

**ECONOMIC GROWTH IN A SMALL ISLAND ECONOMY:
THE CASE OF CYPRUS, 1960-1995**

Thesis submitted for the degree of

Doctorate of Philosophy

at the University of Leicester

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March 2003

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ECONOMIC GROWTH IN A SMALL ISLAND ECONOMY:
THE CASE OF CYPRUS, 1960-1995

Sami Fethi

Abstract

The determinants of economic growth have long been of interest, and have been empirically investigated in a number of recent studies. A common question in this area is: why have some countries achieved high rates of economic growth whilst the others remained at lower levels? Evidence from the literature indicates that some countries, particularly East Asian countries or small island states exploiting their own comparative advantage, achieve very rapid rate of growth and catch up with already well-off countries. Others, in particular those from Sub-Saharan Africa, have very little or no growth. This thesis empirically investigates the determinants of economic growth in Cyprus over the period 1960-1995 to evaluate whether the Cypriot economic growth during this period is better explained in an 'old' or 'new' growth modelling framework. Advanced multivariate time series techniques are applied to test the validity of models and to examine the relative importance of different variables which may have an impact on both the long-run and short-run growth of the Cypriot economy. The empirical findings show that physical capital investment, human capital and tourism investment are the major causes of growth in the Cypriot economy.

Keywords: exogenous and endogenous growth; co-integration analysis; small island economies; Cyprus

To my wife, Meryem and my son, Derviş
and to my parents and my in-laws

Acknowledgements

It is a great honour for me to have this opportunity to extend my appreciation and acknowledge the contribution of many people who have helped me to produce my PhD thesis.

I would like to express my special gratitude to my supervisors, Professor David Fielding and Dr. Barbara Roberts, for their constant support, advice and encouragement. I have benefited extensively from the discussions I had with them. I profoundly owe special gratitude to Professor Peter M. Jackson for providing me with the tutorship, which enables me to maintain my study.

I am deeply indebted to Muhittin Kaplan whose advice and suggestions had great influence in the development of my thesis. My appreciation also goes to colleagues Recep Tekeli, Safa Demirbas, Supruet Thavornyutikarn, Siong Hook Law, Daniela Hristova, and Monica Hernandez whose friendship supported me during my research in Leicester.

I must acknowledge the staff at the Research Department of Finance Ministry and Central Bank of Cyprus for their enormous co-operation in providing data and materials for this thesis. Many thanks go to the staff at the University of Leicester Department of Economics and Management Centre, in particular, Jenni Hern for her invaluable support and kind help.

Many friends need to be thanked, but in particular Ali Ozdemirag, Ozlem Olgu, Suleyman Ozdemir, Yin Xiaoxu, Nilufer Cebeci, Aysun Onet, Neslihan Kahyalar, Dilber Caglar and Nil Gunsel who patiently helped me with final typing, editing and printing of this thesis. I would also like to thank many other friends and colleagues in Cyprus and in the UK whose names were not acknowledged here due to volume capacity.

Last, but not least, I owe a debt of gratitude state to my wife, Meryem, and my son, Derviş for their love, support and constant encouragement. I am greatly indebted to my parents and in-laws for their endless prayers.

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Abbreviations:

ADF	: Augmented Dickey Fuller	FPE	: Final Prediction Error
AIC	: Akaike Information Criterion	G-C	: Granger Causality
AOM	: Additive Outliner Model	H-H	: Holmes-Hutton
CRS	: Constant Returns to Scale	IMF	: International Monetary Fund
DC	: Developing Countries	IOM	: Innovation Outliner Model
DFLR	: Dickey Fuller Likelihood Ratio	IRS	: Increasing Return to Scale
DGP	: Data Generating Process	IS	: Import Substitution
DRS	: Decreasing Return to Scale	LTS	: Least Trimmed Square
DSP	: Differenced Stationary Process	MADF	: Multivariate Form of ADF
ECM	: Error Correction Modelling	ML	: Maximum Likelihood
ECT	: Error Correction Term	OECD	: Organisation for European Economic Cooperation
EG	: Engle-Granger	OLS	: Ordinary Least Squares
EGM	: Engle-Granger Modelling	SBC	: Schwarz Bayesian Criterion
EHR	: Engle-Hendry-Richard	SER	: School Enrolment Rates
EIU	: The Economist Intelligence Unit	SIEs	: Small Island Economies
EMU	: Economic and Monetary Union	TFP	: Total Factor Productivity
EP	: Export Promotion	TSP	: Trended Stationary Process
EU	: European Union	UN	: United Nations
E-Y	: Engle-Yoo	URH	: Unit Root Hypothesis
FDI	: Foreign Direct Investment	VAR	: Vector Auto Regressive
FIML	: Full Information Maximum Likelihood	ZA	: Zivot-Andrews

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CHAPTER 1 Introduction

Introduction

1.1 Introduction

The determinants of economic growth have long been interested and empirically investigated in a number of recent studies in the literature. A common question in this literature is why have some countries achieved high income whilst others remain at lower levels? It is really hard to answer this question; however some evidence from the relevant literature indicates that some countries, particularly East Asian ones or small island states exploiting comparative advantage like, Hong Kong, Taiwan, and Cyprus, achieve very rapid rates of growth and catch up with already well-off countries while others, in particular those from sub-Saharan Africa have succeeded very little or no growth.

Aggregate economic performance in small island economies in the last two decades has indicated that some small countries achieved their own development objectives. They even created an economic miracle, despite their economies having been characterized by small size and narrow resource base after their independence in the late 1950s and the early 1960s. Notwithstanding special problems or characteristics in small island economies, they find themselves more concentrated on products in which they have a comparative advantage. For instance Mauritius: sugar production, tourism and export, Fiji: sugar and tourism, the Caribbean islands: tourism and banana, Malta: textiles and shipping, Lesotho and Botswana: mines (especially diamond), Taiwan: electronic industry, and Cyprus: tourism and financial services (i.e. off-shore banking) [See Streeten, 1993].

In contrast to the robust performance of small island economies, undeveloped countries (such as some in Sub-Saharan Africa) face a number of developmental obstacles like rapid population growth, low human capital development, and inadequate infrastructure, which generate major impediments to the process of economic growth. Moreover, ethnic conflict, political instability, and continued war also undermine the economic performance of these countries. Apart from these economic drawbacks, inefficient public administration, inefficient judicial systems, insufficient institutional framework and inappropriate economic policies

also contribute to the weak aggregate economic performance (See Ghura and Hadjimichael, 1996).

Finding the reasons for the differences between fast growers and low growers indicates the importance of both theoretical and empirical studies. In the growth literature, mainly there are two growth theories (“exogenous” and “endogenous”). Exogenous or neo-classical growth theory defines economic growth as the combination of technology and conventional inputs, namely capital and labour. The major problem with neo-classical growth models is that growth in per capita output converges to zero in the steady-state. This implies that the only possible growth rate is zero. If the only possible growth rate is zero, how did a number of economists who support the neo-classical theory explain long-run growth? The possible answer is that economy gets more productive over time by using exogenous technology which is beyond the control of policy makers. This means that economic policies have no effect on growth in steady-state, though they can affect growth rate in transition from a steady-state period to another. The other problem is that countries with similar technologies and preferences tend to converge to the same steady-state output levels only when they have access to the same technology, and similar rates of saving and investment (See Mankiw, 1995).

However, neo-classical growth theory has come under attack by “new growth theory” since the late 1980s. This endogenous growth theory emanates from serious limitations, empirical difficulties and policy pitfalls associated with the old growth theories, in particular the Solow model. In fact, neo-classical theory is limited to explain observed differences in per capita income across countries. In contrast, endogenous models not only seek to determine what kind of intuition lies behind the exogenous rates of technical progress and growth rates, but also examine the long-run effects of economic policies and economic and political shocks on economic growth. The problems and solutions in estimating and interpreting growth regressions are still disputed, and need to be investigated further.

The objective of this thesis is to derive and empirically investigate the factors that contribute to the rate of economic growth in Cyprus over the period 1960-1995 in

order to evaluate whether the Cypriot economic growth during this period is better explained in an “old” or “new” growth modeling framework. Four models have been derived and empirically tested. The first model embodies physical accumulation and the rate of labour growth, whilst the second one has both physical and human capital accumulation rates as well as the rate of labour population growth, which indicates the implications of the Solow model and the Augmented Solow growth model respectively. The third model is an extended version of the Augmented Solow growth model, which also includes policy variables, namely, openness and public investment. In this model, we attempted to measure the impact of policy variables on economic growth. The fourth model is a disaggregated investment version of the Augmented Solow model in which physical capital is disaggregated into the different investments (i.e. investment in tourism, construction, machinery etc.) to shed light on which type of investment (in particular, tourism) can better simulate economic growth in the case of Cyprus.

We notice that there exist two types of specification errors when we take into account the models presented in chapters 4 and 5. The Solow model (model 1 in chapter 4) is found to be incorrectly specified because the human capital factor is omitted. An extended version of the Augmented Solow model (model 1 and 2 in chapter 5) is also found to be incorrectly specified due to the inclusion of the irrelevant variable(s). This justifies that the Augmented Solow model (model 2 in chapter 4) is the right one which explains the determinants of economic growth in the case of Cyprus. The motivation behind the models in chapter 6 is to investigate what kind of factor(s) can better stimulate economic growth in a small island case (Cyprus) after we discover that economic growth in the Cypriot economy is not fuelled by openness.

1.2 Contributions and Methodologies

This thesis attempts to contribute to the previous literature in two ways. Firstly, there is an extensive literature regarding the modeling and empirical investigation of the determinants of growth, either under the exogenous growth modeling framework or the endogenous one. These are mainly comparative studies which examine the factors that can stimulate the rate of growth in a cross-section or in

panel data. In contrast, there are few studies on economic growth which investigate the nexus between output growth and its determinants in a time series context by using multivariate cointegration techniques to analyze the long-run relationship and utilize an error correction model to capture the short-run dynamics. A few studies are devoted solely to examining the determinants of growth in this respect. We make an attempt at filling this gap by concentrating especially on a small island economy (i.e. Cyprus) and investigate the effects of human capital and trade policy (or openness) as well as the importance of investment in tourism. Secondly, many studies use unsophisticated and simple techniques in time series analysis. We use a wide range of alternative techniques¹ to investigate empirically the determinants of growth. Mainly, we use the Engle-Granger (EG) procedure and the Johansen procedure to analyze the long-run relationship between growth and its determinants, whilst the Engle two step error correction modeling is applied to capture short run dynamics. In order to overcome the main disadvantages of the classical first and second step EG procedure, the Engle-Yoo, the Inder and the Saikkonen procedures are used to obtain unbiased elasticity estimates. Finally we use Granger-Causality (GC), and Holmes-Hutton (HH) frameworks in a bivariate model to determine the causal relationship among the variables in the study. To our knowledge, this study, which combines all the methodologies mentioned above might be the first using the growth modeling framework for a small island economy - Cyprus.

The original contributions of the thesis are in the three empirical chapters (4, 5 and 6). The first one empirically investigates the Solow and the Augmented Solow growth models to emphasize the importance of physical and human capital as well as the rate of labour growth in the case of the Cyprus. The second one especially tests the impact of policy variables, namely, openness and government infrastructure on economic growth. Trade policy reforms increase Cyprus' openness to international trade whereas public infrastructure policy domestically promotes the productive sector's efficiency. The last chapter investigates the link between disaggregated investments (i.e. such as investment in the tourism sector)

¹ In appendix chapter c, we discuss the pros and cons of all different methodologies used in this thesis.

and economic growth: whether certain kinds of investment can stimulate economic growth in Cyprus. The findings in these three empirical chapters could have a role in guiding the policies to enhance economic growth in developing countries, in particular in small island economies.

1.3 Thesis Outline

The thesis is organised as follows: Chapter 2 provides a comprehensive theoretical and empirical review of the relevant growth theories, namely “old or exogenous” and “new or endogenous” growth models. In chapter 3, we review the economic development and progress in the Cyprus economy between the years 1960 and 1995. Chapter 4 is a theoretical and empirical chapter aimed at modelling and empirically investigating the implications of the Solow and the Augmented Solow growth models. The first includes the physical accumulation rate and the rate of labour population growth whilst the other has both physical and human capital accumulation rates, as well as the rate of labour population growth. In chapter 5, an extended version of the Augmented Solow growth model, which includes openness and public infrastructure is derived and investigated to find out the role of both openness and public infrastructure in the Cyprus economy. Chapter 6 investigates the link between different disaggregations of investment and economic growth, deriving a disaggregated investment version of the Augmented Solow growth model in order to shed light on which type of disaggregated investment can better promote economic growth in the Cyprus economy. Chapter 7 draws some concluding remarks. Appendix Chapter A provides the information about data sources, their definitions and the correlation matrices among the variables regarding each model employed in this thesis. This chapter also present the common tables such as the ADF unit root test, the LR joint test and the Perron unit root test. In Appendix Chapter B, we define the concept of smallness, characteristics and constraints of small island economies. This chapter not only defines some important concepts about small island economies, but also attempts to discuss their advantages and disadvantages. Appendix Chapter C introduces cointegration approaches in terms of specification, estimation and testing. It also illustrates the techniques involved in the context of the relationship between non-stationary time series data.

CHAPTER 2 Economic Growth: A Review of The Theoretical And Empirical Literature

2.1 Introduction

This Chapter discusses and presents a comprehensive review of both empirical and theoretical recent developments in the growth literature.

Development economists have long been interested in determining the factors which explain the rate of economic growth across countries as well as in individual countries. Over time in the literature on economic growth, a common question is, why have some countries achieved high income whilst others remain at lower levels? It is really hard to answer this question. However, some evidence from the relevant literature indicates that some countries, particularly East Asian ones or small islands exploiting comparative advantage like Cyprus, and Taiwan achieve very rapid rates of growth and catch up with already well-off countries while others, especially those in Sub-Saharan Africa, have achieved very little or no growth. In recent years, the new growth theory has attempted to allow the effects of some important policies on economic growth such as trade policy and government investment policy, particularly in developing countries. The plan of this chapter is as follows:

Initially, we explain the standard neoclassical growth model of Solow (1956) and the Augmented Solow Growth Model which was first introduced by Mankiw et al. (1992). We then present evaluations and criticisms about neoclassical growth models. This is followed by an analysis of 'new growth' or 'endogenous growth' models. These models generally aim to explain particular policy issues in both developed and developing countries. We then critically evaluate these growth theories in the literature to figure out their strengths and weaknesses. Next, we attempt to point out the econometric problems such as heterogeneity, endogeneity, simultaneity and multicollinearity which have arisen in estimating and interpreting growth regressions.

In addition, we evaluate some important points in terms of policy implications such as human capital and education, investment on infrastructure and trade policy (or openness), especially in developing countries.

Accordingly, we discuss issues and methods relating to empirical growth studies in order to identify strengths and weaknesses, and to see whether evidence found in the relevant literature is consistent with economic theories.

Finally, we compare and contrast the empirical findings from various studies about the relationship between growth and its determinants in the light of endogenous and exogenous models. These papers use different techniques such as time series regression, cross-section regression and growth accounting.

2.2 Theories of Economic Growth

2.2.1 Old Growth Theory: Neoclassical Growth Models

2.2.1.1 The Solow-Swan Model:

In the past three decades, the basic neoclassical model of Solow (1956) and Swan (1956)² has been the center piece of economic growth. The neoclassical model of long-run economic growth is based on a standard production function, which is the key element of the Solow-Swan model. The production function is based on the following assumptions: constant returns to scale, diminishing returns to capital and elasticity of substitution between capital and labour. This model requires a simple general equilibrium, which is generated by the combination of the production function and constant-saving-rate rule.

The Solow-Swan model is the most influential of the early neoclassical growth models, and their model takes the form of a neoclassical supply-side and a primitive Keynesian aggregate demand specification. Although there are lots of arguments about the Solow-Swan model in the literature, it is still useful for introducing some of the main concepts and issues in growth economics. Hereafter, we will concentrate on the Solow growth model rather than Swan's version.

² See Solow (1956) and Swan (1956) for more details.

2.2.1.2 The Classic Textbook Solow Model:

The workhorse of the Solow model is the Cobb-Douglas production function. The Solow model assumes that the rates of saving, population growth (or working population growth) and technological progress are exogenous. It has two inputs, namely capital and labour. These two elements are paid their marginal products.

If we consider a Cobb-Douglas production function at constant returns to scale (hereafter CRS) and productivity growth as purely labour-augmenting or “Harrod-neutral”³, the production function takes the form as follows (see Mankiw et al. 1992):

$$Y_t = K_t^\alpha (A_t L_t)^{1-\alpha} \quad 0 < \alpha < 1 \quad (1)$$

Where Y is the output, L is labour and A is a measure of the level of technology. The subscript t indicates time. L and A are assumed to grow exogenously at rates n and g .

$$L_t = L_0 e^{nt} \quad (2)$$

$$A_t = A_0 e^{gt} \quad (3)$$

The number of effective units of labour, $A_t L_t$, grows at rate $n+g$. The assumption of constant returns allows us to work with the production function in intensive form.

$$y_t = k_t^\alpha \quad (4)$$

or

$$y = f(k)$$

³ See Romer (1996) for three possible alternatives of the technical change factor $[A(t)]$. This factor enters into the production function as follows: 1. Hicks-neutral technical progress, $Y=A(t) F(K, L)$; 2. Capital-augmenting technical progress, $Y=F[A(t) K, L]$ and 3. Labour-augmenting technical progress, $Y=F[K, A(t) L]$.

where $\frac{Y_t}{A_t L_t} = y_t$ $\frac{K_t}{A_t L_t} = k_t$,

Here, the production function is expressed in terms of output per efficiency unit of labour and the amount of capital per efficiency unit of labour.

The neoclassical model emphasises that economic growth may arise from the accumulation of capital. The capital stock per efficiency unit $k_{i,t}$, evolves as follows:

$$\dot{k}_t = s k_t^\alpha - (n + g + \delta) k_t \quad (5)$$

where s is the rate of saving, n is the rate of population (or working population) growth, g is the rate of growth in technology, δ is the rate of depreciation, and dot over k_t denotes the change per unit of time. The model takes s , n , g and δ as exogenous. Equation 5 implies that k_t converges to a steady state value k_t^* and the steady state is defined by $\dot{k}_t = 0$. This yields,

$$k_t^* = \left[\frac{s k^k}{n + g + \delta} \right]^{\frac{1}{1-\alpha}} \quad (6)$$

The steady state capital-labour ratio is related positively to the rate of saving and negatively to the rate of population growth. The central prediction of the Solow model concerns the impact of saving and population on real income. So, by substituting Equation 6 into the production function and taking logs, we find that steady state income per capita is:

$$\ln \left[\frac{Y_t}{L_t} \right]^* = \ln A_0 + g t + \frac{\alpha}{1-\alpha} \ln s^k - \frac{\alpha}{1-\alpha} \ln (n + g + \delta) \quad (7)$$

This term is also called steady state labour productivity. To determine the Solow growth model, we need to find the speed of convergence to steady state. By using a Taylor series formula, we can obtain the rate of convergence for the Solow growth model.

In fact, the Solow growth model does not predict absolute convergence; it predicts only that income per capita converges to a steady state value in a given country. This means that the Solow model predicts convergence only after controlling for the determinants of the steady state. This situation is called 'conditional convergence' [See Mankiw et al. (1992)].

Approximating around the steady state, the speed of convergence can be formulated as follows:

$$\frac{d \ln y_t}{dt} = \lambda [\ln (y^*) - \ln y_t] \quad (8)$$

where $\lambda = (n + g + \delta)(1 - \alpha)$

At the final stage, following Mankiw et al. (1992), Durlauf and Johnson (1992), Islam (1995), Cellini (1997), s_t^k and n_t vary both across countries and over time. The level of steady state can vary across countries and over time, but economies converge around the steady state path. Labour productivity or steady state income per capita can evolve according to the following equation:

$$\ln y_{t+1} - \ln y_t = g + (1 - e^{-\lambda_t}) \left[\ln A_0 + g t + \frac{\alpha}{1 - \alpha} \ln s_t^k - \frac{\alpha}{1 - \alpha} \ln (n_t + g + \delta) - \ln y_t \right] \quad (9)$$

As can be seen in Equation 9, the Solow model⁴ indicates that the growth of income is a function of the determinants of the ultimate steady state and the initial level of income.

⁴ This model is derived and explained comprehensively in chapter 4, section 2.

2.2.1.3 The Augmented Solow Model: Adding Human Capital to the Solow model

Having tested human capital by augmenting the Solow model, it is said that excluding human capital from the Solow model might lead to biased results [See Mankiw et al. (1992)]. In this respect, the human capital issue has been an important phenomenon in the growth process. Many authors provide evidence of the importance of human capital for growth [See Azaridis and Drazen (1990), Romer (1986) and (1990), Lucas (1988) among others]:

Let us consider the following constant returns to scale production function, including a human capital factor, in which the Inada conditions hold⁵ (see Knight et al., 1993 and Cellini, 1997).

$$Y_t = K_t^\alpha H_t^\beta (A_t L_t)^{1-\alpha-\beta} \quad (1)$$

where H is the stock of human capital and all other variables are defined as before.

The assumption of constant returns allows us to work with the production function in intensive form:

$$y_t = k_t^\alpha h_t^\beta \quad (2)$$

where $y_t = \frac{Y_t}{A_t L_t}$, $k_t = \frac{K_t}{A_t L_t}$, $h_t = \frac{H_t}{A_t L_t}$ are quantities per effective unit of labour.

The neoclassical model emphasises that the evolution of the economy is determined by the following equations:

⁵ Following Inada (1963), we can say that if the production function is neoclassical, three properties are satisfied. First, the production function exhibits positive and diminishing marginal products with respect to each input: Capital and Labour. Second, it shows constant returns to scale. Third, the marginal product of capital or labour approaches infinity as capital or labour goes to zero and vice-versa.

$$\dot{k}_t = s_k f(k_t, h_t) - (n + g + \delta) k_t \quad (3)$$

$$\dot{h}_t = s_h f(k_t, h_t) - (n + g + \delta) h_t \quad (4)$$

where s_k and s_h are the fraction of income investment in physical and human capital respectively.

It is assumed that human capital, physical capital, and consumption are such that one unit of consumption turns into one unit of physical capital or human capital costlessly. In these two equations above, human capital and physical capital depreciate at the same rate.

We assume that $\alpha + \beta < 1$, which means, there are decreasing returns to both kinds of capital⁶. In other words, there is a steady state for this model, so that Equations (3) and (4) can be equated with each other in order to get steady state values of h and k in the following steps:

$$k^* = \left[\frac{(s^K)^{1-\beta} (s^H)^\beta}{(n + g + \delta)} \right]^{\frac{1}{1-\alpha-\beta}} \quad (5)$$

$$h^* = \left[\frac{(s^K)(s^H)^{1-\alpha}}{(n + g + \delta)} \right]^{\frac{1}{1-\alpha-\beta}} \quad (6)$$

Substituting Equation 5 and 6 into the production function and taking logs produces an equation for income per capita (or labour productivity) as follows:

$$\ln \left[\frac{Y}{L} \right]^* = \ln A_0 + g + \frac{\alpha}{1-\alpha-\beta} \ln s^K + \frac{\beta}{1-\alpha-\beta} \ln s^H - \frac{\alpha+\beta}{1-\alpha-\beta} \ln(n + g + \delta) \quad (7)$$

This equation shows how income per capita depends on population growth (or working population growth) and the accumulation of physical and human capital.

⁶ If we assume $\alpha + \beta = 1$, so that there will be constant returns to scale in the reproducible factors. This implies that there will be no steady state for the relevant model [See also Mankiw et al. (1992)].

To determine the Augmented Solow Growth model, we need to find the speed of convergence to the steady state.

By using a Taylor series formula, we can obtain the rate of convergence for the Augmented Solow growth model. To do this, we take a first-order Taylor approximation of the expression for k and h around the steady state.

Now, if we use the same information as mentioned earlier (section 2.2.1.2), we will have the following equation, which indicates steady state per capita income or labour productivity evolving around the steady state path.

$$\ln y_{t+1} - \ln y_t = g + (1 - e^{-\lambda_t}) \left[\ln A_0 + g t + \frac{\alpha}{1 - \alpha - \beta} \ln s_t^K + \frac{\beta}{1 - \alpha - \beta} \ln s_t^H - \frac{\alpha + \beta}{1 - \alpha - \beta} \ln(n_t + g + \delta) - \ln y_t \right] \quad (8)$$

2.2.1.4 Predictions in the Neoclassical Model: The Solow Model

The Solow model has many predictions, even though it seems to be a simple model. These predictions have been tested in the relevant literature. For this reason, it is important to stress these predictions. Following Mankiw (1995), some of these predictions can be summarised as follows:

- (a) The economy approaches a steady state in which initial conditions are independent.
- (b) The rate of saving and population growth influence the steady state level of income, which means the higher the rate of saving, the richer the country; and the higher the rate of population growth, the poorer the country.
- (c) The rate of technological progress only affects the steady state rate of growth of income per capita, and this growth rate is not influenced by the rates of saving and population growth.
- (d) The capital-to-income ratio is constant due to the fact that the capital stock grows at the same rate as income in the steady state.

- (e) The marginal product of labour grows at the rate of technological progress so, the marginal product of capital is constant in the steady state.

Many of the predictions in the Solow model are approximately consistent with empirical studies on economic growth. Especially, prediction (b) seems to be consistent with evidence from cross-country studies⁷. In these studies, income per capita is positively correlated with saving rates and negatively correlated with population growth rates. For example, the estimation results in Mankiw et al. (1992) indicate that the correlation between variables is quite strong. Prediction (c) appears inconsistent with the strong correlation between growth and saving in cross-section studies. However, this correlation might result from the transitional dynamics when economies approach their steady states. Prediction (a) is based on the debate over convergence. Macroeconomists cannot easily answer this prediction in the long-run whether poor economies catch the rich ones or remain poor due to initial conditions. Predictions (d) and (e) are consistent with some evidence from the U.S. economy.

2.2.1.5 Neoclassical Growth Theory: Evaluations and Criticisms

The major problem with the Solow model is that growth in per capita output converges to zero in the steady state. This implication is that per capita growth will be zero, but it is important to note that countries may not reach the long-run steady-state or at least that the observations available are for countries that are not in steady-state. If the only possible growth rate is zero, how did a number of economists who supported the neoclassical theory in the 1950's and 1960's explain long-run growth? They basically assumed that economy gets more productive over time due to exogenous technological progress. This may create a problem for policy makers in developing countries: policies have no effect on growth in the steady state of the Solow model.

In the literature, there is evidence of a positive correlation across countries between investment rates and growth; however, the parameters of the Solow

⁷ See Mankiw et al. (1992), Temple (1998a), Nonneman and Vanhoudt (1996) and others. In these articles, correlation between variables is the same.

model affect the long-run level of output, not the rate of growth (see King and Rebelo, 1993).

In this respect, it is believed that if technological change varies across or over time, there might be a positive association between growth and investment, because technological change may induce greater savings in countries with a greater growth rate. Most empirical estimation results in this field suggest that the Solow model has a problem.

The problem in the Solow model is that countries with similar technologies and preferences converge to the same steady state output levels. This situation is indicated for some economies (see Barro and Sala-i-Martin, 1991, and Baumol, 1986). However, Romer (1989), Quah (1992), and De Long (1988) point out that there is little evidence of convergence for a broad sample of countries and this point, especially, is valid for developing countries. Easterly (1990) also shows that there is little or no evidence of sustained economic growth, and persistent differences in growth rates for developing countries, so explaining income levels in terms of exogenous differences in technology levels still remains inadequate.

Another body of empirical evidence suggests that the Solow model is inadequate in that GNP (or GDP) exhibits long-term persistence of shocks. Nelson and Plosser (1982) argue for the existence of a unit root in U.S. GNP, which is opposed to variation around a deterministic trend. Campbell and Mankiw (1989) also show that there is evidence for the persistence of economic fluctuations. The evidence provided by Campbell and Mankiw (1989) suggests that persistence exists in a broader group of countries. This evidence is suggestive, even though the methodological and economic issues are still in debate (See Cochrane, 1988). The importance of this issue is discussed by King and Rebello (1986) for alternative growth models, since shocks in the Solow model are not persistent with trend stationarity in technological change even if technology follows to a random walk. On the other hand, endogenous growth models are able to explain persistent shocks to output even when technology shocks are trend stationary. This point can be taken as a lesson that policy makers are able to understand the potential long-term effects of shocks.

Another serious problem⁸ pointed out by Lucas (1990) is that the Solow model predicts that capital is likely to be eager to migrate from rich to poor countries, but this is not observed. The Solow model indicates that the return to capital in developing countries should be many times higher than in developed countries and this causes new investment to occur in developing countries. However, this does not really happen. In addition, the differential is so large that this situation cannot be explained by economic policies and political risks. These factors are unable to explain the predicted return differentials. Even if, as the Solow model suggests, returns to capital are almost equal, observable wage differentials and worker's flows contradict the prediction of wage equalisation. It is really important to understand international capital flows and immigration in developing countries because the predictions about wages and migration are not consistent with evidence.

2.2.2 New Growth Theory: Endogenous Growth Models

To date, we have explained neoclassical theory based on the Solow model. From now on, our attention will be centered on endogenous growth theory. The neoclassical growth theory has come under attack by “new growth theory” since the late 1980s. The phrase “new growth theory” or “endogenous growth theory” emanates from some serious limitations, empirical difficulties and policy pitfalls associated with the Solow model.

Romer (1986, from his 1983 thesis) and Lucas (1988, from his 1985 Marshall lectures) have revitalised the existing theory of long-run growth by drawing attention to such determinants as investment in human capital, increasing returns to scale and endogenized technological change by explicitly modeling the introduction of new technologies. Other influential theoretical contributions include Rebelo (1991), Barro (1990), Grossman and Helpman (1991a,b), Aghion and Howitt (1992), Stokey (1991) and Young (1991).

⁸ Mankiw (1995) emphasises that neoclassical models have some problems due to its predictions. In particular, he points out three problems to doubt the validity of the neoclassical model such as the magnitude of international differences, the rate of convergence and rates of return.

In general, the economic growth of a nation can be expressed using three factors: growth in capital, growth in labour, and technological progress. In the neoclassical growth models, growth in the long-run is explained by exogenous variables such as technical progress. In addition to this, the neoclassical growth models are arguably limited in explaining the magnitude and persistence of the real income or growth gaps between poor and rich countries, although the models can explain international differences in growth rates as the result of convergence to different steady states. In contrast, endogenous models seek to determine what kind of intuition lies behind the exogenous rate of technical progress as well as a country's growth rate. Unlike the neoclassical theory, the new growth theory distinguishes between two forms of capital and also allows for constant or increasing returns to scale.

It is worth emphasising that new growth theory can be classified in two sections. One is a 'macro' section that indicates how an economy sustains indefinite growth in per capita income, even though there is a lack of exogenous technological change. The other is a 'micro' section that seeks to endogenise changes in technology by introducing an explicit research and development sector.

2.2.2.1 Endogenous Growth Models:

In this section, we focus on the macro-side of endogenous models beginning with the AK model. The simplest possible endogenous growth model is the so-called 'AK' model found by Rebelo (1991). In this model, the production function takes the very simple form of $Y = AK$, where, A is an exogenous constant and K may be considered aggregate capital broadly defined. This means that it includes not only physical capital, but also human capital as well as the stock of knowledge and may be other types of capital such as financial capital. In the basic model, capital is linearly related to output only, so the production function is both constant returns to scale and constant returns to capital. It is easy to demonstrate sustained per capita output growth, without the assumption of exogenous technological progress⁹. To get an idea of the property of constant returns to the accumulation

⁹ See Scott (1989) and Mankiw (1995) for more information.

equation: $\dot{K} = sA - \delta$ with the $Y = AK$ production function, we need to express these two components as $\dot{Y}/Y = sA - \delta$. This equation indicates that as long as $sA > \delta$, income grows indefinitely without any exogenous technical change. Therefore, the predictions about economic growth can be affected by a simple change in the production function. Actually, the neoclassical model emphasizes that saving enhances growth temporarily, but ultimately, the economy approaches a steady state where growth does not depend on the saving rate. In contrast, this endogenous growth model allows saving to lead to growth indefinitely.

Another important issue is that the rate of convergence to the steady state depends on the capital share in the neoclassical model. As the capital share, say α , goes to one, the rate of convergence, say λ , goes to zero. As pointed out by Mankiw (1995), the simplest endogenous model is a limiting case of the neoclassical model where convergence does not exist¹⁰.

In this endogenous model, large differences in income are associated with differences in saving rates across countries but are not associated with differences in the return to capital. This means that countries have vast inequalities in income but capital does not intend to move from rich to poor countries.

Countries differ in their initial $k(0)$, but they grow at the same constant growth rate and this implies that the poor countries always remain relatively poor. Moreover, if countries differ in their productivity parameters, 'low growth countries' remain 'low growth countries' forever. All these explanations mentioned above contradict the neoclassical models in which poorer countries tend to grow faster to their steady state level of income.

Another important point is, how the variable k can be interpreted in the ' AK ' production function. The interpretation of K can be explained in the following steps: the first one is that if K is defined as an economy's stock of plant and equipment, the assumption will be diminishing returns. The second one is that if K is defined as a broad measure of capital, then the assumption of constant returns to capital is more reasonable. The last one is that if K is interpreted as knowledge,

¹⁰ The view of Sala-i-Martin (1990a, b) is similar with the basic endogenous model which does not predict convergence.

the assumption is associated with increasing returns. Therefore, we are now in a position to say that endogenous growth is shaped by knowledge rather than human capital as the source of sustained growth.

Rebelo (1991) argued that sustained growth could be driven by capital, as long as capital can be reproducible regardless of fixed factors. Jones and Manuelli (1990a) show that it is not a necessary condition for technology to be linear in capital in order to have sustained growth, but their approach does not seem to be sufficient for Inada condition. One drawback of the linear production approach is that constant returns to reproducible factors need to be justified when fixed factors are observed¹¹.

Romer (1986) follows Arrow's (1962) learning-by-doing framework and Sheshinski (1967) to solve this difficulty. In this model, knowledge is positively related to economic activity which is assumed to be proportional to capital accumulation. There is also a departure from diminishing returns; hence he suggests increasing returns, which may provide a condition for competitive equilibrium with endogenous technical change. To get sustained growth, there should be constant returns to reproducible factors. This means that increasing returns to scale might devastate the condition for competitive equilibrium. Romer (1986) also postulates that capital with externalities makes firms to face constant returns to scale, but these are increasing returns to scale at the economy-wide level. In this model, the production function takes the form $Y = F(K, L, k) = K^\beta L^{(1-\beta)} k^\alpha$ where K is the aggregate capital, and k is private capital in the economy. In the model, sustained growth is possible without any technological change, however the externality effect causes considerably small capital accumulation in a private economy.

Another model is developed by Lucas (1988), who uses Uzawa's (1965) model of human capital accumulation presents an alternative aggregate production function of the form of $Y = Ak^\beta [uhL]^{(1-\beta)} h_a^\psi$ where the term uhL is often called human capital. In this term, u is the proportion of human capital used in final goods

¹¹ See Easterly (1990) for more details about fixed factors.

production, L is the Labor force, and h_a^ψ represents the externality from average human capital. In the model, Lucas (1988) argues that there are constant returns scale in inputs, which can be accumulated. Unlike Barro (1990) (who uses government externalities) and Romer (1986) (who uses capital externalities), he introduces human capital. This framework allows him to introduce an externality factor for human capital, and so explain observed international flows of capital and workers. In this respect, if the human capital sector has a linear production, this leads to sustained growth. However, Romer (1986) and Lucas (1988) face same problem when they consider externalities to justify the functional forms developed. Another problem facing Lucas (1988) and Rebelo (1991) is that human capital cannot be accumulated without using a 'bounded utility condition'¹².

The externality approach has a problem: there is very little encouragement to produce knowledge under these circumstances, as we do not get any benefit from technology, but research and development (R & D) can be undertaken instead. R & D can contribute to growth in two ways. First, R & D allows the introduction of new types of capital, which may be more productive than existing ones. The second is that R & D may have spillover effects on the aggregate stock of knowledge: 'the development of new products and techniques'. Such problems can be eliminated by explicitly modeling the stock or accumulation of knowledge. Romer (1990 a, b) attempts to sort these problems out by dropping the assumption of competitive behaviour to make a modeling of the fixed cost nature of producing knowledge. He postulates an aggregate production function of the form

$$Y = L^{1-\alpha} \int_0^\alpha x_i^\alpha di \text{ where the } x \text{'s are intermediate capital goods.}$$

In this model, utilising new intermediate products can generate sustained growth. As pointed out by Romer (1990 b), an economy with a larger total knowledge leads to faster growth. This implies that policies influencing capital accumulation have growth effects but policies using human capital in the research and development sector will cause higher growth. To quote Mankiw (1995),

¹² See Sala-i-Martin (1990a, b) for more information.

“knowledge is the quality of society’s textbooks; human capital is the amount of time that has been spent reading them”.

Some other models are proposed by Aghion and Howitt (1992) and Grossman and Helpman (1991b, c) who allow firms to increase the quality of a number of varieties of both consumption and investment goods. Aghion and Howitt (1992) use endogenous technical change based on a Schumpeterian growth model through ‘creative destruction’. In this framework, they construct a formal model where the new innovations may wipe out the previous ones due to learning-by-doing. Unlike in Romer’s model, the private equilibrium may have too much research. To see the intuition behind this approach, we can refer to papers such as Schmitz (1989) and Segerstrom (1991). In these papers, the approach mentioned above can be expanded to incorporate the imitation or copying of previous technologies and resources by firm in developing countries. Schmitz (1989) constructs a model for imitation and entrepreneurship to shed light on this approach. Segerstrom (1991) expands Grossman and Helpman’s dynamic general equilibrium model of product innovation but permits firms to take costly initiatives in R & D. In his model, some firms spend resources to create improved products and others use resources to imitate or copy those products. He also points out that innovation subsidies promote economic growth. These models still face some problems, and their empirical implications are not very clear.

2.2.2.2 Some Criticisms of Endogenous Growth Theory

A central topic of debate among researchers has been the question of what is new in the new growth theory. Nelson (1997) mentions that the basic premises of the ‘new’ growth theory were well known many years ago. Srinivasan (1995) also argues that increasing returns to scale and endogeneity in policy variables are not new issues¹³. Another argument emerged from the paper of Skott and Auerback (1995). They point out that the presence of increasing returns to scale was a crucial part of Marx’s analysis.

¹³ See Kaldor (1966, 1970) and neoclassical models for these issues.

In this respect, Kaldor (1966 and 1970) also emphasizes that the manufacturing sector may be associated with increasing returns whereas the agricultural sector may be subject to diminishing returns.

An argument in the paper of Olson (1993) stresses that the new growth theory overstates the importance of human capital and underestimates the role of institutions. In accordance with Nelson's point of view, some developing countries take their economic performance below their production possibility frontier due to inefficiencies; this issue is not encompassed by new growth theory. Mankiw et al. (1992) reach some conclusions in favour of the augmented Solow growth model. Their findings indicate that sustained growth is driven by technology, not human and physical capital accumulation. This is against the assertion of the new growth theory.

Young (1992, 1995) uses a traditional growth accounting technique to explain the experience of small countries such as Hong Kong, Singapore, South Korea and Taiwan. He also points out that these countries' growth miracles can be described by exogenous theories rather than endogenous theories.

Ultimately, these criticisms do not imply that Solow or the other neoclassical models are a complete theory of growth or that endogenous growth or new growth theories are not important.

2.2.3 Econometric Problems In Growth Applications

When most researchers deal with economic growth in an empirical framework, they usually face substantial problems¹⁴ in estimating and interpreting growth regressions. In this section, we follow Temple (1999) to highlight these problems that can generate biased results. The first one is the existence of parameter heterogeneity. A number of papers have presented strong evidence for problems of heterogeneity. Levine and Revelt (1992) point out that this problem can appear to be more severe in panel data than in other types of growth study such as cross-section or time-series.

¹⁴ Mankiw (1995) points out that three problems especially affect growth regressions. These problems are simultaneity, multicollinearity and the degrees of freedom. He also suggests that these problems should be taken into account for unbiased estimates in growth equations.

For example, there might be internal political unrest in one country that affects some factors such as investment productivity, making it lower than elsewhere. Durlauf and Johnson (1995) use regression trees to shed light on multiple regimes in which parameters exhibit great differences. Durlauf and Quah (1999) also point out the weakness of linear regression method is that assumes common parameters are not plausible when it is used to check the validity of new growth theories. This kind of regression imposes the absence of multiple equilibria from the Solow-Swan point of view.

