure time households spend working,  $h_t$  is a measure of the average quality of workers and  $L_t$  is labour. Thus  $(vhL)$  is the effective labour for the economy or the human capital for the entire economy.

The difference with the Lucas (1988) models, stems from the fact that we use a family utility function connecting utility not only with the stream of consumption the

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<sup>9</sup>The assumption that  $\zeta$  is higher than one implies that there are increasing returns to ideas in the economy. This assumption can be justified by the fact that when the amount of labour and researchers doubles, interactions among researchers eliminate repetition of research projects and lead to the creation of more ideas

<sup>10</sup>In fact we follow the first model in Lucas (1988) which argues that we can have constant returns to scale in inputs that can be accumulated by arguing that all inputs can be accumulated (see also Sala-i-Martin, 1990).

individuals choose but with the number of children in each household as well (Becker et al., 1990). A large share of (altruistic) parental expenditure on children takes the form of educational expenses, which may be viewed as investment in human capital. Suppose an altruistic two-period-lived parent that has optimally divided second period resources between his own family's consumption, investment in his child's human capital and a bequest. Suppose also that the child cannot borrow to finance fully her own education. Then it may well happen that the return to further investment in the child's human capital exceeds the interest rate  $r$ , but that no resources are available to exploit this excess return. Therefore, in that case, bequests are zero, because the child benefits more from extra education than from financial assets that earn only  $r$ .

Therefore, the family utility function - assuming that contains the usual neoclassical properties - will have the following form:

$$U_i = U_i(h_i, n_i, y_i) \quad (6.20)$$

where  $h$  is human capital per child,  $n$  is the number of children in the household and  $y$  is a composite consumption good. A simple form of the family utility function may be the following:

$$U = \sum_{t=0}^T e^{-\rho t} \left[ \frac{c_t^{1-\sigma} - 1}{1-\sigma} + n_i(1 - v_t) \right] \quad (6.21)$$

where we assume that the utility derived from the consumption of the composite good  $y$ , is given by the usual constant intertemporal elasticity of substitution  $\sigma$ ,  $c_t$  denotes the consumption of the composite good and  $n_i(1 - v_t)$  denotes the time each child spends for

education.

Households want to maximize their welfare function subject to the capital accumulation constraint given by:

$$k_{t+1} - k_t = Ak_t^a(v_t h_t)^{1-a} - c_t \quad (6.22)$$

To complete the model we need to specify how households accumulate knowledge. Assuming that they are doing it by studying then we can have the following equation:

$$h_{t+1} - h_t = \phi h_t(1 - v)n_i - xp_x n_i \quad (6.23)$$

where  $\phi$  is the studying productivity parameter or the exogenous endowment (ability) of each child,  $x$  is the purchased schooling inputs and  $p_x$  is the price per unit of good  $x$ .

### *Market Solution*

Households choose a stream of consumption ( $c_{y,t}$ ), the proportion of time they want to spend working ( $v$ ), as opposed of studying ( $1 - v$ ) and the number of children  $n$ , subject to the constraints (6.22) and (6.23). The Hamiltonian is:

$$H = \sum_{t=0}^T e^{-\rho t} \left[ \frac{c_t^{1-\sigma} - 1}{1-\sigma} + n_i(1 - v_t) \right] + \lambda_{1,t} (Ak_t^a(v_t h_t)^{1-a} - c_t - k_{t+1} + k_t) \\ + \lambda_{2,t} (\phi h_t(1 - v)n_i - xp_x n_i - h_{t+1} - h_t) \quad (6.24)$$

The six first order conditions with respect to  $c$ ,  $v$ ,  $n$ ,  $x$ ,  $k$ , and  $h$  respectively are:

$$e^{-\rho t} c_{y,t}^{-\sigma} = \lambda_{1,t} \quad (6.25)$$



$$e^{-\rho t}n - \lambda_{2,t}(\phi h_t n_i) + \lambda_{1,t}(A k_t^a (1-a) v_t^{-a} h_t^{1-a}) = 0 \quad (6.26)$$

$$e^{-\rho t}(1 - v_t) + e^{-\rho t}e_t + \lambda_{2,t}\phi h_t(1 - v_t) - x p_x = 0 \quad (6.27)$$

$$-\lambda_{2,t}n_i p_x = 0 \quad (6.28)$$

$$\lambda_{1,t+1} - \lambda_{1,t} = \lambda_{1,t} A a k_t^{a-1} v_t h_t^{1-a} = 0 \quad (6.29)$$

$$\lambda_{2,t+1} - \lambda_{2,t} = \lambda_{1,t}(1-a) A k_t^a v_t^{1-a} h_t^{-a} - \lambda_{2,t}\phi(1-v_t)n_i = 0 \quad (6.30)$$

Taking logarithms and derivatives of (6.25) and using (6.29) we obtain:

$$\frac{c_{t+1} - c_t}{c_t} \equiv \gamma = \sigma^{-1}(A a k_t^{a-1} v_t h_t^{1-a} - \rho) \quad (6.31)$$

By dividing the dynamic constraint for physical capital accumulation by  $k$  we will find that:

$$\frac{k_{t+1} - k_t}{k_t} \equiv y_k = A k_t^{-(1-a)} v_t h_t^{1-a} - \frac{c_t}{k_t} \quad (6.32)$$

Now we realize that the first part of the second term is (from (6.31)) equal to  $(\frac{\gamma\sigma + \rho}{a})$ . Let's put all the constants on the right hand side, take logarithms and derivatives of both sides to get that  $\frac{c_{t+1} - c_t}{c_t} = \gamma = \frac{k_{t+1} - k_t}{k_t} = \gamma_k$ . So capital and consumption grow at the same rate  $\gamma$ .

We want to find the growth rate of human capital ( $\gamma_h = \frac{h_{t+1} - h_t}{h_t}$ ). Take equation (6.31), put all the constants on the left hand side to set:

$$\frac{\gamma\sigma + \rho}{Aa} = k^{-(1-a)}v h^{(1-a)} \quad (6.33)$$

Taking logarithms and derivatives of both sides of (6.33) we get:

$$0 = -(1-a)\frac{k_{t+1} - k_t}{k_t} + (1-a)\frac{h_{t+1} - h_t}{h_t} \quad (6.34)$$

which implies that:

$$\frac{h_{t+1} - h_t}{h_t} = \gamma_h = \frac{\gamma(1-a)}{(1-a)} \quad \text{or} \quad \frac{h_{t+1} - h_t}{h_t} = \gamma_h = \gamma_k \equiv \gamma \quad (6.35)$$

All growth rates are the same. Now we want to find the value of either  $\gamma$  or  $\gamma_k$  as a function of the parameters of the model. We can start with rearranging (6.26):

$$\lambda_{2,t} = \frac{e^{-\rho t}}{\phi h_t} + \lambda_{1,t} \frac{A k_t^a (1-a) v_t^{-a} h_t^{-a}}{\phi n_i} = 0 \quad (6.36)$$

Taking again logarithms and derivatives of both sides of (6.28) we take:

$$\frac{\lambda_{2,t+1} - \lambda_{2,t}}{\lambda_{2,t}} = -\rho - (1-a)\gamma_h + \frac{\lambda_{1,t+1} - \lambda_{1,t}}{\lambda_{1,t}} + a\gamma_k \quad (6.37)$$

We know from equations (6.29) and (6.31) that:

$$\frac{\lambda_{1,t+1} - \lambda_{1,t}}{\lambda_{1,t}} = A a k_t^{a-1} v_t h_t^{1-a} = -(\gamma\sigma + \rho) \quad (6.38)$$

In order to find the value of  $\frac{\lambda_{2,t+1} - \lambda_{2,t}}{\lambda_{2,t}}$  divide both sides of equation (6.30) by  $\lambda_2$ :

$$\frac{\lambda_{2,t+1} - \lambda_{2,t}}{\lambda_{2,t}} = \frac{\lambda_{1,t}}{\lambda_{2,t}} ((1-a) A k_t^a v_t^{1-a} h_t^{-a}) - \phi_t (1-v_t) n_i \quad (6.39)$$

But from equation (6.26) we have:

$$\frac{\lambda_{1,t}}{\lambda_{2,t}} = -\frac{e^{-\rho t}}{\lambda_{2,t}(Ak_t^a(1-a)v_t^{-a}h_t^{1-a})} + \frac{\phi_t n_i}{Ak_t^a(1-a)v_t^{-a}h_t^{-a}} \quad (6.40)$$

Substituting (6.40) to (6.39) we obtain:

$$\frac{\lambda_{2,t+1} - \lambda_{2,t}}{\lambda_{2,t}} = -\phi_t n_i + B \quad (6.41)$$

where  $B = -\frac{e^{-\rho t} v}{\lambda_2 h}$ . Equation (6.41) says that the shadow price of capital decreases at a constant rate  $\phi$  (the productivity parameter of the 'productivity knowledge' technology) multiplied accordingly for the number of children. Finally, we can substitute the above solutions to (6.37) to take that:

$$\gamma_h = \frac{\phi_t n_i - B - 2\rho}{1 - 2a - \sigma} \quad (6.42)$$

which says that the sector that really drives the economy is the production of human capital.

However, this model, which follows from Lucas (1988) approach, can be criticised as it assumes that returns to education remain constant over time (see equation for human capital determination), which does not seem to be consistent with the empirical evidence on education.

### 6.3 Education in Greece

Education can be seen as a main industry, often one of the largest in each country. In Greece, according to the latest available data, in 1994 it employed more than 100,000

teachers and involved nearly 1,7 million pupils in all levels of formal education, in approximately 18,000 educational institutions. There are three stages in formal education in the Greek economy: primary education, secondary education and higher education.

The primary school system, which includes both public and private schools is the base of the Greek educational system. It provides education for the children from the age of seven to the age of twelve. Both primary and secondary education are compulsory, and we can say that for the case of primary there is a very small number of students who do not have any access to schools. However, the illiteracy rate defined as % of people aged 15 and above, for Greece was 5.2% in 1990, reduced in 3.9% in 1995 and fall further to 3.46% in 1997, which is big compared with the other EU countries, where it is nearly zero<sup>11</sup>. Most of the children who do not have any access to schools live in the sparsely populated rural areas. This fact creates an inequality in opportunities between children of those families with the children of urban-dwelling families to receive a good quality of education and to find their ways into the secondary educational system.

Secondary education is divided in two cycles: the first level (gymnasium) and the second level (lyceum). The first level, which follows primary schools, lasts three years, including the age group 12-15 and prepares students for a higher level of general, technical or vocational education. The lyceum, which lasts also three years prepares students for the universities and other advanced schools.

At the top of educational pyramid, there are universities and other advanced schools. Higher education in Greece ranges from 4 to 6 years. While the enrollments

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<sup>11</sup>The relative figures for Spain were 3.9%, 3.00% and 2.75% respectively, while for Turkey were 20.8%, 18% and 16.76% respectively.

to higher education as a proportion of working age population was 1.29% and 1.36% in 1970 and 1980 respectively, it has been increased to 1.72% in 1990 and during the next four years reached the figure of 2.73%, and it is constantly increasing. In the context of constantly increasing demand for higher education, the capacity problem of the higher educational system is the most crucial issue to be solved for the Greek economy. The presence of a large student body that has been placed according to the results of the university entrance examination in the schools whose graduates are not immediately absorbable by the economy, leading young people to the unemployment pool, with no financial incentive and chance for social recognition, at least in the near future is the second major problem that the Greek society has to face.

In terms of figures, total Autumn enrolments in formal education increased from 1,602,819 in 1960 to nearly 1,714,723 in 1994. As may be seen from Table 6.1, however enrollments in elementary education have decreased relative to 1970, attributed to declining birth rates. At the same time enrolments in institutions of higher education continued to increase. Further enrolment increases in higher education are expected in the near future.

The educational industry in Greece employs a large number of workers. In addition to the approximately 100,000 teachers and institutional staff reported in Table 6.2 for the year 1994 many more workers are employed in non-institutional positions.