In panel data, the estimation of parameter averages can be inconsistent, and this stems from the serial correlation of the regressors. To overcome this problem, one can suggest a model with lagged dependent variables but its result is still inconsistent [see Pesaran and Smith (1995)]. It is important to stress that cross-section techniques are not the best. Temple (1999) argues that parameter heterogeneity can be eliminated by using time-series data rather than cross-section data. Given the paucity of long-run time series data for a wide range of countries, many researchers have investigated the determinants of economic growth using cross-sectional or panel data.

He also suggests that robust estimators such as least trimmed squares (LTS) are a useful technique¹⁵ to overcome this problem. The second problem to be addressed in this section is outliers. This may stem from measurement error, omitted variables or parameter heterogeneity. The outlier problem is also associated with cases where observations that are ‘unrepresentative’ behave as influential outliers or leverage points¹⁶.

To remedy this dilemma, Temple (1999) mentions that observations can be dropped one at a time, or a single-case diagnostic like Cook’s distance can be employed, but these methods are inadequate. He also adds that two effects should be addressed for the sake of unbiased estimates results. These are the ‘mask in effect’ and the ‘swamping effect’. The first one can occur when a single-case

¹⁵ To overcome heterogeneity, a number of techniques can be used such as robust estimation, regression trees, sample splits, interaction terms and dummy variables [see also Temple (1999)].

¹⁶ A leverage point is an observation, which demands extreme values for the regressors [see also Delong and Summers (1991)].

diagnostic does not pick up a group of outliers whilst the second one can be seen in wrongly identifying some observations as unrepresentative.

The other problem is model uncertainty. This problem emerges from the possibility of selecting a different group of right-hand-side variables [see Levine and Renelt (1992)]. A number of models are likely to provide reasonable results but different conclusions can come out due to the parameters and form of the model. Hitherto, many researchers did not take account of this difficulty prudently. Leamer (1983, 1985) points out that this difficulty can be solved using 'extreme bounds analysis'. This also underlines the importance of the paper written by Levine and Renelt (1992).

The fourth problem is endogeneity. Some researchers use variables such as the initial rate of secondary school enrollment to avoid of simultaneity problems, but this creates an endogeneity problem.

One solution is to use instrumental variables, but this technique provides results which may understate the effect of variables like human capital [see Barro and Sala-i-Martin 1995]. The other solution maybe to use a panel data approach to employ lags of the endogenous variables as instruments but there still might exist an exogeneity problem [see Temple (1999)].

Another problem is measurement error, which stems from badly measured variables: this causes biased coefficient estimates. To remedy this difficulty, Klepper's measurement error diagnostics or methods-of-moments adjustment technique can be applied [see Klepper and Leamer (1984)].

The last two problems are error correlation and regional spillovers. These problems, generally, are seen in cross-section growth regressions due to the disturbances, which may not be independently distributed. This situation arises from an omitted variable problem such as the climate.

It is worth pointing out that this study does not investigate these problems mentioned above because they are not relevant for time series studies. In this thesis, we avoid such problems by using time series data.

2.3 Policy Applications

2.3.1 Human Capital and Education:

Human capital and education have crucial roles in explaining growth, and neither of them are new issues¹⁷. Denison (1967) presents an indicator for the quality of labour regarding a Solow based production function when he studies growth accounting. In his paper, education increases the productivity of labour allowing workers to be used more efficiently through new technologies.

Another point on the importance of education and human investment is pointed out by Alderman et al. (1996). They stress that developing countries spend over \$100 billion a year on education, health and other human capital investments and this shows us how important they are for growth in developing countries. It is important to stress that microeconomic studies are very plausible on the returns to schooling, but some comments on externalities to education make macroeconomic studies important in exploring growth in developing countries.

Recently, new macro and development economists have become interested in human capital formation¹⁸. Lucas (1988) emphasises significant effects of human capital accumulation on economic growth. In his paper, human capital accumulation plays an important role as an alternative source of sustained growth. More specifically, Lucas (1988) analyses human capital accumulation as two sources, namely education and learning by doing.

Azariadis and Drazen (1990) also postulate a threshold externality for human capital. More generally, in their paper, they allow human capital to be more productive when human capital accumulation reaches a certain level. They say that the growth rate may be positively correlated with the level of human capital and the income level. A model developed by Becker, Murphy and Tamura (1990) indicates that there are interactions between human capital accumulation and population growth.

¹⁷ See Becker (1964), Schultz (1961 and 1988) and Psacharopoulos (1984, 1988) for more details.

¹⁸ See chapter 10 to get different approaches about human capital and education, which are, based on both micro and macro foundations in Aghion and Howitt (1998).

They also emphasise that in their model there can be an equilibrium with low human capital per labour and high fertility as long as returns to human capital relative to more children remain small.

Another paper about the interrelationship between population growth, human capital, fertility, and economic development is presented by Rosenzweig (1990). He evaluates evidence from different empirical studies and concludes that alterations in the returns to human capital through exogenous technical change can lead to increases in human capital investments and to reductions in fertility.

Stokey (1991) constructs a model with different qualities of labour and goods fuelled by human capital accumulation. She points out that it might be possible to explain simultaneously growth in education and in trade for East Asian countries. Arrau (1989) discusses human capital and growth in a life cycle model. He says that if growth is fuelled by human capital, tax on human capital are much more important than on physical capital, so high human capital taxes may affect growth very badly.

Jones and Manuelli (1990b) propose an overlapping generations model of endogenous growth. In their paper, they argue that education and human capital formation can be revitalised by government policies so that the two factors may have a long-run impact on economic growth.

Mankiw et al. (1992) test the augmented Solow model, which represents the role of human capital in growth. In their model, they find that the predictions of the Solow model are consistent with empirical evidence but the effect of saving and population growth rates are biased since human capital is excluded in the model. A problem is that the trade-off between human capital and growth seems quite simple. Another problem with this analysis is that changes in human capital can explain little of the variation of changes in output.

Gemmel (1995, 1996) also stresses the role of human capital in the growth process for both the neoclassical and endogenous growth theories. He mainly argues that school enrolment rates (SER) may have both stock and accumulation effects. His findings suggest that initial levels and changes in SER can have important effects on growth.

The human capital phenomenon has been modeled in a different aspect by Temple (1998a) and Temple and Voth (1998). They attempt to examine the link between human capital and equipment investment and industrialization. They argue that equipment investment and industrialization should be accompanied by human capital to stimulate productivity growth.

Ultimately, all these studies about human capital accumulation and education might be still disputed but they suggest other mechanisms by which policy might influence economic growth.

2.3.2 Public Infrastructure and Growth

In recent years, many researchers have been renewing a debate about the effects of infrastructure on economic growth. Aschaver (1989a, 1989b, 1989c) opens the debate whether infrastructure matters or not. Gramlich (1994) points out that the role of public capital in the growth process of developing countries has long been discussed. He also mentions that relevant data about infrastructure do not exist properly in determining the contribution of infrastructure to economic growth.

Later work provides support to the view that infrastructure is a leading factor in the process of economic development. For instance, using cross-country data, Easterly and Rebelo (1993) indicate that the share of public infrastructure in transport and communication is robustly correlated with economic growth.

Romer (1986), Jones and Manuelli (1990a), and Rebelo (1991) have centered their attention on infrastructure using two important factors (taxation and subsidization). King and Rebelo (1990) develop a model in which economic growth can be prevented by capital taxation. Another growth model constructed by Barro (1990) attempts to find a link between long-term growth and fiscal policy in which there is an optimal level of infrastructure which maximizes the growth rate. Barro (1990) also emphasizes that growth may rise at low levels of government expenditure and taxation. This model is extended by Barro and Sala-i Martin (1992) and they try to distinguish physical capital as private and public inputs, which may have different impacts on growth. This issue is empirically investigated by Ghali (1998) and his findings are found to be consistent with

recommendations made by Barro and Sala-i Martin (1992). Ghali's estimated results show that public investment is found to have a negative impact on growth and private investment in the long-run. Public investment also has a negative impact on private investment, but no effect on growth in the short-run. Sau-him and Chor-yiu (1997) also investigate the importance of public infrastructure in the growth process employing a multivariate cointegration technique to the U.S. data. However, the evidence they found contradicts the endogenous growth model with public infrastructure.

Another point about disaggregated capital in terms of equipment and non-equipment investment based on the Augmented Solow model is tested by Jalilian and Odedokun (2000). Unlike Delong and Summer (1991), Temple (1998b), and Nonneman and Vanhoudt (1996), they found private fixed investment such as machinery equipment investment, miscellaneous investment and to a smaller extent transport equipment investment have positive effects on economic growth for 55 countries over the period 1965-90 using panel data. A different point of view about distortion, which is associated with different types of capital, comes from Easterly (1993). He demonstrates a model in which growth can be affected by distortions between different types of capital. This may provide a non-linear link between growth and policy variables.

Another aspect comes from Canning and Pedroni (1999), who investigate the long-run consequences of infrastructure on per capita income in a panel of countries over the period 1950-1992. Specifically, they find strong evidence of long-run effects running from infrastructure to income levels for telephones and paved roads. Canning (1999), in another paper, finds a significant impact of both human capital (i.e. schooling workforce) and infrastructure capital (i.e. telephones per worker) on economic growth. Sanchez-Robles (1998) also finds a positive impact of road length and electricity generating capacity on subsequent economic growth. In contrast, Holtz-Eakin (1994) and Holtz-Eakin and Schwartz (1995) suggest that there is a little support to the view that infrastructure plays an important role on income growth in a panel of U.S. state level data when fixed effects are included.

In summary, government infrastructure in its different aspects have been modeled and tested by different development economists and researchers in less developed, developing and developed countries. It is important to note that evidence for infrastructure on growth is still mixed and controversial.

2.3.3 Trade Policy: Openness

The main question of concern is whether foreign trade can have a driving role in a country's development process. The Neoclassical approach supports the notion that foreign trade can make an effective contribution to a country's development. On the one hand, trade is considered not only to be a tool in achieving productive efficiency, but also an 'engine of growth'. On the other hand, opponents of this view maintain that less developed countries will be better off if they rely on policies of import substitution.

The trade-off between trade policy and economic growth is an old and controversial issue¹⁹. The issue has traditionally been one of the central concerns in interpreting developments in the world economy²⁰. In this section, we do not discuss the theoretical literature on growth and trade policy; we only shed light on the nexus between trade policy (or openness) and economic growth in an empirical framework. In this respect, Little, Scitovsky and Scott (1970) provide the most trustable evidence on openness and growth. This study has still been important for many researchers who study both cross-sectional and time series studies.

The success experiences in the Asian NICs countries²¹ have rekindled analysis of the link between foreign trade (or openness) and economic growth. In the light of these experiences, there is now strong evidence that the more outward oriented economies (or more open economies) tend to grow faster than economies with trade distortions²². Several authors, including Balassa (1985), Tyler (1981), Feder

¹⁹ See Hick's famous inaugural lecture (1953), Bardham (1970), and Findlay (1973).

²⁰ See Findlay (1984a, b) for more details.

²¹ See Quibria (1997), Frankel et al. (1996), World Bank (1993), and Young (1992, 1994, 1995) to get more details about the success stories in the East Asian countries.

²² See Edwards (1992, 1993, 1998), Sengupta (1991, 1993), Ghatak et al. (1995) and Greenaway and Sapsford (1994) for the empirical investigation and literature on openness and growth.

(1982), Ram (1985), Dollar (1992) and Edwards (1992) have acknowledged the possibility that there is a positive relationship between a country's growth rate (or GDP in levels) and its openness (or exports) to the international economy.

These studies are based on neoclassical production functions. In particular, Feder (1982) was the first to formalise the structural link between these two variables. The other conceptual framework about the relationship between international openness and economic growth has been proposed by Aghion and Howitt (1992), Romer (1990a), Grossman and Helpman (1991a), Parente and Prescott (1994) and Bernard and Jones (1996). The first two are based on endogenous growth models, and the model of Grossman and Helpman is based on open economy endogenous growth models. The last two provide models of technology adoption.

A major drawback in an empirical investigation of the link between openness and growth is that there are many different measures of international openness²³. However, trade relative to output (Exports+Imports/Gdp) has often been employed as a crude indicator of openness. In this respect, some comparisons across countries might be misleading and this situation allowed authors such as Leamer (1988) and Edward (1992) to take differences between 'predicted' and 'actual' trade intensity ratios to proxy the extent of trade barriers. The predicted trade flows are derived from Leamer's Heckscher-Ohlin model (Leamer, 1984), estimated from cross-country data on factor endowments. Due to the unavailability of time series data on endowments for individual countries, we cannot use of this type of approach in the present study. We then are confined to use crude intensity ratios²⁴, or export volumes, and assume that such openness measures are directly related over time to the degree of trade policy. In addition to this, trade distortion measures are used as a proxy of 'openness' (or 'closeness' in some contexts) such as import duties relative to the value of imports²⁵. Edward (1992) indicates that trade policy can be measured by two alternative indices. These are an openness index and an intervention index. The sign of the

²³ See Proudman and Redding (1998, p17) for more details.

²⁴ Exports plus imports relative to GDP.

²⁵ See Knight at al. (1993, p537) how this proxy is used.

intervention indices generally seems negative whereas the expected sign of other index is positive.

Trade distortions are significant in many developing countries through tariff or quota barriers and these effects create inefficient allocation of investment due to trade distortion which has merely level effects in the Solow model. The accelerated nexus between trade policy and productivity growth is to be discussed²⁶ in terms of both theoretically and empirically in chapter 5.

In the relevant literature, it is suggested by many authors that appropriate measures of trade policy need to capture price distortions (relative incentives) where export/GDP is related to the export-led growth hypothesis rather than trade policy per se (see Rodriguez and Rodrik 2000; Frankel and Romer 1999; 1996; Edwards 1998; Harrison 1996; Sachs and Werner 1995; Ben David 1993).

In a series of papers, Grossman and Helpman (1989, 1990a, b, 1991b, c, d, 1994, 1996) analyze the open economy implications of endogenous growth models which are associated with trade and endogenous technological change. They emphasize that the growth effect may be influenced by quotas due to the misallocation of resources. They also indicate that the importance of the relationship between tariffs and trade policy on growth is related to the protected sector. This probably depends on cross-country differences in efficiency in R & D (Research and Development). At this point, comparative advantage plays a crucial role because it determines how much a country should specialize in the generation of knowledge and in the production of goods. Supposing there are two sectors, namely a research and development sector and a final goods sector. The protection of the first may accelerate growth faster than the later one. In addition, they argue that economic growth in North-South models of international trade arises through technological change, innovation, and imitation. In this respect, they point out that trade of goods has an impact on growth through international transmission of knowledge, and they develop a model in which First World countries try to create new products whilst Third World countries try to imitate them. They also indicate

²⁶ See also Edward (1989) for recent advances.

that policies in an open economy which raise growth rate may not lead to welfare gains.

A different point of view comes from Rivera-Batiz and Romer (1991a, b). They consider two models with different specifications of research and development as the source of growth. First, they point out that there is a connection between economic integration and growth. Economic integration tends to allow two economies to exploit increasing returns to scale: integration may raise growth and trade through expansion of market size. Secondly, they discuss the relationship between trade and growth. In this paper, they emphasize a number of channels²⁷ (such as spillover) that may increase growth. Another effect is redundancy, in which growth may be promoted by free trade because fewer resources are needed to renew old technologies. More specifically, Taylor (1999) emphasizes a number of additional rates of growth effects which are identified by new growth theory, such as market expansion effects following a greater variety of products, capital inputs and intermediate inputs. In this respect, greater factor productivity, more productive R & D, and spillover effects are associated with innovation and avoidance of duplication of R & D costs.

As pointed out by Grossman and Helpman, Batiz and Romer indicate that there are ambiguous effects of trade policy due to the allocation effect. In their model, R& D is used to increase growth considering this effect. In addition, they say that a non-monotonic effect of tariffs on trade may mean that low tariffs reduce growth and high tariffs raise growth, but very high protection rates have negative effects on growth.

Some conclusions can be drawn regarding the link between growth and trade policy²⁸. A major drawback is that differences in growth among countries cannot easily be explained when they follow outward-oriented policies. This issue still remains unclear within growth theories.

²⁷ Taylor (1999) points out that there are four channels such as scale (or integration), allocation, spillover and redundancy effects. In this framework trade and trade policy might influence a country's growth in different degrees.

²⁸ See Greenaway (ed) (1988) to get details about the relationship between trade and growth which is discussed for developing countries from different perspectives.

2.4 Empirical studies of Growth and Policy²⁹

2.4.1 Issues and Methods

In the light of the endogenous and neoclassical growth theories mentioned above, a number of policy choices are detailed which can affect economic growth. In this section, the methodology of studies based on growth accounting, cross-sectional analysis and time series method are presented.

Earlier studies have focused on economic growth in a neoclassical framework. For the first time, Solow (1957) and Denison (1967) attempt to disentangle the contributions of capital and labour to output by observing their share in output.

These two papers are related to pure growth accounting studies. Numerous authors follow Solow (1957) to account for the impact of economic growth for different countries and periods. Chenery (1986) is the first to use a neoclassical production function for growth accounting studies. Growth accounting studies are usually used alongside time series data for a single country. Having formulated the growth accounting issue for international cross-section studies, a number of researchers try to estimate this framework within a neoclassical model.

This basic framework³⁰ is the starting point for most cross-sectional studies. Later, additional variables were taken into account. One problem is that this approach needs some modifications for equilibrium. As pointed out by Chenery (1986), structured variables cannot be added to this framework due to disequilibria effects. Balassa (1985), Tyler (1981) and others attempt to construct structural variables as additional factors of production, such as exports and imports for developing countries.

On the other hand, the theory of economic growth has been revitalised by the models of endogenous growth. This kind of model can analyse structural variables in the broader view of growth effects.

As mentioned above, these models focus on the determinants of long-run growth through investment in human capital and new technologies, and the importance of

²⁹ A selection of some empirical studies in this chapter is tabulated in section 2.6.

³⁰ In this framework, the assumption capital-output ratio and technology are the same for cross-section studies.

openness in international trade. Romer, D. (1993) points out that the positive and negative impacts of openness vary across models. In this framework, some models indicate that greater openness may reduce growth³¹ whilst others show that openness may speed up growth [Romer (1990a)].

2.4.2 Growth Accounting: Total Factor Productivity

Growth accounting is an alternative method to cross-country regression. The main aim of this framework is to measure the contributions of factor inputs to growth and to growth in efficiency (or total factor productivity (TFP)). In this framework, there is a tendency to model input growth and TFP growth separately. It is suggested that decomposition within input and TFP contributions is a useful method that can be applied to describe economic growth. In this respect, Solow (1957) points out that the famous ‘Solow residual’ representing growth which cannot be explained by inputs, but provides the growth in total factor productivity that is driven by exogenous technical change.

A number of growth accounting studies discover a high share of TFP, which is not explained in the model, and the variance in the level of TFP growth should be considered significant because countries are assumed to have similar technology. Chenery (1986) mentions that the contributions of total factor productivity are 50 percent of the total growth in developed countries whereas this situation indicates 30 percent of the total growth for developing countries.

Another study developed by Maddison (1987) indicates a growth accounting exercise for six developed countries. He provides some results, which are very close to the neoclassical methodology. In addition, he considers additional variables such as foreign trade, convergence, and government regulation. The crucial point in his study is that additional variables tend to diminish the unexplained part in growth.

One major drawback in growth accounting is that the exact measurement of capital input does not exist. In this regard, Jorgenson et al. (1987) finds that quality-adjusted capital can give reasonable explanation for unexplained growth.

³¹ See Young (1991) and Stokey (1991) for more details.

Another point of view about capital contribution to growth comes from new growth theory. In accordance with Romer's (1987) argument, capital contribution to growth may fail to state traditional growth accounting studies adequately. Romer (1987) argues that the correlation between output and capital growth is not explained well enough by growth accounting techniques. In his paper, he estimates a regression for different countries and finds some results that can be explained by externalities in capital accumulation. Benhabib and Jovanovic (1991) comment that this link is not supported by U.S. time series. They also add that Romer's (1987) regression is partial with regard to the econometric estimates used in the model. Unlike Romer, they point out that evidence is not very strong in favour of increasing returns or capital externalities [see also Romer (1986) and Scott (1989)]. Under these circumstances, one may think that Romer's estimation is likely to be limited in a similar way to the standard Solow model due to a linear relationship between steady state capital and output.

Having considered the human capital in a model of endogenous growth, a number of studies focus on changes in this factor and assume that some changes in the labour force stem from changes in the human capital and labour's marginal product due to wage changes. This situation may be valid with imperfect labour market and externality effects for the human capital factor.

In a series of studies, Psacharopoulos (1984, 1985, 1988, 1993) mentions that traditional studies may fail to indicate adequately the contribution of education to growth for developing countries. He also points out that a high rate of return to education is a good indicator of the contribution of education to growth. None of these studies are persuaded that the basic neoclassical model's assumptions are sufficient.

2.4.3 Growth in Cross-Section Analysis

The great interest in cross-sectional studies emanates from a lack of long-time series data availability. Hence, many researchers have investigated determinants

of economic growth using cross-sectional data set³². Cross-sectional studies have focused on the correlation between investment and output, the impact of human capital accumulation and other policy variables such as openness and the concept of convergence. The correlation between investment and output in the cross-sectional literature is found to be positive. Romer (1990b, c) argues that his findings show strong and robust evidence of investment on growth, which helps to explain the rate of growth in cross-country regressions. This is probably related to exogenous changes in investment, which increase growth, and to exogenous differences in technological growth which promotes investment.

Delong and Summers (1991) study the link between equipment investment and economic growth using cross-sectional data for both developing and developed countries. They find that the social rate of return on equipment investment is likely to be high. They also emphasise that the successful industrialisation emerges from industrial policies, as in many East Asian countries. In these countries, governments support industrialisation rather than industrialists.

Temple (1998b) also follows the framework introduced by Mankiw, Romer and Weil (1992) and Benhabib and Spiegel (1994), using different techniques to investigate the correlation between equipment and economic growth and its compatibility with the Solow growth model. He mainly investigates a contradiction that has arisen from recent empirical growth literature, in which some authors argued that there is a strong link between equipment investment and economic growth whilst some found no special role for equipment on long-run growth. His main finding is that the implied returns to equipment investment are very high in developing countries.

Another two papers supporting this view for developing countries are conducted by De Long and Summers (1993) and Temple and Voth (1998). They find that the correlation appears to be much stronger than expected. In addition to these findings, Jones (1994) indicates that there is a strong negative relationship between economic growth and the relative price of machinery. This means that a

³² See Summers and Heston (1991) about cross-sectional data set which are available for different countries.

rise in the price of equipment causes a fall in capital accumulation and this reduces the growth rate of the economy in any standard growth framework.

Another paper on this topic is Easterly and Wetzel (1989). They discuss some factors, which influence the efficiency of investment and the level of investment rates, since countries with similar investment rates have a wide variation in growth rates. Sachs and Werner (1995) consider factors such as openness and natural resource endowments to estimate the effect of equipment investment. They find that the effect of equipment is ambiguous, and this may be because of the factors mentioned above. However, they provide little evidence that the effect of equipment is stronger for the whole sample rather than the group of developing countries.

Barro (1991a, b) also points out that investment may depend both on other explanatory variables and on previous growth performance. This means that investment itself tends to be 'endogenous investment'. Some estimation results regarding the link between investment and growth indicate that other explanatory variables are correlated with growth rather than investment, and this is a good indication that investment is endogenous.

Other studies are related to the relationship between human capital accumulation and growth. To understand the role of human capital on growth, a number of proxies have been used such as primary, secondary, tertiary enrollment ratios, literacy rates, and expenditure on education. Here, a common question can be asked that are these proxies the correct measurement of human capital and do they accord with theoretical concept?

Nevertheless, Mankiw et al. (1992) show that growth can be better explained by a model with human capital. They use secondary school enrolment rates as a proxy for human capital and find that the predictions of Solow model are consistent with empirical evidence, but the effects of saving and population growth rates are biased without human capital. They also contradict with findings of De Long and Summers: who claimed that there is no special role for equipment and no effect of investment on long-run growth. Barro (1991a) and Barro and Lee (1993) use years

of schooling as a proxy for human capital, which indicate broad support for the role of education in explaining economic growth.

Romer (1990c) emphasizes the effect of literacy and investment on economic growth in his paper where the literacy rate is used as a proxy for initial human capital. He does not find strong evidence that the literacy rate can explain the rate of growth, but he finds a strong effect in which the literacy rate causes investment. Levine and Renelt (1992) also study the effects of human capital formation on economic growth and they find that there is no robust effect between human capital and economic growth.

De Long and Summers (1991, 1992, 1993, 1994) find that secondary school enrollment has an insignificant negative coefficient, but they do not interpret this result. They only say that secondary school enrolment is “not a very good proxy” for investment in human capital and also mention that the “lack of significance of their human capital investment proxy may be associated with the large divergence between measured schooling and actual skills learned”. Like Delong and Summers, Knight et al. (1993) and Islam (1995) suggest that their findings indicate that the secondary school enrolment rates are not a good proxy in estimating the growth effect of human capital investment. Another paper on this issue is Gundlach (1995). He finds a substantially higher share of human capital in income than Mankiw et al. (1992) by using a proxy for the stock of human capital rather than a flow measure. He also mentions that the existing empirical findings do not suffice to disentangle alternative interpretations of the role of human capital in economic growth.

A number of authors study the link between growth and public expenditure (or taxation). Barro (1991 b), Khan and Reinhart (1990), Diamond (1989), and Ram (1986) focus on these issues. Unlike Barro and Diamond, others find that there is positive correlation between public expenditure (or government spending) and growth. Apart from these, Levine and Renelt (1992) provide strong evidence that consumption expenditure is negatively correlated with growth by employing the Summers and Heston data set. Skinner (1987) also works on these issues to

indicate the relationship between taxation and growth. He finds a negative correlation between them.

Trade is another important issue for growth concept in developing countries³³. This issue has already been discussed in section 2.3.3. The relationship between trade openness (or exports) and output growth (or income) is generally found to be positive, but this evidence is not very strong. The empirical studies can be summarised as follows:

Tyler (1981) and Feder (1982) estimate aggregate production functions including exports for cross-sectional studies in developing countries and they find evidence that there is a positive correlation between exports and income. Nishimizu and Robinson (1984) also find positive effects of export growth on productivity growth. Levine and Renelt (1992) use six different policy measures (exports/gdp, imports/gdp, black market premium etc.) to empirically investigate the relationship between trade openness and GDP growth, however none of them is robustly correlated with the rate of growth. Besides, their model only produces significant coefficients on the relationship between openness and investment.

Another paper on this topic is Balasubramanyam et al. (1996). They use cross-sectional data for both export promotion and import substitution policies to observe whether foreign investment contributes to economic growth or not. They find that foreign direct investment is really important for growth. Petsalides (1989) also empirically investigates growth performance under different trade policies considering export promotion (EP) and import substitute (IS) for a sample of 32 middle-income countries including Cyprus over the period 1960-1980. The evidence he finds, suggests that there exists a strong and robust positive relationship between outward orientation and economic growth. This shows EP generates more growth than IS.

Like Balasubramanyam et al. (1996), more recent literature also place an emphasis on international flow of foreign direct investment (FDI). One aspect of the fast factor accumulation in East Asia is the importance of FDI inflows as a source of technology and management skills in stimulating economic growth.

³³ See Bhagwati (1978), Krueger (1978), and Edwards (1989).

Lloyd and Maclaren (2000) examine the relationship between openness and some macroeconomic variables such as trade in goods, services and foreign direct investment for East Asian Economies. Their findings suggest that the nexus between openness and macroeconomic indicators has a positive marginal effect on growth. Hence, they conclude that the fast-growing East Asian Economies are not relatively open today.

Evidence from cross-section studies does not reveal the behavior of any particular country. When cross-sectional data is used, sometimes it can make the relevant function impossible in controlling unobserved country-specific differences.

Harrison (1996) estimates a general production function which allows for the impact of a wide range of openness measures on economic growth and shows that the openness measure positively affects growth, using cross-sectional data. He uses seven different proxies for openness measures; three of them reveal a positive association with growth. Like Harrison (1996), Romer, D. (1993) tests the prediction that lower average inflation is observed in more open economies due to a dynamic consistency in monetary policy. Using cross-country data sets, the evidence he finds, is that of a strong and robust negative link between openness and inflation in the countries that are less stable and have less independent central banks.

Li (2000) also investigates the relationship between growth and openness using cross-section data sets for Chinese provinces. His estimated results reveal a positive and significant relationship between economic growth and openness (using FDI as a proxy) both in the cross-province regressions and the panel data, along with the determinants of growth such as physical and human capital.

A common characteristic in cross-section studies indicates that the stable and significant relationship between growth and openness proxies results from the use of rapidly growing countries with slow-growing countries at the same time (i.e. Far Eastern and Latin American or African countries). Another common characteristic is an implicit assumption that the production functions are identical. If the production functions are different, biased results are inevitable (see Van den Berg and Schmit, 1994).

Quah and Rauch (1990) find mixed evidence between openness and growth for both cross-section and panel data analysis and they point out that cross-section variables can be misleading about long-run characteristics. Their findings reveal that openness appears to be weakly related to permanent movements in income in the long-run, whilst the nexus between growth and openness is stable and significant in their dynamic panel data analysis. Edwards (1989) uses a measure of trade openness and intervention, calculated by Leamer (1988). These measures are reliable for this purpose, but the use of trade policy variables and their proxies are still disputed because it is believed that they may be better defined. Gundlach (1997) follows Mankiw et al.'s (1992) neoclassical framework to distinguish the difference between open and closed economies predicted by the neoclassical model. He finds out that open DCs (Developed Countries) converge at a much higher rate to their steady state than closed DCs and this shows the importance of openness³⁴.

Convergence is another important issue when the growth regressions are estimated across countries. The convergence hypothesis has created giant amount of empirical literature. Cross-sectional and time series techniques have been applied to examine the neoclassical prediction of per-capita income convergence. The cross-sectional tests generally find evidence for convergence across countries [see Baumol 1986, Dowrick and Nguyan (1989), Barro (1991 a) and De Long (1988)] and across regions within the U.S. and Western Europe (see Barro and Sala-i-Martin 1992).

Time series tests focus on the permanence of shocks to relative per capita incomes by applying a stochastic definition of convergence. This is related to per-capita income disparities between economies, which follow a stationary process. The time series tests indicate little evidence of stationary in per-capita income disparities across countries [see Quah (1992), Bernard (1992), Bernard and Durlauf (1995) and Evans (1996)].

Convergence is usually defined as a tendency of poor countries to grow more rapidly than rich countries. In this respect, convergence is called mean reversion.

³⁴ See Sachs and Warner (1995) for a similar comment.

Evidence on Convergence in empirical studies is sample specific being based on groups of similar economies such as the OECD. These studies provide evidence in favour of convergence³⁵, however the Summers and Heston data set sometimes gives the opposite result. In other words, initial levels of income per capita are not correlated with subsequent growth rates [See Summers and Heston (1991) and Romer (1987)].

Mankiw (1995) points out that the neoclassical model does not necessarily predict convergence and he also mentions that rich economies remain rich and poor economies remain poor, if economies are in different steady states. In addition to this, he emphasises that the model will predict convergence if economies have the same steady state but their initial conditions are different. Actually, the Solow model does predict convergence, only having controlled for the determinants of the steady state. This is called 'conditional convergence'. A number of authors find evidence of convergence of about 2 percent per year [see Barro (1991 a), Barro and Sala-i-Martin (1992), Mankiw et al. (1992) and Levine and Renelt (1992)]. Among them, Mankiw et al. (1992) and Barro and Sala-i-Martin (1992) find evidence for unconditional convergence in the literature. This contradicts the findings of Dowrick and Nguyen (1989). De Long (1988), Romer (1987) and Peseran and Smith (1995) that find no evidence for unconditional convergence. A different paper comes from Ben-David (1996), where he examines the relationship between international trade and income convergence among countries. In this framework, trade-based groups of countries exhibit significant convergence.

As a consequence, the convergence question has important implications for growth theory³⁶. Convergence models have been used in the classic Solow model, which employs a concave aggregate production function. In contrast, the new growth theorists indicate how increasing returns to scale may cause differences in initial conditions to persist, however findings on convergence and its rates are not entirely reliable.

³⁵ See Barro and Sala-i-Martin (1991), and Dowrick and Nguyen (1989).

³⁶ De la Fuente (1997), and Quah (1996) critically review the convergence issue through the earlier key findings and their implications. They also discuss some of the questions about the convergence issue, which are left open by existing work.

Some recent studies suggest that more sophisticated panel data and time series models indicate the convergence rate to be between 20 and 30 percent a year [See Evans (1997a), Islam (1995), and Lee et al. (1997)]. The debate about convergence and its rates may stem from ignored econometric problems such as the possibility of heterogeneity biases, and outlier problems [See Temple (1999)].

2.4.4 Growth in Time series and Panel Data

Given the potential difficulties of cross-country studies³⁷, most researchers' attention has centered on panel data and time series methods. Use of panel data techniques contains some advantages for growth studies. The important one is that it allows researchers to control for omitted variables over time. As it is known in cross-section, conditional convergence studies generally provide biased estimates due to variations in technical efficiency, which are correlated with the variables. In contrast, by employing a panel data approach, unobserved heterogeneity in the initial level of efficiency can be controlled. Another method is to use a number of lags for regressor as instruments and this allows researchers to reduce measurement and endogeneity biases [see Temple (1999)]. On the other hand, time series oriented econometricians say that time series methods should be more reliable than both panel data and cross-section methods. The former does not justify assumptions about parameter homogeneity whilst the latter issues do not take into account useful information. For these reasons, parameters should be estimated individually employing separate time series regressions for each country to describe their behaviour.

Levine and Renelt (1992) make a point about this issue. They argue that the estimation results of cross-section studies might be misleading and there are unmeasured factors (Cultural, political, and environmental), which should be included. Canning et al. (1995) also examine the robustness of the cross-section approach in estimating the long-run parameters through the Granger Representation theorem (GRT).

³⁷ See Harrison (1996), Van der Berg and Smith (1994), and Levine and Renelt (1992).

In their paper, they find that the cross-section estimator has several weaknesses and using time series data permits the estimation of growth models separately for each country and a direct test of parameter equality across countries.

Having developed time series databases and improved new time series techniques such as cointegration, some works follow the pioneering study Jung and Marshall (1985) and Chow (1987) who investigate the correlation between income and exports through time series techniques. This follows a number of researchers who examine the relationship between economic growth and exports such as Ghartey (1993), Giles et al. (1993) and Ghatak et al. (1997). They, especially, use cointegration techniques to analyze the nexus between the two factors.

Next, human capital formation has been a common issue in growth literature since Romer (1986), Lucas (1993), and Stokey (1991) stress the role of human capital on growth. In more recent studies, Cellini (1997) analyses the Solow model by including human capital accumulation through Engel-Granger cointegration and Johansen tests. He finds mixed evidence when the Johansen method is used, whereas the Engle-Granger cointegration tests never provide evidence in favour of the neoclassical growth model.

Cheng and Hsu (1997) investigate the relationship between human capital and economic growth by using time series recent techniques for Japan. They find that there is a bidirectional relationship between them and this confirms the hypothesis that an increase in human capital stock provides positive effects on economic growth and vice versa. Levine and Rast (1992) also suggest that a positive impact of educational investment on growth depends on increasing openness. By contrast, Knight et al. (1993) and Islam (1995) suggest that their findings do not support the importance of secondary school enrollment rates which are not a good proxy in estimating the growth effect of human capital investment.

In and Doucouliagos (1997) utilises Romer's (1990c) and Mankiw et al.'s (1992) studies to test existence of Granger-causality between human capital and economic growth. They employ an error correction mechanism to test not only the long-run relationship but also short-run dynamics. Their findings indicate that there is a strong evidence of causality from human capital to private sector GDP

and vice versa. However, the existing literature is still unresolved on the issue of causality.

Some authors empirically examine the assumption of a lock-in relationship between physical and human capital, which is an effect as a reduced form of the AK model. These kinds of studies provide a direct test of endogenous growth model employing time-series data, but there is no common conclusion in these studies. Specifically, Jones (1995) and Evans (1997 b) find that there is no evidence for the endogenous model and their findings suggest that permanent changes in certain policy variables do not have permanent effects on the role of economic growth. In other words, permanent shocks to the role of investment are not reflected in growth rate. In addition to their conclusion, Canning et al. (1995) also find no evidence in the favour of the endogenous AK growth model. They use panel data methods in testing the validity of the endogenous growth model against the augmented Solow model. On the other hand, Kocherlakota and Yi (1996) provide evidence that permanent changes in policy variables affect the growth rate. Demetriades et al. (1997) also find that there is evidence for the hypothesis of constant returns to reproducible factors, which is required by the endogenous growth hypothesis. However, they also find evidence that disproves the assumption of a lock-in relationship between human and physical capital, which is tied into the reduced form of the AK model.

Another important part of growth literature is the explanation for the relationship between economic growth and public expenditure. Aschaver (1989a) studies whether public expenditure in the U.S. is productive or not. His finding is that public investment (or infrastructure) is an important determinant of economic growth, which supports the new growth theory, however some studies contradict the results of Aschaver (1989a) such as Evans and Karras (1994) and Holtz-Eakin (1994) find no evidence that public capital leads to greater productivity growth. On the other hand, Munnelli (1990), Garcia-Milâ and McGuire (1992), and Morrison and Schwartz (1992) find evidence in favour of Aschver's results. Their finding shows that using a long-time series data, temporary changes in public capital accumulation lead to highly persistent changes in the level of output. This

is a persistence that exogenous growth models ignore but endogenous models capture [see also Kockerlakota and Yi (1996)].

Some other studies for developing countries use human capital, investment, government consumption, imports and exports in the same framework. Piazzolo (1995) tests a growth model for South Korea and finds that human development, investment, exports and import substitution periods contribute to economic growth. However, he finds mixed evidence in favour of endogenous theory. Piazzolo (1996) investigates the new growth theory for Indonesia and finds that exports help economic growth in the short-run but the other factors allow economic growth to rise in the long-run. However, Harrison (1996) argues that the use of annual data is likely to create a major problem in identifying the determinants of long-run growth because short-term fluctuations could affect the observed relationship between policy variables and growth. Quah and Rauch (1990) also mention that most of the observed positive relationship between policy variables and growth in the long-run stems from short-run cyclical fluctuations. Another study by Ghura (1997) finds that the aggregate production function for Cameroon is subject to increased returns. In his paper, physical and human capital have positive influence on economic growth. This is evidence which supports the new growth theory.

International trade (or openness) is one of the most important determinants of economic growth for developing countries. The relationship between economic growth and openness has long been discussed by different researchers using time series and panel data methods.

Knight et al. (1993) employ panel data techniques to determine the impact of outward-oriented trade policies on economic growth. They follow the work of Mankiw et al. (1992) by extending the openness proxy, namely, import duties relative to the value of imports and they find that this proxy provides evidence in which outward-oriented development strategies have a positive impact on economic growth. Villaneuva (1994) finds that the ratio of foreign trade to GDP increases per capita income growth. His findings also support the convergence property of both endogenous and Solow-Swan growth models. An alternative

interpretation is that countries with a lower initial per capita income may have greater opportunity to catch up with more developed countries (See Edwards, 1992).

Ghatak and Milner (1997) study the role of trade policy and growth models for the case of Mauritius. They find some supports for an endogenous growth model in which physical and human capital accumulations and openness are in the long-term cointegrating relationship. Unlike Ghatak and Milner (1997), Romer, P.M. (1993) argues that Mauritius' success is explained by an 'old' rather than 'new' growth modeling perspective.

Another paper, Ghatak et al. (1995), also supports endogenous growth theory for the Turkish economy. They empirically investigate the impact of openness on economic growth. Bahmani-Oskooie and Niroomand (1999) investigate the relationship between trade and economic growth for developed and less developed countries and find a positive long-run relationship between openness and economic growth. Coe and Moghadam (1993) study trade and capital in a different way using recent cointegrating techniques to estimate long-run relationship. They find that European trade integration and decomposition of capital (business sector capital, government infrastructure capital, residential capital, and R&D capital) has boosted the French economy in favour of endogenous growth.

Van den Berg and Schmidt (1994) investigate the relationship between trade and growth by using recent time series techniques for seventeen Latin American economies. They find that their results confirm a positive relationship between the two factors over time for the majority of the seventeen countries. They conclude that there exist some drawbacks when cross-section studies are used, in terms of an assumption that the production function and countries are identical.