Total expenditures for education for the decade 1980-90 (as it can be observed from Table 6.3) have increased from 12,140 million drachmas in 1980 (or 2.91% of the total expenditures of the Greek economy) 18,841 million drachmas (or 3.87% of the total expenditures of the Greek economy) in 1990. However, total expenditures do not provide



a complete view of the magnitude of investment in education. It is now widely recognised that an important element in educational cost is represented by the earnings student forgo while attending school.

Continuing the analysis of the aggregate data, we observe that the contribution of education in the formation of the National Income (added value) increased from 2.66% of GDP in 1980 to 3.26% in 1990 (Table 6.3). The magnitude of the investment in education becomes more apparent when expressed as a percentage of the state budget, which lately is characterised by a continuously decreasing trend. Specifically from 1967 until 1985 fluctuated around 7.78% to 9.78% while from 1990 and after, it is observed a rapid decline to 4.28% in 1990, 4.01% in 1991 and 3.71% in 1992 while today the respective value is estimated to be even smaller, approximately 2.5% (Table 6.4). Here, it is interesting to note that the relative value for military expenditures fluctuates from 8% to 11%, which is almost three times higher.

Finally, unlike other European countries, Greece devotes a relatively small proportion of its wealth and its public funds to education. Greece's educational expenditure per student in the primary sector as % of GNP per capita for 1991 was 8.18%, which was the lowest figure compared with the relatives of 9.09% for Turkey, 12.04% for Cyprus, 15.44% for UK and the very high figures of 49.67%, 34.03% and 32.77% for Sweden, Norway and Switzerland respectively<sup>12</sup>. Similar are the figures for the expenditures in the secondary education, with Greece spending per student, in 1995, 14.74% of GNP per capita, which was the lowest value in comparison to all other European Union countries (the respective

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<sup>12</sup>All the data for the comparisons of the greek educational system with the respective ones from other European countries were taken by the World Development Indicators CD-Rom, published by the World Bank.

figures were 20.59% for UK, 23.66% for Czech Republic, 28.60% for Finland, 30.74% for Germany, and so on). Another interesting figure which shows the position of the Greek educational system in comparison to those of the rest European countries is the number of scientists and engineers in R&D per million people. This number for Greece was 774 in 1993, while it was 1,159 for Czech Republic, 1,210 for Spain and above 2,000 for all the other EU countries (2,414 for UK, 2,584 for France, 2,648 for Denmark, 2,812 for Finland, 2,843 for Germany and 3,678 for Norway).

## 6.4 Methodology and empirical results

In our theoretical section three models were presented suggesting positive effects both in the levels of output (see first model's steady state solution) and in the growth rate of output with respect to education (see second and third model's final equations). Therefore in order to test whether or not education plays a role in Greek economic growth, we perform two types of econometric analyses: cointegration tests, followed by causality tests. The cointegration tests are meant to capture the relationship in the levels while the causality tests are performed in a regression on the growth rates of the variables under examination. We will use the Johansen and Juselius (1990) cointegration method. When the variables are stationary or they are cointegrated, then causality tests can be conducted (see Granger, 1988). We then perform the Granger (1969) causality tests.

We employ data for Greece, covering the period 1960 to 1994. All the data for the present analysis are collected from the Greek Statistical Yearbook, of the Greek Statistical Association (various volumes) and from the Greek Statistics of Education (various volumes).

We have used as a proxy of economic development the GDP per capita (in national currency and constant prices), and its relative growth rate; while for human capital proxies we have used enrolments rates in primary and secondary education and in the institutions of higher education (measured as the percentage of the working age population, which is defined as population aged between 15 and 64).<sup>13</sup> As an alternative proxy for human capital development, coming from political decisions, we have also used the public expenditures on education relative to total public expenditures<sup>14</sup>.

We use the enrollment rates as proxies, because human capital formation means not only the creation of knowledge but also the embodiment of knowledge into a person (see e.g. Kim, 1998). Moreover, along the lines suggested by Wong and Yip (1999), formal education is not only the channel through which persistent human capital occurs but also the rate of human capital accumulation depends on schooling. Mankiw, Romer and Weil (1992) state that is very hard to measure the spending on education, because explicit spending on education takes place at all different levels of government as well as by the family (for which data are not available). We are aware of this restriction, but we use as proxy for human capital the variable reflecting public expenditures on education relative to its total number, because we suppose that it reflects the degree of the willingness of the government to promote education or not.

Before proceeding with the cointegration tests, we perform stationarity tests. In

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<sup>13</sup>At this stage, we have to acknowledge that the human capital proxy for the tertiary education suffers from the bias that does not take into account the number of the Greek students that study abroad. However, firstly data for this figures do not exist and secondly, even if they were available are not sufficient because we have to take into account how many of the Greek students that study abroad return eventually to Greece after the completion of their studies.

<sup>14</sup>Most of these proxy variables are taken from Barro (1991). Similar variables are also used by Kim (1994) and Barro and Lee (1994) among others.

order to test for stationarity we will use the augmented Dickey-Fuller (ADF) test (see Dickey and Fuller, 1979; 1981). From the results of ADF tests on the levels and first differences of all variables it is clear that all our variables have unit roots in their levels but are stationary in their first differences<sup>15</sup>.

Since all variables are stationary after first differencing, it is appropriate to test whether the variables are cointegrated. The first step in the Johansen procedure is to determine the lag order. Since we have annual data and the variables achieve stationarity after first differencing, we use a lag of one. The maximum number of lags used by applied researchers for annual data is two. Although we report the results of only one lag, we have also tested with two lags. However, the results indicated no major differences. Table 6.5 gives the results of the cointegration tests with enrollments in various levels of education, educational expenditures and GDP. For all cases, the trace tests indicate that there is one cointegrating vector<sup>16</sup>. The long run cointegrating vectors for GDP and enrollments in higher education are given by:

$$-0.20744GDP + 0.06757HIGHER = e_t \quad (6.43)$$

where  $e_t$  is error term.

Therefore, we find that there is a positive long run relationship between GDP and

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<sup>15</sup>The ADF test entails estimating the following regression equation (with an autoregressive process):

$$\Delta y_t = c_1 + by_t - 1 + c_2t + \sum_{i=1}^p d_i \Delta y_{t-1} + v_t$$

In the above equation,  $y$  is the relevant time series,  $\Delta$  is a first-difference operator,  $t$  is a linear trend and  $v_t$  is the error term. The above equation can also be estimated without including a trend term (by deleting the term  $c_2t$  in the above equation). The null hypothesis of the presence of a unit root is  $b = 0$ . The results of the ADF test are not presented for economy of space and are available from the authors upon request.

<sup>16</sup>We present the trace results for the non-trended case. Alternative model estimates including a restricted trend in the data generating process are estimated, without changing significantly the results. These tests are not presented here for economy of space and are available from the authors upon request.



enrolments in all stages of education, which was expected and consistent with the predictions of the theoretical models. This result was expected, because educational planning and development planning are closely related, since both of these plans are considered as national frameworks of policies with a common objective: the realisation of a rapid and healthy economic development. Therefore, the fact that we must consider is the causal direction between those two variables in order to recognise which one is a precondition for what and vice versa. In all the other educational variables cases the results provided evidence of a positive relationship<sup>17</sup>.

In the bivariate cointegration case (Engle and Granger, 1987), causality tests can be conducted in the respective ECM form:

$$\Delta y_t = \alpha_0 + \alpha_{1i} \sum_i^m \Delta x_{t-i} + \alpha_3 e_{t-1} + u_t \quad (6.44)$$

$$\Delta x_t = \alpha_4 + \alpha_{5i} \sum_i^m \Delta y_{t-i} + \alpha_6 e_{t-1} + u_t \quad (6.45)$$

where  $e_{t-1} = y_{t-1} - b_1 x_{t-1} + b_2 z_{t-1}$ , is the residual of the cointegration equation.

The null hypothesis, that  $x$  does not Granger cause  $y$ , is  $H_0(\alpha_{1i} = \alpha_3 = 0)$ . This means that there are two sources of causation for  $y$ , either through the lagged terms  $\Delta x$  or through the lagged cointegrating vector. The null hypothesis can be rejected if either one or more of these sources affects  $y$  (i.e. the parameters are different from zero). The hypothesis is tested also for the case where  $y$  does not Granger cause  $x$  restricting  $\alpha_{5i} = \alpha_6 = 0$ .

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<sup>17</sup>The results are not presented here for economy of space. Also, tests for weak exogeneity have been conducted for each case and the results suggested that all the variables were endogenous. Tables and results available from authors upon request.



The results of the causality tests are presented in Table 6.6. We test the null hypothesis: the growth rate of GDP does not Granger cause the growth rate of the educational variables and vice-versa. The overall results suggest (with the exception of enrolments in higher education) that the causality runs from the educational variables to the GDP growth. Specifically, the F-statistics for the case of primary and secondary education (6.25 and 4.58 respectively) are very high indicating a strong causal relationship running from the growth rates of those variables to the growth rate of GDP. In simplest terms this means that an increase in the number of enrolled students in those two levels of education will result in an increase in GDP. The same result also holds for the case of total number of enrollments and for the public expenditures in education. In policy terms this means that the Greek government should remain in strong commitment to the educational development and to the compulsory character of the first two stages of education in order to achieve the highest possible enrollment rates and a rising educational level for its labour force. Evidence for causal relationship from public expenditures for educational purposes and economic growth has also found. This points out clearly, that the Greek government has incentive to increase their investments in education to promote growth.

Alternatively, for the reverse causality (from GDP growth to educational variables), we cannot reject the null hypothesis except for the case of higher education, which suggests that an increase in the GDP growth (indicating a better economic situation in general) will cause an increase in the number of persons which are interested in pursuing studies at a higher level in Greece. This later result, is in contrast with the theoretical predictions, but it can be explained by the unplanned character of the expansion in higher

education that has taken place in Greece, which has led to an always expanding pool of long-term unemployed young people with university degrees. This result may also suggest, that in the period 1960 to 1994, the Greek economy was mostly specialised in low skills, low productivity activities. In policy terms, our findings, thus, suggest that a quantitative expansion of the higher education without qualitative aspects will not contribute to the general welfare of the country.<sup>18</sup>

## 6.5 Summary and conclusions

In this chapter, we look at the relationship between economic growth (in terms of gross domestic product growth) and education in Greece. First, we look at the long run relationship between the educational variables and gross domestic product as it can be explained from the cointegration theory. We find that gross domestic product is cointegrated with all educational variables, indicating a positive long-run relationship between GDP and those variables, which is consistent with the main points of the economic theory about the relationship of education and economic growth. Second, we test for the causality between the growth rates of gross domestic product and those variables. We find that the causality direction runs through educational variables to economic growth (an increase in the number of enrolled students will result in an increase in GDP), with the exception of higher education where there exist reverse causality (an increase in the GDP growth, indicating a better

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<sup>18</sup>One, however, has to take into account the changing nature of the Greek economy and the progress of the Greek firms in the last ten years in sectors such as communications, computer software and financial services. Thus, it might be preferable for policymakers today to channel funds towards education relevant to the above sectors and away from traditional sectors that required mainly vocational skills like the textiles industry in the period 1960-80. This, of course, requires a reorganization of the educational system to reflect the changing nature of a modern economy/society (we are grateful to one referee for pointing out this).

economic situation in general, will cause an increase in the number of candidates pursuing studies in higher institutions in Greece).

The causality direction from the enrolments in the two first levels of education to economic growth, suggests that the larger the number of educated persons the faster the development. However, the finding that the higher the economic development the more the demand for higher education suggests that the expansion of formal schooling and the acquisition of higher degrees and certificates is not necessarily associated with an improved ability to undertake productive work and hence to foster economic growth. However, the discordance between the theory and data analysis, found for the higher education variables, might be worth investigating further by empirical means. For instance, if technical advance drives modern economic growth then there might be a relation between the development of certain types of human capital, such as e.g. mathematicians, trained applied scientists and IT specialists, etc, who generate technical advance rather than graduates of higher education in general. This of course leaves the agenda open for further research.

On the basis of the above analysis one may conclude that educational planning in developing countries orientated in higher levels of education is not a stimulus for economic development but it is exactly the opposite. The economic development 'forces' people to demand higher education in order to improve their social and economic position. Also, it must be stressed that the expansion of higher education in some developing countries, due say to changing social values, ideas, attitudes and aspirations, can divert scarce resources from more socially productive activities (e.g. direct employment creation) and thus be a drag on economic development rather than a stimulus.

Finally, on the basis of our analysis one may suggest that an expansion in higher education, in terms of an increasing number of graduates, does not necessarily lead to more favourable economic conditions for economic growth, as often, is advocated by governments in several countries. Thus, from the social point of view, an educational policy that would simply lead to a larger number of university graduates would not be successful. Moreover, the significance of the secondary education may well suggest that policymakers should rather favour an expansion in vocational training that would lead to the development of specific skills, that are in relative shortages and thus to higher economic growth. Finally, the observed expansion of the Greek financial sector in recent years, the expected expansion of the services sector and the anticipated higher competition resulting due to the future Greek participation in the European Monetary Union, might require more specialised skills and qualifications that could potentially change the above results towards a more favourable causality effect on the role of higher education to economic growth.



Levels	1970	1980	1990	1994
Primary	948,097	899,543	819,142	810,542
Secondary	418,617	618,688	712,260	720,225
Higher	72,612	84,510	117,260	190,946
<b>Total</b>	<b>1,602,819</b>	<b>1,885,682</b>	<b>1,997,635</b>	<b>1,724,713</b>

Source: Statistics of Education, Greek Statistical Association (various volumes)

Levels	1980	1990	1994
Primary	33974	39878	39821
Secondary	32228	44023	47188
Higher	7919	13730	15388
<b>Total</b>	<b>74121</b>	<b>97631</b>	<b>102397</b>

Source: Statistics of Education, Greek Statistical Association (various volumes)

Years	Educational Expenditures as % of Total Expenditures	Investment in Education as % of the GDP
1980	2.91	2.66
1982	3.15	2.75
1984	3.54	2.62
1986	3.67	3.03
1988	3.60	3.08
1990	3.87	3.26

Source: Statistics of Education, Greek Statistical Association (various volumes)

Years	Total Expenditures	as % of the Total State Budget
1967	4,351.2	9.53
1970	5,397.6	8.28
1975	13,247.9	7.78
1980	41,410.3	9.78
1985	150,812.3	8.48
1990	353,758.4	4.28
1991	394,289.0	4.01
1992	443,966.4	3.71

Source: Statistics of Education, Greek Statistical Association (various volumes)



Table 6.5: Test for Cointegration between Education and GDP						
<i>Trace Tests</i>						
		PRIM	SEC	HIGHER	EXPEND	
H <sub>0</sub>	H <sub>a</sub>	Test Statistic				Critical Value
$r = 0$	$r \geq 1$	42.66*	37.25*	41.88*	27.64*	13.75
$r \leq 1$	$r \geq 2$	4.94	3.24	4.57	2.15	7.52

\* Denotes significance at the 10% level

Table 6.6: Test for Causality		
Null hypothesis	Obs.	F(2,19)-statistical
PRIM growth does not cause GDP growth	30	6.254*
GDP growth does not cause PRIM growth	30	0.001
SEC growth does not cause GDP growth	30	4.589*
GDP growth does not cause SEC growth	30	0.004
HIGHER growth does not cause GDP growth	30	1.073
GDP growth does not cause HIGHER growth	30	2.748*
TOTAL growth does not cause GDP growth	30	2.950*
GDP growth does not cause TOTAL growth	30	0.278
EXPEND growth does not cause GDP growth	30	3.218*
GDP growth does not cause EXPEND growth	30	1.789

\* Denotes the rejection of the null hypothesis of no causality. Critical Value:  $F(4,30)=2.69$

GDP: Gross Domestic Product; PRIM: Enrollment rate in primary education; SEC: Enrollment rate in secondary education; HIGH: Enrollment rate in higher education; TOTAL: Enrollment rate in all three educational levels; EXPEND: Public expenditures in education over total expenditures.

## Part III

# Uncertainty

## Chapter 7

# Political Instability and Economic Growth<sup>1</sup>

### 7.1 Introduction

The aim of this chapter is to assess the impact of political instability on economic growth by quantifying and testing for the first time a set of political variables in a case study context using time series data and techniques. The relationship between political instability and growth is that uncertainty stemming from a relatively unstable political system and environment may reduce private investment and therefore foster economic growth.<sup>2</sup>

An extensive number of theoretical and empirical articles argues that political instability hinders economic growth<sup>3</sup>. Specifically, it has been argued that political instability

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<sup>1</sup>A version of this chapter has been accepted for publication on the *Scottish Journal of Political Economy* (forthcoming) with co-author Professor Simon Price.

<sup>2</sup>On the other hand, poor economic performance may lead to an unstable political condition which in turn can cause government collapse and political unrest.

<sup>3</sup>The relevance of political variables has been studied in the context of theoretical models that explain inflation as the outcome of political delays in implementing stabilisation plans (Alesina and Drazen, 1991;

increases policy uncertainty, which has negative effects on productive economic decisions such as investment and saving. A high probability of a change of government implies uncertain future policies, so that risk averse economic agents may avoid taking important economic decisions or might exit the economy by preferring to invest abroad (Alesina et. al., 1996). Recent econometric work on the determinants of economic growth and its cross-country differences has suggested a large number of political variables as growth determinants, in particular measures of democracy, political violence and government stability (see Barro, 1991 and Chen and Feng, 1996). Barro (1996), Levine and Zervos (1996), and Easterly and Rebelo (1993) add indicators of political instability to cross-section regressions in which the dependent variable is either growth or investment. Hibbs (1973), Gupta (1990), and Alesina and Perotti (1996), measure political instability by constructing indices which summarize data on the occurrence of political violence and unrest. The results of all those papers were generally that political instability reduces growth through a reduction to investments. Cukierman, Edwards and Tabellini (1992), Ozler and Tabellini (1991) and Rubini (1991) consider the effects of political instability on inflation, external debt and budget deficits respectively, and they find generally negative effects. In a related area Bussiere and Mulder (1999) examine and test the influence of political instability in economic vulnerability in the context of the 1994 and 1997 crisis episodes using indices that quantify political instability, and confirmed their expected results. Brunetti (1998) provides a comparative test of different measures of policy volatility in cross-country growth regressions and concludes that all these measures are negatively related to economic growth.

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Velasco, 1997), while the literature on political business cycles focused on the increase in budget deficits and inflation by governments seeking popular support (Nordhaus, 1975; Alesina, Roubini and Cohen, 1997).

The problem that appears in all the above mentioned studies is the use of cross sectional data. Cross-sectional studies incorporate for a large span of time only one figure of political instability assigned to each country, which classifies the different countries in the sample as more or less politically risky than the others (for example Alesina and Perotti, 1996 based their analysis on 71 countries for the period 1960-85). Although this may offer a consistent estimator of the long-run effects even in heterogeneous panels, it fails to exhibit significant information about certain time events and their influences on economic growth.

In this chapter we emphasise and test a different link from political instability to economic growth, considering only the case of the UK economy. Thus, in our analysis we capture all these different effects, constructing indices of socio-political instability based on time-series data. The main advantages of analysing political instability in a case study framework using time-series rather than cross-sectional data, are: a more careful and detailed examination of the institutional and historical characteristics of a particular country; the use of a data set comprising the most appropriate and highest quality measures; and a more detailed exposition of the dynamic evolution of the economy.

The remaining of the chapter is constructed as follows. The next section surveys the main recent theories and approaches on political instability and economic growth. In Section 7.3 we discuss the definition, the measurement and the procedure of the construction of the socio-political instability index. Section 7.4 presents the specification of the econometric model and the empirical results. Finally, Section 7.5 concludes.



## 7.2 Political instability and economic growth: a theoretical framework

Social and political instability are variables that are hard to define and measure in a way which can be used in econometric work. Political instability encompasses instability of governments, regimes and communities within a nation. An extreme case is the forceful overthrow, or a high probability of involuntary removal, of existing authority. This may emerge from unconstitutional coups d'état, successful or otherwise, or may take place within the law (constitutional). In the UK, unconstitutional overthrow may seem a remote possibility. But in either case, the central idea is that a high propensity to executive changes is associated with policy uncertainty and, in extreme cases, with threats to property rights. Property rights are frequently advanced as the institutions of greater significance to economic growth, lowering uncertainty and transaction costs associated with economic activities (see Knack and Keefer, 1995).

Political instability may serve to reduce the availability of factors of production. Investment in physical capital, for example, will probably be discouraged<sup>4</sup> as the risk of a capital loss will tend to rise with political instability, primarily because political and economic rules governing investments are likely to change with political regimes, increasing the uncertainty in future net returns and, hence, lowering expected real rates of return associated with investment projects. Socio-political instability discourages investment for at least two types of reasons. First, it creates uncertainty regarding the political and legal environment. Second, it disrupts market activities and labour relations, with a direct

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<sup>4</sup>In general, it is not obvious that investment is lower in an uncertain environment, although the evidence tends towards this conclusion (Driver and Moreton, 1992)

adverse effect on productivity. Such increased risks would also raise the cost of capital, as the likelihood for loans default will rise. Both domestic saving and imported capital would be discouraged due to such risks. Indeed, capital flight might be characteristic of socio-politically unstable and uncertain situations.

A different suggestion has been that political instability increases the uncertainty about government changes, especially in countries where the degree of political polarisation is relatively high. The probability of a government change may not have much effect on the expectations of future economic policies if the next government is likely to follow policies similar to those of its predecessors, while in highly polarized societies government changes may lead to radical changes in policy making hugely affecting the economic activities undertaken in the past as well as the planned for the future economic activities. The political business cycle literature suggests that the degree of political polarisation is important for economic activity as it could hamper the implementation of reforms that are recognised as being necessary. Particularly, it has been argued that reforms are delayed because parties in the government coalition cannot reach an agreement on how to allocate the cost of a necessary reform (Alesina and Drazen, 1991).

In a different line, several authors have argued that governmental stability may not always provide incentives to economic growth<sup>5</sup> and even that a high probability of a government change might be viewed favorably by the economic agents if the current government is considered as incompetent or it is corrupted<sup>6</sup> and its possible successors are

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<sup>5</sup>Olson (1982) for example, states that governments that remain in office for a long duration become easier prey for interest groups and are thus more likely to follow policies that do not maximize social welfare.

<sup>6</sup>Murphy, Sleifer and Vishny (1991) emphasize the negative effects of rent-seeking activities on economic growth. A weak government constantly under threat of losing power may be particularly sensitive to the need to please lobbyists and pressure groups which might lead to a more direct effect of rent-seeking activities on policy decisions. Furthermore, Sleifer and Vishny (1993) argue that 'weak' governments exhibit a type

seen as an improvement, while if the probability of a government change is above one-half, an increase in this probability might actually reduce political uncertainty, since it becomes more and more certain that the current government will collapse. However, in any case the degree of uncertainty is rather ambiguous and usually very high in such situations if the characteristics and even more the identity of the successor government are not known.

A related issue is whether democracy affects positively or negatively economic growth. One strand of research (Lipset, 1959; Friedman, 1961 among others) suggests that democracy fosters economic growth because it assures political and economic freedom and through this enhances property rights and market competition, thus promoting growth. In contrast other studies (Sirowy and Inkeles, 1990) argue that democracy is negatively related with economic growth and that a nation's rapid growth requires autocratic control and reduced freedom.

Finally, an alternative explanation of the interrelationship of political instability and economic growth can be given through the government's decisions in allocating public expenditures between consumption and investment. Forward looking governments which have uncertain prospects of re-election may suffer from government myopia meaning that may not be interested in carrying out long-term investment plans, putting emphasis on the consumption side of the economy (Persson and Tabellini, 1988). Thus, according to this, political uncertainty distorts the future path of investment decisions (Calvo and Drazen, 1997), reduces public investment leading to a shift of government budgets from capital spending to government consumption, (Darby, Li and Muscatelli, 1998), makes governments less inclined to make improvements to the legal system (Svensson, 1993) and finally, encourages 

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of corruption that is more deleterious to economic growth than relatively corrupt but 'strong' governments.

governments to increase capital taxation with the result a reduction in private investment as well (Devereux and Wen, 1996), in each case affecting economic growth negatively.