Sengupta (1991) studies some of the predictions of the new growth theory for the newly industrialised countries in general and South Korea in particular. He finds support in favour of the new growth theory for South Korea in three ways. The important one is that his findings provide evidence for the importance of openness in the case of South Korea much more strongly than that of Japan.

Hwang (1998) also provides empirical evidence from manufacturing in South Korea. He uses Johansen techniques to test both 'old' and 'new' growth theories and finds evidence, which supports the 'learning by doing' effect defined by Lucas (1988). In other words, South Korean manufacturing growth can be described by an endogenous economic growth model.

Unlike Sengupta (1991) and Hwang (1998), Richaud et al. (2000) investigates openness factor for the South America countries, particularly, Argentina. He attempts to find out a relationship between real exchange rate and openness through the trade liberalisation. His findings suggest that the failure of the trade liberalisation attempts make the relationship between exchange rate and trade policies impossible to sustain open trade regimes successfully.

Some authors emphasize the shortcomings of the methodologies used in the trade literature. A common point reveals that the methodologies are unlikely to distinguish a fast-growing economy, which systematically stimulates openness from slow-growing economy, which turns to openness as a remedy.

Rodriguez and Rodrik (2000) argue that the method used to emphasize the nexus between trade policy and growth have serious shortcomings. Their findings provide little evidence that open trade policies are significantly associated with economic growth. They point out that this little evidence may stem from shortcomings in the method used. Harrison (1996) and Edwards (1998) attempt to test the robustness of their findings on openness effect by adding other variables. However, Srinivasan (1995) argues that testing the robustness of a relationship between output and an explanatory variable by including another variable is a problematic concept in the sense of model specification.

In summary, although voluminous studies exist on the topic of trade policy, the debate is not yet resolved. A number of studies reveal a positive nexus between various measure of openness and growth, however some methodological problems remain unsolved. Trade policy effects are generally not strong or robust in the short-term. The channels of influence in which there exist efficiency, productivity, and technological change are all long-term effects. In addition, the nexus between trade and growth may occur through investment rather than resource allocation.

2.5 Conclusion

As far as the economic growth literature is concerned, the link between the theoretical and empirical studies in explaining economic growth seems to be relatively weak. The problems and the solutions in estimating and interpreting growth regressions are still disputed and they need to be investigated further. Generally, these problems are much more likely to be associated with either a cross-section or a panel data approach rather than time series analysis.

The evidence suggests that poor countries are likely to remain poor. In other words, poor countries do not seem to catch up with the richer ones. This is called non-convergence and contradicts the neoclassical models in which poorer countries tend to grow faster to their steady state level of income. This might stem from differences of macroeconomic stability and technologies. On the other hand, the new growth models still have some problem in providing robust answers on the determinants of economic growth. However, the new growth models have made some important contributions regarding policy implications, particularly for developing countries, in spite of a number of criticisms.

The importance of human capital and education policy, trade policies and government investment policies in explaining the implication of growth is still disputed. Nevertheless, they might generate better ideas relating to economic growth in developing countries, even though endogenous growth models are shaped by knowledge rather than capital as the source of sustainable growth. Policy makers can benefit from empirical results of more prudently constructed structural economic growth models, which have policy implications for the role of both private and government sectors in developing countries. In actual fact, neoclassical growth models provide little information for policy makers and development economists, but the new growth framework could generate better policy information for the economies in these countries.

2.6 Tables

Table 2.6.1 A Selection of Some Empirical Studies in Chapter 2 on Economic Growth [Based on The Export-Led Growth (ELG)]

Study	Year	Data	Technique/Model	Dependent variable	Other variable(s)	Conclusion
Tyler	1981	Cross-section 55 countries	OLS/production function	GDP growth and export growth	Labour force growth and investment growth	Support ELG
Feder	1982	Cross-section 31 countries	OLS/production function	GDP growth and export growth	Labour force growth and investment growth	Support ELG
Balassa	1985	Cross-section 10 countries	OLS/production function	GNP growth and export growth	Labour force growth ratio to output of domestic investment	Support ELG
Ram	1985	Cross-section 73 countries	OLS and heteroscedasticity tests/production function	Real GDP growth and real export growth	Labour force growth and investment growth	Support ELG
Jung and Marshall	1985	Cross-section 37 countries and time series 1950-81	Granger-causality and F-test/production function	Real GDP growth and lagged real export growth	Lagged GDP growth	Little support for ELG
Chow	1987	Cross-section 8 countries and time series 1960-80	Sim's test of causality and F-tests/production function	GDP growth and export growth	Exports of manufactured goods	Support ELG
Ghartey	1993	Time series 1960(1)-90(2) 3 countries	Wald-tests of causality/production function	Nominal GNP and nominal export	Capital stock and terms of trade in Japan's model. None for US and Taiwan	Support ELG only in Taiwan case
Giles et al.	1993	Time series 1963-91	Cointegration and causality/production function	Real GDP and Real Export	Different disaggregated data on export sector	Support ELG for some export sectors
Greenaway and Sapsford	1994	Time series 14 countries (most are LDCs)	OLS/production function	Real GDP growth excluding export and real export growth	Capital growth and Labour growth	Reflect the hypothesis of ELG
Ghatak et al.	1997	Time series Malaysia 1955-90	Cointegration/production function	Real GDP growth excluding export and real export growth	Capital, human capital and different export sectors products	Support ELG

Table 2.6.2 A Selection of Some Empirical Studies in Chapter 2 on Economic Growth [Based on The Solow Growth Model]

Study	Year	Data	Technique/Model	Dependent variable	Other variable(s)	Conclusion
Mankiw et al.	1992	Cross-section (most are non-oil countries) 1960-85	OLS/Augmented Solow Model (ASM)	GDP per worker growth	Human capital	The effect of saving and population growth are biased without human capital
Knight et al.	1993	Panel data 98 countries (most are developing) 1960-85	Panel data estimation/ (ASM)	GDP per worker growth	Human capital, government investment and openness proxy	Positive impact between the dependent and other variables
Canning et al.	1995	Panel data 77 countries 1950-90	Panel unit root test/(ASM)	GDP per worker growth	Human capital	Evidence in favour of Solow model
Islam	1995	Panel data (most are non-oil countries) 1960-1985	Panel estimation techniques / (ASM)	GDP per capita growth	Human capital	Support panel estimation approach for the model
Nonneman and Vanhoudt	1996	Panel data 22 OECD countries 1960-85	OLS /ASM	GDP growth	Investment, human capital, expenditure on education and population	Investment shares have significant impact on growth
Ghura and Hadjimichael	1996	Cross-section sub-saharan Africa 1981-92	OLS/ASM	GDP per capita growth	Human capital, private investment, government investment, budget deficit, CPI, REER etc.	Private investment and lower budget deficits have a large impact on growth
Cellini	1997	Time series 4 countries 1960-19988	Cointegration/ASM	GDP per worker growth	Human capital	Mixed evidence in favour of Solow model
Temple	1998a	Cross-section and panel data(most are non-oil countries)	Robust estimation and analyses of sensitivity/ASM	GDP per worker growth	Human capital	Results stand up fairly well using the techniques in favour of the model
Temple	1998b	Cross-section non-oil developing countries and OECD countries 1960-85	OLS-IV/ASM	GDP per worker growth	Human capital, investment, structure and equipment investments	Equipment investment has positive impact on growth for developing countries
Hwang	1998	Time series South Korea 1973(1)-1993(4)	Cointegration/ASM	GDP growth	Manufacturing index, manufacturing capital stock, manufacturing machinery/equipment capital etc.	Manufacturing growth can be described by an endogenous growth model rather than ASM
Jalilian and Odedokun	2000	Panel data 55 countries 1965-90	Panel estimation technique/ Solow	GDP per capita growth	Human capital and five types of private fixed investment	Some types of investment are more conducive to growth

Table 2.6.3 A Selection of Some Empirical Studies in Chapter 2 on Economic Growth [Based on Trade Policy Or Openness]

Study	Year	Data	Technique/Model	Dependent variable	Other variable(s)	Conclusion
Nishimizu and Robinson	1984	Cross-section 4 countries 1955-78	OLS/growth regression	Export growth	Productivity change	Positive effect
Quah and Rauch	1990	Panel data 81 LDCs 1961-85	OLS and heteroskedastic Standard Error technique/growth regression	GDP growth	3 different type of openness proxies, population and land area	Significant impact between growth and openness
Edward	1992	Cross-section 51 developing countries 1970-82	OLS/growth regression	GDP per capita growth	Six different types of openness proxies, investment and stock of knowledge	Positive impact between growth and openness proxies
Romer, D.	1993	Cross-section 114 countries Summer-Heston 1988 data set	OLS/growth regression	Political instability and central bank dependence (inflation proxies)	Openness, revolutions and coups	Strong negative link between inflation and openness
Villanevva	1993	Cross-section 36 developing countries 1975-86	Simulation technique/growth regression	GDP per capita growth	Investment, export plus import to GDP, fiscal deficits, education expenditure etc.	Openness has positive impact on growth
Van den Berg and Schmidt	1994	Time series 17 countries 1960-87	Cointegration/growth regression	GDP growth	Capital stock, labour force and trade proxy	Positive link between trade and growth
Sachs and Warner	1995	Cross-section 79 countries 1970-89	Huber-white heteroskedasticity test/growth regression	GDP per capita growth	Tariff, non-tariff barriers, black market premium etc.	Not fully support for trade policy
Harrison	1996	Time series developing countries 1960-87	Fixed effect estimation/growth regression	GDP growth	6 different types of openness proxies, land, labour and capital stock	Positive impact between growth and openness
Edwards	1998	Panel data 93 advanced and developing countries 1960-90	Different techniques/growth regression	TFP growth	9 different types of openness proxies, GDP and human capital	More open countries show faster TFP growth
Bahmani-Oskoei and Niroomand	1999	Time series 59 developed and less developed countries 1960-92	Cointegration/growth regression	The real GDP	Import plus export to GDP	Most countries show positive link between growth and openness
Frankel and Romer	1999	Cross-section 98 countries	OLS-IV/ growth regression	GDP per capita growth	Trade shares, distance measure, population, land etc.	It does not provide immediate implication for trade policy
Richaud et al.	2000	Time series 1913-1996 Argentina	Contegration/growth regression	Real exchange rate growth	Import plus export/GDP, public expenditure, real interest rate etc.	An appropriate RER policy can sustain open trade regimes successfully
Rodriguez and Rodrik	2000	Panel data 79 countries 1970-89	Heterosdesticity-consistent SE/growth regression	GDP per capita growth	10 different openness indicators	The link between openness and growth provides little evidence

Table 2.6.4 A Selection of Some Empirical Studies in Chapter 2 on Economic Growth [Based on General Growth Models]

Study	Year	Data	Technique/Model	Dependent variable	Other variable (s)	Conclusion
Romer	1990c	Cross-section 1 year	OLS-IV/endogenous growth	GDP growth	Investment, literacy etc.	Literacy rate causes investment
De Long and Summer	1991	Cross-section 61 countries 1960-85	OLS/growth regression	GDP per worker growth	Labour force growth, equipment and non-equipment	Equipment investment has a strong impact on growth
Levine and Renelt	1992	Cross-section 119 countries 1960-89	Sensitivity analysis/growth regression	GDP growth	Investment, population growth and human capital	No robust effect between human capital and growth
Coe and Moghadam	1993	Time series France 1971(1)-1991(4)	Cointegration/growth regression	Growth output	Business sector capital, government infrastructure and residential capital	Growth in France has been boosted by European trade and domestic capitals
Benhabib and Spiegel	1994	Cross-section (most non-oil countries) 1965-85	IV/growth regression	GDP growth	Human capital, labour force growth, equipment and structure investments	Equipment and structure investments have positive impact on growth
Jones	1995	Time series 15 OECD 1950-88	ADF test/growth regression (AK model)	GDP per capita growth and investment growth	R & D and TFP growth	Permanent changes in certain policies are rejected
Ghatak et al.	1995	Time series Turkey 1950-90	Cointegration/growth regression (endogenous growth modeling)	GDP per capita growth	Exchange rate distortion index, export volume, openness index and human capital	The results support endogenous growth modeling
Evans	1996	Cross-section 13 industrial countries 1870-1989, 51 countries 1950-1992 22 OECD and 28 non-OECD 1950-1992	Monte Carlo Simulation/growth regression	GDP per capita growth	Lagged GDP per capita growth	Evidence does not support endogenous growth theory that the countries' outputs have different trend.
Temple and Voth	1998	Cross-section 67 countries 1 year (1960)	Robust estimation techniques/growth regression	Industrialisation index, agriculture and manufacture employment shares and secondary enrollment rate	Labour growth equipment investment, GDP per worker and other types of investment	The link between equipment and growth may be driven by industrialiation
Canning	1999	Cross-section 90 countries 1960-85 (Table 2)	OLS/growth regression	GDP per capita growth	Telecommunication infrastructure, human capital, openness, etc.	Infrastructure and human capital have positive impact on growth
Hendricks	2000	Cross-section 1960-85 Developing countries	OLS/growth regression	GDP per capita growth	Government consumption share, investment share, price level of investment and consumption, human capital etc.	A relationship found among equipment investment, equipment price and growth

CHAPTER 3 The Cyprus Economy In Retrospect: 1960 – 1995

3.1 Introduction

Cyprus is the third largest island in the north east of the Mediterranean Sea and has an area of 9,251 square kilometres with a population of about 723,700 in 1995. Cyprus, like the other small island economies (SIE's, henceforth) have long been characterised as being constrained by their small size and narrow resource base, limiting their economic growth. But Cypriots have experienced a substantial improvement in their living standards since World War II.

The Cyprus economy (Southern Cyprus) has exhibited successful economic performance, reflecting rapid growth, almost full employment conditions, and external and internal stability in the post independence period. The economy inherited an underdeveloped economy from Colonial Rule in 1960. At the beginning, the Cyprus economy was agriculture-dominated until the first oil crisis in 1973 and Turkish intervention in 1974. The economy was based largely on agriculture and had a limited manufacturing base and invisible earnings from tourism. In the post 1974 period, the economy has been transformed into a modern economy by using dynamic services, industrial and agricultural sectors, physical infrastructure and highly educated human capital, despite the fact that most of the fertile agricultural land, the tourist accommodation capacity, and most of the infrastructure were left in the Northern part.

Cypriots developed a comparative advantage using their own labour force, location and attractive climate and beaches. On the one hand, they utilised all of the country's assets with highly educated human capital³⁸ to increase economic growth. On the other, they took full advantage of the island's position as a trade stepping-stone between Europe and the Middle East. Tourism also played a role in stimulating economic growth.

On account of the economic relationship between Cyprus and the European Union (EU henceforth), economic policy in the island is based on adapting to EU standards to support its application for membership and to enjoy a higher standard of living. The economic relationship between the Cyprus government and the EU

³⁸ In terms of university degrees per capita, Cyprus ranks third after USA and Canada (See the Economic Intelligence Unit, Cyprus; Country Profile, 1991-1992).

started in 1973. In May 1987, a new protocol was signed for a customs union. In June 1993, the European Commission produced its decision on Cyprus' application for membership and found that Cyprus is eligible. However, there should be a lasting settlement to the "Cyprus conflict". Cypriots still hope to be a full member by 2004 at the latest.

As a consequence, the success of the Cypriot economy is based on the adoption of a market-oriented economic system, some important macroeconomic policies, a dynamic and flexible entrepreneurial capability and a highly educated labour force. The country enjoys a remarkable standard of living and has deserved to cross over from the status of a developing country to a developed one. The rest of the chapter proceeds as follows: Section 3.2 provides general information about Cyprus. In section 3.3, we explain the economic background of the economy. Section 3.4 introduces Cyprus' economic policies. Section 3.5 discusses the country's economic growth and development plans. In Section 3.6, we present some macroeconomic indicators. In Section 3.7, we make some concluding remarks about the Cyprus economy.

3.2 Country Profile

Cyprus³⁹ is the third largest island in the Mediterranean Sea after Sicily and Sardinia. The island is situated in the northeastern end of the Mediterranean Sea, 33 east of Greenwich and 35 north of the Equator and has an area of 9,251 square kilometres, of which 1,733 square kilometres are forested. Its strategic position at the crossroads of three continents, (Asia, Europe and Africa) has been both advantageous and disadvantageous for Cyprus throughout its history. Cyprus is divisible into three principal topographic features namely, the Pentadaktylos or Kyrenia range to the north, the Troodos Mountains to the south, and the Mesaoria Plain separating the two uplands. Winter rivers starting in the Troodos flow rapidly in all directions. There are two large salt lakes, and many springs along the sides of Troodos mountains and the Kyrenia range. The island has an intense Mediterranean climate, with a cycle of hot, dry summers from June to September,

³⁹ Refer to the map of Cyprus in page 60.

rainy winters from November to March and brief Spring and Autumn seasons between. There exist substantial differences, both daily and seasonally, in the temperatures of coastal and inland areas.

The population in 1995 was about 723,700 of which 84.7 percent were Greeks, Armenians and Maronites, 12.3 percent Turks and 3 percent other nationalities, mainly British. The main religion is Orthodox, followed by Islam and Maronite Christianity. There are three principal languages: Greek, Turkish, and English. Among them, English became second language for Cypriots of both ethnic communities. In the island, level of education is high and literacy rate is 99 percent. Free and compulsory education is offered at pre-primary, primary and secondary levels in academic and technical vocational high schools. Higher education is also available at specialised schools and one university⁴⁰.

The beginning of Cyprus' civilisation goes back to the sixth millennium B.C., when human settlements existed during the Neolithic Era or New Stone Age. The very first known settlers are Hellenic people or Achaean Greeks in the second millennium B.C., followed by the Phoenicians. The island was later reigned by the Assyrians, the Persians, the Ptolemies, the Romans, the Byzantines, the Arabs, the Lusignans, the Venetians and Ottoman Turks who conquered the island in 1571. Ottoman period was over in 1878 when the Sultan ceded the island to Britain. The British Empire annexed the island in 1914 and it became a crown colony in 1925. In the mid 1950's, the Greek Cypriots started a guerrilla war against the British to annex Cyprus to Greece. This illegal movement was called Enosis and led by General Grivas. On the other side, the political war was coordinated by Archbishop Makarios until he was elected president when the island gained independence on 16 August 1960. This was followed by a settlement in London and Zurich, signed by Britain, Turkey and Greece as well as the leaders of both Cypriot communities. The leaders promised to prevent Enosis and ceded direct sovereignty over two military bases on the island.

The first tension rose between the two communities in December 1963 when Archbishop Makarios declared his intention to revise the constitution, which

⁴⁰ There is only one university in Cyprus, established in 1990. However, there are still many Greek Cypriots who prefer to study abroad.

followed a UN peace force being sent to Cyprus. With respect to the political problem, this situation remained unsolved until 15th of July 1974, when a coup backed by the military junta in Athens overthrew Archbishop Makarios through terrorist activities. The coup succeeded in toppling Makarios and replaced him with a puppet regime. This was swiftly followed by the Turkish intervention in the island on 20th of July, and the island has been de facto divided into two territories. In February 1975, a federal Turkish Cypriot state was declared in the Northern territory, formalising the de facto partition of the island. Following the division, Southern Cyprus was accepted as the government of the Republic of Cyprus, which is known as the internationally recognised government of the whole island and occupies the country's seat at the UN. From now on, this study will preoccupy itself with the economic progress of the southern part of the island, which is governed by the constitutional Government of Cyprus.

Figure 3.2.1 Cyprus Map



Source: CIA The World Factbook: (<http://www.cia.gov/cia/publications/factbook/geos/cy.html>)

3.3 Economic Background

At the beginning of the 1950s, the Cyprus economy began to grow as an agriculture-dominated economy until the first oil crisis in 1973 and Turkish intervention in 1974. Cypriot per capita income increased steadily through this

period and this success was achieved despite widespread turmoil stemming from shaking off British rule in 1950s and intercommunal warfare during the 1960s.

Cyprus was affected in 1973 and 1979 by the first and second oil price increases, during which domestic sources of energy were completely disrupted. However, energy related economic disruption was negligible compared with the effects of the Turkish intervention of 1974, which ended in the de facto partition of the Republic of Cyprus. In the post intervention period, the economic progress of Cypriots was negatively affected and almost 40 percent of the territory was lost together with about two thirds of the productive resources and capital stock. One third of its inhabitants fled their homes; the unemployment rate increased to 30 percent and economic disaster was inevitable.

Republic of Cyprus planners adopted an aggressive programme of constructive deficit spending, economic incentives, and targeted investments that led the Greek Cypriot economy to reach pre-1974 levels within a few years. The country enjoys a remarkable standard of living and has managed to cross over from the status of a developing country, towards that of a developed country. This was an astonishing accomplishment or “an economic miracle”⁴¹ achieved by the Cypriot people developing a comparative advantage using their own labour force, location and attractive climate and beaches. Especially, they used the country’s assets with highly educated workers to raise the economic growth in Cyprus (see also Appendix Chapter B).

In the mid 1980’s the economy took full advantage of the island’s position as a trade stepping stone between Europe and the Middle East and of tourism. These years saw healthy growth and low unemployment. In particular, the re-export of goods and services expanded rapidly and the tourist industry swelled to accommodate more than a million tourists, mostly from Western Europe, in each year. Hence, the building and construction sector of the Cypriot economy boomed. Besides, the increase in construction sector has stemmed from the Turkish intervention: the Cyprus government needed to accommodate about one

⁴¹ Hudson and Dymiotou-Jensen (1989) attempted to model and analyse the Cyprus economy for the years between 1960-1986. Having completed their study, they emphasised this term for the Cyprus economy.

third of its population who had become refugees. In addition, manufacturing and trade were encouraged to grow, since the destruction of Beirut permitted the island economy to become a regional centre for services and finance.

The economic relationship between the Cypriot economy and the world economy started to be formed with the European Union (EU henceforth) in 1973. The Cyprus government signed an agreement with the EU to become a full customs union member in two stages over a ten-year period. However, because of the division of the island in 1974, and the EU concerns about the pending entry of other Mediterranean countries, the second phase was postponed. In May 1987, the EU and Cyprus signed a new protocol for a 15-year customs agreement. The customs union would gradually eliminate most trade barriers with Europe over a 10-year period (1987-1997) and would lift tariffs and quotas against Cyprus for Cypriot industrial goods and agricultural products. This protocol would also provide financial help to promote a settlement. On July 4, 1990, the Cyprus government applied for full membership of the community on behalf of the whole island. In June 1993, the European Commission produced its decision on Cyprus' application for membership and concluded that Cyprus is eligible, but there should be lasting settlement to the "Cyprus conflict". Several key members of the EU, namely the UK and Germany, are still unhappy with the idea of Cyprus joining before a settlement is made, and there could be transitional provisions which would delay entry into the year 2000 and onwards whilst Greek Cypriots still hope to be full members by 2004 at the latest.

Notwithstanding that Cyprus is not a EU member, its largest trading partner is the EU, in particular, the UK, from which it took about 53.4 percent of all its imports in the late 1990's and to which it sent almost 37.8 percent of its exports. Actually the UK used to be the largest source of Cypriot imports but it has now fallen behind the USA, which leads the way in its machinery and equipment sales. The main Cypriot exports used to be to Arab countries exporting clothes, food and cement. However, markets were lost as these countries began to develop their own local industries. Now, the new frontier for Cypriot exports is the former Soviet block (The Economist Intelligence Unit, (EIU), various years).

3.4 Economic Policy

Economic policy in the island is based on adapting to the EU standards to support its application for membership. A necessary prerequisite for the achievement of the developmental and social objectives is the gradual improvement of public finances and in particular, the containment of the fiscal deficit and public debt to levels which conform to the corresponding criteria of the Maastricht Treaty (i.e. 3 percent and 60 percent of the GDP respectively). Cyprus meets the fiscal criteria for Economic and Monetary Union (EMU) with respect to the Maastricht Treaty, with a 1995 fiscal deficit of 1 percent of GDP, annual inflation at 2.6 percent and aggregate public debt equal to 53.5 percent of GDP. The crude debt in 1995 is equal to 83.8 percent of GDP. The lower figures are consistent with the EU's definition of general government deficits and debts (Economic Outlook, Planning Bureau, Nicosia, various years).

According to the Maastricht criterion, long-term interest rates should be within 2 percents compared with the three lowest inflation countries in the EU. However, this seems to be inapplicable in the Cyprus economy as interest rates have been held by law at 9 percent since 1940's. This makes it impossible for the central bank to use open market operations to control credit expansions. In 1994 and 1995, the bank deposit rate was cut from 8 percent to 7 percent and the commercial bank lending rate by 0.5 percent to 8.5 percent as a first attempt towards liberalisation. Hence, the government promised not to sell its development stock or other savings at rates higher than 7 percent.

Exchange rate policy is controlled by the Central bank of Cyprus and aims to maintain stability in the Cyprus pound against a basket of currencies derived from Cyprus' main trading partners. The Cyprus pound has been pegged to the ECU at a central rate of ECU 1.7086:C£1, with fluctuations allowed in a narrow band of 2.25 percent on either side. This overvalues the pound and has created difficulties for exporters and the tourist industry. The central bank announced its intention to liberalise both interest rates and the exchange rate before joining the EU membership negotiations so that local bankers and entrepreneurs get used to new mechanisms in advance.

The tax system has been changed in accordance with the EU criteria by simplifying personal income tax and abolishing tax credit systems. This yielded some deductions on the tax rate, which helped to raise individual purchasing power. Corporation taxes were raised by dropping the limits to the threshold on which the basic tax rate (20 percent) can apply. However, the tax rate on dividends was cut from 30 percent to 20 percent and individuals were able to have dividend income taxed separately at 20 percent. This is designed to encourage more private individuals to make entrepreneurial investments.

3.5 Economic Growth and Development Plans⁴²

When the newly formed government of Cyprus gained independence in 1960, it inherited an underdeveloped economy. The productive base was inadequate and was highly dependent on unstable factors. Agriculture was the dominant sector, which depended on fluctuating weather conditions and was characterised by a low productivity rate despite the fact that this sector accounted for 16 percent of the GDP and 45 percent of gainful employment. Manufacturing activities were minimal and centred on small family firms, engaging in handicrafts. Tourism had not yet taken off and was limited to a few hill resorts, so did not attract foreign tourists who would provide foreign exchange directly. Exports were dominated by minerals which made up 53 percent of the total. There were indications of unemployment and underemployment, particularly in agriculture and in some of the service sectors, even though the rate was not beyond 4 percent. The country's infrastructure was that of a third world country and it was lacking in an adequate infrastructure such as roads, ports, and airports etc., that were necessary for the process of development. In the social sphere, urbanisation was extensive whilst the political and economic uncertainty caused mass emigration to take place. The conditions of existing uncertainty caused the outflow of human and physical capital from the country.

These problems and the dominant view that the free market itself would not be adequate to provide the basis for major structural changes and for intensive

⁴² All economic figures (e.g. 16 percent of GDP) used in this section were extracted from Economic Outlook, Planning Bureau, Nicosia, Cyprus, various years.

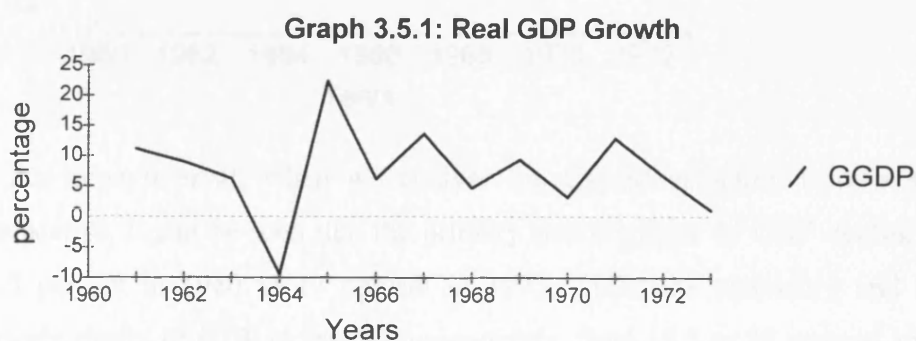
infrastructure building, led to the conclusion that new economic planning was inevitable. The government of Cyprus adopted the basic principles of indicative economic planning, with a view to achieve rapid economic and social development whilst maintaining conditions of external and internal economic stability.

Within this framework, the private sector was encouraged to reach indicative objectives and targets through legislation and monetary and fiscal policies. In addition, the government spent substantial resources to upgrade the physical and social infrastructure and create a stable macroeconomic environment using the smooth functioning of the activities of the private sector. It was believed that the private sector would be efficient in reaching the selected goals or aims with minimal government participation in the day-to-day operations of the economy. The strategy, objectives, targets and economic policies (or programmes) were embodied in five-year development plans. The planning Bureau under the Ministry of Finance managed this. The bureau appointed experts from abroad (i.e. The UN, the World Bank etc.) to formulate the five-year development plans.

The first five-year plan, which covered the period 1961-1966, aimed at achieving higher incomes, full employment, price stability, an improved balance of payments, and greater economic equality between rural and urban areas. The plan provided C£62 million public investment expenditure on development projects for roads, ports, airport facilities, irrigation projects, and telecommunications and electricity systems. The Agricultural Research Institute was established in 1962 to regenerate the quality of agriculture, and the Central bank of Cyprus was founded in 1963 to supply an appropriate volume of credit to the private sector. In this period, the plan achieved remarkable success, most obviously in agricultural production. The economy (Real GDP) increased by an annual rate of 6.5 percent, the exports of goods and services increased at an annual rate of 10.7 percent, while imports grew by about 7 percent per annum and total public sector development expenditure was around C£39 million, rather smaller than the C£62 million which would have been planned.

The second five-year plan, for 1966-1971, moved beyond the fundamental approach of the first plan and aimed at providing the social and legal structures needed by a more advanced economy. The role of the business community was emphasized more clearly. It also initiated the “consultive committees” where private organisations and independent experts made their own contributions in the process of development planning. In this interval, real GDP increased by an annual rate of 8.5 percent, which was regarded as very satisfactory by international comparison.

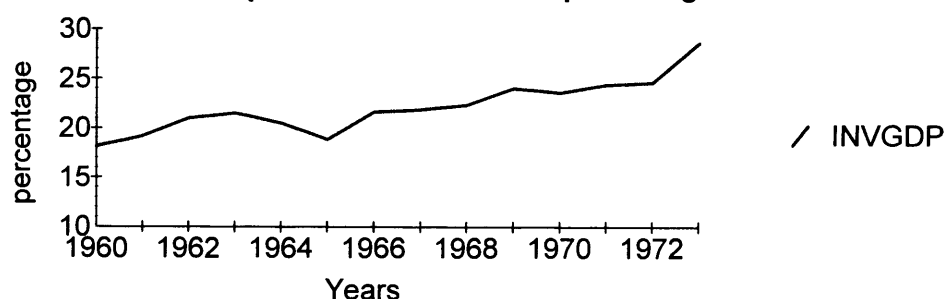
The third five-year plan covered the period 1971-1976 and indicated a continuation of the second one, but was wider in scope. Priority was given to the social and cultural spheres, as well as to a more equitable income distribution, covering in addition the institutional aspects of development. The Cyprus Development Bank was established to provide medium and long-term loans for development projects, as well as technical and administrative assistance. The Higher Technical Institute and the Hotel and Catering Institute were founded to provide specialised training. The government initiated the economic relationship between Cyprus and the EU that would bring about a reduction in trade barriers. The country also joined the International Bank for Reconstruction and Development and the International Monetary Fund (IMF).



In general, the performance of the economy in the first fourteen years of independence prior to the Turkish intervention was impressive. All economic and social indicators pointed out the fact that Cyprus economy went through a period of prosperity up to 1973. Between 1960-1973, GDP grew at an average annual rate of around 7 percent in real terms (see Graph 3.5.1). Agricultural production

doubled, while industrial production and exports of goods and services more than trebled. Tourism became the largest single foreign exchange earner. Fixed capital formation increased from 18 percent of GDP in 1961 to 28.5 percent in 1973 (see Graph 3.5.2). Investment in infrastructure projects like dams, roads, ports, airports, electricity, communication, etc., reached a very satisfactory level. Earnings of employees more than doubled in real terms, whilst registered unemployment was contained at a low level reaching 1.2 percent in 1973. The inflation rate was kept as low as 2.4 percent on average per annum during 1961-1973, and the current account of the Balance of Payments was mostly kept in surplus, notwithstanding a large increase in imports. As a result, accumulated foreign debt in 1973 was relatively low, at a level equivalent to 7 percent of GDP. It is important to note that the economy operated at a level of practically full employment and real wages grew by about 5 percent per annum, so this reflected an increase in the labour productivity growth rate, which was 5.4 percent per annum.

Graph 3.5.2: Investment as percentage of GDP



In the same interval, when we analyse the Cyprus economy from a sectoral perspective, it can be seen that the primary sector's share of GDP declined from 26.3 percent in 1960 to 17 percent in 1973, whilst the secondary and tertiary sector's shares of GDP expanded, respectively, from 19.5 to 25 percent and from 54.2 to 58 percent. Hence, the productivity of these two latter sectors was considerably higher than that of the primary sector. This means that the economy changed from one with an agricultural character to one with the structure of developed economies, dominated by the import industry and service sectors. Around 38.5 percent of workers were engaged in the primary sector, 26.5 percent in the secondary sector, and 34.9 percent in tertiary production activities.

In summary, the Cyprus economy experienced steady and sustained progress in almost all fields of economic and social activity, despite the severe disturbances in the world markets at the beginning of the 1970s, and prospects for future growth seemed bright. However, the economic progress was suddenly halted by the 1974 Turkish intervention, which resulted in the occupation of nearly 40 percent of the territory of Cyprus, and one third of the population became refugees. The loss of approximately two thirds of the country's resources shattered the economy. Most of the fertile agricultural land and most of the tourist accommodation capacity was situated in the districts of Famagusta and Kyrenia. The economy was also deprived of most of its infrastructure-including Nicosia International Airport, the largest port in Famagusta, and a number of government buildings. As a result of the economic dislocation, GDP dropped sharply by 18 percent per annum in real terms during 1973-1975. Unemployment shot up and reached 30 percent of the economically active population during the latter part of 1974. For the first time, the Cyprus economy experienced conditions of mass poverty and increased dependence for survival when the government revenues declined drastically. Shortages existed in all sectors, especially in housing and social infrastructure. The need for reconstruction and development was imminent. To meet these economic problems, a series of emergency economic action plans was conceived to be applied over two periods.

The first emergency economic action plan covered the years 1975-1976. It aimed at establishing a housing programme for refugees. The plan also directed the government to stimulate the economy (i.e. domestic demand in general and investment in particular) by adopting expansionary fiscal and monetary policies. Reducing the tax rate and taking the exemption from import duties on various raw materials encouraged private sector economic activities and products intended for local industry. This plan also contained the new development strategy in which the Cyprus economy was initiated as a centre for services and trade for the region.

The second emergency economic action plan (covering the period of 1977 to 1978) aimed to solve the basic problem of unemployment, and continued to revive the private sector's activity. In this short term, a high rate of investment and growth was targeted and exports would be the main momentum for growth.

The results of the two emergency plans were positive. GDP at current market prices in 1976 reached its pre-intervention level of 1973. The economy expanded by about 6 percent per year, and the unemployment rate declined to about 2 percent in 1978. This was an unprecedented situation (the unemployment rate was 30 percent at the end of 1974). The economy was operating under conditions of full employment. Exports of goods and services grew on average by almost 20 percent annually between 1974 and 1978 whilst imports of goods and services grew by 16 percent. This indicates the increased dependence on imported raw materials and final goods after the loss of the majority of resources owing to the intervention. Fixed investment increased from 18.5 percent in 1975 to 30.2 percent in 1978. This was financed by domestic savings which accounted for 44.7 percent of investment and 31.1 percent was financed by foreign savings. These figures reflected borrowing from abroad, which was demanded by the government. There were also net transfers within which 13.5 percent of investment and 10.7 percent of investment were financed by foreign aid and Cypriot workers' remittances respectively.

However, success had its price in that increased domestic consumption and rising oil prices produced some overheating of the economy. Hence, the inflation rate reached 7.4 percent in 1978, which compared with the rate was about 2 percent for the period 1960-1973. Besides this, the current account deficit expanded, reaching 11.6 percent of GDP in 1978. There was an undesirable relationship between rapid growth and economic stability (i.e. monetary stability in particular).

The third Emergency Economic Action Plan, covering 1979-1981 aimed at countering the overheating of the economy by adopting a restrictive monetary policy. In this period, both export promoting and import-substituting policies were adopted to generate an expansion in productivity growth, but there was no real success.

A glance at the progress of the economy over the period 1975-1981, exhibits the impressive rate of growth at an average of 10 percent per annum in real terms. This stemmed from the foreign demand for goods and services, which rose on average by 15 percent in constant prices. On the production side, the leading

sectors were tourism, construction and manufacturing. In this period, the Cyprus government regularly invested more than 30 percent of GDP to recover lost productivity capacity, and economic and social infrastructure. So, a large number of new employment opportunities were provided. Gainful employment increased on average by 6 percent per year and the rate of unemployment declined to 2 percent. The unemployment rate in 1981 was 2.6 percent of the economically active population.

In actual terms, the impressive growth performance emanated from a number of exogenous and endogenous factors. Exogenous factors, such as the booming Arab markets and Lebanese Crisis of 1975 helped the Cypriot economy to be lifted. On the other hand, endogenous factors like the aggressive and expansionary fiscal and monetary policies, the entrepreneurial capabilities of Cypriots, the hard work of the people and a substantial cut in wage and price levels by trade unions led the economy to reach the path of recovery.

The main target and strategy of the Forth Emergency Action Plan, covering 1982 and 1986 was to offset economic expansion with monetary stability. In this period, it was decided to adopt a new strategy, focusing on capital rather than labour intensive projects and on the restructuring of the economy whilst in parallel sorting out the problem of the external and internal instability by reducing the fiscal deficit. GDP attained an average real rate of growth of almost 6 percent per annum, much higher than the planned target of 4 percent because of the excellent performance of tourism. Employment continued to rise rapidly, by 2.5 percent per annum, although unemployment followed an upward trend and reached 3.7 percent in 1986. This was because of the oversupply created by the tertiary level education graduates. Inflation was reduced from 10.8 percent in 1981 to 1.2 percent in 1986, due to the steep reduction of oil prices in the world market and the subsequent improvement of the terms of trade.

The period 1987-1988 was marked by the reduction in import tariffs as part of the implementation of the customs union agreement with the EU. During this period, economic growth was export driven and the average annual real GDP growth was about 7.9 percent due to the continuingly rapid increase in tourism receipts and

industrial exports. The rate of unemployment decreased to 2.8 percent in 1988 while inflation pressure remained moderate. For the first time (1987-88) since the intervention, the current account of the Balance of Payments illustrated a surplus for the Cypriot economy. However, imports increased much faster, and wiped out the current account surplus achieved in 1987-88.

Overall, the economy performed relatively well in three areas: namely, economic growth, full employment, and moderate stability between 1976 and 1988. During this period, GDP grew at an average annual rate of 8.4 percent in real terms. Per capita GNP in constant prices increased from C£932 in 1975 to C£2,325 in 1989 and this was one of the highest figures in the Mediterranean area. Unemployment averaged 3.2 percent per annum and price increased 6.3 percent per year. The government of Cyprus supported the private sector through tax incentives, loan guarantees for export industries, and grants and loans to agriculture, the manufacturing sector and construction. This contributed to the “economic miracle”.

The five-year Development plan covering the period 1989-1993, aimed to achieve high growth, balanced sectorally and regionally under conditions of economic stability in the price level and in the Balance of Payments. With respect to the Custom Union Agreement between the EU and Cyprus, the government started to upgrade technological facilities and to improve competitiveness in all sectors of the economy. The major development targets were achieved, notwithstanding the adverse effects on the economy during the first half of 1991 due to the Gulf War and the slowdown of economic activity in 1993. However, some limitations were observed regarding the structure and the internal stability of the economy.

The real GDP growth rate during this period was 5.5 percent. In 1993, economic growth slowed, reflecting the deprivation of the external environment and, in parallel, the structural weaknesses of competitiveness in the manufacturing sector. From the demand side, private consumption increased because of high earnings and the expansion in fiscal, monetary and export services. This indicated the comparative advantages of Cyprus in the region. On the supply side, the main

pillars of growth were private services sectors such as telecommunications, financial institutions, insurances, business and social services.