### 7.3 Construction of political instability indices using UK time series data

#### 7.3.1 The theoretical hypothesis and variables selection

Socio-political instability can be measured by constructing indices which summarize various variables capturing phenomena of social unrest. In our analysis we adopt this approach to measure political instability, and construct indices of socio-political instability for the case of UK for the period 1960-1997 using quarterly time series data. Specifically, the indices are constructed by applying the method of principal components to the following variables: *TERROR*, the number of terrorist activities which caused mass violence, *STRIKES*, the number of strikes which were caused by political reasons, *ELECT*, the number of elections, *REGIME*, a dummy variable which takes the value of one for government changes to different political parties, zero otherwise, *FALKL*, a dummy variable which takes the value of 1 for the period of the Falkland's war (1982; q1-q4), zero otherwise, and finally *GULF*, a dummy variable which takes the value of 1 for the period of the gulf war (1994; q1-q4), zero otherwise.

In choosing these variables to include in the index, we want to capture the idea of political instability viewed as a threat to property rights (Alesina and Perotti, 1996). However, explanations are needed for the causal relationship between the group of variables that expresses socio-political instability and economic growth indicators. The first variable



(*TERROR*) captures phenomena of mass violence as well as illegal forms of political expressions. One can reasonably argue that a relatively rare event such as the assassination of a prominent politician or a terrorist act in general, is disruptive of the social and political climate and affects political and economic decisions. In fact, mass violence, political disorder and physical threats to entrepreneurs engaged in productive activities can have direct effects on productivity and therefore on the rate of return of investment. In addition, high levels of social and political unrest, including a high frequency of terrorist acts and of episodes of violence on politicians, might drastically shorten the horizon of politicians and change the political climate. The other two variables (*STRIKES* and *ELECT*) capture the political uncertainty which may have negative effects on productive economic decisions. Strikes affect labour cost and may have a negative effect on expectations concerning the evolution of companies' profits, and, consequently on the general share price index, while elections capture the uncertainty of government changes. For example a government change which is expected to increase state intervention may again have a negative effect concerning the evolution of companies' profits and alter the investment decisions. In general, a high probability of a change of government implies uncertain future policies, so that risk averse economic agents may avoid to take important economic decisions or might exit the economy by preferring to invest abroad. The *REGIME* variable captures the effects of uncertainty about the government. Different types of political parties have different, sometimes rather contradicting, opinions about the economic functioning and evolution of one country, causing therefore an uncertainty to the public.<sup>7</sup> Finally the two 'war dummies' tend to capture

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<sup>7</sup>However, changes in the political environment coming from changes in the regime and from elections should be treated as expected in a democracy and this fact may reduce their relative impact on growth.



the uncertainty that was caused during those two specific periods due to the fact that the UK was actively involved in a war with other countries.

### 7.3.2 The principal components method

Economic time series are frequently highly collinear. There is often very little additional information in a fourth or fifth series beyond the first three. Factor analysis with principal components provide a useful way of examining the similarities of data series, it offers a means of identifying unobserved common factors (instability in our case). The method of principal components provides a technique by which a larger set of observed variables can be expressed as a linear combination of a smaller set of variables that are linearly independent. In the principal components method the aim is to construct a set of new technical variables ( $PC_i$ ) out of an initial set of variables ( $X_j, j = 1, 2, \dots, k$ ). The new technical variables, which are linear combinations of the  $X$ 's are called principal components:

$$PC_1 = l_{11}X_1 + l_{12}X_2 + \dots + l_{1k}X_k$$

$$PC_2 = l_{21}X_1 + l_{22}X_2 + \dots + l_{2k}X_k$$

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(7.1)

$$PC_k = l_{k1}X_1 + l_{k2}X_2 + \dots + l_{kk}X_k$$

The  $l$ 's are called loadings and are chosen so that the constructed principal components satisfy two conditions: first, the principal components are uncorrelated (orthogonal), and second, the first principal component absorbs and accounts for the maximum possible

proportion of the total variation in the set of all  $X_j$ , the second principal component absorbs the maximum of the remaining variation in the  $X_j$  (after allowing for the variation accounted for by the first principal component) and so on. Once loadings are estimated, it is possible to estimate the values of principal components with the assistance of  $X_j$ , for each period  $t$ .

The empirical data are quarterly and cover the period 1960-1997. The results of the analysis are presented in Tables 7.1 and 7.2. Table 7.1 presents the percentage of the variables accounted for by each principal component, while Table 7.2 shows the loadings of each component. The principal components analysis derives as many principal components as the variables used (in our case 6). From Table 7.1, it can be seen that the first Principal Component (*PC1*) absorbs 26% of the total variation, the second absorbs 18.4%, the third 16.9% and so on. The first four *PC*'s account for more than the 77% of the total variation. Table 7.2 shows the factor loadings obtained for each *PC*, and examines the statistical significance of each loading<sup>8</sup>. For 152 observations and for a 1% level of statistical significance each loading, in order to be significant, must be greater than  $\pm 0.987$ . As it can be observed from Table 7.2, *PC1* has four out of six factor loadings statistically significant, while the second component (*PC2*) has five significant loadings. All the other components have at least two statistically significant loadings with the exception of the third principal component (*PC3*) which is the only one providing significant loading for the *STRIKES* variable; is the only significant loading. Using the statistically significant loadings given by principal component analysis we obtain six different indices of political instability, each one including some aspects of the political instability proxies defined above. Plots of the *PC*'s

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<sup>8</sup>According to Koutsoyiannis (1977, Table 17.8 on p. 432).

are presented in Figure 7.1.

## 7.4 Model specification and empirical results

### 7.4.1 Causality and Hausman tests for endogeneity

Before proceeding with the econometric analysis examining the effect of the political uncertainty proxies on GDP growth, we have to test for the existence of endogeneity among the variables. Political instability is said to affect growth, but on the other hand it is widely believed that economic growth may affect political instability as well. In order to determine the causal direction among our variables, we perform Granger causality tests, including four lags of each variable (growth of GDP, growth of investments and political proxies) in VAR. The results, which are not presented here for economy of space, suggested that mainly political instability affects economic growth, and not vice versa. Specifically we have found that there is a causal direction from *STRIKES*, *TERROR* and *REGIME* to the growth rate of GDP, while GDP growth was found to cause changes in regime only. For the *PC*'s we found only one case where the null hypothesis of no causality could be rejected, this was *PC3*.

We also performed Hausman (1978) tests of endogeneity of the political uncertainty proxies and of the *PC*'s. The Hausman tests are based first on a regression which has as dependent variable the one that we want to test for endogeneity (either the political uncertainty proxies or the *PC*'s) and as explanatory variables exogenous and predetermined variables, in this case lagged terms of the growth rate of GDP and the growth rate of gov-

ernment expenditures. From this equation we can obtain the fitted values of the dependent variables and the residuals which are used in an equation of the form:

$$\Delta \log(y_t) = \gamma_0 + \gamma_1 \hat{P}_{it} + \gamma_2 \hat{v}_t + u_t \quad (7.2)$$

where  $\hat{P}_{it}$  and  $\hat{v}_t$  are the fitted values and the estimated residuals from the first regression for each case.

However, for efficient estimation, Pindyck and Rubinfeld (1981) suggest regressing GDP growth on  $P_{it}$  and  $\hat{v}_t$ . We have estimated both versions for all the political instability variables and for the PC's and we have found that in all cases - with the exception of the Pindyck and Rubinfeld suggestion for *PC3* - the variables are not endogenous. Therefore, we can proceed with the econometric examination of their effects on GDP, bearing in mind the possibility the *REGIME* or *PC3* may be endogenous.

#### 7.4.2 Simple OLS regression; preliminary results

A first methodology that we use in order to examine the relation between socio-political instability and economic growth is based on the following standard regression:

$$\Delta \log(y_t) = a_0 + a_1 \Delta \log(inv_t) + \sum_{i=1}^6 b_i X_{it} + u_t \quad (7.3)$$

where  $y_t$  denotes the UK's GDP per capita,  $inv_t$  denotes gross domestic fixed capital formation, and  $X_{it}$  denotes a set of political instability proxies (we use first the political instability variables and then the principal components obtained). Finally  $u_t$  is an

error term.

We expect to estimate a set of estimators  $b_i$  with negative signs in order to conclude that political instability is affecting negatively economic growth as the theory suggests. We expect a positive sign for  $a_1$ .

The results of the estimation of equation (7.3) are summarized at Table 5.3. The first regression presents the regression results when we include as independent variables only the growth rate of investment. The second regression includes strikes, in the third we add one more indicator, and so on. All of the variables enter with the anticipated signs, but not all of them are consistently significant at the 0.05 level. The only variable that provides sufficient evidence that the political instability is affecting the growth negatively is the strikes variable. The other political instability indicators, although having the expected negative signs are not significant.

Similar results were obtained from simple OLS regressions with the inclusion of the principal components instead of the political instability variables. Specifically, we obtained statistically significant estimates for the growth rate of investments at each specification and for the third principal component (*PC3*) which actually captures the effect of strikes on economic growth (see the significant factor loading at Table 7.2).

We re-estimated both specifications (with the political dummies and the principal components) including four lags of each variable entering the equation in order to examine the dynamic - lagged effects of the political instability to growth. The results obtained<sup>9</sup> indicated again that in all cases the political instability as captured by our proxy variables is

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<sup>9</sup>The results are not presented here for economy of space. Tables and results available from authors upon request.



negatively related to growth, while this time we found significant lagged effects for the variables *STRIKES*, *TERROR*, *REGIME* and *ELECTIONS* for the first specification and for the *PC3*, *PC4*, *PC5* and *PC6* variables in the regression with the principal components variables.

Summarizing, the first simple OLS regression results indicate that the political instability - captured by different proxy variables and dummies or by principal components constructed from those variables - affects UK economic growth negatively. Although most of these effects are proved to be statistically insignificant, they provide some evidence in favour of the theoretical hypothesis that we want to test.

### 7.4.3 Results from GARCH models

An alternative approach is to argue that as uncertainty may be affected by instability, thus affecting growth, we should model uncertainty directly. The natural framework is to look at the conditional variance of output. Thus, we examine GARCH processes, in a more general framework than in the previous section.

The model estimated here is a GARCH(1,1) process. In particular we estimate the following model:

$$\Delta \log(y_t) = a_0 + a_{1i} \sum_{i=0}^4 \Delta \log(y_{t-i}) + a_{2i} \sum_{i=0}^4 \Delta \log(inu_{t-i}) + \sum_{j=1}^6 d_j X_{jt} + e_t \quad (7.4)$$

$$e_t \sim N(0, h_t) \quad (7.5)$$

$$h_t = b_1 e_{t-1}^2 + b_2 h_{t-1} \quad (7.6)$$

That is, the growth rate of GDP is modelled as an  $AR(4)$  process, including the instantaneous growth rate of investments as well as four lags of it, plus, the political instability proxies  $X_{jt}$ , where the variance is conditioned on the lagged variance and lagged squared residuals.

In the estimation of the above model, as indeed in the OLS regression reported in Table 7.3, in principle we face a problem of endogeneity of the instantaneous growth rate of investments with the growth rate of GDP per capita. Therefore, we instrument the growth rate of investments through the estimation of a regression of the growth rate of investments on its lagged terms, the growth rate of GDP per capita, government expenditures and interest rates all lagged for four periods. We then estimated a parsimonious version of this reduced form and we obtained the fitted values of the growth rate of investments from this model, to be used as an instrument for the contemporaneous investment variable in the following estimations.

At Table 7.4, we first present results of a  $GARCH(1,1)$  model for GDP growth for reference without including the political dummies<sup>10</sup>. Despite the low  $R^2$ , the variance part of the model is well fitting. Continuing, we re-estimate the above model including in equation (7.4) the political dummies. All the dummies entered the equation with the expected negative sign while three of the them were statistically significant. The results of

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<sup>10</sup>In each case we first estimate the model with four lagged terms of GDP per capita and the instantaneous and four lagged terms from the fitted values of the rate of growth of investment and after that we estimate the parsimonious model, including only the significant regressors. Results from the first model specification are not presented for economy of space. Tables and results available from authors upon request.

the parsimonious model are reported at Table 7.5, and from these we observe that regime, terror and strikes are highly significant and negative. The variance equation is improved and the  $R^2$  while it remains relatively low is increased compared to the previous specification.