The unemployment rate was about 2.3 percent of the economically active population on average during 1989-1993. In this period, the government allowed the employment of foreign workers on a large scale and this accounted for 5 percent of the total in 1993. Earnings expanded at an average annual rate of 9.3 percent in nominal terms which was the outcome of the Collective Bargaining Agreements. As a result, unit labour cost rose by 6 percent, which was higher than corresponding average increase in the EU and this devastated business competitiveness. During the period 1989-1993, inflation reached 5 percent and the current account of the Balance of Payments was on an average level.

The development Plan of the Cyprus economy, covering the period 1994-1996, aimed at supporting the restructuring and administration of the policies of the Cyprus economy with the aim of meeting present challenges and preparing for the accession of Cyprus to the EU. In this period, the average annual growth rate was around 4.5 percent in real terms compared to 4 percent, which was the target of the plan. This rate can still be considered as satisfactory in the light of the constrained rate of growth in the EU member countries, which buy the greater part of domestic exports and constitute the main tourist market of Cyprus. From the demand point of view, growth was private consumption-driven due to the expansion of monetary and credit targets. In contrast, according to the Plan, external demand should have been the source of rapid growth, hence the goal for the restructuring of investment activity in favour of machinery and equipment was not achieved to the desired level. The gap between investment expenditure and domestic savings widened significantly, and domestic savings decreased from 24 percent of GDP in 1993 to 20 percent in 1996.

From the sectoral point of view, the objectives for the restructuring and modernization of the sectors of agriculture and manufacturing have not been reached to the desired extent, but the private services sectors surpassed the set targets.

The rate of unemployment was contained to 2.8 percent of the economically active population, on average, for the period 1994-1996 and this was one of the main objectives of the Plan. The rate of increase of real earnings exceeded the rate of increase of labour productivity (the nominal rate increased on average by 5.5 percent in Cyprus and 3.5 percent in the EU countries), so the competitiveness of the Cypriot economy was badly affected.

The rate of inflation (excluding VAT effects) fluctuated at around 3 percent on average compared with the average rate in the EU countries, satisfying the Maastricht convergence criterion. The current account was a surplus of around 1 percent of GDP.

Foreign debt continued its downward trend from 33 percent of GDP in 1993 to 24 percent of GDP in 1996 due to the internal borrowing faced by the Government. Meanwhile, foreign exchange reserves increased from 1,350 million in 1993 to 2,015 million in 1996 because of the increased demand for imports of goods and services.

The fiscal deficit was held down to 1.2 percent of GDP and public debt decreased to 54 percent of GDP for this period. This was also a satisfactory level for the Maastricht convergence criteria and the stability of the economy. On the other hand public revenue rose from 30.5 percent of GDP in 1993 to 32.5 percent in 1996 and this indicated the amelioration in the efficiency of the tax system.

In general, the targets of the Plan were realised as far as the growth of the GDP, the unemployment rate, and the inflation rate are concerned. The main deviations concerned the structure of production, the decline in the manufacturing sector in particular, the fall in domestic savings, the restrained rise in productivity and the widening deficit of the current account.

The strategic Development Plan, covering 1996 and onwards, aims at meeting the following targets⁴³:

- (a) The preparation for the accession of Cyprus to the EU regarding the intermediate goals:

⁴³ The concept of the strategic development plan was taken from Statistical Abstract, Department of Statistics and Research, Ministry of Finance, 1995.

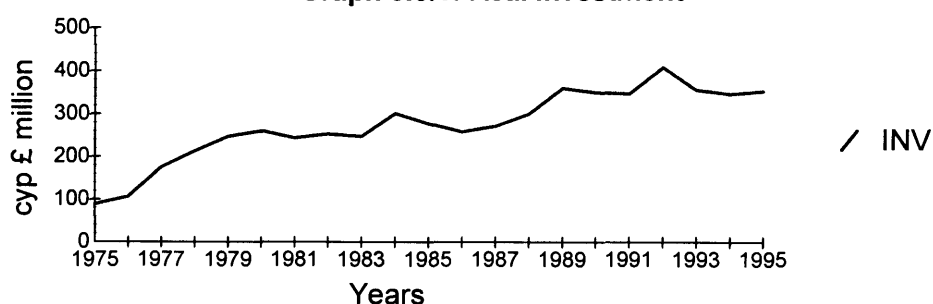
- i) The upgrading of the relations of Cyprus with EU within the framework of the Customs Union Agreement,
 - ii) The gradual adjustment to the *Acquis Communautaire*, and the gradual convergence with the criteria set by the Treaty of Maastricht.
 - iii) The preparation for the accession negotiations.
- (b) The technological upgrading, restructuring, encouragement of competitiveness and the modernization of the Cyprus economy and in general the creation of the necessary conditions for the achievement of a satisfactory growth rate within conditions of external and internal economic stability.
- (c) The improvement of the quality of life in Cyprus, with emphasis on the upgrading the environment and cultural development.
- (d) The improvement of the existing Social Insurance scheme.
- (e) The restructuring of the educational system.
- (f) The consolidation of the various housing schemes.
- (g) The combating of urbanization.

3.6 Economic Performance and Macroeconomic Indicators

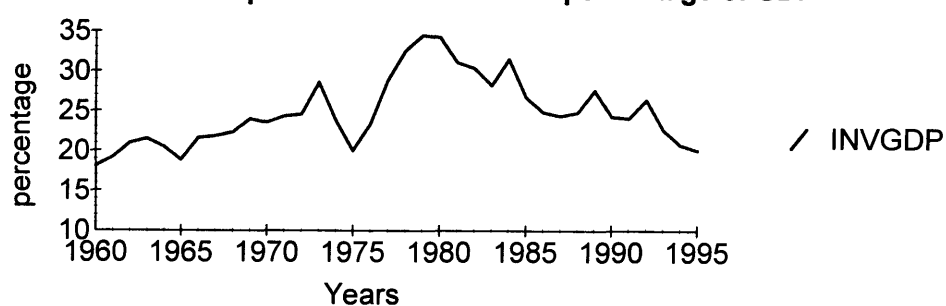
Cyprus, like other island nations, is small in terms of the domestic market, the business sphere, and the labour force and is open in character. It is highly sensitive to external shocks but, due to its size, can also bounce back quickly. Especially in the post-1974 period, performance of public policy was poor. After the war, the government lost most of the fertile agricultural land, the tourist accommodation capacity, and most of its infrastructure including the international airport and its largest port. Therefore, fixed capital accumulation in constant prices has accelerated from C£88.7 million in 1975 to C£351.4 million in 1995 (see Table 3.8.1 and Graph 3.6.1). The share of investment in GDP has increased over time, from 17.6 percent in 1960 to 34.2 percent in 1975 (see Table 3.8.3). However, it has fallen from 34.2 percent in 1980 to 20.3 percent in 1995 because

of the satisfaction of the housing needs for the refugees and the decrease of the demand for tourist accommodation (see Graph 3.6.2). Construction figures tell us that total investment in construction rose from 49.5 percent in 1960 to 64.1 percent in 1980 and from 1980 to 1995, it decreased to 58.4 as percentage of total investment. Investment in machinery and equipment indicated an improvement and their contribution to total investment increased from 19.5 percent in 1980 to 27.5 percent in 1995, however this is still low compared to the corresponding level in other developed countries (i.e. around 40-50 percent). This also illustrates that the Cyprus economy did not utilise advanced technology, which directly affects economic growth (see Table 3.8.1 for the figures in parentheses and Graph 3.6.3).

Graph 3.6.1: Real Investment

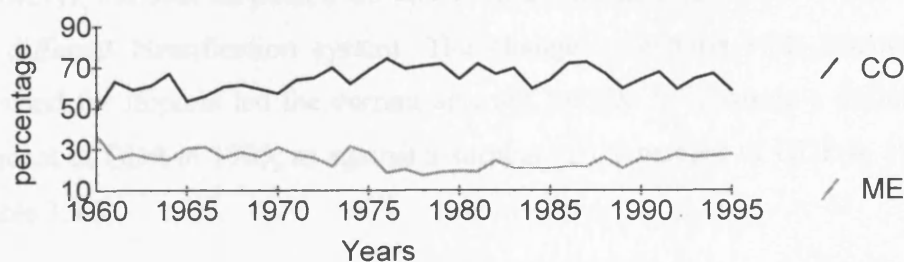


Graph 3.6.2: Investment as percentage of GDP



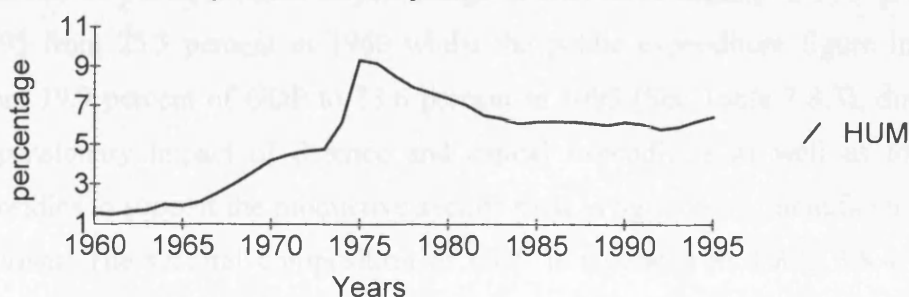
Cypriots developed their comparative advantages using their own labour force, location, and attractive climate and beaches. In particular, they utilised all of the country's assets with highly educated human capital to increase the economic growth in Cyprus. In terms of university degrees per capita, Cyprus ranks third after USA and Canada. Human capital in terms of tertiary enrollments increased from 1.5 percent in 1960 to 6.5 percent in 1995 as a percentage of the labour force

Graph 3.6.3: Construction, Machinery and Equipment to total investment



(see Table 3.8.1 and graph 3.6.4). Labour productivity also increased over time and improved 1.9 percent in 1995 (see Table 3.8.2). In contrast to the corresponding figures, it increased around 2.5 percent in the EU. This illustrated limited progress in the technological upgrading of the industrial sector. Besides this, the unemployment rate was about 2.8 percent in 1960 and this rate was the same in 1995 (see Table 3.8.1). In 1991, the rate of inflation was around 0.7 percent. Previously it exhibited a considerable increase to 13.5 percent in 1980 on account of an increase in the world oil prices and, to a lesser extent, of the increase in prices of domestically produced manufacturing goods which is attributed to the expansion of labour costs. This rate gradually fell to 2.5 percent in 1995 (see Table 3.8.2), which met the relevant Maastricht convergence criterion.

Graph 3.6.4: Tertiary Enrollment rate to labour Force

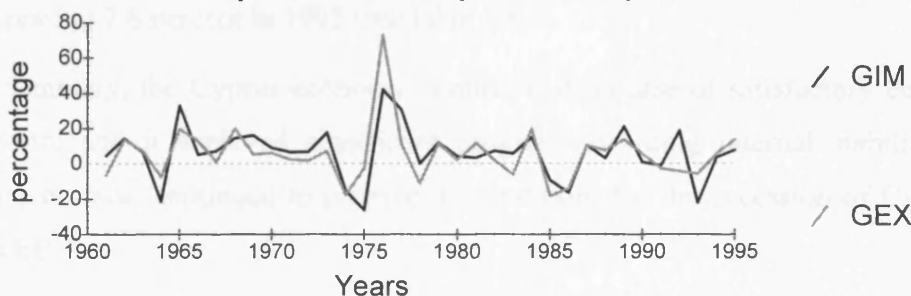


Exports of goods and services expanded from (negative) 6.4 percent in 1961 to 13.4 percent in 1995 whilst imports of goods and services also increased from 4.5 percent in 1961 to 7.6 percent in 1995 (see Table 3.8.2 and Graph 3.6.5).

At sectoral level, the sector composition of exports and imports are tabulated in Tables 3.8.5 and 3.8.6. In these tables, the characteristics of both sectors show an

increased trend over time (i.e. between 1980-85) except the year 1974- war effect. However, the data between 1985 and 1995 do not exist in the relevant tables due to different classification system. The change in exports with respect to the demand for imports led the current account balance to illustrate a deficit of 2.6 percent of GDP in 1995, as against a surplus of 1.1 percent of GDP in 1990 (see Table 3.8.3).

Graph:3.6.5: Real Exports and Imports Growth



In 1994, the fiscal deficit was restricted, which contributed positively towards the internal and external stability of the economy. The fiscal deficit was reduced to 1.3 percent of GDP in 1995 as against 2.3 percent in 1990 and 3.9 percent in 1985. This also satisfied the Maastricht convergence criterion. However, total public debt rose from 11.6 percent in 1961 to 53.0 percent in 1995 as percentage of GDP (see Table 3.8.3).

The rate of public revenue as percentage of GDP rose slightly to 32.5 percent in 1995 from 25.5 percent in 1960 whilst the public expenditure figure increased from 19.9 percent of GDP to 33.6 percent in 1995 (See Table 3.8.3), due to the expansionary impact of defence and capital expenditure as well as to higher subsidies to support the productive sectors such as agriculture, manufacturing and tourism. The sectoral composition of GDP is tabulated in Table 3.8.4. In this table, sectoral figures of GDP for the three sectors rose over time (i.e. 1960-1995) except the year has structural break-1974.

The trade deficit has been partly covered by the rapid growth in tourism receipts, which rose from C£5.3 million in 1960 to C£363.9 million in 1995 in real terms (see Table 3.8.1). This showed that a substantial increase in tourism receipts led the Cyprus pound to appreciate against other foreign currencies.

Notwithstanding the variation in the value of Cyprus pound, overall stability of the currency has largely been achieved. This stability was however at an overvalued level and adversely affected exporters and tourism industry. The value of Cyprus pound remained the same between 1960 and 1970, and it depreciated against the dollar in 1985, falling 3.7 percent in this year. In 1990, the pound appreciated against the dollar, rising 8.1 percent due to the worldwide weakening of the dollar. The Cyprus pound continued to appreciate against the dollar, increasing 7.6 percent in 1995 (see table 3.8.2).

In summary, the Cyprus economy continued its course of satisfactory economic growth, and it achieved significant progress regarding internal stability. The economy also continued to prepare its conditions for the accession of Cyprus to the EU.

3.7 Conclusion

Cyprus has overcome many serious constraints and adversities to reach the current state of relatively well-advanced economic and social development. In fact, the case of Cyprus may be taken into account as an exemplary case and a lesson for other developing countries⁴⁴ (see also Appendix Chapter B).

The important driving forces behind the achievement of the country in the economic sphere are, firstly, the encouragement of the private sector which stimulates the rapid growth. Secondly, highly educated and well trained workers as well as the country's natural resource endowments have been utilised to contribute to Cyprus's recent success. Thirdly, the colonial rule introduced the English language, the first international language of the world, the British judicial system and the administration for civil service. Fourthly, political life is more stable than the third world countries (see Hudson and Dymiotou-Jensen (1989)).

The key point, among other factors, behind the accomplishment of Cyprus economy, is the planning process. The Cyprus government seriously adopts this planning process employing highly trained and competent staff as well as experts and advisors from international associations such as the UN, and the World Bank.

⁴⁴ See Hudson and Dymiotou-Jensen (1989) for a similar comment.

The role of the government, via the planning process, is a very important “milestone”. They really identified the potential problems, obstacles and shortages before they are a serious handicap to threaten an economic progress. Besides this, the government kept their staff updated by sending them to international training courses. It is also worth noting that human capital is the country’s major comparative advantage, apart from the role of the government. Cypriots have already proved that they were capable, versatile efficient, productive, and hard working when an “economic miracle” was created for their own country.

In conclusion, two important points should be expanded, which have been crucial forces in explaining the successful development through the Cyprus’ economic history. One is the British heritage of language, and judicial system and the other one is political system in Cyprus. In such political system, there exists a democratic opposition and freedom of the press to provide equal opportunity for every single citizen. In such circumstances, effective development is inevitable.

3.8 Tables

Table 3.8.1 Main Economic Indicators at Constant Market Prices of 1980 (in Million C£)

Economic Indicators	1960	1965	1970	1975	1980	1985	1990	1995
GDP	268.3	381.8	542.5	443.5	760.4	1000.7	1396.2	1753.4
GDP/Worker	1254.3	1747.4	2241.7	3285.2	4044.7	4594.6	5522.5	6217.7
Fixed Capital Formation	72.8	106.2	162.8	88.7	260	276.9	348.6	351.4
-Public	33.03	30.7	25.8	27.7	61.8	75.1	85.8	85.1
-Private	39.82	75.5	137	61.0	198.2	201.8	262.8	266.3
--Tourism	2.3 (3.1)	1.9 (1.8)	3.5 (2.5)	2.2 (2.5)	21.2 (8.1)	20.4 (7.3)	35 (10.1)	21.2 (6.1)
--Construction	36 (49.5)	54.7 (54.3)	89.7 (55.1)	58.3 (65.7)	166.6 (64.1)	156.2 (56.4)	188.2 (53.9)	205.2 (58.4)
--Machinery	26.8 (36.8)	32.3 (30.4)	50.5 (31.1)	25.1 (28.3)	50.7 (19.5)	57.2 (20.6)	88 (25.3)	96.8 (27.5)
--Transport Equipment	7.7 (10.6)	17.3 (16.3)	19.1 (11.7)	3.1 (3.5)	21.5 (8.3)	43.1 (15.6)	37.4 (10.7)	23.5 (6.6)
Human Capital								
-Tertiary* Enrolments (000's)	3.277 (1.5)	4.201 (1.9)	10.148 (4.2)	12.539 (9.3)	13.840 (7.4)	13.446 (6.2)	15.582 (6.2)	18.087 (6.5)
-Expenditure* On education	9.7	13.5	23.0	29.4	42.8	62.2	77.5	119.9
Labour Force* (000's)	213.9	218.5	242.0	135.0	188.0	217.8	253.4	282.0
Unemployment* (000's)	6.0	4.0	2.8	33.5	4.3	8.3	5.1	7.9
Unemployment* to Labour force (%)	2.8	1.8	1.1	24.8	2.2	3.8	2.0	2.8
Exports	56.39	71.04	108.11	96.74	188.04	196.23	283.43	249.59
Imports	108.79	144.38	234.93	196.37	424.3	514.72	593.59	602.92
Income From Tourism	5.3	6.2	19.4	9.3	71.7	156.7	313.7	363.9
Consumer* Price Index	42.2	42.7	47.1	67.3	100	137.8	160.9	202.7
Exchange Rate* (\$, dollar)	2.80	2.80	2.40	2.71	2.83	1.64	2.18	2.19

Table 3.8.2 Annual Rate of Change (%) of Main Economic Indicators at Constant Market Prices of 1980

Economic Indicators	1961	1965	1970	1975	1980	1985	1990	1995
GDP	11.1	22.3	3.1	-19.0	5.9	4.7	7.3	5.2
GDP/Worker	8.3	17.7	1.8	24.9	1.3	1.1	4.4	1.9
Fixed Capital Formation	11.3	19.3	7.2	-37.1	5.2	-7.6	-2.7	1.8
-Tourism	-8.6	35.7	6.1	-45.0	112.0	-19.6	3.0	-8.6
-Tertiary Enrolments (000's)	3.9	-0.4	18.1	-4.3	7.3	5.6	5.4	7.7
-Expenditure On education	7.2	29.8	5.9	-5.6	8.9	4.5	6.3	8.4
Labour Force (000's)	2.3	2.5	1.3	-36.85	4.6	3.7	2.7	3.4
Unemployment (000's)	16.6	-28.6	3.7	6.0	16.2	3.7	-17.7	-1.2
Exports	-6.4	19.7	6.0	-2.7	1.9	-18.3	5.3	13.4
Imports	4.5	32.8	8.9	-26.3	4.1	-9.4	0.6	7.6
Income From Tourism	56.6	113.8	0.5	-62.8	25.4	3.6	11.2	-2.7
Consumer Price Index	0.7	0.2	2.6	4.5	13.5	4.9	4.5	2.5
Exchange Rate (US\$)	0.0	0.0	0.0	-0.9	0.4	-3.7	8.1	7.6

Table 3.8.3. Main Economic Indicators as Percentage (%) of GDP at Current Market Prices

Indicators	1960	1965	1970	1975	1980	1985	1990	1995
Gross Domestic Fixed Capital Formation	17.6	18.3	23.5	19.6	34.2	26.7	24.2	20.3
Gross Domestic Saving	6.4	15.2	14.8	1.4	19.5	22.2	27.4	28.5
Public Revenue and Foreign Grants	25.5	18.0	18.3	26.0	22.9	26.3	27.9	32.5
Public Expenditure and Net Lending	19.9	15.9	17.6	34.0	29.8	30.2	30.2	33.6
Fiscal Deficit	0.6	3.8	1.5	7.9	6.9	3.9	2.3	1.3
Total Debt	11.6	7.2	6.1	16.1	29.8	41.0	41.5	53.0
Trade Balance (Deficit)	16.4	15.2	19.7	22.8	27.4	29.1	26.2	25.4
Invisible Balance (Surplus)	16.3	16.9	16.5	17.4	16.5	22.5	27.3	22.8
Current Account Balance (+/-)	0.1	1.7	3.2	5.4	10.9	6.6	1.1	2.6

Notes: The data used for Table 3.8.1, 3.8.2, and 3.8.3 are obtained from Department of Statistics and Research, Ministry of Finance, Nicosia, Cyprus, 1995. The figures in these tables are compiled by ourselves and we are responsible for remaining errors. In Table 3.8.1, the numbers in the bracket are the percentage of total fixed capital formation and labour force (i.e. tertiary enrolment) and one star indicates that the number is not in million terms.

Table 3.8.4 The sector composition of GDP at constant market prices of 1980 (in million C £)

A selection of sector composition on GDP	1960	1965	1970	1975	1980	1985	1990	1995
Agriculture	42.5	77.7	85.9	57.8	72.9	78.4	93.2	101.7
Manufacturing	33.7	45.8	79.1	78.3	133.4	166.8	206.3	206.9
Wholesale retail trade restaurants and hotels	30.6	53.1	78.8	47.6	115.6	186.2	290.3	346.3
Finance, insurance, real estate and business services	41.3	56.7	83.6	72.1	108.9	166.3	255.5	351.9

Table 3.8.5 The sector composition of exports (domestic + re-exports) at current market prices of 1980 (in million C £)

A selection of sector composition on exports	1960	1965	1970	1975	1980	1985	1990	1995
Food and live animals	5.4	11.2	19.2	19.1	42.6	59.3	-	-
Crude materials inedible	10.6	9.9	14.9	8.8	10.7	9.7	-	-
Chemical products	0.03	0.03	0.3	0.5	5.2	15.1	-	-
Manufactured goods	0.2	0.2	1.1	9.5	29.2	22.8	-	-
Machinery and transport equipment	1.1	1.3	3.6	4.6	14.3	31.5	-	-

Table 3.8.6 The sector composition of imports at current market prices of 1980 (in million C £)

A selection of sector composition on imports	1960	1965	1970	1975	1980	1985	1990	1995
Food and live animals	6.4	7.7	13.7	24.3	50.5	82.5	-	-
Crude materials inedible	1.2	1.2	2.3	1.3	8.6	13.3	-	-
Chemical products	3.2	4.6	7.6	10.3	31.1	57.1	-	-
Manufactured goods	8.7	14.1	28.5	28.8	113.9	176.9	-	-
Machinery and transport equipment	6.9	12.6	27.6	17.5	95.4	199.4	-	-

Notes: The classification systems for exports and imports sectors between 1960 and 1987 are based on System of International Trade classification (SITC). The year 1988 and onwards, the classification system is based on Harmonised System of International Trade Classification (HSITC). We are therefore confined to report the sectoral composition of imports and exports between the relevant years 1960-1987.

CHAPTER 4 Testing The Neoclassical Theory In Economic Growth

4.1 Introduction

The aim of this chapter is to derive and investigate empirically the implications of the neo-classical exogenous growth model, namely, the Solow and the Augmented Solow growth models for the case of Cyprus. The first model includes the physical capital accumulation rate and the rate of labour population growth whilst the latter has both physical and human capital accumulation rates and the rate of labour population growth. In these models, we assume that these variables mentioned above are stochastic and vary over time. Hence, the steady-state path for per capita growth (or labour productivity) in a country (i.e. each country) should be considered as stochastic. The concept of convergence⁴⁵ therefore, has a distinct interpretation, in the time series context.

The standard growth model proposes that if the neo-classical production function indicates constant returns to scale (CRS) with decreasing returns to capital and the Inada conditions hold, then income per capita converges to a steady-state path. If economies have identical structure in which they converge to the same per capita income, the poorer country is expected to grow faster and catch up with the richer one. Several economists have empirically investigated this issue using cross-section regressions (see Baumol, 1986; Barro 1991; Mankiw *et al*, 1992).

In the time series context, the rates of physical and human capital accumulation as well as the labour growth rates influence the steady-state level of per capita growth (or labour productivity) (see Cellini 1997; Lau 1999). Thus, we apply multivariate co-integration techniques for analysing the Solow growth model and the Augmented Solow growth model.

Stationarity tests such as Augmented Dickey-Fuller⁴⁶ indicate that the variables embodied within the two models are integrated of order one⁴⁷.

⁴⁵ Kelly (1992) and Leung and Quah (1996) make a clear point that convergence can be consistent with both endogenous-exogenous growth models.

⁴⁶ King *et al.* (1988a, b) and Lau and Sin (1997) suggest that the source of growth and its time series properties may be different, but unit root, non-stationary and cointegration in exogenous growth model are caused by I(1) impulse processes.

⁴⁷ Cochrane (1991) argues that economic theory does not provide any guidance regarding the specification of deterministic trend, which is very important to unit root tests. In addition, Cellini (1997) suggests that if the steady path is considered as deterministic, unit roots in labour productivity would be a result against Solow's model, however if it is considered as stochastic, the integration level of labour productivity can be consistent with model.

This means that the Solow model can satisfy a co-integration relationship between the relevant variables. For instance, King et al. (1991) mention that if labour productivity is integrated of order one, it can be co-integrated with total factor productivity. However, if it is assumed that the total factor productivity is exogenous and deterministic, as in the Solow model whilst the variables are considered as time series integrated of order one, current and steady-state productivity level must be cointegrated. This implies that the stationarity of their difference will be consistent with the stationarity of labour productivity growth rate.

It is worth noting that a number of recent studies either use time series or panel data to investigate growth model (see Knight et al. 1993; Bernard and Durlauf 1995; King et al. 1991; Easterly et al. 1993; Jones 1995; Cellini 1997; Lau and Sin 1997 and Lau 1999). None of them takes the error correction mechanism as the main issue of neo-classical exogenous growth theory except Cellini (1997). We therefore use an error correction model to capture the short-run dynamics. With regard to Solow's model, if the current level of per capita income is lower (greater) than the equilibrium level or 'steady-state level', the subsequent variation will be positive (negative). This leads to an error correction mechanism.

The value of the error correction term should be between -1 and 0 and this term relates the labour productivity growth rate to the previous difference between current and equilibrium productivity. This is the stochastic implication of the Solow model. In this paper, we find some evidence in favour of the Augmented Solow growth model whereas the Solow growth model is found as a misspecified model which is not the true model in explaining economic growth for the Cyprus economy.

The remaining of this chapter is organised as follows: Section 2 theoretically provides the derivation of the Solow and the Augmented Solow growth models, which is associated with exogenous growth theories. Section 3 indicates the empirical methodology, model, and data description. In section 4, the empirical results are presented. Section 5 explains a brief comparison between the two models. Finally, section 6 provides some conclusions.

4.2 Theoretical Modelling

4.2.1 The Solow Growth Model

The most basic characteristic of growth theory is that in order to achieve a high rate of economic growth in the long run, technological knowledge should have a propulsive role in terms of new markets and new goods. This characteristic can be observed using the neoclassical growth model developed by Solow (1956) which indicates that if there is no technological progress, the law of diminishing returns will cause economic growth to stop.

The Solow model assumes that the rates of saving, population growth and technological progress are exogenous. The model has two inputs, capital and labour. These are paid their marginal products. Following Mankiw et al. (1992), we consider a Cobb-Douglas production function at constant returns to scale (CRS) and productivity growth that is purely labour-augmenting or “Harrod-neutral”. So the production function takes the form as follows:

$$Y_t = K_t^\alpha (A_t L_t)^{1-\alpha} \quad 0 < \alpha < 1 \quad (4.2.1-1)$$

where Y is output, K is capital, L is labour and A is a measure of the level of technology. The subscript t indicates time. L and A are assumed to grow exogenously at rates n and g :

$$L_t = L_0 e^{nt} \quad (4.2.1-2)$$

$$A_t = A_0 e^{gt} \quad (4.2.1-3)$$

The number of effective units of labour, $A_t L_t$, grows at rate $n+g$. The assumption of constant returns allows us to work with the production function in intensive form:

$$y_t = k_t^\alpha \quad (4.2.1-4)$$

or

$$y = f(k)$$

Where $\frac{Y_t}{A_t L_t} = y_t$, $\frac{K_t}{A_t L_t} = k_t$

Equation (4.2.1-4) indicates the ratio of output per efficiency unit of labour to the amount of capital per efficiency unit of labour. The net increase in the stock of physical at a point in time equals gross investment less depreciation:

$$\dot{K}_t = I_t - \delta K_t \quad (4.2.1-5)$$

where δ is the rate of depreciation and $I_t = s Y_t$, I is investment and s is a constant saving rate for physical capital (the dot is the derivative with respect to time t).

The Solow model assumes that people save a constant fraction s of their gross income Y , and the constant fraction δ of the capital stock vanishes each year as a result of depreciation. New capital accumulates at the rate sY where old capital depreciates at the rate δK . So the net rate of growth of the capital stock can take the form⁴⁸:

$$\dot{K}_t = s^k Y_t - \delta K_t \quad (4.2.1-6)$$

Equation (4.2.1-6) is the fundamental equation of neoclassical growth theory. This shows how the rate of change of the capital stock at any time which is determined by the amount of existing capital at that time.

s^k denotes the fraction of output devoted to physical capital accumulation and other variables are defined as before.

Now, we substitute Equation (4.2.1-1) into Equation (4.2.1-6) to get:

$$\dot{K}_t = s^k K_t^\alpha (A_t L_t)^{1-\alpha} - \delta K_t \quad (4.2.1-7)$$

Dividing equation (4.2.1-7) by $A_t L_t$, we get:

$$\begin{aligned} \frac{\dot{K}_t}{A_t L_t} &= s^k \frac{K_t^\alpha (A_t L_t)^{1-\alpha}}{A_t L_t} - \delta \frac{K_t}{A_t L_t} \\ \frac{\dot{K}_t}{A_t L_t} &= s^k \frac{K_t^\alpha}{(A_t L_t)(A_t L_t)^{\alpha-1}} - \delta \frac{K_t}{A_t L_t} \end{aligned}$$

⁴⁸ We assume that there are no taxes, no government expenditure, and no international trade, therefore saving and investment are identical.

$$\frac{\dot{K}_t}{A_t L_t} = s^k \left(\frac{K_t}{A_t L_t} \right)^\alpha - \delta \frac{K_t}{A_t L_t}$$

$$\frac{\dot{K}_t}{A_t L_t} = s^k (k_t)^\alpha - \delta k_t \quad (4.2.1-8)$$

Equation (4.2.1-8) indicates that economic growth may arise from the accumulation of capital. The capital stock per efficiency unit, k_t , evolves as follows:

To find out $\frac{\dot{k}_t}{k_t}$, we need to apply the chain rule.

$$\dot{k}_t = \frac{\partial k_t}{\partial K_t} \dot{K}_t + \frac{\partial k_t}{\partial L_t} \dot{L}_t + \frac{\partial k_t}{\partial A_t} \dot{A}_t \quad (4.2.1-9)$$

where $k_t = \frac{K_t}{A_t L_t}$

$$\dot{k}_t = \frac{1}{A_t L_t} \dot{K}_t - \frac{K_t}{A_t L_t^2} \dot{L}_t - \frac{K_t}{L_t A_t^2} \dot{A}_t \quad (4.2.1-10)$$

$$\dot{k}_t = \frac{\dot{K}_t}{A_t L_t} - \frac{K_t}{A_t L_t} \frac{\dot{L}_t}{L_t} - \frac{K_t}{A_t L_t} \frac{\dot{A}_t}{A_t} \quad (4.2.1-11)$$

where $\frac{\dot{K}_t}{A_t L_t} = s^k k_t^\alpha - \delta k_t$, $\frac{\dot{L}_t}{L_t} = n$, $\frac{\dot{A}_t}{A_t} = g$

Plugging these expressions into Equation (4.2.1-11) to get:

$$\dot{k}_t = s^k k_t^\alpha - \delta k_t - k_t n - k_t g \quad (4.2.1-12)$$

If we rearrange Equation (4.2.1-12), we can have Equation (4.2.1-13) as follows:

$$\dot{k}_t = s^k k_t^\alpha - (\delta + n + g) k_t \quad (4.2.1-13)$$

or

$$\dot{k}_t = s_k f(k_t) - (\delta + n + g) k_t$$

Dividing Equation (4.2.1-13) by k_t to get capital growth as below:

$$\frac{\dot{k}_t}{k_t} = s^k \frac{k_t^\alpha}{k_t} - (\delta + n + g) \frac{k_t}{k_t} \quad (4.2.1-14)$$

Rearranging Equation (4.2.1-14), we get:

$$\frac{\dot{k}_t}{k_t} = s^k (k_t)^{\alpha-1} - (\delta + n + g) \quad (4.2.1-15)$$

Equation (4.2.1-15) implies that k_t converges to a steady-state value k_t^* and the steady-state is defined by $\dot{k}_t = 0$. This yields,

$$\begin{aligned} 0 &= s^k (k_t^*)^{\alpha-1} - (\delta + n + g) \\ s^k (k_t^*)^{\alpha-1} &= (\delta + n + g) \\ (k_t^*)^{\alpha-1} &= \frac{(\delta + n + g)}{s^k} \\ k_t^* &= \left[\frac{\delta + n + g}{s^k} \right]^{\frac{1}{\alpha-1}} \quad \text{or} \quad k_t^* = \left[\frac{s^k}{\delta + n + g} \right]^{\frac{1}{1-\alpha}} \end{aligned} \quad (4.2.1-16)$$

Taking logs both sides of Equation (4.2.1-16) we get:

$$\ln k_t = \frac{1}{1-\alpha} \ln s^k - \frac{1}{1-\alpha} \ln (n + g + \delta) \quad (4.2.1-17)$$

Recall Equation (4.2.1-4) to find output in level as follows:

$$y_t = (k_t)^\alpha \quad (4.2.1-4)$$

Taking logs both sides of Equation. (4.2.1-4), yields:

$$\ln y_t = \alpha \ln k_t \quad (4.2.1-18)$$

Substituting Equation (4.2.1-17) into Equation (4.2.1-18), we get the Solow model in levels.

$$\ln y_t^* = \frac{\alpha}{1-\alpha} \ln s^k - \frac{\alpha}{1-\alpha} \ln (n + g + \delta) \quad (4.2.1-19)$$

where s is the fraction of resources devoted to physical capital, n is the rate of population (or labour force) growth, g is the rate of growth in technology (or technological progress), δ is the rate of depreciation.

If we consider Equation (4.2.1-4) in the form of Equation (4.2.1-21), we can have steady-state income per capita by using the following steps:

$$y_t = (k_t)^\alpha \quad (4.2.1-4)$$

$$\frac{Y_t}{A_t L_t} = (k_t)^\alpha \quad (4.2.1-20)$$

$$\frac{Y_t}{L_t} = A_t (k_t)^\alpha \quad (4.2.1-21)$$

where $y_t^* = \left(\frac{Y_t}{L_t} \right)^*$

Taking logs both sides of Equation (4.2.1-21), we get:

$$\ln \left(\frac{Y_t}{L_t} \right)^* = \ln A_t + \alpha \ln k_t$$

where $A_t = A_0 e^{g t}$

$$\begin{aligned} \ln \left(\frac{Y_t}{L_t} \right)^* &= \ln A_0 (0) + g t + \alpha \ln \left(\frac{s^k}{n + g + \delta} \right)^{1/\alpha} \\ \ln \left(\frac{Y_t}{L_t} \right)^* &= \ln A_0 + g t + \frac{\alpha}{1-\alpha} \ln s^k - \frac{\alpha}{1-\alpha} \ln (n + g + \delta) \end{aligned} \quad (4.2.1-22)$$

Equation (4.2.1-22) indicates steady-state income per capita. The central prediction of the Solow model concerns the impact of saving and population growth on real income. This equation also indicates steady-state labour productivity.

To determine the Solow growth model, we need to find the speed of convergence to the steady-state. First, we focus on the behaviour of k rather than y to define how rapidly k approaches k^* . By omitting t , we know that $\dot{k}$ is determined by k , so we can write $\dot{k} = \dot{k}(k)$ and when k equals k^* , $\dot{k}$ is zero.

Now, we can use approximations around the steady-state to find the speed of convergence by using the Taylor series formula:

The Taylor series formula is:

$$f(x) = \frac{f(x_0)}{0!} + \frac{f'(x_0)}{1!}(x - x_0) + \frac{f''(x_0)}{2!}(x - x_0)^2 + \dots$$

The first-order Taylor-series approximation of $\dot{k}(k)$ around $k = k^*$ is:

$$\dot{k} = \left(\frac{\partial \dot{k}(k)}{\partial k} \Big|_{k=k^*} \right) (k - k^*) \quad (4.2.1-23)$$

We differentiate expression (4.2.1-13) with respect to k and evaluate at $k=k^*$ to get:

$$\frac{\partial \dot{k}(k)}{\partial k} \Big|_{k=k^*} = s f'(k^*) - (n + g + \delta) \quad (4.2.1-24)$$

From Equation (4.2.1-13) when $\dot{k} = 0$

$$s = \frac{(n + g + \delta)k^*}{f(k^*)} \quad (4.2.1-25)$$

Substituting (4.2.1-25) into (4.2.1-24), we get:

$$\frac{\partial \dot{k}(k)}{\partial k} = \frac{(n + g + \delta)k^* f'(k^*)}{f(k^*)} - (n + g + \delta) \quad (4.2.1-26)$$

where $\alpha_k(k^*) = \frac{f'(k^*)}{f(k^*)}$

Rearranging Equation (4.2.1-26), yields:

$$(\alpha_k(k^*) - 1)(n + g + \delta) \quad (4.2.1-27)$$

Equation (4.2.1-27) indicates the rate of convergence in the Solow model and substituting Equation (4.2.1-27) into Equation (4.2.1-23), we have the first-order Taylor-series as follows:

$$\dot{k} = -[1 - \alpha_k(k^*)][n + g + \delta][k - k^*] \quad (4.2.1-28)$$

Now if we define $x = k - k^*$ and $\lambda = (1 - \alpha_k)(n + g + \delta)$, Equation (4.2.1-28) implies that the growth rate of x is constant and equals $-\lambda$, ($\dot{x} = -\lambda x$). Therefore we can write a formula for the path of x as follows:

$$x = x(0)e^{-\lambda t} \quad (4.2.1-29)$$

Equation (4.2.1-29) can be written in terms of k in the following form:

$$k - k^* = e^{-(1-\alpha_k)(n+g+\delta)t} (k(0) - k^*) \quad (4.2.1-30)$$

Equation (4.2.1-30) can be formulated in terms of y . To do this, we can provide the following steps between Equation (4.2.1-31) and (4.2.1-36);

Taking logs for both sides of Equation (4.2.1-30), yields:

$$\ln k - \ln k^* = -\lambda (\ln k(0) - \ln k^*) \quad (4.2.1-31)$$

From Equation (4.2.1-21), we know:

$$\frac{Y}{AL} = k^\alpha \text{ or } \frac{Y}{L} = A k^\alpha \text{ (Omitting index t)}$$

where $\left(\frac{Y}{L}\right)^* = y^*$

$$y^* = A k^\alpha \quad (4.2.1-32)$$

Taking logs and derivatives with respect to time (t) of Equation (4.2.1-32), we get:

$$\ln y - \ln y^* = g + \alpha (\ln k - \ln k^*) \quad (4.2.1-33)$$

Substituting Equation (4.2.1-31) into Equation (4.2.1-33), we get:

$$\ln y - \ln y^* = g - \alpha \lambda (\ln k(0) - \ln k^*) \quad (4.2.1-34)$$

To rearrange Equation (4.2.1-34), we can take logs and derivatives with respect to time (t) of Equation (4.2.1-4):

$$\ln y(0) - \ln(y^*) = \alpha (\ln k(0) - \ln k^*) \quad (4.2.1-35)$$

Plugging Equation (4.2.1-35) into Equation (4.2.1-34), we get Equation (4.2.1-36) as follows:

$$\ln y - \ln y^* = g - \lambda (\ln y(0) - \ln y^*) \quad (4.2.1-36)$$

Equation (4.2.1-36) implies that $\ln(y)$ approaches $\ln(y^*)$ exponentially, thus Equation (4.2.1-36) takes the form of the following equation, (Equation (4.2.1-37) - Equation (4.2.1-40))

$$\ln y - \ln y^* = g + e^{-\lambda t} (\ln y(0) - \ln y^*) \quad (4.2.1-37)$$

Adding $\ln y^* - \ln y(0)$ to the both sides of Equation (4.2.1-37), yields an expression for the growth of income, (see Equation 4.2.1-38).

$$\begin{aligned} \ln y - \ln y^* + \ln y^* - \ln y(0) &= g + e^{-\lambda t} \ln y(0) - e^{-\lambda t} \ln y^* + \ln y^* - \ln y(0) \\ \ln y - \ln y(0) &= g + \ln y(0) (e^{-\lambda t} - 1) - \ln y^* (e^{-\lambda t} - 1) \\ \ln y - \ln y(0) &= g + (e^{-\lambda t} - 1)(\ln y(0) - \ln y^*) \end{aligned}$$

$$\ln y - \ln y(0) = g + (1 - e^{-\lambda t}) (\ln y^* - \ln y(0)) \quad (4.2.1-38)$$

Finally, we can substitute Equation (4.2.1-22) into Equation (4.2.1-38) to get Equation (4.2.1-40), which shows labour productivity or steady-state income per capita.

$$\begin{aligned} \ln y - \ln y(0) &= g + (1 - e^{-\lambda t}) \left[\ln A_0 + gt + \frac{\alpha}{1-\alpha} \ln s^k - \frac{\alpha}{1-\alpha} \ln(n + g + \delta) \right] \\ &\quad - (1 - e^{-\lambda t}) \ln y(0) \end{aligned} \quad (4.2.1-39)$$

we can rearrange Equation (4.2.1-39) as follows:

$$\ln y - \ln y(0) = g + (1 - e^{-\lambda t}) \left[\ln A_0 + gt + \frac{\alpha}{1-\alpha} \ln s^k - \frac{\alpha}{1-\alpha} \ln(n + g + \delta) - \ln y(0) \right] \quad (4.2.1-40)$$

Following Mankiw *et al.* (1992), Durlauf and Johnson (1992), Islam (1995), Cellini (1997), s_t^k and n_t can be assumed to vary over time. The level of steady-state income can vary over time in economies that converge. Around the steady-state path, labour productivity or steady-state income per capita evolves according to the following equation:

$$\ln y_{t+1} - \ln y_t = g + (1 - e^{-\lambda_t}) \left[\ln A_0 + gt + \frac{\alpha}{1-\alpha} \ln s_t^k - \frac{\alpha}{\alpha-1} \ln(n_t + g + \delta) - \ln y_t \right] \quad (4.2.1-41)$$

where $\lambda_t = (n_t + g + \delta)(1 - \alpha)$.