The results from the alternative specification, with the inclusion of the *PC*'s in the place of the political instability variables - presented at Table 7.6 - are similar to the previous model. Negative and significant coefficients were obtained for the first and the third components.

Continuing, we estimated all the above specifications without including the investment terms in order to test whether political uncertainty has a direct impact on GDP growth. The results for the case of the political uncertainty dummies<sup>11</sup> are presented at Table 7.7 and show clearly that there is a strong negative direct impact. Thus, political uncertainty does not appear to operate from the investment.

#### 7.4.4 Results from GARCH-M models

A main theoretical argument is that political instability affects uncertainty and thereby instability growth. So it is of considerable interest to allow uncertainty to affect growth. In this section we allow this using the *GARCH – M* class of models. First; we want to test whether uncertainty in GDP (conditioned by the 'in mean' term of the *GARCH – M* model) affects GDP growth; and second, we want to test whether political instability (conditioned by the political dummies and by the *PC*'s in the variance equation) affects GDP growth separately.

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<sup>11</sup>Tables and results from the other specifications are not presented here for economy of space and are available from authors upon request.

The *GARCH – M* model may be presented as follows:

$$\Delta \log(y_t) = a_0 + \sum_{i=0}^4 a_{1i} \Delta \log(y_{t-i}) + \sum_{i=0}^4 a_{2i} \Delta \log(inv_{t-i}) + \gamma h_t + e_t \quad (7.7)$$

$$e_t \sim N(0, h_t) \quad (7.8)$$

$$h_t = b_1 e_{t-1}^2 + b_2 h_{t-1} + \sum_{i=1}^6 b_{3i} X_{it} + u_t \quad (7.9)$$

That is, growth rate of GDP is modeled as an *AR* process, including four lags of the growth rate of investments and the variance of the error term. Equation (7.8) defines  $h_t$  as the variance of the error term in (7.7) and (7.9) states that the variance of the error term is in turn a function of the lagged variance and lagged squared residuals as well as the political instability proxies  $X_{it}$ . In order to accept the first hypothesis we must find that  $\gamma$  is non-zero, while in order to accept the second testable hypothesis we must have evidence of positive statistically significant estimates for the coefficients of the political instability proxies ( $b_{3i}$ ).

Table 7.8 report the results of estimating a *GARCH – M*(1, 1) model without political instability proxies<sup>12</sup>. The model is satisfactory given that the parameters ( $b_1$ ,  $b_2$ ) are strongly significant. The inclusion of the ‘in mean’ specification turns out to be redundant as  $\gamma$  is insignificant, suggesting that GDP uncertainty does not itself affect GDP growth.

<sup>12</sup>Again, as in the previous Section, in each case we first estimate the model with four lagged terms of GDP per capita and the instantaneous and four lagged terms from the fitted values of the rate of growth of investment and after that we estimate the parsimonious model, including only the significant regressors. The reported results are only from the parsimonious models. Tables and results from the first specification are not presented here for economy of space and are available from authors upon request.



However, this turns out to be misleading and follows from the fact we are ignoring political factors.

When we estimate a *GARCH* – *M*(1, 1) model including in the variance equation the political dummies, (the results are reported at Table 7.9) we observe that all the political instability variables - with the exception of *REGIME* - are entering the equation with the expected positive sign, indicating that the political uncertainty increases the variance of GDP growth. All variables are statistically significant. The ‘in mean’ term is now highly significant and negative. The results from the alternative specification, with the inclusion of the *PC*'s in the place of the political instability variables - presented at Table 7.10 - are similar to the previous model, with the exception that positive and significant coefficient were obtained only for the fifth component.

Continuing, we estimated more general *GARCH* – *M*(1, 1) models, first including the political dummies and the *PC*'s in the growth equation and second including the political dummies and the *PC*'s in both the growth and the variance equation.

With the first version of the model we wanted to test whether the inclusion of the dummies in the growth equation will affect the significance of the ‘in mean’ term which captures the uncertainty of GDP. The results, presented in Table 7.11, show clearly that after the GDP growth is significantly negatively affected only from the political uncertainty captured either by the dummies or by the *PC*'s<sup>13</sup>, continuing the importance of political factors rather than the *GARCH* process.

The final and most general specification is used to capture both effects stemming

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<sup>13</sup>We report only the results from the model with the political uncertainty dummies. The results with the *PC*'s are similar and are not presented here for economy of space. Tables and results available from authors upon request.



from political uncertainty, namely the effect of political uncertainty to GDP growth and its effect on the variance of the GDP together. The results are presented in Table 7.12. After the inclusion of the political dummies in the variance equation, the model is improved (the political dummies alter significantly the variance of GDP), but the effect on GDP growth is coming only from the political uncertainty proxies that are included in the growth equation. The 'in mean' term is negative but insignificant.

The implication is that political instability has two identifiable effects. First, some measures impact on the variance of GDP growth, while others directly affect growth itself. Instability has a direct impact on growth and does not operate indirectly via the conditional variance of growth. Note that this is over and above any effect coming through investment which we are conditioning. Examining the direct impact of political uncertainty to growth, we estimated all the above mentioned models without the inclusion of the investment terms<sup>14</sup>. The results were in line with the previous findings. Political uncertainty has found to have a negative direct impact on growth, while the inclusion of uncertainty in variance equation increases the effect of the 'in mean' term which only after that becomes significant.

## 7.5 Conclusions

The empirical results suggest that there is a strong link between political instability (measured either by dummy variables or by PC's constructed from those variables) and growth of UK's GDP per capita. The simple evidence of a negative effect of political

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<sup>14</sup>Tables and results are not presented here for economy of space and are available from authors upon request.

uncertainty on GDP growth from simple OLS regressions, is followed by evidence from GARCH models including political instability proxies in the growth equation, which shows clearly that political uncertainty affects negatively GDP growth.

We also estimated GARCH-M specifications including political instability proxies first in the variance equation, second in the growth equation and finally in both equations, testing in each case alternative hypotheses for the relationship among political uncertainty and economic growth. In the first specification we obtain clear evidence that political uncertainty increases uncertainty in the growth rate of GDP. The second specification suggests that the political uncertainty is the major cause of GDP growth; while, finally, the results also suggest that uncertainty of GDP growth itself does not cause or affect the growth of GDP, when the political uncertainty proxies are included both in the growth and the variance equations. This creates a substantial case for the direct impact of political stability on growth therefore.

Principal Component	Percentage of Variance Explained	Cumulative Percentage
PC1	0.260	0.260
PC2	0.184	0.444
PC3	0.169	0.613
PC4	0.158	0.771
PC5	0.142	0.913
PC6	0.087	1.000

Variables	PC1	PC2	PC3	PC4	PC5	PC6
Elect	0.247*	0.429*	-0.102	0.776*	0.369*	0.071
Regime	0.370*	0.456*	0.081	0.021	-0.805*	0.022
Falkl	-0.140	-0.644*	0.015	0.612*	-0.416*	-0.132
Gulf	-0.606*	0.391*	0.076	0.080	-0.066	-0.681*
Terror	-0.642*	0.198*	-0.156	0.095	-0.177	0.696*
Strikes	0.059	-0.018	-0.976*	-0.079	-0.089	-0.172

\* Denotes statistical significance at 1% level. Critical Values from Koutsoyiannis (1977).

Dep. Var.	Regressions						
GDP growth	1	2	3	4	5	6	7
constant	0.004* (5.912)	0.006* (7.064)	0.006* (7.143)	0.007* (6.589)	0.007* (6.589)	0.007* (6.532)	0.007* (6.645)
Growth of GFCF	0.161* (6.208)	0.153* (6.124)	0.150* (5.960)	0.149* (5.906)	0.149* (5.906)	0.149* (5.888)	0.150* (5.881)
Strikes		-0.018* (-3.359)	-0.018* (-3.512)	-0.018* (-3.507)	-0.018* (-3.507)	-0.018* (-3.488)	-0.019* (-3.582)
Terror			-0.002 (-1.276)	-0.003 (-1.383)	-0.003 (-1.383)	-0.003 (-1.389)	-0.002 (-0.766)
Regime				-0.001 (-0.787)	-0.001 (-0.787)	-0.001 (-0.761)	-0.001 (-0.888)
Elect						-0.005 (-0.191)	-0.0006 (-0.210)
Falkl							-0.004 (-0.911)
Gulf							-0.005 (-0.985)
D-W	2.24	2.04	2.07	2.07	2.07	2.07	2.07
R <sup>2</sup>	0.20	0.26	0.27	0.27	0.27	0.27	0.28

\* Denotes statistical significance at 95%. In parentheses values of t-statistic. Sample:

1960-1997, Quarterly Data.

Table 7.4: GARCH estimates of GDP growth			
dependent variable: $\Delta \log(y_t)$ ; sample: 1961q2 1997q4			
Parameter	Estimate	Std. Error	t-statistic
constant	0.003	0.001	3.491
$\Delta \log(y_{t-3})$	0.135	0.099	1.360
$\Delta \log(y_{t-4})$	0.131	0.106	1.237
$\Delta \log(inv_{t-2})$	0.180	0.080	2.225
Variance Equation			
constant	0.00001	0.00001	1.839
ARCH(1)	0.387	0.118	3.274
GARCH(1)	0.485	0.163	2.958
$R^2$	0.006		
S.E. of d. v.	0.010		
S.E. of Reg.	0.010		

Table 7.5: GARCH estimates of a model with Political Proxies			
dependent variable: $\Delta \log(y_t)$ ; sample: 1961q2 1997q4			
Parameter	Estimate	Std. Error	t-statistic
constant	0.005	0.001	3.784
$\Delta \log(y_{t-3})$	0.194	0.097	1.997
$\Delta \log(y_{t-4})$	0.129	0.105	1.223
$\Delta \log(inv_{t-2})$	0.132	0.089	1.483
Regime	-0.012	0.002	-4.918
Terror	-0.004	0.001	-2.727
Strikes	-0.011	0.004	-2.580
Variance Equation			
constant	0.00001	0.000009	1.668
ARCH(1)	0.314	0.128	2.440
GARCH(1)	0.543	0.173	3.140
$R^2$	0.099		
S.E. of d. v.	0.010		
S.E. of Reg.	0.010		



Table 7.6: GARCH estimates of a model with PC's dependent variable: $\Delta \log(y_t)$ ; sample: 1961q2 1997q4			
Parameter	Estimate	Std. Error	t-statistic
constant	0.004	0.001	3.806
$\Delta \log(y_{t-3})$	0.186	0.099	1.871
$\Delta \log(y_{t-4})$	0.122	0.082	1.487
$\Delta \log(inv_{t-2})$	0.162	0.084	1.926
<i>PC1</i>	-0.005	0.001	-4.334
<i>PC3</i>	-0.003	0.001	-2.023
Variance Equation			
<i>constant</i>	0.000006	0.000005	1.164
<i>ARCH(1)</i>	0.491	0.117	4.185
<i>GARCH(1)</i>	0.566	0.091	6.214
$R^2$	0.030		
<i>S.E. of d. v.</i>	0.010		
<i>S.E. of Reg.</i>	0.010		

Table 7.7: GARCH estimates of a model with PC's dependent variable: $\Delta \log(y_t)$ ; sample: 1961q2 1997q4			
Parameter	Estimate	Std. Error	t-statistic
constant	0.006	0.001	5.663
$\Delta \log(y_{t-3})$	0.270	0.079	3.423
$\Delta \log(y_{t-4})$	0.131	0.101	1.298
<i>Regime</i>	-0.012	0.002	-5.636
<i>Terror</i>	-0.005	0.002	-2.665
<i>Strikes</i>	-0.015	0.004	-3.442
Variance Equation			
<i>constant</i>	0.00006	0.000009	1.719
<i>ARCH(1)</i>	0.491	0.114	4.469
<i>GARCH(1)</i>	0.566	0.167	3.366
$R^2$	0.104		
<i>S.E. of d. v.</i>	0.010		
<i>S.E. of Reg.</i>	0.010		