As Cellini (1997) says about the term inside of the square brackets in Equation (4.2.1-41), there is a difference between steady-state value of y_t and the current value of y_t so the subsequent labour productivity growth rate can be influenced by the sign and magnitude of this difference. He adds that the current productivity can rise in the next period when the current level of labour productivity is lower than its equilibrium level and vice-versa. This implies that movements of labour productivity lead to an error correction mechanism. It is worth noting that the speed of convergence, λ , is not constant because of the variability of the employment growth rate n . The coefficient $(1 - e^{-\lambda_t})$ measures the sensitivity of the growth rate of labour productivity to the difference between equilibrium and current level of productivity. If $\lambda = 0$ (or $\alpha = 1$), steady-state and the convergence mechanism do not exist.

Dropping the log-notation and collecting constants together, Equation (4.2.1-41) can be expressed as:

$$\begin{aligned} \Delta y_t &= c + \mu \left[y - A_0 - A_1 T - A_2 s^k - A_3 (n + g + \delta) \right]_{t-1} \\ \Delta y_t &= c + \left[y - y^* \right]_{t-1} \end{aligned} \quad (4.2.1-42)$$

where A_0 is a constant and T is a time trend.

Equation (4.2.1-42) indicates that the lagged difference between current and equilibrium levels of $\ln y_t$ determines the variation of $\ln y_t$ and this situation leads

to an error correction mechanism. The estimated error correction term μ should be negative and statistically significant. This means that $(-1 < \mu < 0)$.

Under these circumstances, the Solow growth model should be considered as an error correction model, although the original Solow growth model does not take into account the short-run components. However, there do exist short-run components, and if they are neglected, there could be a misspecification or biased estimation (see Stock, 1987 and Cellini, 1997).

To obtain the ECM, we can consider a time series, integrated of order 1 in terms of a vector such as $A = [A_1, A_2, \dots, A_n]$. If $Z = y - A_1 X_1, \dots, A_n X_n = y - A'x$ is stationary then $[y, x]$ are cointegrated with rank equal to 1. Granger's Representation Theorem (GRT) says if y and x are cointegrated, we can express y in the following way:

$$\Delta y = \mu (y - A'x)_{t-1} + b(L) \Delta x_t + \varepsilon_t \quad (4.2.1-43)$$

This equation indicates a standard linear error correction model, where $(y - A'x) = e$ is the residuals from the long-run equilibrium relationship. $b(L) \Delta x$ captures the short-run components of Δy and ε is a white noise process.

In the case of the Engle-Granger two step procedure, Banerjee et al. (1986) argue that ignoring lagged and differenced terms in a static equation may lead to substantial biases in an estimation. They propose an unrestricted error correction model which incorporates all dynamics. Hendry advocates this method in several papers and suggests that this may start with a sufficient large number of lags and progressively to simplify it (i.e. Hendry's general-to-specific modelling strategy). We therefore, combine the two notions mentioned above to obtain an ECM with respect to Equation (4.2.1-43) as follows: (see also Gilbert, 1986; and Miller 1991; Maddala and Kim, 1998).

$$\Delta \ln y_t = c_0 + \mu e_{t-1} + \sum_{i=0}^m \phi_i \Delta \ln s_{t-i}^k + \sum_{k=0}^r \pi_k \Delta \ln (n_{t-k} + g + \delta) + \varepsilon_t \quad (4.2.1-44)$$

where Δ denotes first differences and others are defined as before.

4.2.2 The Augmented Solow Growth Model: Adding Human-capital accumulation to the Solow growth Model

In this section, we analyse the effects of human capital accumulation to the Solow model. We augmented the Solow growth model adding this factor for two reasons: (i) human capital accumulation might be correlated with saving rates and population growth rates. This means that omitting⁴⁹ this factor may provide biased coefficients on saving and population growth rates. (ii) When the human capital accumulation rate is not taken into account, physical capital accumulation and population growth rates may seem to have greater impact on output. Many authors provide evidence of the importance of human capital for economic growth [See Mankiw *et al.* (1992), Azaridis and Drazen (1990), Romer (1986; 1990c) and Lucas (1988)].

Following Mankiw *et al.* (1992) and Cellini (1997), we consider the following constant returns to scale production function including a human capital factor in which the Inada conditions hold:

$$Y_t = K_t^\alpha H_t^\beta (A_t L_t)^{1-\alpha-\beta} \quad (4.2.2-1)$$

where H is the stock of human capital and all other variables are defined as before.

The assumption of constant returns allows us to work with the production function in intensive form:

$$y_t = k_t^\alpha h_t^\beta \quad (4.2.2-2)$$

where $\frac{Y_t}{A_t L_t} = y_t$, $\frac{K_t}{A_t L_t} = k_t$, $\frac{H_t}{A_t L_t} = h_t$

Now, we can define the net increase in the stock of both physical and human capital at a point in time to be equal to gross investment less depreciation. Physical capital has already been discussed in the previous section. Human capital can be formulated in the same way as physical capital.

⁴⁹ See our empirical results for the Solow growth model which justify this statement in section 4.3.

This factor grows according to the following equation:

$$\dot{H}_t = I_t - \delta H_t \quad (4.2.2-3)$$

where δ is the rate of depreciation, $I_t = s_H Y_t$, I_t is investment and s_H is a constant saving rate for human capital accumulation.

If we rearrange Equation (4.2.2-3), we have the following equation:

$$\dot{H}_t = s_H Y_t - \delta H_t \quad (4.2.2-4)$$

Where s_H is the fraction of output devoted to human capital accumulation.

Now, we substitute Equation (4.2.2-1) into Equation (4.2.2-4) to get:

$$\dot{H}_t = s K_t^\alpha H_t^\beta (A_t L_t)^{1-\alpha-\beta} - \delta H_t \quad (4.2.2-5)$$

Dividing Equation (4.2.2-5) by $A_t L_t$, we get Equation (4.2.2-6):

$$\begin{aligned} \frac{\dot{H}_t}{A_t L_t} &= \frac{s K_t^\alpha H_t^\beta (A_t L_t)^{1-\alpha-\beta}}{A_t L_t} - \delta \frac{H_t}{A_t L_t} \\ \frac{\dot{H}_t}{A_t L_t} &= \frac{s K_t^\alpha H_t^\beta}{A_t L_t (A_t L_t)^{\alpha+\beta-1}} - \delta \frac{H_t}{A_t L_t} \\ \frac{\dot{H}_t}{A_t L_t} &= s \left(\frac{K_t}{A_t L_t} \right)^\alpha \left(\frac{H_t}{A_t L_t} \right)^\beta - \delta \frac{H_t}{A_t L_t} \\ \frac{\dot{H}_t}{A_t L_t} &= s (k_t)^\alpha (h_t)^\beta - \delta h_t \end{aligned} \quad (4.2.2-6)$$

Equation (4.2.2-6) indicates that economic growth may arise from the accumulation of human capital. The capital stock per efficiency unit h_t evolves as follows:

To find out $\frac{\dot{h}_t}{h_t}$, we need to apply chain rule:

$$\dot{h}_t = \frac{\partial h_t}{\partial H_t} \dot{H}_t + \frac{\partial h_t}{\partial L_t} \dot{L}_t + \frac{\partial h_t}{\partial A_t} \dot{A}_t \quad (4.2.2-7)$$

where $h_t = \frac{H_t}{A_t L_t}$

$$\dot{h}_t = \frac{1}{A_t L_t} \dot{H}_t - \frac{H_t}{A_t L_t^2} \dot{L}_t - \frac{H_t}{L_t A_t^2} \dot{A}_t \quad (4.2.2-8)$$

$$\dot{h}_t = \frac{\dot{H}_t}{A_t L_t} - \frac{H_t}{A_t L_t} \frac{\dot{L}_t}{L_t} - \frac{H_t}{A_t L_t} \frac{\dot{A}_t}{A_t} \quad (4.2.2-9)$$

where $\frac{\dot{H}_t}{A_t L_t} = s (k_t)^\alpha (h_t)^\beta - \delta h_t$, $\frac{\dot{L}_t}{L_t} = n$, $\frac{\dot{A}_t}{A_t} = g$

Plugging these expressions above into Equation (4.2.2-9), we get Equation (4.2.2-10):

$$\dot{h}_t = s (k_t)^\alpha (h_t)^\beta - \delta h_t - n h_t - g h_t \quad (4.2.2-10)$$

If we rearrange Equation (4.2.2-10), it yields:

$$\dot{h}_t = s (k_t)^\alpha (h_t)^\beta - (n + g + \delta) h_t \quad (4.2.2-11)$$

or

$$\dot{h}_t = s f(k_t, h_t) - (n + g + \delta) h_t$$

Dividing Equation (4.2.2-11) by h_t , we get capital growth as follow:

$$\frac{\dot{h}_t}{h_t} = \frac{s (k_t)^\alpha (h_t)^\beta}{h_t} - (n + g + \delta) \frac{h_t}{h_t} \quad (4.2.2-12)$$

If we rearrange Equation (4.2.2-12), we get:

$$\frac{\dot{h}_t}{h_t} = s (k_t)^\alpha (h_t)^{\beta-1} - (n + g + \delta) \quad (4.2.2-13)$$

where all variables are defined as before. Equation (4.2.2-13) implies that h_t converges to a steady- state value h_t^* when $\dot{h}_t = 0$. This yields:

$$0 = s^H (k^*)^\alpha (h^*)^{\beta-1} - (n + g + \delta) \quad (\text{index } t \text{ is omitted})$$

$$\begin{aligned}
 (k^*)^\alpha &= \frac{(n+g+\delta)(h^*)^{1-\beta}}{s^H} \\
 k^* &= \frac{(n+g+\delta)^{1/\alpha} (h^*)^{1-\beta/\alpha}}{(s^H)^{1/\alpha}} \quad (4.2.2-14)
 \end{aligned}$$

By using Equation (4.2.2-13), we can write the following equation for $\frac{\dot{k}_t}{k_t}$

$$\frac{\dot{k}_t}{k_t} = s (k_t)^{\alpha-1} (h_t)^\beta - (n+g+\delta) \quad (4.2.2-15)$$

The steady-state implied by Equation (4.2.2-15) is:

$$\begin{aligned}
 0 &= s (k_t)^{\alpha-1} (h_t)^\beta - (n+g+\delta) \\
 (k^*)^{\alpha-1} &= \frac{(n+g+\delta)(h^*)^{-\beta}}{s^K} \quad (t \text{ is omitted}) \\
 k^* &= \frac{(n+g+\delta)^{1/\alpha-1} (h^*)^{-\beta/\alpha-1}}{(s^K)^{1/\alpha-1}} \quad (4.2.2-16)
 \end{aligned}$$

Equation (4.2.2-14) and (4.2.2-16) can be equated to each other in order to get steady-state values of h and k in the following steps:

$$\begin{aligned}
 \frac{(n+g+\delta)^{1/\alpha} (h^*)^{1-\beta/\alpha}}{(s^H)^{1/\alpha}} &= \frac{(n+g+\delta)^{1/\alpha-1} (h^*)^{-\beta/\alpha-1}}{(s^K)^{1/\alpha-1}} \\
 (h^*)^{-(1-\beta)/\alpha} (h^*)^{-\beta/\alpha-1} &= \frac{(s^K)^{1/\alpha-1} (s^H)^{-1/\alpha}}{(n+g+\delta)^{1/\alpha-1} (n+g+\delta)^{-1/\alpha}} \\
 (h^*)^{1-\alpha-\beta/\alpha(\alpha-1)} &= \frac{(s^K)^{1/\alpha-1} (s^H)^{-1/\alpha}}{(n+g+\delta)^{1/\alpha(\alpha-1)}} \\
 h^* &= \left(\frac{(s^K)^{1/\alpha-1} (s^H)^{-1/\alpha}}{(n+g+\delta)^{1/\alpha(\alpha-1)}} \right)^{\alpha(\alpha-1)/1-\alpha-\beta}
 \end{aligned}$$

$$h^* = \left(\frac{(s^K)^\alpha (s^H)^{1-\alpha}}{(n+g+\delta)} \right)^{1/(1-\alpha-\beta)} \quad (4.2.2-17)$$

Equation (4.2.2-17) indicates the steady-state value of h . In order to find out the steady-state value of k , we can substitute Equation (4.2.2-17) into Equation (4.2.2-16) as follows:

$$\begin{aligned} k^* &= \left(\frac{(n+g+\delta)^{1/\alpha-1}}{(s^K)^{1/\alpha-1}} \right) \left\{ \left(\frac{(s^K)^\alpha (s^H)^{1-\alpha}}{(n+g+\delta)} \right)^{1/(1-\alpha-\beta)} \right\}^{-\beta/\alpha-1} \\ k^* &= \left(\frac{(n+g+\delta)^{1/\alpha-1}}{(s^K)^{1/\alpha-1}} \right) \left(\frac{(s^K)^{-\beta\alpha/(1-\alpha-\beta)(\alpha-1)} (s^H)^{\beta/(1-\alpha-\beta)}}{(n+g+\delta)^{-\beta/(1-\alpha-\beta)(\alpha-1)}} \right) \\ k^* &= \frac{(s^K)^{-1/\alpha-1} (s^K)^{-\beta\alpha/(1-\alpha-\beta)(\alpha-1)} (s^H)^{-\beta/(1-\alpha-\beta)(\alpha-1)}}{(n+g+\delta)^{-1/\alpha-1} (n+g+\delta)^{-\beta/(1-\alpha-\beta)(\alpha-1)}} \\ k^* &= \frac{(s^K)^{1-\beta/(1-\alpha-\beta)} (s^H)^{\beta/(1-\alpha-\beta)}}{(n+g+\delta)^{1/(1-\alpha-\beta)}} \\ k^* &= \left(\frac{(s^K)^{1-\beta} (s^H)^\beta}{(n+g+\delta)} \right)^{1/(1-\alpha-\beta)} \quad (4.2.2-18) \end{aligned}$$

Equation (4.2.2-18) indicates steady-state value of k . To obtain output y^* , we substitute equation (4.2.2-17) and (4.2.2-18) into Equation (4.2.2-2) as below:

$$y^* = (k^*)^\alpha (h^*)^\beta \quad (\text{it is omitted}) \quad (4.2.2-2)$$

$$\begin{aligned} y^* &= \left[\left(\frac{(s^K)^{1-\beta} (s^H)^\beta}{n+g+\delta} \right)^{1/(1-\alpha-\beta)} \right]^\alpha \left[\left(\frac{(s^K)^\alpha (s^H)^{1-\alpha}}{n+g+\delta} \right)^{1/(1-\alpha-\beta)} \right]^\beta \\ y^* &= \left[\frac{(s^K)^{(1-\beta)\alpha} (s^H)^{\beta\alpha}}{(n+g+\delta)^\alpha} \frac{(s^K)^{\alpha\beta} (s^H)^{(1-\alpha)\beta}}{(n+g+\delta)^\beta} \right]^{1/(1-\alpha-\beta)} \\ y^* &= \left[\frac{(s^K)^\alpha (s^H)^\beta}{(n+g+\delta)^{\alpha+\beta}} \right]^{1/(1-\alpha-\beta)} \quad (4.2.2-19) \end{aligned}$$

Equation (4.2.2-19) shows the steady-state value of y .

Taking logs both sides of Equation (4.2.2-19), we obtain the Augmented Solow model in level as follows:

$$\ln y^* = \frac{\alpha}{1-\alpha-\beta} \ln s^K + \frac{\beta}{1-\alpha-\beta} \ln s^H - \frac{\alpha+\beta}{1-\alpha-\beta} \ln(n+g+\delta) \quad (4.2.2-20)$$

If we consider Equation (4.2.2-2) as the form of Equation (4.2.2-21), we will have Equation (4.2.2-22), i.e. steady-state income per capita or labour productivity.

$$\begin{aligned} \frac{Y_t}{A_t L_t} &= (k_t)^\alpha (h_t)^\beta \\ \frac{Y_t}{L_t} &= A_t (k_t)^\alpha (h_t)^\beta \end{aligned} \quad (4.2.2-21)$$

where $y_t^* = \left(\frac{Y_t}{L_t} \right)^*$

Taking logs both sides of Equation (4.2.2-21), we get:

$$\ln \left(\frac{Y}{L} \right)^* = \ln A + \alpha \ln k^* + \beta \ln h^* \quad (\text{t is omitted})$$

where $A = A(0)e^{gt}$

$$\ln \left(\frac{Y}{L} \right)^* = \ln A_0 + gt + \frac{\alpha}{1-\alpha-\beta} \ln s^K + \frac{\beta}{1-\alpha-\beta} \ln s^H - \frac{\alpha+\beta}{1-\alpha-\beta} \ln(n+g+\delta) \quad (4.2.2-22)$$

To determine the Augmented Solow growth model, we need to find the transitional dynamics by using a log-linearization of Equations (4.2.2-13) and (4.2.2-15) around the steady-state. This gives the speed of convergence. To do this, we take a first order Taylor approximation of the expressions for $\dot{k}$ and $\dot{h}$ around $\ln k = \ln k^*$ and $\ln h = \ln h^*$.

Recall equations $y = k^\alpha h^\beta$ (4.2.2-2)

$$\frac{\dot{k}}{k} = s^K k^{\alpha-1} h^\beta - (n + g + \delta) \quad (4.2.2-15)$$

$$\frac{\dot{h}}{h} = s^H k^\alpha h^{\beta-1} - (n + g + \delta) \quad (4.2.2-13)$$

The Taylor series formula for $\frac{\dot{k}}{k}$ is as follows:

$$\frac{\dot{k}}{k} = f(k^*, h^*) + f'_k(k - k^*) + f'_h(h - h^*)$$

It is worth noting that we do not take into account the first term because it is zero. (i.e. $f(k^*, h^*) = 0$). We then start from the second term as follows:

$$\left. \frac{\partial \dot{k}}{\partial k} \right|_{k^*=0} = [(\alpha - 1) s^K (k^*)^{\alpha-1} (h^*)^\beta] (k - k^*) + [\beta s^K (k^*)^{\alpha-1} (h^*)^\beta] (h - h^*)$$

where $s^K = \left(\frac{(n + g + \delta) h^{-\beta}}{(k)^{\alpha-1}} \right)$, $s^H = \left(\frac{(n + g + \delta) h^{1-\beta}}{(k)^\alpha} \right)$

Substitute s^K into the Equation above to get:

$$\left. \frac{\partial \dot{k}}{\partial k} \right|_{k^*=0} = \left[\frac{(\alpha - 1) (n + g + \delta) (k^*)^{\alpha-1} (h^*)^\beta (h^*)^{-\beta}}{(k^*)^{\alpha-1}} \right] (k - k^*) + \left[\frac{\beta (n + g + \delta) (k^*)^{\alpha-1} (h^*)^\beta (h^*)^{-\beta}}{(k^*)^{\alpha-1}} \right] (h - h^*)$$

$$\frac{\dot{k}}{k} = [(\alpha - 1)(n + g + \delta)](k - k^*) + [\beta (n + g + \delta)](h - h^*) \quad (4.2.2-23)$$

The Taylor series formula for $\frac{\dot{h}}{h}$ is:

$$\frac{\dot{h}}{h} = f(k^*, h^*) + f'_k(k - k^*) + f'_h(h - h^*)$$

where $f(k^*, h^*) = 0$

$$\left. \frac{\partial \dot{h}}{\partial h} \right|_{h^*=0} = \left[\alpha s^H (k^*)^\alpha (h^*)^{\beta-1} \right] (k - k^*) + \left[(\beta - 1) s^H (k^*)^\alpha (h^*)^{\beta-1} \right] (h - h^*)$$

Substitute s^H into the Equation above;

$$\left. \frac{\partial \dot{h}}{\partial h} \right|_{h^*=0} = \left[\frac{\alpha (n+g+\delta)(k^*)^\alpha (h^*)^{\beta-1} (h^*)^{1-\beta}}{(k^*)^\alpha} \right] (k - k^*) + \left[\frac{(\beta-1)(n+g+\delta)(k^*)^\alpha (h^*)^{\beta-1} (h^*)^{1-\beta}}{(k^*)^\alpha} \right] (h - h^*)$$

$$\frac{\dot{h}}{h} = [\alpha (n+g+\delta)] (k - k^*) + [\beta - 1 - (n+g+\delta)] (h - h^*) \quad (4.2.2-24)$$

Having taken log and derivatives with respect to time (t) of Equation (4.2.2-2), we get the following form:

$$y = k^\alpha h^\beta \quad (4.2.2-2)$$

$$\frac{\partial(\ln y)}{\partial t} = \alpha \frac{\partial(\ln k)}{\partial t} + \beta \frac{\partial(\ln h)}{\partial t} \quad \text{or}$$

$$\frac{\partial(\ln y)}{\partial t} = \alpha \frac{\dot{k}}{k} + \beta \frac{\dot{h}}{h}$$

These Equations can be written in the following form:

$$\ln \left(\frac{y}{y^*} \right) = \alpha \ln \frac{\dot{k}}{k^*} + \beta \ln \frac{\dot{h}}{h^*}$$

or

$$\ln(y - y^*) = \alpha (\ln k - \ln k^*) + \beta (\ln h - \ln h^*) \quad (4.2.2-25)$$

If we plug Equations (4.2.2-23) and (4.2.2-24) into Equation (4.2.2-25), we have the speed of convergence rate as follows:

$$\begin{aligned} \ln(y - y^*) = & \alpha [(\alpha - 1)(n + g + \delta) (k - k^*) + \beta (n + g + \delta)(h - h^*)] \\ & + \beta [\alpha (n + g + \delta)(k - k^*) + (\beta - 1)(n + g + \delta)(h - h^*)] \end{aligned}$$

$$\begin{aligned} \ln(y - y^*) = & [\alpha (\alpha - 1)(n + g + \delta) + \beta \alpha (n + g + \delta)] (k - k^*) \\ & + [\alpha \beta (n + g + \delta) + \beta (\beta - 1)(n + g + \delta)] (h - h^*) \end{aligned}$$

$$\ln(y - y^*) = (n + g + \delta) [(\alpha + \beta - 1)\alpha](k - k^*) + (n + g + \delta) [(\alpha + \beta - 1)\beta](h - h^*)$$

$$\ln(y - y^*) = (n + g + \delta)(\alpha + \beta - 1)[\alpha(k - k^*) + \beta(h - h^*)]$$

where $-(1 - \alpha - \beta)(n + g + \delta) = -\lambda$

$$\ln(y - y^*) = (-\lambda) [\alpha(k - k^*) + \beta(h - h^*)]$$

$$\ln(y - y^*) = (-\lambda) [\ln y(0) - \ln y^*]$$

where $\ln y(0) - \ln y^* = [\alpha(k - k^*) + \beta(h - h^*)]$

$$\ln y - \ln y^* = -\lambda (\ln y(0) - \ln y^*) \quad (4.2.2-26)$$

If we rearrange Equation (4.2.2-26) regarding to Equation (4.2.1-36), we have Equation (4.2.2-27):

$$\ln y - \ln y^* = g - \lambda (\ln y(0) - \ln y^*) \quad (4.2.2-27)$$

Equation (4.2.2-27) indicates that $\ln y$ approaches $\ln y^*$ exponentially. So;

$$\ln y - \ln y^* = g + e^{-\lambda t} (\ln y(0) - \ln y^*) \quad (4.2.2-28)$$

Adding $\ln y^* - \ln y(0)$ to the both sides of Equation (4.2.1-37) yields an expression for the growth of income:

$$\ln y - \ln y(0) = g + (1 - e^{-\lambda t}) (\ln y^* - \ln y(0)) \quad (4.2.2-29)$$

Finally, we substitute Equation (4.2.2-22) into Equation (4.2.2-29) to get the relevant growth equation as below:

$$\begin{aligned} \ln y - \ln y(0) = & g + (1 - e^{-\lambda t}) \left[\ln A_0 + gt + \frac{\alpha}{1 - \alpha - \beta} \ln s^K + \frac{\beta}{1 - \alpha - \beta} \ln s^H \right. \\ & \left. - \frac{\alpha + \beta}{1 - \alpha - \beta} \ln (n + g + \delta) - \ln y(0) \right] \end{aligned} \quad (4.2.2-30)$$

Now, if we use the same information as mentioned earlier (see section 4.2.1), we have the following equation, which indicates steady-state per capita income, or labour productivity evolving around the steady-state path.

$$\ln y_{t+1} - \ln y_t = g + (1 - e^{-\lambda_t}) \left[\ln A_0 + gt + \frac{\alpha}{1 - \alpha - \beta} \ln s_t^K + \frac{\beta}{1 - \alpha - \beta} \ln s_t^H - \frac{\alpha + \beta}{1 - \alpha - \beta} \ln(n_t + g + \delta) - \ln y_t \right] \quad (4.2.2-31)$$

where $\lambda_t = (n_t + g + \delta)(1 - \alpha - \beta)$

As we mentioned in the previous section, Equation (4.2.2-31) can be formulated in the linear form by omitting log terms:

$$\begin{aligned} \Delta y_t &= c + \mu \left[y - A_0 - A_1 T - A_2 s^K - A_3 s^H - A_4 (n + g + \delta) \right]_{t-1} \\ \Delta y_t &= c + \mu \left[y - y^* \right]_{t-1} \end{aligned} \quad (4.2.2-32)$$

Equation (4.2.2-32) leads an error correction mechanism as we explained in the previous section. We then obtain our modified ECM regarding Equation (4.2.1-43) as follows:

$$\Delta \ln y_t = c_0 + \mu e_{t-1} + \sum_{i=0}^m \phi_i \Delta \ln s_{t-i}^K + \sum_{j=0}^p \eta_j \Delta \ln s_{t-j}^H + \sum_{k=0}^r \pi_k \Delta \ln(n_{t-k} + g + \delta) + \varepsilon_t \quad (4.2.2-33)$$

where all variables are defined as before.

4.3 The Empirical Methodology, Model and Data

Using annual data⁵⁰ for Cyprus over the period 1960-1995, we investigate the evidence of the Solow and the Augmented Solow growth models employing appropriate estimation methods.

⁵⁰ We estimate the matrices of correlation coefficients of the relevant variables which are based on each model used in this thesis (see appendix chapter A for details).

We apply multivariate co-integration techniques to highlight both the long-run and the short-run influences on the economic growth of Cyprus in the models for which the steady-state (based on Equations (4.2.1-22) and (4.2.2-22)) is represented by Equations (4.3.1) and (4.3.2).

$$LCAPL_t = a_0 + a_1 T + a_2 LKR_t + a_3 LNGD_t + a_4 VDUM_t + u_t \quad (4.3-1)$$

$$LCAPL_t = b_0 + b_1 T + b_2 LKR_t + b_3 LHR_t + b_4 LNGD_t + b_5 VDUM_t + v_t \quad (4.3-2)$$

where⁵¹

$LCAPL_t$ = Real gross domestic product, (GDP), per worker⁵² at constant prices of 1980, (C£).

LKR_t = The real gross domestic fixed capital formation to GDP ratio is used as a proxy for the real investment to GDP ratio (investment share in GDP).

LHR_t = Third level (or tertiary) enrolment rates: This proxy refers the ratio of the number of students enrolled at universities (abroad and home) and at post-secondary institutes to the total number of workers. Post-secondary education institutes include the higher technical institute, the forestry college, the school of nursing, the Mediterranean institute of management, and the higher hotel and catering institute, which are below the university degree level. University education is mainly pursued abroad because the Cyprus University was established in the academic year 1992/93.

$LNGD_t$ = is the empirical counterpart of $\log(n_1 + g + \delta)$. That is the log of the sum of the labour (or worker) growth rate plus the estimation of technological progress rate plus the depreciation rate ($g + \delta = 0.05$ is assumed)⁵³.

⁵¹ The data are obtained from the various issues of the Department of Statistics and Research Institute, Ministry of Finance, Nicosia, Cyprus.

⁵² In the existing literature, It is believed that GDP per worker has more explanatory power than GDP per capita because it reflects working population rather than whole population.

⁵³ We follow Mankiw et al. (1992) in assuming that $(g+\delta)$ is equal to 0.05.

VDUM = A vector of Dummy Variables which contains the following dummies:

DUM64 = A dummy variable is used to capture the effects due to intercommunal conflict. This dummy variable takes the value of one for 1964 and zero otherwise.

DUM74 = A dummy variable that takes into account the war effects. This dummy variable takes the value of one for the war situation, 1974 and zero otherwise.

u_t and v_t are serially uncorrelated, with zero mean and constant variance disturbance and L denotes the natural logarithm.

Before explaining the methodologies used in this study, it is worth to note that human capital investment and education play crucial role to stimulate economic growth, especially, in developing countries (see Alderman et al. 1996). Most cross-section studies commonly use secondary enrolment rate as human capital proxy rather than using the other proxies such as tertiary, R&D and expenditure on education due to data limitations. A common question arises here: Are these proxies the correct measurement of human capital and do they accord with theoretical concept? However it is really hard to answer these questions because the existing literature is still unresolved on the issue of the correct measurement of human capital.

In this thesis, we actually use four different (alternative) human capital proxies in the relevant models. In turn, these are secondary (general), secondary (technical and vocational), tertiary enrolment (university plus post secondary) rates and expenditure on education. We empirically investigate the four different human capital proxies one by one in the models, however we found out that tertiary enrolment rate only have significant impact on output growth whilst the others have no significant influence in the process of Cypriots' economic growth. This situation may stem from the tertiary enrolment rate itself because it is the combination of different types of human capital proxies which may partly reflect the correct measure for the Cypriots' economic growth. As mentioned before, this proxy not only consists of the number of students enrolled at universities but also

the number of students enrolled at different technical institutes and colleges which may directly give contribution to the growth process in the case of Cyprus.

Unlike Mankiw et al. (1992), Delong and Summer (1991; 1992), knight et al. (1993), and Islam (1995) suggest that their findings indicate that the secondary school enrolment rates are not a good proxy in estimating economic growth. Our findings on human capital proxy does not contradict with this part of existing empirical literature, notwithstanding this literature does not suffice to disentangle alternative interpretations of the correct measure of human capital in economic growth process.

In the next step, we first examine the stationary properties⁵⁴ of our data using the Augmented Dickey-Fuller (ADF)⁵⁵ and the Multivariate Augmented Dickey Fuller (MADF)⁵⁶ unit root tests proposed by Dickey and Fuller (1979; 1981) and Johansen and Juselius (1992) respectively.

Then we proceed to investigate whether the time series are ‘difference stationary processes’ (DSP), against the alternative of ‘Trend Stationary processes’ (TSP), using a Dickey-Fuller LR joint test (or F-test) [See Dickey and Fuller, 1979 and 1981]. In other words, the test is used to examine whether the trend is stochastic or deterministic (see also Madalla, 1992:259-262).

⁵⁴ Nelson and Plosser (1982) point out that the data generating process (DGP) for most macroeconomic time series data consist of a unit root, which is commonly accepted in the relevant literature. However, the counterpart of this assumption argues that non-linear or segmented trend stationary might be a better alternative for the traditional one (See Kwiatkowski et al. 1992 and Lau and Sin 1997). In addition, Jones (1995) mentions that DGP with unit root still a useful hypothesis in applied studies.

⁵⁵ The ‘ADF’ command in Microfit includes the intercept term in the ADF equation. Therefore the corresponding critical values should take the intercept term into account. In addition to this, we included trend in levels, but we excluded it in first difference (Pesaran and Pesaran, 1997).

⁵⁶ See Coe and Moghadam (1993) for more details about the application of MADF.

With respect to the series, we observed a potential break in 1974 – the war effect. Any kind of structural break may cause biased results obtained from the ADF test. Hence, we utilise the additive outlier model (AOM) Perron test for unit roots to check the validity of the break. In other words, we test whether the order of integration is changed by the potential structural break. Omitting this phenomenon may create ‘spurious unit roots’. This test can be regarded as an improvement in time series procedure (see Perron, 1990).

We also use an alternative approach which is suggested by Zivot and Andrews (1992) (ZA). Unlike the Perron’s 1989 approach where the break date is determined a priori, the ZA approach treats the break date as endogenously determined.

On the basis of the results obtained from both the ADF and the MADF unit root tests, we test equations (4.3-1) and (4.3-2) by utilising the Engle-Granger (1987), and the Johansen (1988) cointegration procedures in order to estimate a long-run relation among the variables. Co-integrating analysis by Engle-Granger (1987) assumes only one co-integrating vector whereas the Johansen full information maximum likelihood (FIML) method provides (P-1) co-integration vectors⁵⁷. In addition, we use the Johansen method to test a number of restrictions on the estimated coefficients of the relevant factors of production after normalizing the co-efficient of output to -1 .

Having constructed our model(s) for the variables in hand, the long-run OLS estimates may still be biased if the explanatory variables are not weakly exogenous. This means that if the variables are not weakly exogenous, they cannot enter on the right side of the model as explanatory variables. In order to test for weak exogeneity⁵⁸, we use the Engle-Hendry-Richard (EHR) framework (1983) and the Johansen procedure (1992).

⁵⁷ P is the number of parameters used in a model (see appendix chapter C for more details for this).

⁵⁸ In both the Johansen and the EHR procedures, models are considered closed-form where all variables depend on one another (i.e. all variables are considered as endogenous). However, some certain variables can be treated as weakly exogenous for the estimation of the long-run relationship.

In order to establish the short-run relations among the variables embodied within equations (4.3-1) and (4.3-2), we utilise an error correction mechanism (ECM) estimated by ordinary least square (OLS), and derive the ECM using the residuals from the estimated co-integrating regressions for both equations (4.3-1) and (4.3-2) respectively ⁵⁹.

Thus,

$$\Delta LCAPL_t = a_0 + a_1 u_{t-1} + \sum_{i=0}^m a_i \Delta LKR_{t-i} + \sum_{k=0}^r a_k \Delta LNGD_{t-k} + \sum_{j=0}^n a_j \Delta D_{t-j} + \varepsilon_t \quad (4.3-3)$$

$$\Delta LCAPL_t = b_0 + b_1 v_{t-1} + \sum_{i=0}^m b_i \Delta LKR_{t-i} + \sum_{k=0}^r b_k \Delta LHR_{t-k} + \sum_{j=0}^n b_j \Delta LNGD_{t-j} + \sum_{p=0}^s b_p \Delta D_{t-p} + \varepsilon_t \quad (4.3-4)$$

Where u_{t-1} and v_{t-1} are the lagged estimated residual from Equations (4.3-1) and (4.3-2) respectively. LKR , LHR , $LNGD$, and dummy (D) are already defined in Equations (4.3-1) and (4.3-2) and Δ denotes the first differences.

It is worthwhile noting that the estimated error correction terms (i.e. u_{t-1} and v_{t-1}) should be negative and statistically significant in the short-run equations (4.3-3) and (4.3-4) with respect to the Granger Representation Theorem (GRT). Hence, negative and statistically significant error correction coefficients are a necessary condition for the variables in question to be co-integrated.

Furthermore, we employ three methods: the Engle and Yoo (1991) three-step correction method, the Inder (1993) fully modified error correction method and the Saikkonen (1991) time domain correction method to obtain unbiased long-run elasticity estimates.

Finally, having applied the Final Prediction Error (FPE) criterion to determine the optimal lag length for the variables, we employ the Granger-Causality (G-C) testing procedure, the Holmes-Hutton (HH) procedure, the Wald test and Sim's

⁵⁹According to the information given in section (4.2.1), we first construct a short-run ECM with one lag of each variable and eliminate those lags with insignificant parameter estimates. Then, we estimate restricted one to find out the most suitable model.

LR test to see whether there is a pattern to causal relationships among the variables⁶⁰.

4.4 Empirical Results

In order to construct long-run relationship among the variables, the EG and the Johansen cointegration procedure are employed⁶¹. Prior to modelling the relationships between the variables, the univariate time series properties⁶² are established. The results of the Augmented Dickey-Fuller (ADF) and the Multivariate Augmented Dickey-Fuller (MADF) test indicate that the variables in question – LCAPL, LKR, LHR, and LNGD – are all non-stationary in levels but stationary in first differences. In other words, the ADF and the MADF tests results for unit roots confirm that all variables are integrated of order one, $I(1)$ in levels but integrated of order zero in first differences (i.e. stationary in first differences). This situation is denoted as $LCAPL \sim I(1)$, $LKR \sim I(1)$, $LHR \sim I(1)$, and $LNGD \sim I(1)$ (see Common Tables A.5.1 and A.5.2 in Appendix Chapter A).

The next step is to examine the type of trend (i.e. stochastic or deterministic) in times series data. We then employ Dickey-Fuller LR joint test or (F-test)⁶³ to check whether the relevant series are DSP or TSP (see Dickey and Fuller, 1981). ‘Differencing’ for stochastic processes has been suggested to get rid of the trend and make them stationary. Thus the variables⁶⁴ in question are said to DSP (see Nelson and Plosser, 1982).

Common Table A.5.3 (in Appendix Chapter A) suggests that the test statistics, i.e. 2.43, 6.37, 2.45 and 3.39 seem to be too high to claim that we have a pure DSP process. In other words, it is more likely that we have a DSP dominant mixed process⁶⁵.

⁶⁰ It is noteworthy that we discuss the cost and benefits of all different methods why we use more than one for the same purpose.

⁶¹ All our estimations are carried out by Microfit 4.0 (Pesaran and Pesaran, 1997).

⁶² See footnote 54.

⁶³ This test is not the standard F-test (see appendix chapter C for more details about this test).

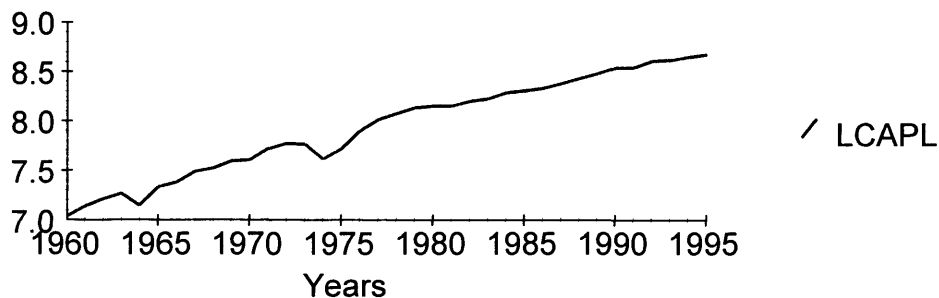
⁶⁴ The steady-state growth path for labour productivity seems to be a stochastic process with unit root due to the stochastic nature of the variables (See also King et al. 1991; Quah 1993; Cellini 1997). Our findings show this situation as we expected.

⁶⁵ For a similar comment, see Charemza and Deadman (1997, Chapter 5, p 90).

As regards to the dependent variable (i.e., LCAPL) for the period 1960-1995, we observed a decline after 1973 (see figure 4.4.1). This may be capturing a structural break on the variables for Cyprus economy. We then employ the Additive Outlier Perron test for unit roots with structural break (see Perron, 1990, Perron and Vogelsang, 1992)⁶⁶. The results presented in Common Table A.5.4 (See Appendix Chapter A) suggest that there are no ‘spurious roots’ resulting from structural breaks, which occurred in 1974.

It is important to stress that we investigate four possible break points. These are (i) intercommunal conflict in 1964, (ii) excluding Turkish Cypriots from the government due to the military conflict in 1967, (iii) the first Oil Crisis in 1973 and (iv) the war effect in 1974. We separately run the Perron test for the other possible break points (i.e. 1964, 1967 and 1973) for the variables under consideration. However, we only report the t-values for the break year 1974. Our unreported computations show that there are no ‘spurious roots’ created artificially by possible breaks occur in 1964, 1967 and 1973.

Figure 4.4.1 Gross Domestic Product per worker



However, Zivot and Andrews (1992) argue that Perron’s procedure involves ‘data mining’ by assuming that the data of the break year is known a priori. Hence, we use the ZA unconditional unit root test to confirm that the previous conclusion obtained from the Perron’s test is not contradicted by the ZA modification. The results in Common Table A.5.5 (in Appendix Chapter A) indicate that no series

⁶⁶ Perron (1990) suggests two types of models for test unit roots with structural break, the Additive Outlier Model (AOM) and the Innovation Outlier Model (IOM) respectively. The AOM is recommended for ‘sudden’ structural changes whilst the IOM is applied for ‘gradual’ structural changes. We believe that ‘sudden’ is more appropriate than ‘gradual’; we therefore prefer to use AOM in the case of Cyprus (see Ghatak et al, 1997; p 217 for a similar comment).

contain two unit roots. Based on the results of the four break years, the ZA test confirms that the break time minimizes t-values for 1964.

Before going a step further to analyse long-run relationship, we apply the EHR framework and the Johansen procedure to test for ‘weak exogeneity’ of the explanatory variables. The first part of Common Table A.5.6 (in Appendix Chapter A) shows that the hypothesis of weak exogeneity cannot be rejected at 10% level based on F-test whereas the second part of this table demonstrates that we can accept the null hypothesis of weak exogeneity of the explanatory variables (i.e. LKR, LHR, LNGD)⁶⁷ according to the test statistics of $x^2(k)$.

It should be noted that the Johansen weak exogeneity test for the explanatory variables are implemented separately rather than investigated in a system based framework⁶⁸.

4.4.1 The Engle-Granger Procedure

The next step is to test for co-integration between the relevant variables which are all I(1). We employ a residual-based⁶⁹ cointegration technique to test the existence of a long-run relationship among the variables. A sufficient condition for joint co-integration among the variables in a long-run regression is that the error term should be stationary. The residual based ADF test statistics for the error term ensure that we reject the null hypothesis of non-stationary (or no co-integration) at 5% significant level for both the Solow growth equation (4.3-1) and the Augmented Solow growth equation (4.3-2) (see Table 4.7.1 in section 4.7). The estimation results from the cointegration tests for models 1 and 2 (i.e., the Solow and the Augmented Solow models) presented in Table 4.7.2 (see section 4.7) indicate that there is evidence of a long-run relationship between labour productivity (LCAPL) and its determinants (the explanatory variables).

⁶⁷ Hall and Milne (1994); Mosconi and Giannini, (1993) find that saving rates and the rate of labour growth are weakly exogeneous in their studies.

⁶⁸ Boswijk and Franses (1992) investigate different techniques based on exogeneity assumption and they find that the Johansen procedure have higher power than the others which are based on single equation system (i.e. EHR).

⁶⁹ Haug (1993) suggests that Engle-Granger’s residual-based ADF test indicates the least size distortion among seven different residual-based cointegration tests based on Monte Carlo analysis.

As regards the cointegration regression equation for model 1, we can conclude that the corresponding critical values as a whole show that the underlying model is incorrectly specified⁷⁰. This means that the coefficients estimated for this model are inconsistent with the prediction of the Solow's model, notwithstanding that the estimated values are statistically significant and correctly signed which are presented in Table 4.7.2. In addition, based on the diagnostic test results, model 1 has a functional form problem (i.e. specification error). This implies that misspecification occurs due to omission of one or more explanatory variables that should have been included in the model⁷¹.

As a necessary fact, this situation provides a justification for the inclusion of human capital factor into the model (i.e. model 2) presented in Table 4.7.2. In this model the investment rate in physical and human capital as well as the rate of labor growth have the right sign and they are statistically significant. This means that they have a long-term impact on output growth (labour productivity)⁷². In addition to this, the investment rate in physical capital and the rate of labour growth have greater impact when the human capital factor is taken into account⁷³.

It should be noted that the estimated t-values in parentheses in model 2 have only a descriptive role to play since the variables are non-stationary. High R^2 suggests that our long-run OLS estimators are not substantially biased as $CRDW > R^2$ and the joint co-integration is ensured (Banarjee et al, 1993).

It is noteworthy that without the use of dummies, a cointegration relation among the variables has not been established. This situation provides a justification for the inclusion of dummy variables for both models. In turn, we use dummy variable for the year 1964, taking the value of 1 and 0 otherwise. The dummy

⁷⁰ Akaike information criterion (AIC) also confirms that model 2 is the one correctly specified.

⁷¹ Although model 1 is not correctly specified, we keep the model in its standard framework and then check the result found in the EG cointegration procedure by applying different techniques whether these techniques provide the same conclusion, whereas the EG procedure does. However, we mainly focus on model 2 due to the omitted variable bias (underfitting model) problem which occurred in model 1.

⁷² The coefficient of trend which is known as exogenous technological progress plays very crucial role in the growth process. Unlike Romer (1986) and Lucas (1988) who support the view that technology is an endogenous factor, we found evidence that exogenous technical progress accords well with the prediction of Solow growth model.

⁷³ See Mankiw et al. (1992) for a similar comment.

used for DUM64 represents the effects of the inter-communal conflict (or violence), which broke out between Turkish and Greek Cypriots and this situation hindered the development process in the Cyprus economy. Moreover, The dummy variable used for DUM74 reflects the adverse effects on the Cypriot economy owing to the deterioration of the economic activities after the war between Turkish and Greek Cypriots. Hence, both population became refugees and transferred from the North to the South of the island and vice versa.

Due to the concept of dummy variables used in this study, one could ask whether the structural break exists in long-run or short-run. To put it another way, do structural breaks have temporary or permanent effects on the relevant variables? However, the type of model used in this study may have a permanent effect on the relevant series, even if the dummy variables are used under the definition mentioned earlier (i.e. one year dummy-pulse).

In practice, the effect of the intervention on data series is generally described by either ‘step’ or ‘pulse’ functions. A step dummy variable is likely to have a permanent effect (long-run) on the level of series whilst a pulse dummy variable is used to defined the effect of intervention on a variable which is temporary (short-run)⁷⁴.

In the present study, the variables may exhibit temporary (short-run) effects of shocks on the economy because of the concept dummy variables. Nelson and Plosser (1992) emphasize that there is a classical view of economic fluctuations in real variable which has permanent effect rather than temporary due to a form of stochastic nonstationarity. However, Perron (1989,1990) argues that there is only certain ‘big shocks’ such as great crash of 1929 which have permanent (long-run) effects for time series data.

⁷⁴ Charemza and Deadman (1997) point out that “in the random walk with drift model, ... even a pulse or ‘blip’ at one period (usually called an ‘additive outlier’) will have a permanent effect on the series”.

Table 4.4.1: A Summary table for Structural break: Perron and Zivot-Andrews

Series	Year of break	Perron test	Zivot-Andrews
LCAPL _t	1964	Less strong	Strong
	1967	Weak	Weak
	1973	Weak	Weak
	1974	Strong	Less strong
LKR _t	1964	Less strong	Strong
	1967	Weak	Weak
	1973	Weak	Weak
	1974	Strong	Less strong
LHR _t	1964	Less strong	Strong
	1967	Weak	Weak
	1973	Weak	Weak
	1974	Strong	Less strong
LNGLD _t	1964	Less strong	Strong
	1967	Weak	Weak
	1973	Weak	Weak
	1974	Strong	Less strong
LGIR _t	1964	Less strong	Strong
	1967	Weak	Weak
	1973	Weak	Weak
	1974	Strong	Less strong
LOP _t	1964	Less strong	Strong
	1967	Weak	Weak
	1973	Weak	Weak
	1974	Strong	Less strong
LMTAR _t	1964	Less strong	Strong
	1967	Weak	Weak
	1973	Weak	Weak
	1974	Strong	Less strong
LTR _t	1964	Less strong	Strong
	1967	Less strong	Weak
	1973	Weak	Weak
	1974	Strong	Less strong
LANTR _t	1964	Less strong	Strong
	1967	Less strong	Weak
	1973	Weak	Weak
	1974	Strong	Less strong
LCNTR _t	1964	Less strong	Strong
	1967	Less strong	Weak
	1973	Strong	Weak
	1974	Weak	Less strong
LTER _t	1964	Less strong	Strong
	1967	Less strong	Weak
	1973	Strong	Weak
	1974	Weak	Less strong
LMTR _t	1964	Less strong	Strong
	1967	Less strong	Weak
	1973	Weak	Weak
	1974	Strong	Less strong

Notes: The critical values for both the Perron and the Zivot-Andrews tests are reported in Appendix chapter A. These two tests indicate that the years 1964 and 1974 are the most significant structural breaks which should be taken into account for the Cyprus economy.

To distinguish between temporary and permanent effects of shocks on the economy, we use the Perron ‘additive outlier’ model in which the dummy variables have one period shock to the relevant series. Having applied this test, it can be decided whether the series are stationary regarding permanent effect or nonstationary series which is subject to temporary (short-run) effects at the break points (i.e. 1964 and 1974). This implies that the two dummy variables have a ‘pulse’ or one year shock which exhibits a temporary increase in its mean at the break points.

From Table 4.4.1, it can be concluded that the break years (i.e. 1967 and 1973) have less strong (or weak) influence than 1964 and 1974 in changing the growth patterns of the relevant variables for the Cyprus economy. This means that the influences of dummies for 1967 and 1973 are not as major as the others-indirect effect.

4.4.2 The Johansen Procedure

To confirm the uniqueness of the co-integrating vectors, we adopt the Maximum likelihood ML test (Johansen, 1988; Johansen and Juselius, 1990)⁷⁵. The VAR model is estimated with one lag which minimises Schwarz Bayesian Criterion (SBC), and is used with unrestricted intercepts and restricted trends. The dummy variables used in model 2 (the Augmented Solow growth model) are considered as exogenous $I(0)$ (see Pesaran and Pesaran, 1997).

Table 4.7.3 confirms the unique co-integration vector⁷⁶ among the variables for model 2⁷⁷. In this table, the maximum eigen value statistics and trace statistics are corrected by the statistics for small samples suggested by Reimers (1992).

⁷⁵ It is worth emphasising that the residual-based tests of a single co-integrating regression and system-based tests are grounded in different econometric methodologies. Charemza and Deadman (1997: 178) suggest that the Johansen method can be used for single equation modelling as a supplementary tool (or auxiliary tool). In this case, as pointed out by Charemza and Deadman, this could be regarded as a confirmation of the single equation method to which the Engle-Granger method is employed.

⁷⁶ Cellini (1997) also finds a unique cointegration vector for the U.S. and France in favour of the Augmented Solow growth model.

⁷⁷ Despite model 1 is misspecified, all results estimated for this model are also reported in the relevant Tables in section 4.7.

This is a Monte Carlo study of the Johansen LR test. The main conclusion is that the $\lambda_{\max}$ and λ_{trace} test statistics should be corrected for the number of estimated parameters to obtain satisfactory size properties in finite samples⁷⁸.

Table 4.7.4 also reports the unique co-integrating vector for model 2, after normalising the coefficient of LCAPL (output) to -1 . all of the estimated coefficients have the expected signs and are reasonably in magnitude. The reported coefficients on the relevant variables are similar to those found for model 2 in Table 4.7.2 where the Engle and Granger method is applied.

In order to test whether model 2 is consistent with exogenous growth modelling, we test the restriction that the sum of the coefficients is unity. Sala-i-Martin (1990) argues that “in order to have endogenous growth model, there must be constant returns to the factors that can be accumulated”. Mankiw *et al.* (1992) also point out that “our model with physical and human capital would become an endogenous-growth model if their coefficients are equal to 1”.

In the light of these statements, we find that the restriction regarding the sum of the coefficients on (LKR, LHR, LNGD) for model 2 is unity cannot be accepted. Table 4.7.5 shows the result for the Augmented Solow growth model in favour of exogenous growth modelling rather than endogenous growth modelling (See also Coe and Moghadam, 1993).

To check whether the results obtained from the EG cointegration procedure are unbiased, robust, and asymptotically efficient, we employ three different methods. Namely, the Engle-Yoo three step correction approach, the Inder fully modified unrestricted ECM approach and the Saikkonen time domain correction approach. In turn, The Engle-Yoo approach is used for two reasons: (i) the EG long-run static regression gives consistent estimates but they may not be fully efficient (ii) Plausible explanation cannot be made on the significance of parameters because of the non-normality of the distribution of the cointegrating vector. The Inder

⁷⁸ Reimers (1992) finds that the Johansen procedure over-rejects when the null-hypothesis is true in the case of small samples. Thus he suggests that (T-P) version is the corrected statistics for the small samples and this can be corrected by using $(T-P) \log(1-\lambda_i)$ rather than $T \log(1-\lambda_i)$. In this test, $p=nk$ takes account of the number of estimated parameters and T is the number of usable observations (See also Doornik and Henry, 1994: 278, Banerjee et al., 1993: 286 and Walter, 1995: 391).

approach is employed to obtain the long-run estimators which are free from ‘endogeneity’ bias. The Saikkonen approach can remove the asymptotic inefficiency of the least square estimators by using the stationary information⁷⁹ (see also Ghatak and Milner, 1997).

All the long-run multivariate estimates are reported in Table 4.7.6 for both models 1 and 2. These results reveal that our original static OLS estimates for the relevant variables in model 2 are fine. Although there are some differences in magnitudes for the relevant variables, the estimates are broadly similar and all the signs are consistent. Nevertheless, we cannot make the same comment for model 1 due to the presence of misspecification⁸⁰. This also justifies the results obtained from EG cointegration procedure for model 1.

Since the existence of joint co-integration among the variables in long-run regressions Equations 4.3-1 and 4.3-2 is confirmed, the next step is to model the short-run dynamics with the use of ECM⁸¹. In order to model output (GDP/number of worker) or labour productivity movements according to the Solow and the Augmented Solow models, we can obtain an ECM adding the residuals from equations (4.3-1) and (4.3-2).

In actual fact, the original Solow model does not take into account the short-run components. However, short-run components are indeed present, and their omission in applied econometric studies would represent a misspecification, leading to biased estimates. Thus, “short-run components”⁸² must be explicitly accounted for, in applied research.

⁷⁹ See appendix chapter C and Maddala and Kim (1998) for more details.

⁸⁰ The results are as follows: the Engle-Yoo - $x_{ff} = 4.49$ (prob=0.034), the Saikkonen - $x_{ff} = 5.51$ (prob=0.019) and the Inder - $x_{ff} = 4.28$ (prob=0.038).

⁸¹ Note that if two or more time series variables are co-integrated, then there exists an error-correction mechanism (ECM). Empirically, in small samples, statistically significant error-correction terms provide further evidence in favour of the presence of a ‘genuine’ long-run relationship.

⁸² In this study, in order to save some degrees of freedom due to small sample size, we use Hendry’s general to specific modelling strategy. We then first estimated a short-run ECM with one lag of each variable and eliminated those lags with insignificant parameters. Secondly, we reestimated the simpler model to find out the most suitable model. In addition to this, we apply the instrumental variable (IV) method to ensure OLS short-run estimates are not jeopardised by the presence of some contemporaneous effects (see Common Table A.5.11 in appendix chapter A).

With respect to the specification of the short-run dynamics, we prefer to follow an unrestricted ECM proposed by Banerjee et al. (1986) using the idea that we should ‘start with a sufficiently large number of lags and progressively simplify it’ suggested by Hendry (see also Gilbert (1986) and Miller (1991)).

We therefore employ an ECM to test for short-run adjustment towards long-run equilibrium, and to explore the relationship between output and its determinants (if any) for both models in the short-run. The results of the parsimonious dynamic models, using the error terms from OLS regressions are in Table 4.7.7.

In model 1, there exists an ‘incorrect functional form’ (omitted variables bias) with respect to the diagnostic test results. Even though, we do not comment on the estimates for model 1, we just make sure whether this estimate confirms the previous estimated results for model 1⁸³.

Model 2 presented in Table 4.7.7 shows that the error correction term’s coefficient is negative and significant at the 1% level. The magnitudes of the corresponding coefficients show that 94% of last period’s disequilibrium is corrected after one year. In other words, output adjusts to its equilibrium level quickly and the error correction term gives further evidence that the variables in the equilibrium regression are co-integrated⁸⁴.

The appropriately signed and significant error correction term for model 2 confirms the earlier findings that the investment share in GDP (LKR), the ratio of tertiary enrolment to the labour force (LHR) and the rate of labour growth (LNGD) have a long-term effect on growth output. Model 2 also provides evidence of a short-term effect of physical capital, human capital, and the rate of labour growth on per capita growth.

It is worth noting that the Augmented Solow growth model explains 88% of total variation of labour productivity for the short-run period whilst the same model explains 98% of total variation of GDP per worker in the long-run period.

⁸³ See the diagnostic test results in Tables 4.7.2 and 4.7.6.

⁸⁴ Cellini (1997) does not provide any evidence to support ECM for the Augmented Solow growth models due to the absence of cointegration emerging from the first step Engle and Granger’s method.

Finally we conduct different techniques⁸⁵ to see whether there is a causal relationship between the relevant variables (i.e. LCAPL-LKR, LCAPL-LHR, LCAPL-LNGD) in both level and differences.

This refers to the earlier evidence of cointegration among the variables in a sense that if they are cointegrated, causality should exist at least in one direction⁸⁶. In brief, the estimated results show that there exists an evidence of unidirectional causality from LCAPL (labour productivity) to LKR (Physical capital), and LHR (human capital). There is also bidirectional causality between LCAPL and LNGD (the rate of labour growth) in both the long-run and short-run period (see Common Tables A.5.7, A.5.8, A.5.9, and A.5.10).

⁸⁵ See appendix chapter C to get information about the techniques which are used for the direction of causality between output and its determinants in a bivariate context.

⁸⁶ In our application, we do not take into account the error correction term when we determine the direction of the causality. We just follow the standard causality test in a bivariate context.

4.5 A Brief Comparison of The Solow and The Augmented Solow Growth Models

To be more specific, let us revert to the models (models 1 and 2) which are presented in Equations (4.3-1) and (4.3-2) with respect to the estimated results for these Equations. If we omit or leave out the variable defined as human Capital (LHR) from the Equation (4.3-2) and this variable is correlated with included variables LKR and LNGD, a_2 and a_3 in Equation (4.3-1) are biased. This means that their average or expected values do not coincide with their true values. Second, a_2 and a_3 are also inconsistent, that is, it does not matter how large the sample size we have so that the bias appears inevitably. Third, if they are not correlated (i.e., LKR, LNGD and LHR) in Equation (4.3-2), b_3 will be zero and thus, a_2 and a_3 will be unbiased and consistent. However, a_0 and a_1 will be remained biased. In addition, the error variance estimated from the true model (Equation 4.3-2) and that estimated from the misspecified model (equation 4.3-1) will not be the same⁸⁷. This also justifies Mankiw et al.'s (1992) findings that if human capital is not accounted for in the model, the quantitative implication of saving and population (or labour) will be upwardly biased. This implies that it will overestimate the true values since human capital is positively correlated with both saving and population growth.

⁸⁷ These are the consequences of omitting an important variable from the model. This situation is called 'under fitting' or 'misspecifying' a model (see Gujarati, 1992).

4.6 Conclusion

We did derive the Solow and the Augmented Solow growth models with the saving rates and a growth rate of employment that are stochastic variables with unit roots. These are the crucial variables for the steady-state equilibrium level of labour productivity in the Solow or the Augmented Solow models. The equilibrium level of productivity is likely to be a stochastic process with a unit root. As a consequence, the Solow and the Augmented Solow growth models can be investigated by using multivariate time series techniques.

Solow's model predicts that the labour productivity growth rate depends on the difference between the actual and the equilibrium level of labour productivity in the previous period. If the actual level of labour productivity is lower (greater) than its steady-state equilibrium level, it will increase (decrease) in the next period. In the Solow model, when the relevant variables are under the stochastic nature, they can be integrated of order one. In other words, the difference between the actual and the equilibrium levels of productivity should be stationary. It follows that subsequent growth rate of labour productivity is a stationary series. Thus, the error correction term must be negative.

We used annual data for the case of Cyprus over the period 1960-1995. Given the small sample size, our results are indicative rather than definitive. Employing this annual data, the data series were found to be non-stationary in levels, but stationary in difference. Then, the models were found to be co-integrated. Co-integration is essential for a valid test of our models in the long-run. At this point, we included some dummy variables to capture the effects of the structural break in different years for the Cypriot economy. Accordingly a Perron test and an alternative approach Zivot and Andrews were applied to obtain unbiased unit root test results. These test results indicate that the assumed order of integration is not changed by the potential structural break.

We preceded Dickey-Fuller LR joint test to find out whether the time series are 'DSP' or 'TSP'. The result was that we have a DSP dominant mixed process. Furthermore, we employed the Johansen method and the EHR procedure to test for weak exogeneity. The result indicates that the explanatory variables used in

the models are weakly exogenous. The next step was to confirm the uniqueness of the co-integration vector amongst the variables by conducting the Johansen method. One cointegrating vector was found for both models. In addition, we imposed some restrictions to figure out whether these models are consistent with the exogenous modelling assumptions or not. We found evidence that model 2 (the Augmented Solow growth model) is consistent with exogenous growth modelling.

The Engle and Yoo three-step correction method, the Inder method and the Saikkonen method were employed to obtain unbiased long-run elasticity estimates. These methods provide some evidence in favour of the Augmented Solow growth models. For the short-run relation between labour productivity and its determinants, we applied an ECM. This provides further evidence regarding both the static long-run and the dynamic short-run components of the Augment Solow growth model.

Finally, we made six important points: Firstly, both the Solow and the Augmented Solow growth models can be used to investigate the productivity movements in a country. Secondly, though the non-augmented model does not appear to be consistent, the Augmented model was found to be consistent with annual data. Thirdly, multivariate time series techniques can be employed for growth models, which are based on the Solow growth model. Fourthly, the Solow type growth model can be considered as an error correction mechanism. Fifthly, allowing for human capital eliminates the high coefficients on investment and on labour growth in the Solow model. Finally, physical and human capital accumulation rates as well as the rate of labour growth embodied in the Augmented Solow growth model have both long-term and short-term effects on per capita growth. This accords well with the prediction of the exogenous growth model for the Cypriot economy.

4.7 Tables

Table 4.7.1 The Residual-based ADF Test for Cointegration:

Cointegration Regression	R^2	$\overline{R}^2$	CRDW	Calculated ADF residuals	Critical Value
					Mackinnon (5%)
MODEL 1 $LCAPL_t = f(LKR_t, LNGD_t, VD)$	0.98	0.97	1.75	-5.75(0)	-5.24
MODEL 2 $LCAPL_t = f(LKR_t, LHR_t, LNGD_t, VD)$	0.98	0.97	2.28	-6.51(0)	-5.64

The reported critical value is obtained from Mackinnon (1991) and reported by MFIT 4.0. The numbers in parentheses indicate number of lags, which are chosen by the Schwarz Bayesian criterion (SBC). This means that zero augmentation is necessary to be sufficient to secure lack of autocorrelation of the error terms for the relevant cointegration regressions. VD contains DUM64 and DUM74.

Table 4.7.2 Engle Granger Static Long-run Regressions

Explanatory Variables	Dependent Variable: LCAPL _t	
	Model 1	Model 2
C	4.61 (10.98)	3.65 (10.95)
T	0.051 (25.04)	0.051 (25.39)
LKR _t	0.21 (4.78)	0.18 (5.84)
LHR _t	-	0.11 (5.78)
LNGD _t	-0.76 (-9.83)	-0.51 (-7.51)
DUM64 _t	-0.17 (-4.99)	-0.14 (-5.69)
DUM74 _t	-0.23 (-4.87)	-0.18 (-5.29)
R ²	0.98	0.98
$\overline{R}^2$	0.97	0.97
CRDW	1.75	2.28
ADF*	-5.75	-6.51
CV	-5.24	-5.64
SER	0.033	0.022
X ² _{SC}	0.48 (Prob=0.48)	1.31 (Prob=0.25)
X ² _{FF}	18.76 (Prob=0.00)	2.47 (Prob=0.12)
X ² _{NORM}	2.32 (Prob=0.32)	1.04 (Prob=0.59)
X ² _{HET}	7.48 (Prob=0.06)	2.15 (Prob=0.14)

Notes: t-statistics are in parentheses and all diagnostic pass at 5% level of significance for model 2. Reported diagnostics also suggest that there exists evident misspecification at 5% level of significance for model 1. It is worth emphasising that the star (*) indicates no augmentation is necessary to remove autocorrelation from the error terms.

Table 4.7.3 The Johansen Maximum Likelihood (ML) procedure

Cointegration likelihood Ratio (LR) Test to determine the number of cointegration vectors (r) based on Maximal Eigen Value of Stochastic Matrix, Trace of the stochastic matrix, and the (T-P) version is for the small sample suggested by Reimers (1992).

Cointegration Regression	H_0	H_1	$\lambda_{\max}$	$\lambda_{\max}$ (T-P)	C.V. at 5%	λ_{Trace}	λ_{Trace} (T-P)	C.V. at 5%
MODEL 1	$r = 0$	$r = 1$	58.95	50.76	25.54	87.91	75.71	42.44
	$r \leq 1$	$r = 2$	17.24	14.85	18.96	28.95	24.93	25.32
	$r \leq 2$	$r = 3$	11.71	10.08	12.25	11.71	10.08	12.25
MODEL 2	$r = 0$	$r = 1$	50.36	41.97	31.46	81.18	67.65	62.99
	$r \leq 1$	$r = 2$	27.42	22.85	25.54	30.82	25.68	42.44
	$r \leq 2$	$r = 3$	2.58	2.15	18.96	3.40	2.83	25.32
	$r \leq 3$	$r = 4$	0.81	0.68	12.25	0.81	0.68	12.25

r indicates the number of cointegrating relationships, $\lambda_{\max}$ is the maximum eigen value statistics, λ_{trace} is the trace statistics and the (T-P) version is the corrected statistics for small samples suggested by Reimers (1992). Var1, based on SBC is used in the Johansen procedure and unrestricted intercepts and restricted trends in the VAR model are not rejected in all cases. DUM64 and DUM74 are considered as exogenous $I(0)$ variables. The critical values are obtained from Osterwald-Lenum (1992).

Table 4.7.4 The Johansen Method

Coefficients in the long-run cointegration relationship between LCAPL (output) and its determinants: coefficients normalised on output to -1.

MODEL 1			
Variables	LKR _t		LNGD _t
Coefficients	0.19		-0.88
t-values	2.64		-3.03
MODEL 2			
Variables	LKR _t	LHR _t	LNGD _t
Coefficients	0.17	0.12	-0.47
t-values	5.33	7.43	-6.27

Table 4.7.4 reports the unique cointegrating vector for the relevant variables, which is obtained after normalising the coefficient of: LCAPL_t (output) to -1.

Table 4.7.5 Tests of Parameter Restrictions: The Johansen Method

MODEL 1		
Parameter Restrictions	Chi-squared test statistics	Critical value at 5%
$a_1 + a_2 = 1.0$	31.54(1)*	3.84
MODEL 2		
Parameter Restrictions	Chi-squared test statistics	Critical value at 5%
$b_2 + b_3 + b_4 = 1.0$	25.67(1)*	3.84

Table 4.7.5 indicates the results of the cointegrating vector reported in Table 4.7.4 for a number of restrictions on the estimated coefficients of the relevant variables. Star (*) shows that χ^2 -test rejects the null hypothesis that the sum of the coefficients is equal to 1, for both models mentioned above.

Table 4.7.6 Elasticity Estimates

MODEL 1				
Variable	Static OLS (Engle-Granger)	Engle-Yoo Three step corrected values	OLS with time domain correction (Saikkonen)	Fully modified ECM (Inder)
C	4.61 (10.98)	5.03 (7.08)	4.87 (8.88)	5.05 (13.15)
T	0.051 (25.04)	0.060 (14.87)	0.061 (19.56)	0.061 (27.48)
LKR _t	0.21 (4.78)	0.29 (3.22)	0.26 (4.84)	0.11 (2.77)
LNGD _t	-0.76 (-9.83)	-0.62 (-4.13)	-0.80 (-7.67)	-0.86 (-12.16)
DUM64 _t	-0.17 (-4.99)	-0.15 (-2.15)	-0.16 (-5.93)	-0.18 (-5.89)
DUM74 _t	-0.23 (-4.87)	-0.17 (-2.83)	-0.25 (-4.76)	-0.26 (-6.01)
MODEL 2				
C	3.65 (10.95)	3.72 (8.45)	3.51 (6.52)	4.18 (15.33)
T	0.051 (25.39)	0.051 (25.36)	0.050 (17.48)	0.052 (15.33)
LKR _t	0.18 (5.84)	0.18 (3.27)	0.13 (1.86)*	0.08 (3.04)
LHR _t	0.11 (5.78)	0.12 (4.21)	0.11 (5.34)	0.12 (4.81)
LNGD _t	-0.51 (-7.51)	-0.49 (-5.44)	-0.49 (-4.35)	-0.63 (-4.42)
DUM64 _t	-0.14 (-5.69)	-0.13 (-3.25)	-0.14 (-5.57)	-0.13 (-6.29)
DUM74 _t	-0.18 (-5.29)	-0.17 (-3.41)	-0.16 (-3.51)	-0.19 (-7.53)

Different approaches have been run on the relevant regressions above and t- values are shown in parentheses. One star indicates that it is significant at 10% level, and others are significant at 5% and 1% levels respectively.

Table 4.7.7 Error Correction Modelling: Short-run Dynamics

Explanatory Variables	Dependent Variable: ΔLCAPL_t	
	MODEL 1	MODEL 2
C	0.05 (12.23)	0.04 (11.33)
ECT (-1)	-0.61 (-3.63)	-0.94 (-6.39)
ΔLKR_t	0.15 (2.42)	0.13 (3.27)
ΔLHR_t	-	0.16 (2.92)
ΔLNGD_t	-0.57 (-7.76)	-0.35 (-5.44)
ΔDUM64	-0.14 (-7.44)	-0.15 (-9.56)
ΔDUM74	-0.15 (-5.35)	-0.18 (-8.12)
R^2	0.79	0.88
$\bar{R}^2$	0.76	0.86
DW	1.85	2.37
SER	0.02	0.01
X^2_{SC}	0.47 (Prob=0.49)	2.17 (Prob=0.12)
X^2_{FF}	7.47 (Prob=0.06)	0.96 (Prob=0.33)
X^2_{NORM}	2.32 (Prob=0.31)	2.03 (Prob=0.36)
X^2_{HET}	0.61 (Prob=0.43)	0.18 (Prob=0.67)

Notes: t-statistics are in parentheses and all diagnostic pass at the 5% or 1% level of significance for model 2. It is worth stressing that reported diagnostic (i.e., X^2_{FF} - 7.47 (Prob=0.06) suggests that there exists evident misspecification at the 5% level of significance for model 1.

CHAPTER 5 Testing The Role Of Trade Policy In Economic Growth

5.1 Introduction

This chapter extends empirical investigation of the determinants of growth in the Cypriot economy, following Mankiw et al. (1992), Knight et al. (1993) and Ghura and Hadjimichael (1996) to derive and investigate empirically the implications of the neo-classical exogenous growth model, namely, the Augmented version of Solow model to include openness to foreign trade, and public infrastructure. First we assume that labour, physical and human capital accumulation rates are not constant and vary over time. Second assume that labour-augmenting technical change is affected by two potentially important factors: (a) openness, and (b) public infrastructure.

In this Chapter, we apply multivariate cointegration techniques for analysing an extended version of Mankiw et al.'s (1992) framework, which contains trade policy and government policy variables. Our empirical results show that the model under study can satisfy a cointegration relationship among the variables and this leads an error correction mechanism.

However, the results are not in favour of the extended version of the Augmented Solow growth model with the relevant variables. This implies that this model does not explain economic growth's determinants better than the Augmented Solow growth model which is investigated in the previous chapter. This justifies that the Augmented Solow growth model is the one correctly specified for the Cypriot economy.

The rest of the chapter is organised as follows: Section 2 presents the derivation of an extended version of the Augmented Solow model, which includes policy variables and associated with exogenous growth theories. Section 3 indicates the empirical methodology, model, and data description. In section 4, the empirical results are presented. Section 5 explains a brief comparison of the Augmented Solow growth model and an extended version of the Augmented Solow growth model. Finally, section 6 provides some conclusions.

5.2 Theoretical Modelling:

An Extended Version of the Augmented Solow Growth Model; adding openness to foreign trade and public infrastructure to the relevant growth Model.

In this section, we analyze the impact of trade policy⁸⁸ (openness) along with physical-human investment and public infrastructure on economic growth. Recently, many developments economists' and researchers' attention has centered on the relationship between trade policy and economic growth in developing countries [See Tyler (1981), Feder (1982), Ballasa (1985), Ram (1985), Dollar (1992) and Edwards (1992)]. In the light of the success experiences in the Asian NIC countries, the more outward economies tend to grow faster than economies with closed ones [See Edwards (1993), Sengupta (1991), 1993 and Greenaway and Sapsford (1994)]. On the other hand, this issue has also been analyzed in the framework of endogenous growth models, which assume constant or increasing return to capital. In this framework, outward-oriented trade policies promote competition, encourage learning-by-doing, utilize positive externalities, and allow access to improved technology [See Romer (1990a), Grossman and Helpman (1991a, b) and Aghion and Howitt (1992)].

Here, we adopt the frameworks introduced by Mankiw et al. (1992), Knight et al. (1992); (1993) and Ghura and Hadjimicheal (1996) to investigate the role of trade policy in economic growth.

Let us consider the following Cobb-Douglas production function:

$$Y_t = K_t^\alpha H_t^\beta (A_t L_t)^{1-\alpha-\beta} \quad (5.2-1)$$

where Y is real output, K is the stock of physical capital, H is the stock of human capital, L is the raw labour, A is a labour-augmenting factor reflecting the level of technology and efficiency in the economy and the subscript t indicates time.

⁸⁸ The relevant literature is largely uninformative whether the policy proxies are appropriate for the measures of trade policy or trade volume (Rodriguez and Rodrik 2000).

We assume that $\alpha + \beta < 1$, so there are constant returns to factor inputs jointly and decreasing returns separately. Raw labour and labour-augmenting technology are assumed to grow according to the following functions:

$$L_t = L_0 e^{nt} \quad (5.2-2)$$

$$A_t = A_0 e^{g't + P'\theta} \quad (5.2-3)$$

Where n is the exogenous rate of growth of the labour force, g is the exogenous rate of technological progress, P is a vector of policy and the other factors that can affect the level of technology and efficiency in the economy, and θ is a vector of coefficients related to this policy and other variables.

In this model, variable A depends on exogenous technological improvements, the degree of openness of the economy and the level of other variables such as public infrastructure. It is obvious that A in this study differs from A used by Mankiw et al. (1992). This modification is more likely to be particularly relevant to the empirical cases of economic growth in developing countries. In these countries, technological improvements are encouraged by using exports plus imports of capitals goods and the level of infrastructure, which tend to increase the productive sector's efficiency (Knight et al. 1993).

Furthermore, in the steady state, output per worker grows at the constant rate g (the exogenous component of the growth rate of the efficiency variable A). This outcome can be obtained directly from the definition of output per effective worker as follows:

$$\begin{aligned} \frac{Y_t}{A_t L_t} &= (k_t)^\alpha (h_t)^\beta \\ \frac{Y_t}{L_t} &= A_t (k_t)^\alpha (h_t)^\beta \end{aligned} \quad (5.2-4)$$

$$\text{Let } y_t^* = \left(\frac{Y_t}{L_t} \right)^*$$

Taking logs both sides of Equation (5.2-4), we get Equation (5.2-5):

$$\ln\left(\frac{Y}{L}\right)^* = \ln A + \alpha \ln k^* + \beta \ln h^* \quad (t \text{ is omitted})$$

where $A_t = A_0 e^{(g + \theta + \rho)t}$

$$\ln\left(\frac{Y}{L}\right)^* = \ln A_0 + g + \theta \ln P + \frac{\alpha}{1 - \alpha - \beta} \ln s^K + \frac{\beta}{1 - \alpha - \beta} \ln s^H - \frac{\alpha + \beta}{1 - \alpha - \beta} \ln(n + g + \delta) \quad (5.2-5)$$

Equation (5.2-5) indicates steady state output per worker or labour productivity where a vector of policy and the other variables exist.

To determine the extended version of Augmented Solow growth model, we need to find the transitional dynamics by using a log-linearization of equations (4.2.2-13) and (4.2.2-15) in the previous chapter around the steady-state⁸⁹. This gives the following growth Equation:

$$\begin{aligned} \ln y - \ln y(0) = & g + (1 - e^{-\lambda t}) \left[\ln A_0 + g + \theta \ln P + \frac{\alpha}{1 - \alpha - \beta} \ln s^K + \frac{\beta}{1 - \alpha - \beta} \ln s^H \right. \\ & \left. - \frac{\alpha + \beta}{1 - \alpha - \beta} \ln(n + g + \delta) - \ln y(0) \right] \end{aligned} \quad (5.2-6)$$

where P is a vector of policy and the other factors that can affect the level of technology and efficiency in the economy.

Now, if we rearrange Equation (5.2-6), we have the following equation, which indicates steady-state output per worker, or labour productivity evolving around the steady-state path.

$$\begin{aligned} \ln y_{t+1} - \ln y_t = & g + (1 - e^{-\lambda_t}) \left[\ln A_0 + g + \theta \ln P + \frac{\alpha}{1 - \alpha - \beta} \ln s_t^K + \frac{\beta}{1 - \alpha - \beta} \ln s_t^H \right. \\ & \left. - \frac{\alpha + \beta}{1 - \alpha - \beta} \ln(n_t + g + \delta) - \ln y_t \right] \end{aligned} \quad (5.2-7)$$

where $\lambda_t = (n_t + g + \delta)(1 - \alpha - \beta)$

⁸⁹ The linearization of the transition path around the steady state is derived in the previous chapter (see section 4.2.2).

As we mentioned in the previous chapter, Equation (5.2-7) can be expressed as follows, omitting the log notation:

$$\begin{aligned}\Delta y_t &= c + \mu \left[y - A_0 - A_1 P - A_2 T - A_3 s^K - A_4 s^H - A_5 (n + g + \delta) \right]_{t-1} \\ \Delta y_t &= c + \mu \left[y - y^* \right]_{t-1}\end{aligned}\quad (5.2-8)$$

Equation (5.2-8) leads an error correction mechanism as we explain in the previous chapter (see section 4.2.1). We therefore, construct our modified ECM with respect to Equation (4.2.1-43) as follows:

$$\Delta \ln y_t = c_0 + \mu e_{t-1} + \sum_{i=0}^m \phi_i \Delta \ln s_{t-i}^K + \sum_{j=0}^p \eta_j \Delta \ln s_{t-j}^H + \sum_{k=0}^r \pi_k \Delta \ln (n_{t-k} + g + \delta) + \sum_{z=0}^s \delta_z \Delta \ln P_{t-z} + \varepsilon_t \quad (5.2-9)$$

where P stands for a vector of policy and other factors that can influence the level of technology and efficiency in the economy. Other variables are defined as in the previous chapter.