Table 7.8: GARCH-M(1,1) estimates of GDP growth			
dependent variable: $\Delta \log(y_t)$ ; sample: 1961q2 1997q4			
Parameter	Estimate	Std. Error	t-statistic
<i>constant</i>	0.008	0.003	2.672
$\Delta \log(y_{t-3})$	0.154	0.097	1.596
$\Delta \log(y_{t-4})$	0.128	0.102	1.245
$\Delta \log(inv_{t-2})$	0.136	0.080	1.691
<i>SQR(GARCH)</i>	-0.498	0.353	-1.409
Variance Equation			
<i>constant</i>	0.00001	0.000009	1.683
<i>ARCH(1)</i>	0.335	0.108	3.079
<i>GARCH(1)</i>	0.554	0.156	3.533
$R^2$	0.054		
<i>S.E. of d. v.</i>	0.010		
<i>S.E. of Reg.</i>	0.010		

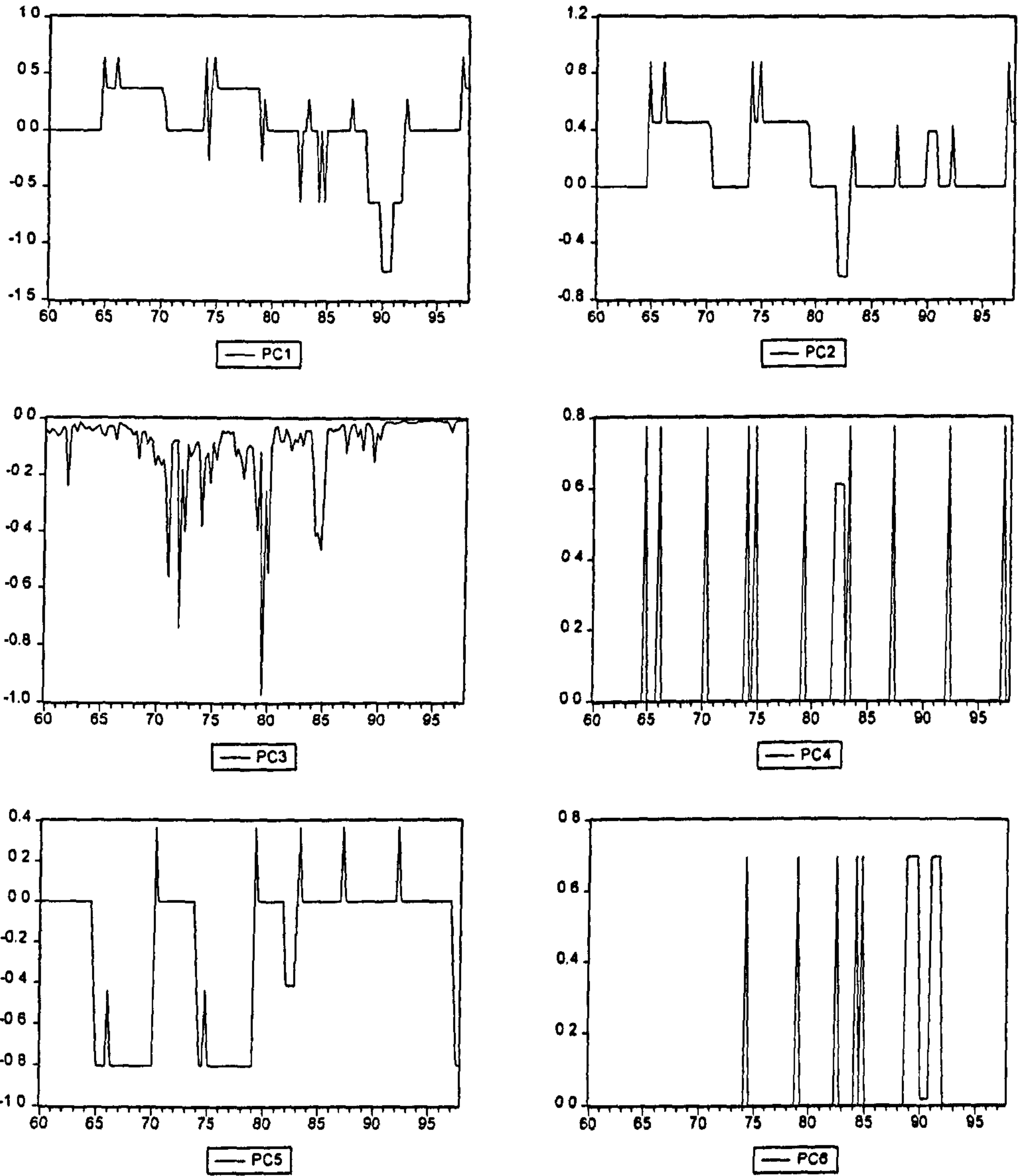
Table 7.9: GARCH-M(1,1) estimates of a model with Political Proxies			
dependent variable: $\Delta \log(y_t)$ ; sample: 1961q2 1997q4			
Parameter	Estimate	Std. Error	t-statistic
<i>constant</i>	0.009	0.002	4.222
$\Delta \log(y_{t-3})$	0.175	0.115	1.151
$\Delta \log(y_{t-4})$	0.089	0.110	0.815
$\Delta \log(inv_{t-1})$	0.132	0.099	1.336
<i>SQR(GARCH)</i>	-0.674	0.219	-3.075
Variance Equation			
<i>constant</i>	0.00005	0.00004	1.212
<i>ARCH(1)</i>	0.133	0.099	1.338
<i>GARCH(1)</i>	0.650	0.154	4.004
<i>Elect</i>	0.0071	0.002	3.110
<i>Regime</i>	0.0065	0.007	0.845
<i>Falkl</i>	0.0025	0.0005	5.116
<i>Strikes</i>	0.0663	0.002	2.912
$R_2$	0.053		
<i>S.E. of d. v.</i>	0.0106		
<i>S.E. of Reg.</i>	0.0108		

Table 7.10: GARCH-M(1,1) estimates of a model with PC's dependent variable: $\Delta \log(y_t)$ ; sample: 1961q2 1997q4			
Parameter	Estimate	Std. Error	t-statistic
<i>constant</i>	0.007	0.001	4.338
$\Delta \log(y_{t-3})$	0.161	0.076	2.106
$\Delta \log(y_{t-4})$	0.141	0.076	1.848
$\Delta \log(inv_{t-4})$	0.126	0.068	1.848
<i>SQR(GARCH)</i>	-0.444	0.183	-2.427
Variance Equation			
<i>constant</i>	0.000002	0.000003	0.805
<i>ARCH(1)</i>	0.460007	0.113580	4.050
<i>GARCH(1)</i>	0.580920	0.087401	6.646
<i>PC1</i>	0.000047	0.000033	1.452
<i>PC2</i>	0.000002	0.000023	0.095
<i>PC5</i>	0.000031	0.000009	3.203
$R^2$	0.064		
<i>S.E. of d. v.</i>	0.0106		
<i>S.E. of Reg.</i>	0.0107		

Table 7.11: GARCH-M(1,1) estimates with Political Proxies dependent variable: $\Delta \log(y_t)$ ; sample: 1961q2 1997q4			
Parameter	Estimate	Std. Error	t-statistic
<i>constant</i>	0.009	0.003	2.964
$\Delta \log(y_{t-3})$	0.206	0.093	2.203
$\Delta \log(y_{t-4})$	0.123	0.102	1.213
$\Delta \log(inv_{t-4})$	0.109	0.088	1.241
<i>SQR(GARCH)</i>	-0.447	0.365	-1.304
<i>Regime</i>	-0.012	0.002	-5.084
<i>Terror</i>	-0.005	0.001	-3.018
<i>Strikes</i>	-0.012	0.004	-2.753
Variance Equation			
<i>constant</i>	0.00001	0.000008	1.648
<i>ARCH(1)</i>	0.285	0.120	2.380
<i>GARCH(1)</i>	0.575	0.161	3.553
$R^2$	0.124		
<i>S.E. of d. v.</i>	0.0106		
<i>S.E. of Reg.</i>	0.0103		

Table 7.12: GARCH-M(1,1) estimates with Political Proxies			
dependent variable: $\Delta \log(y_t)$ ; sample: 1961q2 1997q4			
Parameter	Estimate	Std. Error	t-statistic
<i>constant</i>	0.005	0.001	3.611
$\Delta \log(y_{t-3})$	0.172	0.095	1.799
$\Delta \log(y_{t-4})$	0.123	0.090	1.353
$\Delta \log(inv_{t-4})$	0.181	0.089	2.023
<i>SQR(GARCH)</i>	-0.169	0.254	-0.667
<i>Regime</i>	-0.013	0.006	-1.925
<i>Gulf</i>	-0.007	0.003	-1.899
<i>Strikes</i>	-0.020	0.006	-3.356
Variance Equation			
<i>constant</i>	0.00002	0.00001	2.013
<i>ARCH(1)</i>	0.265	0.126	2.091
<i>GARCH(1)</i>	0.527	0.171	3.076
<i>Elect</i>	0.00004	0.00001	2.608
<i>Regime</i>	0.0001	0.0001	1.131
<i>Falkl</i>	0.00002	0.00002	1.326
$R^2$	0.141		
<i>S.E. of d. v.</i>	0.0106		
<i>S.E. of Reg.</i>	0.0103		

Figure 7.1: Plot of the Principal Components





## Chapter 8

# Uncertainty, Investment and Economic Growth: Evidence from a Dynamic Panel

### 8.1 Introduction

A pervading theme of recent theories of economic growth<sup>1</sup> is that something is excluded from the traditional list of growth factors. There are several candidates, but a neglected one is uncertainty. In this paper, we use panel data to examine the issue by estimating reduced form specifications for investment and growth.

The approach pioneered by Solow (1956) and others was based on the assumption that growth followed from three potential sources; increasing capital stock, population and

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<sup>1</sup>There are now several surveys of the new growth literature. Barro and Sala-i-Martin (1995) continues to serve as an excellent introduction. Temple (1999) surveys the empirical literature.

technical efficiency. There were some clear problems with this paradigm, the foremost being that while theory predicted all countries would eventually grow at the same rate, this was refuted by the evidence. Other factors must also be driving growth. This helped start a new literature, aiming to explain this phenomenon.

One explanation is that there is a missing factor of production. Labour supply and capital are important, but there is another, less easily measured factor; human capital, or knowledge. The idea was introduced by Arrow (1962). It was revisited by Romer (1986), who helped to popularise the concept, and added the idea that knowledge has spillover effects.<sup>2</sup> Uncertainty is relevant here because investment in knowledge is likely to be affected by risk. We examine this further below.

Of course, many previous studies have explored the determinants of economic growth. Factors examined include political, public finance, trade and other macroeconomic variables. The majority of those studies concludes that the most robust effect is the positive relationship between investment and the growth rate of output (see for example Levine and Renelt, 1992). Indeed, the new growth theory further emphasises the role of investment in the growth process (e.g. Romer 1986, 1987; Lucas, 1988).

A relatively recent theoretical literature has increased understanding of the role played by uncertainty in shaping the investment decisions (Dixit and Pindyck (1994)). It is now well known that the combination of the typically irreversible nature of investment, uncertainty about the future benefits or costs of the investment project, and some flexibility about investment timing, may have a substantial impact on the investment behaviour

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<sup>2</sup>Other issues, not explored here, include the role of public capital (Barro (1990)), and the conundrum of constant or increasing returns to capital and the convergence puzzle.

(Chirinko (1996)). Specifically, then there may be a gain to be achieved by waiting in an uncertain environment. The decision not to invest is equivalent to the purchase of an option. By not investing, we forego an expected profit stream, but this enables us to make more profitable choices in the future.<sup>3</sup> Analysis has concentrated on physical investment but the insights apply to investment in knowledge. Thus we would expect uncertainty to affect growth through the impact on physical investment and also via unobserved investment in knowledge. Additionally, although this is less emphasised, uncertainty also affects conditional factor demands and will require resources off-setting its effects (for example, for insurance and inventories) which will reduce output.