5.3 The Empirical Methodology, Model and Data

Empirical studies to analyse the impact of openness (or trade policy) on economic growth rates has largely been undertaken on cross-country growth regression and much of the existing empirical literature is based on the Solow growth model. However, the literature has devoted very little attention to the effect of openness (or trade policy) on economic growth within the context of time series analysis. The modelling framework of this study is based on the Solow growth model by adding some policy variables (i.e. openness) within the time series context.

In the light of the modelling developed in the previous section, we apply cointegration analysis and error correction mechanisms (ECMs) to investigate both the long-run and the short-run influence of trade policy on the economic growth rate of Cyprus in the models represented by Equations (5.3.1) and (5.3.2). We use OP (exports plus imports relative to GDP) as openness and MTAR (imports duties relative to the value of imports) as trade policy proxies to examine the relationship between real GDP per worker and openness (or trade policy). The long-run relationship is investigated using multivariate cointegration techniques,

while the short-run dynamics are captured within an error correction modelling (ECM) framework.

We test for cointegration in the Engle and Granger sense (EG) (Engle and Granger, 1987) using the following multivariate growth models for the Cypriot economy employing the data⁹⁰ over the period 1960-1995.

$$LCAPL_t = a_0 + a_1T + a_2LKR_t + a_3LHR_t + a_4LN GD_t + a_5VPV_t + a_6VDUM_t + u_t \quad (5.3-1)$$

where

- VPV = The Vector of policy variables are which defined as follows.
- LOP_t = Openness index of Cyprus defined as the ratio of the sum of real exports and imports to real GDP expressed in Cyprus pounds at constant prices of 1980, (C£).
- LMTAR_t = Imports-share of tariffs on intermediate and capital goods defined as the ratio of imports duties to the value of imports expressed in Cyprus pounds at constant prices of 1980, (C£).
- LGIR_t = The ratio of general government fixed investment to GDP expressed in Cyprus pounds at constant prices of 1980, (C£).
- VDUM = The vector of Dummy variables: DUM64, DUM74, and others are already defined in the previous chapter.

In addition to the information given above, it would be appropriate to move to a more detailed analysis of the problems of data availability, quality and the modelling framework which embodies openness or different policy variables.

The different implications of both the Solow growth model and endogenous growth models have led to renewed empirical literature in recent years. The latter one is often thought to have a missing link between trade openness and growth whereas trade openness in the neoclassical models of growth have no effect on the steady-state rate of output growth (see Rodriguez and Rodrik, 2000). However, there might be growth effects during the transition period to the steady-state. This

⁹⁰ See appendix chapter A for more details about data descriptions.

kind of effect could be positive or negative depending on long-run level of output which is affected by trade openness or trade policy.

One point should be made clear on the concept of trade policy and openness, because this conceptual issue still remains unclear within growth literature. However, some authors point out that appropriate measures of trade policy need to capture price distortions whereas exports and imports to GDP or export itself to GDP are related to the export-led growth hypothesis rather than trade policy (see Rodriguez and Rodrik, 2000 and Frankel and Romer, 1999). On the other hand, some authors still accentuate the ratio of exports or imports and total trade to GDP as trade policy measures (Levine and Renelt, 1992).

In the present chapter, we model openness (or trade policy) and the other policy variables in the neoclassical modelling framework which is based on the Solow growth model. In this model, openness or trade policy may affect the rate of adoption of technologies from advance countries thereby increasing a country's rate of labour productivity growth. In this context, first the imports and exports sectors serve as a driven force for technology transfer in terms of the importation of technologically advanced capital goods. Second, increasing exports trade help to disentangle the foreign exchange constraint which is related to a country's ability to import technologically advance capital goods (see also Proudman and Redding, 1997).

In this study, the level of technology depends on the degree of the economy and the level of government fixed investment where technological improvements increase through these two factors. Here, modelling government fixed investment may create biased result when this proxy is included into the model with total fixed investment. However, it is argued that government and private fixed investment have different impacts on output growth and they should be considered together in a model⁹¹.

⁹¹ Barro and Sala-i-Martin (1992) modelled investment capital as private and public inputs and pointed out that both should have different impacts on growth. Ghura and Hadjimichael (1996) also disaggregated investment capital and showed that the impact of private investment on growth is positive and significant whereas the other is not statistically significant.

Problem of data availability and quality have put some constraints parts of this study when the interest is especially to measure the link between openness and growth. The recent literature indicates that trade-off between policy proxies (i.e. openness) is closely related to data quality (see Dollar, 1992; Edwards, 1992; 1998; Sachs and Warner, 1995 and Lee, 1993)

Further, it is important to explain the trade and government policy proxies in more detail. In the relevant area, some authors believe that aggregate implicit tariff (or indices of price distortions) is clearly a better measure than exports plus imports to GDP. Quah and Rauch (1990) point out that “ the positive relationship between openness and growth becomes still looser when we observe openness not in terms of tariff barriers, but instead of measure openness by the ratio exports (or imports) to GDP”. Another point mentioned by Harrison (1996) is that the simplest measure of trade orientation such as imports plus exports as a share of GDP shows a positive association with GDP growth, but argue that it is an imperfect proxy for trade policy.

Dollar (1992) uses two indices which are index of real exchange rate distortion and index of real exchange rate variability as trade proxies. These two proxies has been criticized by Rodriguez and Rodrik (2000). They argued that distortion has serious conceptual flaws as a measure of trade whilst variability appears to be robust. They also found out that their findings are contradicting with Edwards’s (1998) results whereas Edwards (1998) uses nine alternative indicators of openness such as the average black market premium, the average import tariffs etc.

Stiglitz (1998) also mentions that most empirical growth regressions determine some openness measures such as price distortions or average tariff level are strongly associated with per capita income growth. Nevertheless, Rodriguez and Rodrik (2000) conclude that the most direct indicators of trade policy proxy such as trade-weighted tariff level are misleading as indicators of the stance of trade policy. Frankel and Romer (1999) also argue that their results cannot be directly applied to the effects of trade policies.

In this chapter, two alternative trade policy proxies are used. First, exports plus imports to GDP, which is defined as a indicator of openness. Second, imports duties to volume of imports as a proxy for aggregate implicit tariff which is related to trade policy. However, we still believe that export sector should be considered in the context of trade policy because openness or trade policy can raise an economy's rate of growth by increasing the extent of product market composition (i.e. exports plus imports) (see Grossman and Helpman, 1991a; Nickell, 1996; and Aghion et al. 1997).

Consequently, the bottom line is that there does not exist a commonly accepted point which particularly indicates appropriate measure(s) for trade policy due to different and controversial views exist in the relevant literature.

Having defined the problems stemmed from the data (i.e. appropriateness of the proxies for trade policy) and the modelling framework which is based on the neo-classical theory, we will explain the methodologies employed in this chapter. Firstly, the Augmented Dickey-Fuller (ADF) test and the residual based ADF test are used to test for the integration level of each variable and for the possible potential cointegration among the variables⁹². We then conduct the Dickey-Fuller LR joint test (or F-test) to investigate whether the time series have stochastic or deterministic trend characteristics (see Madalla, 1992:259-262).

In order to find out if there exists any exogenous or endogenous break years (i.e. the war effect in 1974 and intercommunal conflict in 1964), We employ the the Perron's (1990) Additive Outliner Model (AOM) and the Zivot-Andrews (ZA) (1992) approach respectively.

On account of the results estimated by the Engle-Granger (1987) and the Johansen (1988) cointegrating procedures, we use the Johansen method to test a number of restrictions on the estimated coefficients of the relevant factors of production after normalising the coefficient on output to -1 .

⁹² In order to confirm the results obtained from the ADF unit root test and the residual based the EG cointegration procedure, we use the Multivariate Augmented Dickey Fuller (MADF) unit root test and the system based Johansen cointegration procedure to investigate the stationary properties of each variable as well as the existence of cointegration among the variables in the relevant model respectively.

Before going one step further to model an ECM, we check our explanatory variables to see if they are weakly exogenous or not by using Engle-Hendry-Richard (EHR) and the Johansen procedures. We then conduct an error correction mechanism (ECM) estimated by ordinary least square (OLS) and derive the ECM using the residuals from the cointegrating regression Equation (5.3-1)⁹³ for the short-run relationship among the variables embodied within Equation (5.3-2).

Thus,

$$\begin{aligned} \Delta LCAPL_t = & a_0 + a_1 u_{t-1} + \sum_{i=0}^m a_i \Delta LKR_{t-i} + \sum_{j=0}^p a_j \Delta LHR_{t-j} + \sum_{k=0}^r a_k \Delta LNGD_{t-k} + \sum_{z=0}^s a_z \Delta LP_{t-z} \\ & + \sum_{l=0}^v a_l \Delta D_{t-l} + \varepsilon_t \end{aligned} \quad (5.3-2)$$

where

Δ denotes the first difference operator, L is natural logarithms, U_{t-1} is the lagged estimated residual from equation (5.3-1), P is a vector of policy and the other factors that can affect the level of technology and efficiency in an economy, D is the vector of Dummy variables and other variables are defined in Equation (5.3-1).

Moreover, we employ three different methods: namely, the Engle and Yoo (1991) three-step correction method, the Inder (1993) fully modified error correction method and the Saikkonen (1991) time domain correction method to obtain unbiased long-run elasticity estimates to confirm the results estimated by the EG cointegration procedure.

Having applied 1st step Engle and Granger and 2nd step Error correction modelling, we mainly apply two different techniques in order to determine a causal relationship between the variables in a bivariate model⁹⁴.

⁹³ See chapter 4 to get full detail how we construct the ECM for the short run dynamics.

⁹⁴ In this chapter, due to the insignificance of the policy variables (i.e., LOP, LMTAR, LGIR), we did not estimate a causal relation between output and the policy proxies. The rest of them were already investigated in the previous chapter.

5.4 Empirical Results

Before we estimate long-run relationship, we first investigate the stationarity properties of the policy variables employing the ADF and the MADF unit root tests. The sequential testing results in the Common Tables A.5.1 and A.5.2 confirm that the policy proxies, namely LOP, LMTAR, and LGIR are non-stationary in levels but stationary in differences. This situation is denoted as $LOP \sim I(1)$, and $LMTAR \sim I(1)$ $LGIR \sim I(1)$ (see Appendix Chapter A).

Following the LR joint test (Dickey-Fuller, 1981, and Madalla, 1992), we check the type of trend of the policy variables whether they are characterised by stochastic or deterministic trends. Common Table A.5.3 suggests that the test statistics, (i.e. 2.84, 6.27, and 2.85) imply a DSP dominant mixed process.

The results in Common Tables A.5.1, A.5.2, and A.5.3 are validated by applying the Perron test (AOM) because of the structural change occurring in 1974. Common Table A.5.4 suggests that there is no ‘spurious unit root’ resulting from changing means as far as the technique is concerned. As we mentioned earlier, the Perron AOM model takes into account only an exogenous break so that we use the ZA approach for the endogenous break to check the results obtained from the Perron AOM test. The estimated results in Common Tables A.5.5 indicate that Perron’s test results are not contradicted by the ZA modification.

There are a number of criticisms to the potential endogeneity of measure of openness (or trade policy) proxies within a growth regression. In this context, Grossman and Helpman (1995) point out that trade policy itself is not free of endogeneity problems. Proudman and Redding (1997) also emphasize that the choice of the appropriate measure of openness (i.e. exports plus imports to GDP) is likely to be endogenous and it may be true for measure of trade policy (i.e. imports tariffs). However, it is possible to use econometric techniques to minimize any potential biases (see Proudman and Redding 1997). Hence, we use two different procedures to investigate if the policy variables are weakly exogenous (or endogenous). Common Table A.5.6 reports the weak exogeneity test results estimated by both the EHR and the Johansen procedures. Our calculations illustrate that LOP, LMTAR, LGIR are weakly exogenous.

In accordance with the estimated results so far, all variables used in this chapter are stationary and weakly exogenous (i.e. except output). This is a necessary condition for the variables to be cointegrated and placed on the right hand side of the model represented by Equation (5.3-1). Tables 5.7.1 and 5.7.2 show that the residual based ADF test results for cointegration appear to be conclusive with the dummy variables used for the years 1964 and 1974. However, the policy variables embodied in the model represented by Equation (5.3-1) are not statistically significant with regard to t-statistics at a conventional level. In other words, the coefficients of trade policy proxies (namely, LOP and LMTAR) and government policy proxy (LGIR) are not consistent with the predictions of the model. We are therefore able to conclude that the extended version of the Augmented Solow growth model is not justified⁹⁵.

Although the results above indicate that our model is not correctly specified, we would like to make sure that this situation is confirmed by the other techniques employed in this chapter. We therefore, continue to test a unique vector assumption by using the Johansen (1988) procedure. Table 5.7.3 confirms that there is a unique cointegrating vector among the variables for both models when the Reimers (1992) method is applied. In actual fact, the maximum eigen value and trace statistics indicate two cointegrating vectors among the variables.

One can ask whether adding variables to the relevant model in this chapter are consistent in terms of number of cointegrating vectors among the variables when the Johansen (1988) and the Reimers (1992) methods are applied. However, one cointegrating vector is still found when we add another two variables compared with the earlier results found in the previous chapter. The current results are still consistent because the additional variables: LOP (or LMTAR) and LGIR are not statistically significant at conventional levels.

Table 5.7.4 also reports the results which are based on the uniqueness assumption that all of the estimated coefficients, after normalising the output to -1, have the

⁹⁵ Even if the variables seem to be irrelevant or unnecessary, they should be kept within the model to check whether the other techniques employed in this chapter provide the same conclusion (see Gujarati, 1992).

expected signs and a slightly different magnitude compared with the reported coefficients on the variables when the EG cointegration procedure is applied.

Table 5.7.5 shows the results for both models in favour of exogenous growth modelling rather than endogenous growth modelling, notwithstanding the fact that the variables: LOP, LMTAR, LGIR are not statistically significant at conventional level.

One drawback of the Engle-Granger approach is that estimates of the static cointegration regression may be biased and statistical inferences cannot be drawn on the t-statistics (i.e. they might not be valid) because of nonnormality of the distribution. This can be corrected through the Engle-Yoo (EY) three step procedure (Engle Granger and Yoo, 1991). Our results in Table 5.7.6 indicate the estimates obtained from the EY three step procedure. As can be seen from this table, the policy proxy variables (LOP, LMTAR, LGIR) are found to be insignificant and this confirms the estimated results when the EG cointegration test is applied. In the same Table, the results estimated by the Saikkonen and the Inder approaches are not different from the EY three step procedure.

Since the series are found to be cointegrated, we use an ECM to test the existence of short-run movements in output per worker with regard to the extended version of the Augmented Solow model (Equation 5.3-2). The reason for carrying on is that the policy proxy variables might have a short-run effect. The results of the dynamic models are presented in Table 5.7.7.

For both models, the error correction term's coefficient is negative and significant at the 1% level. The magnitudes of the corresponding coefficients show that 83% and 79% of last period's disequilibriums are corrected after one year. This implies that output adjusts to its equilibrium level quickly and the error correction terms provide further evidence that the variables in the equilibrium regression are co-integrated. Since we take the contemporaneous effects into consideration in both short-run models, we report the relevant t-statistics and the estimates of the error correction term by using the instrumental variables (IV) method to ensure OLS short-run estimates are not jeopardised by the presence of some contemporaneous effects (see Common Table A.5.11).

However, the estimates for both models in Table 5.7.7 confirm the earlier findings that policy variables LOP, LMTAR, and LGIR are insignificant⁹⁶ and they are inconsistent with the assumptions that a country's trade policy increases its openness to international trade and public infrastructure contributes to its domestic economy.

5.5 A Brief Comparison Of The Augmented Solow model and The Extension Version Of The Augmented Solow model:

Let us consider models represented by Equation (4.3-2) (in the previous chapter) and Equation (5.3-1) (in this chapter). When we include the policy variables in regression Equation (5.3-1) (i.e. incorrect model or the case of overfitting), the OLS estimator of Equation (5.3-1) may be still unbiased and consistent. In addition, the standard confidence interval, and the usual hypothesis testing procedure on the basis of t-test and F-test also may still remain valid. However, the estimated coefficient of Equation (5.3-1) can be inefficient since their variances are generally larger than the coefficients estimated of Equation (4.3-2). As a consequence, the confidence interval based on the standard errors of the coefficients in Equation (5.3-1) can be larger than those based on Equation (4.3-2) even though Equation (5.3-1) is acceptable for the usual hypothesis testing procedure.

It is important to notice that there are two types of specification errors we have taken into account so far. The first is the model (Equation 4.3-1) in which we exclude a relevant variable (human capital, the case of underfitting): the coefficients of the variables left in the model are generally biased as well as inconsistent, the error variance is incorrectly estimated, the standard errors of estimators are biased, and the usual hypothesis testing procedure becomes invalid. On the other hand, including one irrelevant variable (or more) in the model (Equation 4.3-2) (the case of overfitting), still gives us unbiased and consistent estimates of the coefficients of the true model, the error variance is correctly estimated, and the usual hypothesis testing procedure is still valid. However, the

⁹⁶ In this chapter, with regard to the insignificance of policy proxies, we do not take into consideration the causal relationships between output and its determinants.

problem for the inclusion of the irrelevant variable(s) is that the estimated variances of coefficients are larger, and as a result, the probability inferences about, say, true parameters are less precise because the confidence interval tends to be wider.

In such cases, we may fail to recognise significant relationships between the dependent variable and the explanatory variable(s)⁹⁷. In this regard, Gujurati (1992) argues that it is better to include irrelevant variables rather than exclude the relevant ones and this process should be based on a theory.

In the light of this information, we keep the model represented by equation (5.3-1) in the standard framework and estimate our results by applying different techniques whether our assumptions are corrected. As a result, our extended version of the Augmented Solow growth model are found that it is not correctly specified. Now we are in a situation to justify that the Augmented Solow growth model (Equation 4.3-2) is the right model⁹⁸ which explains the determinants of economic growth in the case of Cyprus.

It is very important to emphasize that the extended version of the Augmented Solow growth model is confirmed that it is incorrectly specified after our empirical testing procedure. In this model, policy proxies; LOP, LMTAR, and LGIR have no significant role on either the output level or output growth. This means that openness and government policy proxies do not influence the level or output growth through the investment ratios or the efficient terms which stand for technological improvement.

⁹⁷ Gujurati (1992) discusses that it is better to include irrelevant variables than exclude the relevant ones. However, this should not be encouraged because additional (irrelevant) variables may provide loss information in efficiency of the estimators (larger standard errors) and also can create the problem of multicollinearity.

⁹⁸ Modeling criteria such as Akaike Information and Schwarz Bayesian also confirm that the Augmented Solow Growth model is the right one correctly specified compared to the Solow and the extended version of the Augmented Solow growth models.

Openness proxies⁹⁹, LOP and LMTAR and government policy proxy, LGIR are confirmed by all methodologies employed that they are not found significant at conventional levels. The first reason behind this insignificance is that openness¹⁰⁰ proxies seem most likely to be used in conjunction with the other explanatory variable in a more complicated model (Demirguc-kunt and Detragiache 1999). Secondly, it may stem from the information that is lost when they are used as crude proxies (see Ghatak et al. 1995). Third it might be the reason pointed out by Rodriguez and Rodrik (2000), where they evaluate that strong results in the literature arise either from obvious misspecification or from the use of measure of openness proxies that have adverse effect on growth.

In addition, Wacziarg (2001) finds out that openness affects economic growth along with the other determinants of growth such as investment (i.e. government). He also adds that investment is the most important factor in which openness stimulates growth (see also Quah and Rauch 1990). This may confirm the reason behind the insignificant coefficient on government investment in our case. The other reason for the insignificance of government policy proxy is that it is not proper data¹⁰¹. Gramlich (1994) also points out that the relevant data about infrastructure investment do not exist in the literature in determining the contribution of infrastructure to economic growth.

It should be noted that we disagree with the two statements¹⁰² which are empirically found out in the cross-sectional studies. This makes us to look for another factor(s) that can really stimulate economic growth for the Cypriot economy¹⁰³.

⁹⁹ As far as data availability are concerned, it is clear that this is particularly a limitation. Such problem is severe for the other types of openness (or trade policy) such as black market premium, import of capital goods and import tariffs. In some studies, data may be gathered using interpolations technique to fill in the missing gap but we did not prefer this way because it yields biased results due to sample selection problems (see Harrison 1996).

¹⁰⁰ It is noteworthy that between 1963 and 1975, Cyprus was not a very open economy even though it seemed to be an opened one as measured by the ratio of exports plus imports as a proportion of GDP.

¹⁰¹ See appendix chapter A for more details about this proxy variable.

¹⁰² First one is that 'the more open outward economies tend to grow faster than closed ones'. The second is that 'the benefits from openness might be higher for a more educated population [See Edwards 1992; Levin and Rast 1992; Bhalla and Lau 1992].

¹⁰³ This issue will be empirically investigated in chapter 6 (i.e. Investment in the tourism sector).

In general subtle, the true model is the Augmented Solow growth model which embodies the rate of labour growth, the rates of investment in both physical and human capital. These proxies accurately depict the determinants of growth in the Cyprus economy for both the long and the short-run periods and this situation is confirmed by the government development plans. Especially, in the first fourteen years, dependence prior to the Turkish intervention was impressive-1960 and 1973. The economic and social indicators point out the fact that first fourteen years went through a period of prosperity. Fixed capital formation increased from 18 percent of GDP in 1961 to 28.5 percent in 1973. Investment in infrastructure projects like dams, roads, ports, airports, electricity, and communication reached a very satisfactory level. The registered unemployment reached at a low level of 1.2 percent in 1973. Human capital was highly initiated by providing long-term loans for technical and administrative assistance as well as specialised bureaucrats for the relationship between Cyprus and EU. These all reflected an increase in the labour productivity growth rate which was 5.4 percent per annum. The development plan for the Cyprus economy, covering the post 1974 period indicates that the performance of public policy was very poor due to the war. In this period, the government thus initiated investment policy to satisfy the demand for the refugees' houses and tourist accommodation and continued to support the education sector providing more employment.

5.6 Conclusion

We derived an extended version of the work of Mankiw, Romer, and Weil (1992) (the Augmented Solow growth model) in two directions where policy proxy variables exist. Unlike their studies which relies on cross-sectional data, we investigate the model using time series data. We are aware that our time series data are too short to give ultimate answers to the topic at hand. Of course, longer time series are better to highlight the features of economic growth.

We applied different time series techniques for both the long-run and the short-run periods to draw indicative conclusions rather than definitive considering short time series data under the stochastic nature. As mentioned earlier in the previous chapter, the models based on Solow growth model can be investigated employing multivariate time series techniques.

The relevant variables embodied in the model were found to be non-stationary in levels, but stationary in difference. The models then were found to be cointegrated including the two dummy variables to capture the effects of the structural break in different years for the Cypriot economy. We also found that the order of integration level is not changed by the potential structural break when the Perron and the Zivot-Andrews tests were applied respectively.

Furthermore, one cointegrating vector was found for both models. Having put the particular restrictions, we found the evidence that both models accord well with exogenous growth modelling. The relevant variables are also confirmed by the Johansen and the EHR techniques that they are weakly exogenous. In the next stage, the results estimated by the EY three-step correction, the Inder, and the Saikkonen methods respectively suggest that they are unbiased long-run elasticity estimates.

Our empirical results indicate that there exists some evidence for both the long-run and the short-run periods. However, a common point is for all our empirical findings show that policy proxy variables: LOP, LMTAR, LGIR were found statistically insignificant and inconsistent with our assumptions even though they are the economically and theoretically relevant variables. This implies that the estimates coefficients of policy proxies are irrelevant variables biased. Hence, it

can be supported the view that the Augmented Solow growth model (in the previous chapter, Equation 4.3-2) is the one correctly specified rather than the model represented by Equation (5.3-1). In an ultimate conclusion, our findings confirm that economic growth for the Cypriot economy is not fuelled by openness factor so this leads to further investigation into which kind of factors can better stimulate economic growth in the case of Cyprus. This will be empirically investigated in the next chapter. For instance, Investment in tourism may be the engine of growth for the Cypriot economy.

5.7 Tables

Table 5.7.1 The Residual-based ADF Test for Cointegration:

Cointegration Regression	R^2	$\bar{R}^2$	CRDW	Calculated ADF residuals	Critical Value
					MacKinnon (5%)
Model 1 $LCAPL_t = f(LKR_t, LHR_t, LNGD_t, VPV_t, VD_t)$	0.98	0.97	2.14	-7.24(0)	-5.90
Model 2 $LCAPL_t = f(LKR_t, LHR_t, LNGD_t, VPV_t, VD_t)$	0.98	0.97	2.24	-7.81(0)	-5.90

The reported critical value is obtained from MacKinnon (1991) and reported by MFIT 4.0. The numbers in parentheses indicates number of lags, which are chosen by the Schwarz Bayesian Criterion. This means that zero augmentation is necessary to be sufficient to secure lack of autocorrelation of the error terms for the relevant cointegration regressions. VPV and VD contain policy variables: LOP, LMTAR, LGIR and dummy variables: DUM64, DUM74 respectively.

Table 5.7.2 Engle-Granger Static Long-run Regressions

Explanatory Variables	Dependent Variable: LCAPL _t	
	Model 1	Model 2
C	3.37 (8.61)	3.72 (9.12)
T	0.047 (14.21)	0.05 (18.93)
LKR _t	0.12 (2.60)	0.14 (3.93)
LHR _t	0.14 (4.97)	0.13 (3.98)
LNGD _t	-0.42 (-4.68)	-0.37 (-4.29)
LGIR _t	0.03 (1.09)**	0.01 (0.32)**
LOP _t	0.06 (0.74)**	-
LMTAR _t	-	-0.03 (-0.72)**
DUM64	-0.15 (-5.26)	-0.14 (-4.71)
DUM74	-0.16 (-4.63)	-0.18 (-4.94)
R ²	0.98	0.98
$\bar{R}^2$	0.97	0.97
CRDW	2.14	2.24
ADF*	-7.24	-7.81
C.V.	-5.90	-5.90
SER	0.022	0.024
χ^2_{SC}	2.54 (prob=0.11)	3.84 (prob=0.05)
χ^2_{FF}	3.84 (prob=0.05)	1.82 (prob=0.18)
χ^2_{NORM}	0.66 (prob=0.72)	1.97 (prob=0.37)
χ^2_{HET}	1.25 (prob=0.26)	3.29 (prob=0.07)

Notes: t-statistics are in parentheses and all diagnostics pass at 5% level of significance. Two stars show that the relevant variables are not significant at 5% level. It is worth emphasizing that CRDW and CV are the cointegration Durbin-Watson statistics and the critical value for cointegration respectively. ADF* means no augmentation is necessary to remove autocorrelation from the error terms.

Table 5.7.3 The Johansen Maximum Likelihood (ML) procedure

Cointegration Likelihood Ratio (LR) Test to determine the number of cointegration vectors (r) based on Maximal Eigen Value of Stochastic Matrix, Trace of the stochastic matrix, and the (T-P) version is for the small sample suggested by Reimers (1992).

Cointegration Regression	H_0	H_1	$\lambda_{\max}$	$\lambda_{\max}$ (T-P)	C.V. at 5%	λ_{Trace}	λ_{Trace} (T-P)	C.V. at 5%
MODEL 1	$r = 0$	$r = 1$	65.39	52.67	43.97	169.12	136.23	114.9
	$r \leq 1$	$r = 2$	45.63	36.75	37.52	103.72	83.55	87.31
	$r \leq 2$	$r = 3$	29.06	23.41	31.46	58.09	46.79	62.99
	$r \leq 3$	$r = 4$	13.48	10.86	25.54	29.02	23.38	42.44
	$r \leq 4$	$r = 5$	9.64	7.76	18.96	15.53	12.51	25.32
	$r \leq 5$	$r = 6$	5.89	4.75	12.25	5.89	4.75	12.25
MODEL 2	$r = 0$	$r = 1$	56.43	45.45	43.97	156.48	126.05	114.9
	$r \leq 1$	$r = 2$	45.12	36.61	37.52	100.04	80.58	87.31
	$r \leq 2$	$r = 3$	29.04	23.39	31.46	54.91	44.23	62.99
	$r \leq 3$	$r = 4$	13.43	10.81	25.54	25.87	20.83	42.44
	$r \leq 4$	$r = 5$	10.16	8.18	18.96	12.44	10.02	25.32
	$r \leq 5$	$r = 6$	2.27	1.82	12.25	2.27	1.82	12.25

r indicates the number of cointegrating relationships. $\lambda_{\max}$ and λ_{trace} are the maximum eigen value and the trace statistics respectively. The (T-P) version is the corrected statistics for small samples suggested by Reimers (1992). Var 2 based on SBC is used in the Johansen procedure and unrestricted intercepts and unrestricted trends in the VAR model are not rejected in all cases. DUM64 and DUM74 are considered as exogenous $I(0)$ variables. The critical values are obtained from Osterwald-Lenum (1992).

Table 5.7.4 The Johansen Method

Coefficient in the long-run cointegration relationship between LCAPL (output) and its determinants: coefficients normalised on output to -1.

MODEL 1					
Variables	LKR _t	LHR _t	LNGL _t	LGIR _t	LOP _t
Coefficients	0.16	0.11	-0.35	0.05	0.09
t-values	3.66	2.20	-2.15	1.03	0.45
MODEL 2					
Variables	LKR _t	LHR _t	LNGL _t	LGIR _t	LMTAR _t
Coefficient	0.17	0.23	-0.59	0.09	-0.06
t-values	2.07	9.58	-7.14	1.16	-0.75

Table 5.7.4 reports the unique cointegrating vector for the relevant variables, which was obtained after normalising the coefficient of: LCAPL_t (output) to -1.

Table 5.7.5 Tests of Parameter Restrictions: The Johansen Method

MODEL 1		
Parameter Restrictions	Chi-squared test statistics	Critical value at 5%
$a_2 + a_3 + a_4 = 1.0$	8.75(1)*	3.84
MODEL 2		
Parameter Restrictions	Chi-squared test statistics	Critical value at 5%
$b_2 + b_3 + b_4 = 1.0$	5.59(1)*	3.84

Table 5.7.5 indicates the results of the cointegrating vector reported in Table 5.7.4 for a number of restrictions on the estimated coefficients of the relevant variables. Star (*) shows that χ^2 -test rejects the null hypothesis that sum of the coefficients is equal to 1, for both equations mentioned above.

Table 5.7.6 Elasticity Estimates:

Elasticity estimates of multivariate long-run relationship: A comparison of different approaches:

MODEL 1				
Variable	Static OLS (Engle-Granger)	Engle-Yoo Three step corrected values	OLS with time domain correction (Saikkonen)	Fully modified ECM (Inder)
C	3.37 (8.61)	3.89 (12.36)	4.13 (13.58)	5.41 (12.68)
T	0.047 (14.21)	0.048 (6.67)	0.051 (7.80)	0.049 (17.04)
LKR _t	0.12 (2.60)	0.19 (1.94)**	0.28 (2.57)	0.12 (2.30)
LHR _t	0.14 (4.97)	0.13 (2.96)	0.11 (3.11)	0.14 (7.71)
LNGD _t	-0.42 (-4.68)	-0.31 (-1.74)**	-0.21 (-2.50)	-0.44 (-5.92)
LGIR _t	0.03 (1.09)**	0.09 (1.75)**	0.05 (1.99)**	0.08 (1.39)*
LOP _t	0.06 (0.74)**	0.05 (0.43)*	0.21 (1.57)*	0.09 (0.18)*
DUM64 _t	-0.15 (-5.26)	-0.12 (-2.06)	-0.10 (-3.58)	-0.11 (-5.27)
DUM74 _t	-0.16 (-4.63)	-0.13 (-2.02)	-0.07 (-2.04)	-0.19 (-5.71)
MODEL 2				
C	3.72 (9.12)	3.99 (12.97)	4.52 (11.30)	5.43 (19.23)
T	0.05 (18.93)	0.04 (8.14)	0.04 (8.34)	0.05 (23.50)
LKR _t	0.14 (3.93)	0.12 (1.95)**	0.10 (2.25)	0.13 (2.44)
LHR _t	0.13 (3.98)	0.16 (3.32)	0.16 (4.75)	0.18 (5.48)
LNGD _t	-0.37 (-4.29)	-0.30 (-1.74)**	-0.22 (-2.35)	-0.39 (-4.23)
LGIR _t	0.01 (0.32)*	0.09 (1.78)**	0.07 (1.69)**	0.08 (1.49)*
LMTAR _t	-0.03 (-0.72)*	-0.08 (-1.12)*	-0.06 (-1.41)*	-0.07 (-0.83)*
DUM64 _t	-0.14 (-4.71)	-0.10 (-2.11)	-0.11 (-3.72)	-0.11 (-4.30)
DUM74 _t	-0.18 (-4.94)	-0.12 (-2.01)	-0.10 (-2.13)	-0.16 (-4.48)

Different approaches have been run on the relevant regressions above and t-values are shown in parenthesis. One star (*) indicates that they are not significant at conventional levels. Two stars (**) show that they are significant at 10% level. Rests are significant at conventional levels (5% and 1%).

Table 5.7.7 Error Correction Modelling: Short-run dynamics

Explanatory Variables	Dependent Variable: ΔLCAPL_t	
	Model 1	Model 2
C	0.05 (10.61)	0.05 (11.45)
ECT(-1)	-0.83 (-5.63)	-0.79 (-6.49)
ΔLKR_t	0.12 (3.17)	0.11 (2.34)
ΔLHR_t	0.17 (3.27)	0.17 (3.19)
ΔLNGLD_t	-0.24 (-3.31)	-0.29 (-4.51)
ΔLGIR_t	0.05 (1.65)*	0.06 (1.67)*
ΔLOP_t	0.06 (1.28)*	-
ΔLMTAR_t	-	-0.05 (-1.46)*
ΔDUM64_t	-0.11 (-5.97)	-0.11 (-6.41)
ΔDUM74_t	-0.14 (-5.70)	-0.13 (-4.85)
R^2	0.91	0.90
$\bar{R}^2$	0.87	0.88
DW	2.05	2.15
SER	0.018	0.017
χ^2_{SC}	3.56 (prob=0.07)	1.44 (prob=0.23)
χ^2_{FF}	2.20 (prob=0.13)	0.46 (prob=0.49)
χ^2_{NORM}	1.58 (prob=0.45)	4.94 (prob=0.08)
χ^2_{HET}	0.18 (prob=0.66)	0.18 (prob=0.67)

Notes: t-statistics are in the parentheses and all diagnostics pass at 5% level of significance. One star indicates that the relevant variables are not significant at conventional levels. It is worth noting that the unreported diagnostics suggest no evidence of misspecification at the 5% level of significance.

CHAPTER 6 Testing The Impact Of Disaggregated Investment In Economic Growth

6.1 Introduction

In the recent empirical growth literature, a contradiction has emerged from the relationship between equipment investment and long run growth rates, especially in cross-country studies. In a series of papers, De Long and Summers (1991, 1992, 1993) have argued that there is a strong and robust link between equipment investment and economic growth. The same is true for equipment prices (Jones, 1994), import (Lee, 1995), and adoption of technologies that are embodied in equipment (Hendricks, 2000). The result is also found in studies employing the best practical techniques advocated in the statistics literature (Temple, 1999; Temple and Voth, 1998), and disaggregating investment as equipment and non-equipment private investment (Jalilian and Odedokun, 2000).

This chapter investigates the link between different disaggregation of investment and economic growth, and its compatibility with the Solow growth model¹⁰⁴ in order to shed light on which type of disaggregated investment can better promote economic growth in the Cyprus economy. We adopted the framework introduced by Mankiw et al. (1992), by Benhabib and Spiegel (1994), and Temple (1998b) to investigate the role of different disaggregation of investment on economic growth.

We employed multivariate cointegration and causality techniques (as mentioned in the previous chapters) for analysing a disaggregated investment version of the Augmented Solow Growth model, which basically embodies investment in the tourism sector and investment in the non-tourism sector under the stochastic nature.

Generally, most of previous studies have attempted to breakdown equipment (i.e. machinery and transport) investment in order to test their effect on economic growth, especially, in the case of either developed or developing countries. To our knowledge, nobody took into account the effect of different types of investment (i.e. investment in the tourism sector) in the case of small island economies.

¹⁰⁴ Temple (1998b) uses the Solow growth model to investigate the role of disaggregation of investment and concludes that the model can be used to measure the effect of different type of investment (i.e. equipment and non equipment), however it needs to be modified to capture externalities to different types of investment.

In this chapter, on the basis of the findings¹⁰⁵ found in the previous chapter and for the purpose of policy, investment in the tourism sector, and investment in the non-tourism sector are investigated for the Cypriot economy.

Openness is a crucial factor in order to foster economic growth in small island economies. However, it does not have any effect on Cypriot economic growth. The question then becomes what kind of factor(s) can be encouraged to promote economic growth in the case of the Cyprus economy. Our findings suggest that investment in the tourism sector, investment in construction, and to a smaller extent, investment in transport equipment are the ones whose ratios to GDP have a positive effect on economic growth.

This Chapter is organised into five sections. In section 2, we present the derivation of a disaggregated investment version of the Augmented Solow Growth model. In section 3, we indicate the empirical methodology, model, and data description. In section 4, the empirical results are presented and evaluated. Finally, section 5 provides some conclusions.

6.2 Theoretical Modelling: A Disaggregated Investment Version of The Augmented Solow Growth Model

In this chapter, we investigate the link between different disaggregation of investment and economic growth in order to evaluate which type of investment can better explain Cypriot growth. De Long and Summer (1991; 1992; 1993) argue that there must be a special role and strong externalities associated with disaggregated investment-equipment on economic growth. We therefore take this statement into account when we breakdown investment into its different components. Unlike the works of De Long and Summers (1991, 1992, 1993)¹⁰⁶ and others¹⁰⁷, we disaggregate investment into two kinds of investment (i.e. investment in the tourism sector and in the non-tourism sector). It is believed that investment in the tourism sector is much more important than investment in the

¹⁰⁵ In chapter 5, openness and government policy proxies were found to be insignificant.

¹⁰⁶ They claim that 'equipment investment' has much more explanatory power on the rate of productivity growth than other type of investment.

¹⁰⁷ Benhabib and Spiegel (1994) and Temple (1998b).

non-tourism sector for small island economies, since tourism is a growing source of foreign exchange inflow in many small economies. Dommen and Hein (1985) point out that investment in tourism is the key issue, which offers good prospects for economic progress.

In the case of Cyprus, Kammas and Salehi-Esfahani (1992) analyse the direct contribution of tourism to gross domestic product (GDP) and mention that the contribution from tourism to gross domestic product is much more than the contribution from both the agriculture and the manufacturing sectors. Demetriades, Aljebory and Kamperies (1993: 259-268) assess the contribution of manufacturing to the economy of Cyprus and they find that manufacturing has a small impact on economic growth.

We adopt the framework introduced by Mankiw et al. (1992), by Benhabib and Spiegel (1994), and by Temple (1998b) to investigate the role of different disaggregations of investment on economic growth. Due to the importance of investment in the tourism sector, we especially follow the model proposed by Temple (1998b: 40). It is worth emphasising that we take into account Temple's work from his modelling point of view¹⁰⁸.

Let us consider the following Cobb-Douglas production function in the beginning of our study:

$$Y_t = T_t^\alpha NT_t^\gamma H_t^\beta (A_t L_t)^{1-\alpha-\gamma-\beta} \quad (6.2-1)$$

where Y is output, T is investment in the tourism sector, NT is investment in the non-tourism sector which includes non-tourism construction and machinery-transport equipment, H is investment in human development (the proxy is the tertiary enrolment rate), L is the labour force and A is a labour-augmenting factor reflecting the level of technology and efficiency in the economy.

¹⁰⁸ In this study, we basically have attempted to disaggregate capital investment into two investment groups (i.e. investment in the tourism sector and investment in the non-tourism sector). The former includes hotel and restaurant construction whilst the latter consists of non-tourism construction, machinery and transport equipment. To get more information about disaggregating investment on the basis of the Solow model, see also Jalilian and Odedokun, (2000).

Since the inputs in the Cobb-Douglas function are collapsible, we can write Equation (6.2-1) as

$$Y_t = K_t^{\alpha+\gamma} H_t^\beta (A_t L_t)^{1-\alpha-\beta} \quad (6.2-2)$$

where $K_t = T_t^{\alpha/\alpha+\beta} NT_t^{\gamma/\alpha+\gamma}$

However, this index of capital is different from that implicit in MRW's work [i.e. $(K=T+NT)$]. Since substitution possibilities between tourism and non-tourism are likely to be imperfect, the index employed here may be closer to the correct one.¹⁰⁹ MRW used the investment rate as aggregate physical capital in their equation whereas we use investment rates for tourism and non-tourism investment rates.