Contrary to common opinion, theory does not lead to any clear-cut conclusions regarding the impact on investment, so that the importance of uncertainty is clearly an empirical matter. Two empirical studies (Caballero and Pindyck (1993) and Pindyck and Solimano (1993)) found a positive correlation between the threshold value of the marginal revenue product of capital (a function of uncertainty) and its variance, whilst Ferderer (1993) found a negative impact of uncertainty on investment. Three UK studies, despite different theoretical frameworks and measures of uncertainty, concluded that uncertainty reduces investment (Driver and Moreton (1991) and Price (1995, 1996)); while Asteriou and Price (2000) established a strong negative correlation between political uncertainty and UK growth.

Cross-sectional studies examining the role of uncertainty on investment and growth rates include those of Alesina and Perotti (1993) which found social and political instability

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<sup>3</sup>However, recent work by Abel *et al* (1996) emphasises that investment also has a value as a *call* option, as there may be limits on 'expandability' in the future.

affects investment negatively. Negative effects of uncertainty on economic growth have been found by Aizenman and Marion (1993), and Todd (1996). However, none of these studies uses the dynamic panel techniques we employ. Much of the growth literature emphasises political instability as a source of uncertainty. For example, in a recent paper Brunetti (1998) provides a comparative test of different measures of policy volatility in cross-country growth regressions and concludes that these measures are negatively related to economic growth.<sup>4</sup> Some studies exist that look at volatility and investment, but only a limited number examine growth. Bleaney (1994) looks at aggregate South African investment, as does Fielding (1997). Other authors have explored political events and financial market measures: for example, Gemmill (1992) and Clarke (1997).

There are also methodological issues. Use of a country panel of the type we use raises some important econometric methodological issues that are not always fully appreciated. There has been an increasing interest in the use of panel data in macroeconomics, removed from the micro and labour based areas in which panels have traditionally been analysed. Country panels tend to have dimensions in  $T$  and  $N$  of roughly equal orders. As static models are rarely adequate for typical time series, dynamic models are usually appropriate. The small  $T$  problems with dynamic panels<sup>5</sup> are not relevant here as the fixed-effects problem from the initial conditions declines rapidly as  $T$  rises. But instead, there are profound problems that result from heterogeneity in the model parameters that emerge as soon as a lagged dependent variable is introduced.<sup>6</sup> This problem was forcefully addressed by Pesaran and Smith (1995). Unlike in static models, estimates are inconsistent even in

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<sup>4</sup>See also Barro (1996) and Easterly and Rebelo (1993).

<sup>5</sup>Arellano and Bond (1991).

<sup>6</sup>See Hall and Urga (1998) for a recent survey and analysis of some panel estimation issues that are relevant to the case we consider here.



large samples. Happily, in typical data sets  $T$  is sufficiently large to allow individual country estimation. Pesaran and Smith observe that while it is implausible that the dynamic specification is common to all countries, it is at least conceivable that the long-run parameters of the model may be common. We can then exploit the cross-sectional dimension to gain more precise estimates of these average long-run parameters. They then propose estimation by either averaging the individual country estimates, or by pooling the long-run parameters, if the data allows; this is the method we adopt, although we compare the results with those from (inconsistent) conventional estimators.

In this paper, then, we examine the effects of uncertainty on investment and economic growth using a panel of 59 industrial and developing countries. We measure uncertainty as the conditional variance of output and we explicitly examine its effects on investment and growth rates, both for all countries and for different sub-sets of countries with similar characteristics. The plan of the paper is as follows. Section 2 specifies the model and presents the econometric methodology and the empirical findings. The results are presented in Section 3. Some conclusions are drawn in the final section.

## 8.2 Specification and methodology

### 8.2.1 A simple econometric model

We employ a standard log-linear production function. Temporarily suppressing time and cross-country indices,

$$Y = AK^\alpha L^\beta \tag{8.1}$$



where  $Y$  is output,  $K$  is capital,  $L$  is labour and  $A$  denotes the level of technology. Taking logarithms of (8.1) and assuming constant returns to scale,

$$(y - l) = a + \alpha(k - l) \quad (8.2)$$

where lower case letters denote logs. Total factor productivity growth is assumed to have a deterministic component at  $t$ , but is also affected by the level of uncertainty ( $h$ ) which affects the level of investment in 'knowledge'. Thus in growth rates,

$$\Delta(y - l) = a_0 + a_1 h + \alpha \Delta(k - l). \quad (8.3)$$

Denoting per capita variables as  $\hat{y}$  and  $\hat{k}$  and introducing an error term,

$$\Delta \hat{y}_{i,t} = a_{0,i} + a_{1,i} h_{i,t} + \alpha_i \Delta \hat{k}_{i,t} + \epsilon_{i,t}. \quad (8.4)$$

We first estimate (8.4) using the traditional but inappropriate pooled methods. We then use the Mean Group (MG) and Pooled Mean Group (PMG) estimators,<sup>7</sup> with a dynamic ECM equation that has (8.4) as a long-run solution.

### 8.2.2 Econometric methodology: Dynamic heterogeneous panels

The data set we are examining covers 59 countries ( $N = 59$ ) over 28 ( $T = 28$ ) years. Such data sets<sup>8</sup> raise special problems in estimation. Pesaran and Smith (1995) show that, unlike in static models, pooled dynamic heterogeneous models generate estimates that are inconsistent even in large samples.<sup>9</sup> It has become conventional to view long-run parameters as reflecting cointegrating relationships among a set of  $I(1)$  variables. The

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<sup>7</sup>Described below.

<sup>8</sup>Termed 'data fields'; Quah (1993).

<sup>9</sup>The problem cannot be solved by extending the sample, as it flows from heterogeneity: extending the dimension of the cross-section increases the problem. Baltagi and Griffin (1997) argue that the efficiency gains of pooling the data outweigh the losses from the bias induced by heterogeneity. They support this

standard methodology in such cases first establishes the order of integration of the variables in question, and then - having established that the variables are of the same order of integration - tests whether there is at least one linear relationship among these variables.

Our analysis follows a different approach. This can be justified by two facts. First, there are only a few (and even fewer statistically satisfactory) tests of cointegration in a panel data context, while it is also well known that tests of order of integration in panel data do not reliably distinguish between series that contain a unit root and those that are stationary with a "near-unit root". Second, long-run parameters may be consistently estimated using the traditional autoregressive-distributed lag (ARDL) approach (Pesaran and Shin, 1998). Moreover, as Pesaran, Shin and Smith (1999) have shown, this approach yields consistent and asymptotically normal estimates of the long-run coefficients irrespective of whether the underlying regressors are  $I(1)$  or  $I(0)$ . Further, it compares favourably in Monte Carlo experiments with conventional methods of cointegration analysis.

In the type of data set we are considering  $T$  is sufficiently large to allow individual country estimation. Nevertheless, we may still be able to exploit the cross-section dimension of the data to some extent. Pesaran and Smith observe that while it is implausible that the dynamic specification is common to all countries, it is at least conceivable that the long-run parameters of the model may be common. They propose estimation by either averaging the individual country estimates, or by pooling the long-run parameters, if the data allows, and estimating the model as a system. Pesaran, Shin and Smith (1998) (PSS) refer to

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argument in two ways. Firstly, they informally assess the plausibility of the estimates they obtain for a model of gasoline demand using different methods. This is hard to evaluate as it relies upon a judgement about what is 'plausible'. Monte Carlo simulations would make the comparison clearer. Secondly, they compare forecast performance. However, this is a weak test to apply to the averaging technique, which is designed only to estimate long-run parameters and not the short-run dynamics. Baltagi and Griffin do not consider the next method to be discussed, the PMG.

this as the pooled mean group estimator, or PMG. It combines the efficiency of pooled estimation while avoiding the inconsistency problem flowing from pooling heterogeneous dynamic relationships. It is this latter method we apply.

The unrestricted specification for the system of ARDL equations for  $t = 1, 2, \dots, T$  and  $i = 1, 2, \dots, N$  is

$$y_{it} = \sum_{j=1}^p \lambda_{ij} y_{i,t-j} + \sum_{j=1}^q \delta'_{ij} x_{i,t-j} + \mu_i + \varepsilon_{it} \quad (8.5)$$

where  $x_{i,t-j}$  is the  $(k \times 1)$  vector of explanatory variables for group  $i$  and  $\mu_i$  are the fixed effects. In principle the panel can be unbalanced and  $p$  and  $q$  may vary across countries.

(8.5) can be reparametrised as a VECM system.

$$\Delta y_{it} = \theta_i (y_{i,t-1} - \beta'_i x_{i,t-1}) + \sum_{j=1}^{p-1} \gamma_{ij} \Delta y_{i,t-j} + \sum_{j=1}^{q-1} \gamma'_{ij} \Delta x_{i,t-j} + \mu_i + \varepsilon_{it} \quad (8.6)$$

where the  $\beta_i$  are the long-run parameters and  $\theta_i$  are the equilibrium (or error) correction parameters. The pooled mean group restriction is that the elements of  $\beta$  are common across countries:

$$\Delta y_{it} = \theta_i (y_{i,t-1} - \beta' x_{i,t-1}) + \sum_{j=1}^{p-1} \gamma_{ij} \Delta y_{i,t-j} + \sum_{j=1}^{q-1} \gamma'_{ij} \Delta x_{i,t-j} + \mu_i + \varepsilon_{i,t}. \quad (8.7)$$

Estimation could proceed by OLS, imposing and testing the cross-country restrictions on  $\beta$ . However, this will be inefficient as it ignores the contemporaneous residual covariance. A natural estimator is Zellner's SUR method, which is a form of feasible GLS. However, SUR estimation is only possible if  $N$  is smaller than  $T$ . Thus PSS suggest a maximum likelihood estimator.<sup>10</sup>

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<sup>10</sup>This is implemented in a GAUSS procedure, downloadable as JASA.EXE, made available at Hashem Pesaran's website. We use this software in estimation, and are grateful to the authors for making it available.

There are also issues of inference. PSS argue that in panels omitted group specific factors or measurement errors are likely to severely bias the country estimates. It is a commonplace in empirical panel to report a failure of the ‘poolability’ tests based on the group parameter restrictions.<sup>11</sup> So PSS propose a Hausman test. This is based on the result that an estimate of the long-run parameters in the model can be derived from the average (mean group) of the country regressions. This is consistent even under heterogeneity. However, if the parameters are in fact homogeneous, the PMG estimates are more efficient. Thus we can form the test statistic

$$H = \hat{q}'[var(\hat{q})]^{-1}\hat{q} \sim \chi_k^2$$

where  $\hat{q}$  is a  $(k \times 1)$  vector of the difference between the mean group and PMG estimates and  $var(\hat{q})$  is the corresponding covariance matrix. Under the null that the two estimators are consistent but one is efficient,  $var(\hat{q})$  is easily calculated as the difference between the covariance matrices for the two underlying parameter vectors. If the poolability assumption is invalid then the PMG estimates are no longer consistent and we fail the test.

### 8.3 Empirical results

We use data for GDP per capita (worker) and capital per capita taken from the Penn World Tables.<sup>12</sup> Prior to estimation of the main model, we estimate GARCH(1,1) models for GDP per capita growth in order to obtain the variance series, used as uncertainty proxies in the subsequent analysis.

<sup>11</sup>For example, Baltagi and Griffin (1997, p 308) states that although the poolability test is massively failed ( $F(102,396) = 10.99$ ; critical value about 1.3), ‘like most researchers we proceed to estimate pooled models.’

<sup>12</sup>The Penn World Tables data set is freely available and downloadable on the internet site: <http://bizednet.bris.ac.uk:8080/dataserv/penn.htm>



### 8.3.1 Traditional panel data estimation

We begin with traditional panel data techniques, fixed effects and random effects. We know these to be inappropriate, but they are nevertheless widely used in the literature. We report them partly to illustrate how misleading they may be. The results are presented in Table 8.1. We present estimates of equation (8.4) for three alternative cases: first, assuming that the constant in the model is common and homogeneous for all countries, which is a rather restrictive assumption; second, assuming fixed effects; and third, assuming the existence of random effects.<sup>13</sup> In all cases (see panels A, C and D of Table 8.1) the reported coefficients are similar and significant. Where capital growth is included, the uncertainty proxy enters the equation negatively, so that higher levels of uncertainty are associated with lower levels of growth. Capital growth has the expected positive sign. However, when we exclude the growth rate of capital per capita term from the equation, the uncertainty proxy coefficients obtained are positive and highly significant (see panels B, D and F of Table 8.1). This implies investment is increasing in uncertainty. But regressions of the growth rate of capital on uncertainty<sup>14</sup> reveal that uncertainty has a significant negative impact. These results are therefore hard to interpret.

### 8.3.2 Mean Group and Pooled Mean Group estimates

In this section we report the results of the MG and PMG methodology. Table 8.2 shows the effects of uncertainty on GDP per capita growth in three cases. These are: pooling only the effect of uncertainty; pooling only capital; pooling both uncertainty and

<sup>13</sup>The country specific constants have been omitted from Table 1.

<sup>14</sup>The results are not reported here for economy of space. Tables and results available from authors upon request.



capital. The results show that the Hausman test rejects pooling of the long-run variance term, but accepts pooling of the capital stock effect. The joint test in Panel C accepts, but the individual test rejects. Thus the key results are in panel B.<sup>15</sup> The PMG coefficient on  $\Delta k$  is on the small side but correctly signed and significant.<sup>16</sup> The impact of uncertainty is apparently large, but the variance terms are small. The (average) error correction coefficients reported show adjustment is rapid, 93% occurring within one year. Compared to the traditional estimates, the variance effect is larger by two orders of magnitude.

Table 8.2 shows the effect of uncertainty over and above that working through investment. Table 8.3 reports the direct impact on investment.<sup>17</sup> The PMG specification is easily accepted by the Hausman test. As discussed above, the impact of uncertainty is ambiguous, but we expect a negative coefficient; this is the case.

### 8.3.3 Results for industrialised and developing countries

Plausibly, despite the Hausman test results, effects might differ between types of country. It is certainly worth investigating. We therefore split the sample into 37 developing and 22 industrial countries.<sup>18</sup>

The results are presented in Table 8.4. We report the PMG results suggested by

<sup>15</sup>The inefficient MG results are given for comparison. The  $\Delta k$  term is incorrectly signed but insignificant.

<sup>16</sup>As usual in growth studies, one has a potential difficulty interpreting these results, as the equation is specified in first differences. These are marginal effects we are observing.

<sup>17</sup>However, the coefficient of uncertainty is only marginally significant.

<sup>18</sup>**Industrial Countries:** Austria, Australia, Belgium, Canada, Denmark, Finland, France, Germany, Greece, Ireland, Iceland, Italy, Japan, Luxembourg, Netherlands, Norway, New Zealand, Portugal, Spain, Sweden, UK, USA. **Developing Countries:** Argentina, Bolivia, Botswana, Chile, Colombia, Czechoslovakia, Dominican Republic, Ecuador, Guatemala, Hong Kong, Honduras, India, Iran, Israel, Ivory Coast, Jamaica, Kenya, Korea, Madagascar, Malawi, Mauritania, Mauritius, Mexico, Nigeria, Oman, Panama, Paraguay, Peru, Philippines, Sri Lanka, Sierra Leone, Syria, Thailand, Turkey, Yugoslavia, Zambia, Zimbabwe.

the Hausman test.<sup>19</sup> Again, only the restrictions in that panel (pooling  $\Delta k$ ) are accepted by the Hausman test. Perhaps surprisingly, the point estimates are very similar to those reported for the whole sample. The main difference is that the precision of the estimates falls.

#### 8.3.4 Reduced forms and robustness

As a check, we estimated equations for both sub-samples which included either only the uncertainty measure or only the growth rate of capital.<sup>20</sup> As expected, given the negative impact of uncertainty on growth conditional on capital growth and the negative impact on capital growth itself, there is a negative relationship between growth and uncertainty in both cases. The estimated coefficients were -0.360 for the industrial and -0.053 for the developing countries, although only the latter was significant (t-statistics -0.217 and -1.985). In both cases the PMG estimates were accepted. For the effect of capital growth on output, we found PMG coefficients of 0.193 (insignificant) for industrial countries and 0.051 (significant) for developing. For the effect of uncertainty on investment, the PMG results revealed a significant negative relationship for both sub-groups, with higher negative magnitudes for the industrial countries (-3.280) comparing to the developing countries (-0.081) ( $t$  -1.931 and -2.065). Finally, we also estimated the aggregated relationships using the (inefficient) OLS estimator. The ML estimator is clearly to be preferred, but we would have been concerned had the OLS results radically differed. In fact, they did not.

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<sup>19</sup>That is, in Panel A: MG; in Panel B and C, PMG. The main interest is in panel B.

<sup>20</sup>Detailed results not presented.

## 8.4 Conclusions

A neglected aspect of cross country growth studies is uncertainty, modelled here as the conditional variance of output. In theory, this may have indirect effects via investment and other effects working through unobservable investments in knowledge and possibly other factors. There are also some methodological issues surrounding the correct estimation of dynamic models on panel data. We use the Pooled Mean Group estimator developed by Pesaran, Shin and Smith (1998). Utilising panel data for a sample of 59 industrial and developing countries between 1966 and 1992, we estimate reduced form equations to explore the possible effects of uncertainty on investment and economic growth. We find that uncertainty reduces both investment and growth.

Table 8.1: Traditional Panel Data Estimation						
	Common Constant		Fixed Effects		Random Effects	
Variable	A	B	C	D	E	F
<i>constant</i>	0.01 (12.6)	0.01 (5.13)			0.01 (8.5)	0.02 (9.7)
$h_{i,t}$	-0.10 (-5.7)	0.63 (13.5)	-0.06 (-2.6)	0.92 (13.5)	-0.08 (-4.1)	0.48 (14.0)
$\Delta \hat{k}_{i,t}$	0.12 (7.2)		0.10 (6.4)		0.11 (6.7)	
$R^2$	0.05	0.08	0.14	0.11	0.13	0.05

t-statistics in parentheses in this and subsequent tables.

Table 8.2: MG and PMG Estimates:					
A. Common parameter on $h$					
	PMG Estimates		MG Estimates		
variable	coef.	t-ratio	coef.	t-ratio	h-test
<i>Common Long-run Coefficients</i>					
$h$	-0.061	-1.891	-26.618	-1.967	3.85[0.05]
<i>Unrestricted Long-Run Coefficients</i>					
$\Delta k$	0.086	1.323	-0.214	-0.487	-
<i>Error Correction Coefficients</i>					
$\phi$	-0.952	-32.988	-0.926	-22.300	-
B. Common parameter on $\Delta k$					
	PMG Estimates		MG Estimates		
variable	coef.	t-ratio	coef.	t-ratio	h-test
<i>Common Long-run Coefficients</i>					
$\Delta k$	0.061	3.324	-0.214	-0.487	1.19[0.27]
<i>Unrestricted Long-Run Coefficients</i>					
$h$	-10.325	-1.762	-26.618	-1.967	-
<i>Error Correction Coefficients</i>					
$\phi$	-0.929	-25.798	-0.926	-22.300	-
C. Common parameter on $\Delta k$ and $h$					
	PMG Estimates		MG Estimates		
variable	coef.	t-ratio	coef.	t-ratio	h-test
<i>Common Long-run Coefficients</i>					
$\Delta k$	0.160	7.949	-0.214	-0.487	2.21[0.14]
$h$	-0.027	-1.019	-26.618	-1.967	3.86[0.05]
<i>Joint Hausman test : 3.89[0.14]</i>					
<i>Error Correction Coefficients</i>					
$\phi$	-0.945	-35.920	-0.926	-22.300	-

notes:

panel A restricts the uncertainty coefficient to be the same in all countries

panel B restricts the capital coefficient to be the same in all countries

panel C restricts both coefficients to be the same in all countries



Table 8.3: MG and PMG Estimates					
	PMG Estimates		MG Estimates		
variable	coef.	t-ratio	coef.	t-ratio	h-test
<i>h</i>	-5.956	-4.310	-316.0	-1.003	0.97[0.33]
<i>Error Correction Coefficients</i>					
$\phi$	-0.345	-5.972	-0.414	-7.409	-

Table 8.4: Estimates for Sub-Samples of Countries						
A. Common parameter on $h$						
	Industrial			Developing		
variable	coef.	t-ratio	h-test	coef.	t-ratio	h-test
<i>Common Long-run Coefficients</i>						
$h$	-28.39	-1.954	5.74[0.02]*	-0.063	-1.944	1.61[0.20]
<i>Unrestricted Long-Run Coefficients</i>						
$\Delta k$	0.003	0.027	-	0.180	2.555	-
<i>Error Correction Coefficients</i>						
$\phi$	-0.981	-24.241	-	-0.934	-24.599	-
B. Common parameter on $\Delta k$						
variable	coef.	t-ratio	h-test	coef.	t-ratio	h-test
<i>Common Long-run Coefficients</i>						
$\Delta k$	0.060	1.571	0.29[0.59]	0.104	4.706	1.25[0.26]
<i>Unrestricted Long-Run Coefficients</i>						
$h$	-11.491	-0.899	-	-9.936	-1.620	-
<i>Error Correction Coefficients</i>						
$\phi$	-0.938	-25.478	-	-0.921	-17.806	-
C. Common parameter on $\Delta k$ and $h$						
variable	coef.	t-ratio	h-test	coef.	t-ratio	h-test
<i>Common Long-run Coefficients</i>						
$\Delta k$	0.013	0.360	0.01[0.93]	0.187	7.878	1.76[0.18]
$h$	-7.630	-3.558	6.23[0.01]	-0.023	-0.855	1.61[0.20]
<i>Error Correction Coefficients</i>						
$\phi$	-0.952	-28.247	-	-0.933	-25.300	-

Panel A: MG; Panels B and C: PMG

## Chapter 9

# Conclusions

The aim of this dissertation was to assess the determinants of economic growth. It was consisted of three parts. The first part was dealing with the issue of income per capita convergence examining the validity of the convergence hypothesis for the case of the Greek regions. The empirical analysis exploited, both cross sectional and time series methods and techniques. The main results suggested absence of convergence, a result supportive to the endogenous growth theory predictions.

The focus of the second part was the unexplained factors on the process of economic growth and mainly the role of financial development and the effects of human capital development. Both these topics have attracted great deal of attention in the endogenous growth literature. Accordingly, an empirical literature exploring the validity of relevant theories has developed. In this dissertation, these hypotheses were examined by utilising recent econometric techniques from the time series (integration, cointegration and GARCH models) literature. In accordance to the conclusions of endogenous growth literature, the

empirical research revealed a direct correlation, in the form of a positive relationship, between financial development and economic growth for the case of UK. These conclusions were based on an empirical study for the case of UK using an array of newly developed financial and stock market development indicators in Granger-causality tests and cointegration techniques. The empirical research for the effects of human capital development (proxied by enrollments in various levels of formal education and by government expenditures on educational purposes) on growth were examined in a case study context (in contrast to the traditional studies upon this subject) and namely for the Greek economy. The results suggested a positive relationship among human capital and economic growth, but with a causal link which runs from human capital (proxied by formal education in the primary and secondary sectors) to growth, and an opposite causality relation (from growth to human capital development) for the higher education sector.

Finally, the aim of the last part was to assess the impact uncertainty on economic growth. Firstly, we examined the role of uncertainty stemming from political instability, constructing indices of socio-political instability based on time-series data, considering the case of the UK economy. The empirical results suggested the existence of a negative effect of political instability on economic growth. The results also suggested that uncertainty of GDP growth itself, does not cause or affect the growth of GDP. Second, we examined the role of uncertainty on the outcome of an investment plan and consecutively how does this affect economic growth. Uncertainty proxies were obtained from the variance of GARCH models for GDP per capita for 59 industrial and developing countries between 1966 and 1992. Using dynamic panel data and techniques, we estimated reduced form equations to

explore the possible effects of uncertainty on investment and economic growth. Overall, we found that uncertainty reduces both investment and growth, while this result held both for developed and underdeveloped countries.



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