In MRW's work, total factor productivity growth and labour force growth are given as:

$$\frac{\dot{A}_t}{A_0} = g \quad (6.2-3)$$

and

$$\frac{\dot{L}_t}{L_0} = n \quad \text{respectively.} \quad (6.2-4)$$

The assumption of constant returns allows us to work with production function in intensive form:

$$y_t = t_t^\alpha n t_t^\gamma h_t^\beta \quad (6.2-5)$$

where $\frac{Y_t}{A_t L_t} = y_t$, $\frac{T_t}{A_t L_t} = t_t$, $\frac{NT_t}{A_t L_t} = n t_t$, $\frac{H_t}{A_t L_t} = h_t$

¹⁰⁹ These substitution possibilities between disaggregated components of investment are likely to be imperfect and the work of Greenwood et al. (1997) supports the view that capital disaggregation is important.

The net increase of the stock of tourism capital at a point in time equals gross investment less depreciation,

$$\dot{T}_t = I_t - \delta K_t \quad (6.2-6)$$

where δ is the rate of depreciation, $I_t = s' Y_t$, I is investment and s' is a constant savings rate. If we rearrange Equation (6.2-6) to plug investment into this Equation, this yields:

$$\dot{T}_t = s' Y_t - \delta T_t \quad (6.2-7)$$

Now, we substitute Equation (6.2-6) into Equation (6.2-7) to get:

$$\dot{T}_t = s' T_t^\alpha - \delta T_t N T_t^\gamma H_t^\beta (A_t L_t)^{1-\alpha-\gamma-\beta} - \delta T_t \quad (6.2-8)$$

dividing Equation (6.2-8) by $A_t L_t$ we get:

$$\begin{aligned} \frac{\dot{T}_t}{A_t L_t} &= s' \frac{T_t^\alpha N T_t^\gamma H_t^\beta (A_t L_t)^{1-\alpha-\gamma-\beta}}{A_t L_t} - \delta \frac{T_t}{A_t L_t} \\ \frac{\dot{T}_t}{A_t L_t} &= s' \frac{T_t^\alpha N T_t^\gamma H_t^\beta}{A_t L_t (A_t L_t)^{-(1-\alpha-\gamma-\beta)}} - \delta \frac{T_t}{A_t L_t} \\ \frac{\dot{T}_t}{A_t L_t} &= s' \left[\frac{T_t^\alpha}{A_t L_t} \right]^\alpha \left[\frac{N T_t^\gamma}{A_t L_t} \right]^\gamma \left[\frac{H_t^\beta}{A_t L_t} \right]^\beta - \delta \frac{T_t}{A_t L_t} \\ \frac{\dot{T}_t}{A_t L_t} &= s (t_t)^\alpha (n t_t)^\gamma (h_t)^\beta - \delta t_t \end{aligned} \quad (6.2-9)$$

Equation (6.2-9) shows that economic growth may arise from the accumulation of capital. The capital stock per efficiency unit t_t evolves as follows:

To find out $\frac{\dot{t}_t}{t_t}$, we need to apply the chain rule.

$$\dot{t}_t = \frac{\partial t_t}{\partial T_t} \dot{T}_t + \frac{\partial t_t}{\partial L_t} \dot{L}_t + \frac{\partial t_t}{\partial A_t} \dot{A}_t \quad (6.2-10)$$

where $t_t = \frac{T_{t,t}}{A_{t,t} L_{t,t}}$

$$\dot{t}_t = \frac{1}{A_t L_t} \dot{T}_t - \frac{T_t}{A_t L_t^2} \dot{L}_t - \frac{T_t}{L_t A_t^2} \dot{A}_t \quad (6.2-11)$$

$$\dot{t}_t = \frac{\dot{T}_t}{A_t L_t} - \frac{T_t}{A_t L_t} \frac{\dot{L}_t}{L_t} - \frac{T_t}{A_t L_t} \frac{\dot{A}_t}{A_t} \quad (6.2-12)$$

where $\frac{\dot{T}_t}{A_t L_t} = s (t_t)^\alpha (nt_t)^\gamma (h_t)^\beta - \delta t_t$, $\frac{\dot{L}_t}{L_t} = n$ and $\frac{\dot{A}_t}{A_t} = g$.

Plugging these expressions into Equation (6.2-12) to get Equation (6.2-13):

$$\dot{t}_t = s (t_t)^\alpha (nt_t)^\gamma (h_t)^\beta - \delta t_t - nt_t - gt_t \quad (6.2-13)$$

Rearranging Equation (6.2-13), it yields:

$$\dot{t}_t = s (t_t)^\alpha (nt_t)^\gamma (h_t)^\beta - (n + g + \delta)t_t \quad (6.2-14)$$

or

$$\dot{t}_t = s f(t_t, nt_t, h_t) - (n + g + \delta)t_t$$

If we divide Equation (6.2-14) by t_t , we can obtain tourism capital growth in the following equation:

$$\frac{\dot{t}_t}{t_t} = s \frac{(t_t)^\alpha (nt_t)^\gamma (h_t)^\beta}{t_t} - (n + g + \delta) \frac{t_t}{t_t} \quad (6.2-15)$$

Rearranging equation (6.2-15) to get equation (6.2-16):

$$\frac{\dot{t}_t}{t_t} = s (t_t)^{\alpha-1} (nt_t)^\gamma (h_t)^\beta - (n + g + \delta) \quad (6.2-16)$$

This Equation implies that t_t converges to a steady-state value t_t^* when $\dot{t}_t = 0$ and gives:

$$0 = s^T (t^*)^{\alpha-1} (nt^*)^\gamma (h^*)^\beta - (n + g + \delta)$$

Beyond this point, time t will be omitted for simplicity.

$$(t^*)^{\alpha-1} = \frac{(n + g + \delta) (nt^*)^{-\gamma} (h^*)^{-\beta}}{s^T}$$

Rearrangement of the equation above yields the Equations (6.2-17) and (6.2-18) as follows:

$$t^* = \frac{(n + g + \delta)^{\frac{1}{\alpha-1}} (nt^*)^{\frac{-\gamma}{\alpha-1}} (h^*)^{\frac{-\beta}{\alpha-1}}}{(s^T)^{\frac{1}{\alpha-1}}} \quad (6.2-17)$$

$$t^* = \left[\frac{(n + g + \delta) (nt^*)^{-\gamma} (h^*)^{-\beta}}{s^T} \right]^{\frac{1}{\alpha-1}} \quad (6.2-18)$$

This time we can use the same logic for $\frac{nt_t}{nt_t}$, applied to Equation (6.2-16).

$$\frac{nt_t}{nt_t} = s^{NT} (t^*)^\alpha (nt^*)^{\gamma-1} (h^*)^\beta - (n + g + \delta) \quad (6.2-19)$$

Imposing a steady-state on Equation (6.2-19), we then obtain Equation (6.2-20) and (6.2-21):

$$0 = s^{NT} (t^*)^\alpha (nt^*)^{\gamma-1} (h^*)^\beta - (n + g + \delta) \quad (t \text{ is omitted})$$

$$(t^*)^\alpha = \frac{(n + g + \delta) (nt^*)^{-(\gamma-1)} (h^*)^{-\beta}}{s^{NT}}$$

$$t^* = \frac{(n + g + \delta)^{\frac{1}{\alpha}} (nt^*)^{\frac{1-\gamma}{\alpha}} (h^*)^{-\frac{\beta}{\alpha}}}{(s^{NT})^{\frac{1}{\alpha}}} \quad (6.2-20)$$

$$t^* = \left[\frac{(n+g+\delta)(nt^*)^{1-\gamma}(h^*)^{-\beta}}{s^{NT}} \right]^{\frac{1}{\alpha}} \quad (6.2-21)$$

Now we can follow the same procedure for $\frac{\dot{h}_t}{h_t} = 0$ to reach the steady-state value of h (namely, h^*) by finding t^* .

$$\frac{\dot{h}_t}{h_t} = s (t_t)^\alpha (nt_t)^\gamma (h_t)^{\beta-1} - (n+g+\delta) \quad (6.2-22)$$

$$0 = s^H (t^*)^\alpha (nt^*)^\gamma (h^*)^{\beta-1} - (n+g+\delta) \quad (t \text{ is omitted})$$

$$(t^*)^\alpha = \frac{(n+g+\delta)(nt^*)^{-\gamma}(h^*)^{-(\beta-1)}}{s^H}$$

$$t^* = \frac{(n+g+\delta)^{\frac{1}{\alpha}} (nt^*)^{\frac{-\gamma}{\alpha}} (h^*)^{\frac{1-\beta}{\alpha}}}{(s^H)^{\frac{1}{\alpha}}} \quad (6.2-23)$$

$$t^* = \left[\frac{(n+g+\delta)(nt^*)^{-\gamma}(h^*)^{1-\beta}}{s^H} \right]^{\frac{1}{\alpha}} \quad (6.2-24)$$

Now we can find out the steady-state values of t , nt , and h by Equating (6.2-17) and (6.2-20). This equality gives us nt^* as follows:

$$\frac{(n+g+\delta)^{\frac{1}{\alpha-1}} (nt^*)^{\frac{-\gamma}{\alpha-1}} (h^*)^{\frac{-\beta}{\alpha-1}}}{(s^T)^{\frac{1}{\alpha-1}}} = \frac{(n+g+\delta)^{\frac{1}{\alpha}} (nt^*)^{\frac{1-\gamma}{\alpha}} (h^*)^{\frac{-\beta}{\alpha}}}{(s^{NT})^{\frac{1}{\alpha}}}$$

$$(nt^*)^{\frac{-\gamma}{\alpha-1}} (nt^*)^{\frac{\gamma-1}{\alpha}} = \frac{(s^T)^{\frac{1}{\alpha-1}} (s^{NT})^{-\frac{1}{\alpha}} (h^*)^{\frac{-\beta}{\alpha}} (h^*)^{\frac{\beta}{\alpha-1}}}{(n+g+\delta)^{\frac{1}{\alpha-1}} (n+g+\delta)^{-\frac{1}{\alpha}}}$$

$$\begin{aligned}
(nt^*)^{\frac{1-\alpha-\gamma}{\alpha(\alpha-1)}} &= \frac{(s^T)^{\frac{1}{\alpha-1}} (s^{NT})^{-\frac{1}{\alpha}} (h^*)^{\frac{\beta}{\alpha(\alpha-1)}}}{(n+g+\delta)^{\frac{1}{\alpha(\alpha-1)}}} \\
nt^* &= \left[\frac{(s^T)^{\frac{1}{\alpha-1}} (s^{NT})^{-\frac{1}{\alpha}} (h^*)^{\frac{\beta}{\alpha(\alpha-1)}}}{(n+g+\delta)^{\frac{1}{\alpha(\alpha-1)}}} \right]^{\frac{\alpha(\alpha-1)}{1-\alpha-\beta}} \\
nt^* &= \left[\frac{(s^T)^{\alpha} (s^{NT})^{-(\alpha-1)} (h^*)^{\beta}}{(n+g+\delta)} \right]^{\frac{1}{1-\alpha-\beta}} \quad (6.2-25)
\end{aligned}$$

and then Equation (6.2-20) and Equation (6.2-23) can be equated as follows:

$$\begin{aligned}
\frac{(n+g+\delta)^{\frac{1}{\alpha}} (nt^*)^{\frac{1-\gamma}{\alpha}} (h^*)^{-\frac{\beta}{\alpha}}}{(s^{NT})^{\frac{1}{\alpha}}} &= \frac{(n+g+\delta)^{\frac{1}{\alpha}} (nt^*)^{-\frac{\gamma}{\alpha}} (h^*)^{\frac{1-\beta}{\alpha}}}{(s^H)^{\frac{1}{\alpha}}} \\
(nt^*)^{\frac{1-\gamma}{\alpha}} (nt^*)^{\frac{\gamma}{\alpha}} &= \frac{(s^{NT})^{\frac{1}{\alpha}} (s^H)^{-\frac{1}{\alpha}} (h^*)^{\frac{1-\beta}{\alpha}} (h^*)^{\frac{\beta}{\alpha}}}{(n+g+\delta)^{\frac{1}{\alpha}} (n+g+\delta)^{-\frac{1}{\alpha}}} \\
nt^* &= (s^{NT}) (s^H)^{-1} (h^*) \quad (6.2-26)
\end{aligned}$$

Having found Equations (6.2-25) and (6.2-26), they can be equated to obtain a steady-state value of h (namely, h^*).

$$\begin{aligned}
(s^{NT}) (s^H)^{-1} (h^*) &= \frac{(s^T)^{\frac{\alpha}{1-\alpha-\gamma}} (s^{NT})^{\frac{-(\alpha-1)}{1-\alpha-\gamma}} (h^*)^{\frac{\beta}{1-\alpha-\gamma}}}{(n+g+\delta)^{\frac{1}{1-\alpha-\gamma}}} \\
(h^*) (h^*)^{\frac{-\beta}{1-\alpha-\gamma}} &= \frac{(s^T)^{\frac{\alpha}{1-\alpha-\gamma}} (s^{NT})^{-1} (s^H) (s^{NT})^{\frac{-(\alpha-1)}{1-\alpha-\gamma}}}{(n+g+\delta)^{\frac{1}{1-\alpha-\gamma}}}
\end{aligned}$$

$$\begin{aligned}
 (h^*)^{\frac{1-\alpha-\gamma-\beta}{1-\alpha-\gamma}} &= \frac{(s^T)^{\frac{\alpha}{1-\alpha-\gamma}} (s^{NT})^{\frac{\gamma}{1-\alpha-\gamma}} (s^H)}{(n+g+\delta)^{\frac{1}{1-\alpha-\gamma}}} \\
 h^* &= \left[\frac{(s^T)^{\frac{\alpha}{1-\alpha-\gamma}} (s^{NT})^{\frac{\gamma}{1-\alpha-\gamma}} (s^H)}{(n+g+\delta)^{\frac{1}{1-\alpha-\gamma}}} \right]^{\frac{1-\alpha-\gamma}{1-\alpha-\gamma-\beta}} \\
 h^* &= \left[\frac{(s^T)^\alpha (s^{NT})^\gamma (s^H)^{1-\alpha-\gamma}}{(n+g+\delta)} \right]^{\frac{1}{1-\alpha-\gamma-\beta}} \quad (6.2-27)
 \end{aligned}$$

To find out nt^* , we can substitute Equation (6.2-27) into Equation (6.2-26).

$$\begin{aligned}
 nt^* &= (s^{NT}) (s^H)^{-1} \frac{(s^T)^{\frac{\alpha}{1-\alpha-\gamma-\beta}} (s^{NT})^{\frac{\gamma}{1-\alpha-\gamma-\beta}} (s^H)^{\frac{1-\alpha-\gamma}{1-\alpha-\gamma-\beta}}}{(n+g+\delta)^{\frac{1}{1-\alpha-\gamma-\beta}}} \\
 nt^* &= \frac{(s^{NT})^{\frac{1-\alpha-\beta}{1-\alpha-\gamma-\beta}} (s^H)^{\frac{\beta}{1-\alpha-\gamma-\beta}} (s^T)^{\frac{\alpha}{1-\alpha-\gamma-\beta}}}{(n+g+\delta)^{\frac{1}{1-\alpha-\gamma-\beta}}} \\
 nt^* &= \left[\frac{(s^{NT})^{1-\alpha-\beta} (s^H)^\beta (s^T)^\alpha}{(n+g+\delta)} \right]^{\frac{1}{1-\alpha-\gamma-\beta}} \quad (6.2-28)
 \end{aligned}$$

Now, we can obtain a steady-state value of t (i.e. t^*) plugging Equations (6.2-28) and (6.2-27) into (6.2-24):

$$t^* = \left[\frac{(n+g+\delta) (s^{NT})^{\frac{-\gamma(1-\alpha-\beta)}{1-\alpha-\gamma-\beta}} (s^H)^{\frac{-\beta\gamma}{1-\alpha-\gamma-\beta}} (s^T)^{\frac{-\gamma\alpha}{1-\alpha-\gamma-\beta}} (h^*)^{1-\beta}}{(n+g+\delta)^{\frac{-\gamma}{1-\alpha-\gamma-\beta}} (s^H)} \right]^{\frac{1}{\alpha}}$$

$$\begin{aligned}
t^* &= \frac{(s^{NT})^{\frac{-\gamma(1-\alpha-\beta)}{\alpha(1-\alpha-\gamma-\beta)}} (s^H)^{\frac{-\beta\gamma}{\alpha(1-\alpha-\gamma-\beta)}} (s^T)^{\frac{-\gamma\alpha}{1-\alpha-\gamma-\beta}}}{(n+g+\delta)^{-1/\alpha} (n+g+\delta)^{\frac{-\gamma}{\alpha(1-\alpha-\gamma-\beta)}}} \\
t^* &= \frac{(s^{NT})^{\frac{-\gamma(1-\alpha-\beta)}{\alpha(1-\alpha-\gamma-\beta)}} (s^H)^{\frac{-\beta\gamma}{\alpha(1-\alpha-\gamma-\beta)}} (s^T)^{\frac{-\gamma}{1-\alpha-\gamma-\beta}} (s^H)^{-1/\alpha} (s^T)^{\frac{1-\beta}{1-\alpha-\gamma-\beta}} (s^{NT})^{\frac{\gamma(1-\beta)}{\alpha(1-\alpha-\gamma-\beta)}} (s^H)^{\frac{(1-\beta)(1-\alpha-\gamma)}{\alpha(1-\alpha-\gamma-\beta)}}}{(n+g+\delta)^{-1/\alpha} (n+g+\delta)^{\frac{1-\gamma-\beta}{1-\alpha-\gamma-\beta}} (n+g+\delta)^{\frac{1-\beta}{\alpha(1-\alpha-\gamma-\beta)}}} \\
t^* &= \frac{(s^{NT})^{\frac{\gamma}{1-\alpha-\gamma-\beta}} (s^T)^{\frac{1-\gamma-\beta}{1-\alpha-\gamma-\beta}} (s^H)^{\frac{\beta}{1-\alpha-\gamma-\beta}}}{(n+g+\delta)^{\frac{1}{1-\alpha-\gamma-\beta}}} \\
t^* &= \left[\frac{(s^{NT})^\gamma (s^T)^{1-\gamma-\beta} (s^H)^\beta}{(n+g+\delta)} \right]^{\frac{1}{1-\alpha-\gamma-\beta}} \quad (6.2-29)
\end{aligned}$$

Equations (6.2-27), (6.2-28), and (6.2-29) indicate a steady-state values of t , nt , and h respectively. To obtain output y^* , we substitute Equations (6.2-27), (6.2-28), and (6.2-29) into Equation (6.2-25).

$$y^* = (t^*)^\alpha (nt^*)^\gamma (h^*)^\beta \quad (t \text{ is omitted for simplicity}) \quad (6.2-5)$$

$$\begin{aligned}
y^* &= \left[\left(\frac{(s^{NT})^\gamma (s^T)^{1-\gamma-\beta} (s^H)^\beta}{n+g+\delta} \right)^{\frac{1}{1-\alpha-\gamma-\beta}} \right]^\alpha \left[\left(\frac{(s^{NT})^{1-\alpha-\beta} (s^H)^\beta (s^T)^\alpha}{n+g+\delta} \right)^{\frac{1}{1-\alpha-\gamma-\beta}} \right]^\gamma \\
&\quad \cdot \left[\left(\frac{(s^T)^\alpha (s^{NT})^\gamma (s^H)^{1-\alpha-\gamma}}{n+g+\delta} \right)^{\frac{1}{1-\alpha-\gamma-\beta}} \right]^\beta
\end{aligned}$$

$$y^* = \left[\frac{(s^{NT})^{\gamma\alpha} (s^T)^{(1-\gamma-\beta)\alpha} (s^H)^{\beta\alpha} (s^{NT})^{(1-\alpha-\beta)\gamma} (s^H)^{\beta\gamma} (s^T)^{\alpha\gamma} (s^T)^{\alpha\beta} (s^{NT})^{\gamma\beta} (s^H)^{(1-\alpha-\gamma)\beta}}{(n+g+\delta)^\alpha (n+g+\delta)^\gamma (n+g+\delta)^\beta} \right]^{\frac{1}{1-\alpha-\gamma-\beta}}$$

$$y^* = \left[\frac{(s^T)^\alpha (s^{NT})^\gamma (s^H)^\beta}{(n+g+\delta)^{\alpha+\gamma+\beta}} \right]^{\frac{1}{1-\alpha-\gamma-\beta}} \quad (6.2-30)$$

This Equation shows the steady-state value of y and it leads to the following a disaggregated investment version of the Augmented Solow model:

$$\ln y^* = \frac{\alpha}{1-\alpha-\gamma-\beta} \ln s^T + \frac{\gamma}{1-\alpha-\gamma-\beta} \ln s^{NT} + \frac{\beta}{1-\alpha-\gamma-\beta} \ln s^H - \frac{\alpha+\gamma+\beta}{1-\alpha-\gamma-\beta} \ln(n+g+\delta)$$

(6.2-31)

If we take Equation (6.2-5) in the form of Equation (6.2-32), we have equation (6.2-33), steady-state income per worker or labour productivity.

$$\frac{Y}{AL} = (t)^\alpha (nt)^\gamma (h)^\beta$$

$$\frac{Y}{L} = At^\alpha nt^\gamma h^\beta \quad (6.2-32)$$

where $y^* = \left(\frac{Y}{L} \right)^*$

Taking logarithms for both sides of Equation (6.2-32) we have the following equation:

$$\begin{aligned} \ln\left(\frac{Y}{L}\right)^* &= \ln A_0 + gt + \frac{\alpha}{1-\alpha-\gamma-\beta} \ln s^T + \frac{\gamma}{1-\alpha-\gamma-\beta} \ln s^{NT} + \frac{\beta}{1-\alpha-\gamma-\beta} \ln s^H \\ &\quad - \frac{\alpha+\gamma+\beta}{1-\alpha-\gamma-\beta} \ln(n+g+\delta) \end{aligned} \quad (6.2-33)$$

Equation (6.2-33) indicates steady-state output per worker where the disaggregated capitals and the other relevant variables exist.

In order to find the disaggregated version of the Augmented Solow model, we need to determine the transitional dynamics by using a log-linearization around the steady-state. This gives the following growth Equation (see section 4.2.2 in chapter 4 for a derivation of the linearization of the transition path):

$$\begin{aligned} \ln y - \ln y(0) &= g + (1 - e^{-\lambda}) \left[\ln A_0 + gt + \frac{\alpha}{1-\alpha-\gamma-\beta} \ln s^T + \frac{\gamma}{1-\alpha-\gamma-\beta} \ln s^{NT} \right. \\ &\quad \left. + \frac{\beta}{1-\alpha-\gamma-\beta} \ln s^H - \ln(n+g+\delta) - \ln y(0) \right] \end{aligned} \quad (6.2-34)$$

Around the steady-state path, labour productivity or steady-state income per worker evolves according to the following equation:

$$\begin{aligned} \ln y_{i+1} - \ln y_i &= g + (1 - e^{-\lambda_i}) \left[\ln A_0 + gt + \frac{\alpha}{1-\alpha-\gamma-\beta} \ln s^T + \frac{\gamma}{1-\alpha-\gamma-\beta} \ln s^{NT} \right. \\ &\quad \left. + \frac{\beta}{1-\alpha-\gamma-\beta} \ln s^H - \ln(n_i + g + \delta) - \ln y_i \right] \end{aligned} \quad (6.2-35)$$

where. $\lambda_i = (n_i + g + \delta)(1 - \alpha - \gamma - \beta)$.

Using the same information as in chapter 4, Equation (6.2-35) can be formulated in linear form (omitting log notation):

$$\Delta y_t = c + \mu \left[y - A_0 - A_1 T - A_2 s^T - A_3 s^{NT} - A_4 s^H - A_5 (n + g + \delta) \right]_{t-1}$$

or

$$\Delta y_t = c + \mu \left[y - y^* \right]_{t-1} \quad (6.2-36)$$

This Equation indicates that the lagged difference between actual and equilibrium $\ln y_t$ determines the variation of $\ln y_t$ and this leads to an error correction mechanism.

Following Durlauf and Johansen (1992) and Cellini (1997), s_t^T , s_t^{NT} , s_t^H and n_t can be assumed to vary overtime. Therefore, our ECM regarding Equation (4.2.1-43) can only be modified for an empirical estimation as follows:

$$\begin{aligned} \Delta \ln y_t = & c_0 + \mu e_{t-1} + \sum_{i=0}^m \phi_i \Delta \ln s_{t-i}^T + \sum_{j=0}^p \eta_j \Delta \ln s_{t-j}^{NT} + \sum_{k=0}^r \Pi_k \Delta \ln s_{t-k}^H \\ & + \sum_{z=0}^s \delta_z \Delta \ln (n_{t-z} + g + \delta) + \varepsilon_t \end{aligned} \quad (6.2-37)$$

where ε_t is a stochastic error term (assumed to be white noise) and all the variables used in ECM are already defined at the beginning of this chapter.

6.3 The Empirical Methodology, Model and Data

Modelling disaggregating investment based on the conventional approach in which the model embodies equipment and non-equipment investment is introduced by Delong and Summer (1991). This approach then has gained acceleration when the Solow model has been modified by using investment in human capital by Mankiw et al. (1992). Recently, Temple (1998b) and Jalilian and Odedokun (2000) pay particular attention to the role of disaggregating investment in this framework based on the modelling modified by Mankiw et al. (1992). The model presented in this chapter follows the framework described above.

From the previous section, following Equation (6.2-33), the long-run model specification for the link between different disaggregation of investments and GDP per worker can be represented by the following Equation (6.3-1):

$$LCAPL_t = a_0 + a_1 T + a_2 LTR_t + a_3 LNTR_t + a_4 LHR_t + a_5 LNGD_t + a_6 VDum + u_t \quad (6.3-1)$$

where¹¹⁰

LTR_t = Gross domestic fixed capital formation is used by type of construction in the tourism sector as proxy for investment in the tourism sector defined as the ratio of tourism investment to GDP.

$LNTR_t$ = The vector of non-tourism sector variables which can be decomposed of LANTR, LCNTR, LTER and LMTR defined as follows:

LANTR = This is the combination of construction, machinery, and equipment. Here, Gross domestic fixed capital formation is used by type of construction, machinery and transport equipment in the non-tourism sector as a proxy for investment in the non-tourism sector defined as the ratio of the non-tourism investment to GDP.

LCNTR = Gross domestic fixed capital formation is used by type of non-tourism construction as proxy investment in the non-tourism construction sector defined as the ratio of non-tourism construction to GDP.

LTER = Gross domestic fixed capital formation is used by type of transport equipment as proxy for investment in transport equipment unit defined as the ratio of transport equipment investment to GDP.

LMTR = Gross domestic fixed capital formation is used by type of machinery-transport equipment as proxy for investment in machinery-transport equipment unit defined as machinery-transport equipment investment to GDP.

VDUM = The vector of Dummy variables which contain DUM64, DUM67, DUM73 and DUM74.

¹¹⁰ We attempt to disaggregate investment as much as the availability of data permits.

It is noteworthy that the dummy variables: DUM64 and DUM74 are already defined in the previous chapters and the other two: DUM67 and DUM 73 are explained as follows:

DUM67 = This dummy variable reflects the effects that Turkish Cypriots administration withdrew their partnership from the government due to the unrest situation (intercommunal conflict). This may capture a positive impact on Cyprus economy since income was distributed among Greek Cypriots population rather than the entire population. Thus GDP per capita (worker) recorded was greater than the amount it should have been. However, this is not recorded officially in the relevant statistical publications. This dummy takes the value of one for 1967 and zero otherwise.

DUM73 = This dummy variable takes in to account the effect of first oil crisis in the world and may capture adverse effect on the Cypriot economy. It takes the value of one for 1973 and zero otherwise.

Due to one of the comparative advantages in small island economies, we especially breakdown aggregate investment as tourism and non-tourism investment rather than following the existing literature in which many empirical cross-section studies have attempted to investigate the effects of equipment and non-equipment investment on growth. This may be partly because of the lack of data not to permit a further breakdown of aggregate investment, especially within the time series context.

As pointed earlier, we use investment for the tourism sector, which refers to non-residential building construction-restaurants and hotels whilst investment in the non-tourism sector is associated with residential¹¹¹ building construction, machinery and transport equipment.

An important point should be noted that it is really difficult to employ more disaggregated data for our study, particularly, at sectoral level (i.e. trade sector) because of the availability and the quality of data are either very poor or relatively

¹¹¹ Using investment in the tourism sector or residential investment is relatively less conventional to include it as a breakdown of capital investment (Jalilian and Odedokun 2000).

little information for the Cyprus economy. So doing some empirical investigation are almost impossible for trade sector where enough data do not exist (see also Proundman and Redding, 1997).

In the model above, we mainly study investment in the tourism sector and in the non-tourism sector by applying cointegration analysis to investigate empirically which type of investment can better explain Cypriot growth using annual data over the period 1960-1995.

Prior to modelling the relationships between economic growth and disaggregated capital, we examine their univariate time series properties. This is confirmed by the Augmented Dickey Fuller (ADF) unit root test (Dickey and Fuller, 1979, 1981) and the multivariate form of the Augmented Dickey-Fuller (MADF)¹¹² test proposed by Johansen and Juselius (1992).

Following the Engle and Granger¹¹³ cointegration procedure (EG) (see Engle and Granger, 1987) and the cointegration technique developed by Johansen¹¹⁴ (1988), we answer the question whether there exists a long-run relationship among the variables.

In addition to the Johansen procedure, we use some methods to test a number of restrictions on the estimated coefficient of the relevant factors of production after normalising the coefficient of output to -1 and also check whether the model accords well with the prediction of exogenous growth model. Besides this, exogeneity tests-the EHR and the Johansen are conducted to find out whether the explanatory variables (i.e. disaggregated investment proxies) are weakly exogenous. This gives us an indication that the explanatory variables can take their place on the right hand side of the model.

The next step is to model the short-run dynamics using an ECM¹¹⁵. In order to establish a short-run relationship among the variables, we use the residuals

¹¹² We also use the Perron (AOM) and the Zivot-Andrews (ZA) tests whether the order of integration is changed by structural breaks or not.

¹¹³ Before we construct a long-run relationship, we examine the disaggregating series if they have stochastic or deterministic properties by conducting Dickey-Fuller LR joint test.

¹¹⁴ Gonzales and Lee (1998) point out that the Johansen test tends to find spurious cointegration relation whereas the EG test is found more robust.

¹¹⁵ See section 4.2.1 in chapter 4 to get more information how we construct the ECM.

estimated from the cointegration regression (Equation 6.3-1) in the following Equation (6.3-2):

Thus,

$$\begin{aligned} \Delta LCAPL_t = & a_0 + a_1 u_{t-1} + \sum_{i=0}^m a_i \Delta LTR_{t-i} + \sum_{j=0}^p a_j \Delta LNTR_{t-j} + \sum_{k=0}^r a_k \Delta LHR_{t-k} \\ & + \sum_{z=0}^s a_z \Delta NGD_{t-z} + \sum_{l=0}^v a_l \Delta VD_{t-l} + \varepsilon_t \end{aligned} \quad (6.3-2)$$

where Δ denotes the first difference operator, L is natural logarithms, u_{t-1} is the lagged residual estimated from equation (6.3-1), TR is investment in tourism, NTR is a vector of investment in non-tourism sector capitals, D is the vector of Dummy variables and other variables are defined in equation (6.3-1) and in previous chapters.

Finally, the causal orderings between the output growth and the disaggregated investment are investigated in a bivariate model employing different techniques as explained in appendix chapter C.

6.4 Empirical Results

Most of the existing empirical studies regarding the modelling approach pointed out earlier have been based on cross-sectional data for the number of countries-non-oil, developing, developed and OECD. To our knowledge, none or a few of studies take this framework using integration and cointegration analysis and employing time series data for a single country. The present study and its results are important from this point of view.

Many macroeconomic time series contain unit roots and the techniques are very important in examining the stationarity of a time series because non-stationary regressors invalidate most of the standard empirical results. As mentioned in the previous chapters, the presence of a unit root in both level and first differences is investigated by using both the ADF and the MADF unit root tests.

These sequential testing results are shown in Common Tables A.5.1 and A.5.2 in the Appendix Chapter A. The inspection of the relevant variables confirms the view that the variables in question – LTR (the ratio of real investment in the tourism sector to GDP), LANTR (the ratio of real investment in the non-tourism sector to GDP), LCNTR (the ratio of real investment in non-tourism construction to GDP), LTER (the ratio of real investment in transport equipment to GDP), LMTR (the ratio of real investment in transport and machinery equipment to GDP) are all non-stationary in levels but stationary in first differences. It is worth emphasizing that LMTR was found to be $I(0)$ when the ADF was used. However, we found LMTR integrated of order one in level when the MADF unit root test¹¹⁶ was applied. These are denoted as, $LTR \sim I(1)$, $LANTR \sim I(1)$, $LCNTR \sim I(1)$, $LTER \sim I(1)$, $LMTR \sim I(0) / I(1)$.

As Cellini (1997) discusses the variables, under the standard formulation of the neoclassical model, are stochastic. The steady-state level (or equilibrium level in a country should be considered as being stochastic as well. For this purpose, we use DFLR joint test whether our disaggregated series are stochastic. The test statistics, i.e. 6.95, 6.88, 3.78, and 3.46 in Common Table A.5.3 suggest that we have a DSP dominant mixed process (i.e. stochastic-deterministic). In the same table, disaggregated investment capital proxies (i.e. $LTER_t$ and $LMTR_t$) are not robust evidence in favour of difference stationary process (DSP), although they pass at the 5% significance level.

In order to find out whether the effects of both exogenous and endogenous breaks are significant for disaggregated capitals, we employ the Additive Outlier Perron (1990) test and the Zivot-Andrews testing procedure respectively. The results presented in Common Tables A.5.4 and A.5.5 show that t-values for the exogenous break year 1974 and the endogenous one 1964 are not significant. This implies that there is no ‘spurious unit root’ created by either exogenous or endogenous breaks. Actually, the results obtained from both tests are not contradictory.

¹¹⁶ The MADF test complements the ADF test in a sense that the power of either test can be addressed by comparing their significance (see also appendix chapter C).

Prior to modelling the long-run and the short-run relationships among the variables, weak exogeneity properties are established. The results of the EHR and the Johansen procedures indicate that all disaggregated variables considered by the study qualify as weak exogenous (see Common Table A.5.6).

The next step is to consider the cointegration relationship among the variables, which are all $I(1)$ by employing the Engle and Granger (1987) cointegration procedure. The estimation results of the cointegration regression for models 1, 2, and 3 are in Table 6.6.1 and 6.6.2. These Tables indicate that there is evidence of a long-run relationship between labour productivity ($LCAPL_t$) and its determinants (the explanatory variables). In Table 6.6.2, the corresponding critical values show that the underlying models are correctly specified.

In other words, the coefficients are consistent with the predictions of the model where cointegration regression occurs¹¹⁷ and the estimated values¹¹⁸ are statistically significant and correctly signed for all models¹¹⁹ in Table 6.6.2.

The results for testing the number of cointegration vectors are reported in Table 6.6.3. In this table, maximum eigen value statistics ($\lambda_{\max}$) and trace statistics (λ_{trace}) are corrected by the Reimer statistics (λ_{T-P}). Both ($\lambda_{\max}$) and (λ_{trace}) tests results show that there exist two cointegrating vectors whereas (λ_{T-P}) test results confirm the presence of one cointegrating vector for each model.

Note that compared with the number of cointegrating vector in chapter 4, one can make a comment on the two cointegrating vector found in this chapter regarding the model used in chapter 4. Here, we decomposed the variable into its components rather than adding more variables to the model, so one cointegrating vector must not contradict with the previous results. In addition to this, one of the two cointegrating vectors may satisfy positive sign whereas the other one is likely to have negative sign among its coefficients (see also Hwang 1998).

¹¹⁷ Cointegration relationships are not established without including the relevant dummy variables in the models (see section 6.2 to get details for the dummy variables).

¹¹⁸ In Table 6.6.2, exogenous technological progress has a positive impact on economic growth and accord well with the prediction of exogenous growth model.

¹¹⁹ The estimated forecast performance technique shows that model 2 has minimum forecast errors (i.e. model 1 is 0.0099, model 2 is 0.0039, model 3 is 0.0092).

Table 6.6.4 also reports the unique cointegrating vector for all models, after normalising the coefficient of LCAPL (output) to -1 . In model 1, all of the estimated coefficients have the expected signs and slightly different magnitudes compared with the reported coefficients on the variables where first-step Engle-Granger method is applied. In this model, LTR (investment in the tourism sector) are more important than LANTR (investment in the non-tourism sector) compared with their reported coefficients. In model 2, LCNTR (investment in non-tourism construction) are significant at the 10% level whereas LTER (investment in transport equipment) have no impact on output. In model 3, LMTR (investment in transport-machinery equipment) has no influence on output either¹²⁰. This indicates that investment in the tourism sector is more likely to be important than investment in the non-tourism sector¹²¹. In other words, findings suggest that investment in non-tourism-sector such as transport and machinery are not as productive as investment in the tourism sector.

Disaggregating investment could also be investigated at different sector-exports or imports. However, It is almost impossible to investigate the impacts of disaggregating investment from different sectoral point of view due to unavailability of data where the data are not long enough to make sensible judgement about sector performance.

Accordingly we impose the restriction that the sum of the coefficients equals unity¹²². The restriction that the sum of the coefficients on disaggregated capitals, LHR and LNGD for the models (models 1, 2, and 3) is unity cannot be accepted. Table 6.6.5 shows the results in favour of exogenous growth modelling.

In the next step, unlike the static OLS procedure, we apply the Engle and Yoo, the Saikkonen, and the Inder methods which contain dynamic OLS properties. The

¹²⁰ As pointed out by Jalilian and Odedokun (2000), their findings indicate that “not all types of investment are conducive to growth”.

¹²¹ From the sectoral point of view, the goals for restructuring and modernization of investment activities in favour of machinery and equipment was not achieved to the desired level whilst tourism and financial services surpassed the set targets (Statistical abstract, ministry of finance, 1995).

¹²² Sala-i-Martin (1990) argues that ‘in order to have endogenous growth model, there must be constant returns to the factors than can be accumulated’. Mankiw et al. (1992) also point out that ‘our model with physical and human capital would become an endogenous growth model if their coefficients ($\alpha + \beta = 1$) is equal to 1’.

three methods are suggested to use after an OLS static regression because they have advantages to obtain unbiased, robust and asymptotically efficient estimates. The results are reported in Tables 6.6.6, 6.6.7, and 6.6.8. There are slightly differences in magnitudes, but estimates are broadly similar and signs are consistent.

However, it is worth stressing that investment in machinery-transport equipment (LMTR) and investment in transport equipment (LTER) are only significant at the 10% level for all models. This means that investment in machinery and transport-equipment are less likely to contribute to the process of economic growth compared with other types of investment¹²³. This is also very important for the purpose of policy applications in an economy. For example, investment in tourism sector (i.e. investment on restaurants and hotels) should be more encouraged to foster more economic growth, especially, in an small island economy- Cyprus. Another point here is that government should formulate and implement appropriate policies for investment in machinery and transport-equipment. This may stem from a reduction policy on the two investments.

The next step is to model the short-run dynamics with the use of an ECM since the existence of joint cointegration among the variables in the long-run regressions equation 6.3-1 is confirmed. To consider labour productivity movements with respect to the disaggregated investment version of the Augmented Solow model, we obtain an ECM adding the residuals from the models (i.e. models 1, 2, and 3) in Table 6.6.9 and a list of regressors capturing the short-run movements of output.

The results of the parsimonious dynamic model, using the error terms from the OLS regressions are in Table 6.6.9. For all models (i.e. models 1, 2, and 3), the error correction term's coefficient is negative and significant at the 1% level. The magnitudes of the corresponding coefficients show that 92%, 95%, and 96% of last period's disequilibria are corrected after one year. This implies that output adjusts its equilibrium level quickly and the error correction terms provide further evidence that the variables in the equilibrium regression are cointegrated. It is

¹²³ See Demetriades et al. (1993) for a similar comment about investment in machinery equipment.

noteworthy that all contemporaneous values are also significant which supports the previous findings¹²⁴. The appropriately signed and significant error correction term for the models in Table 6.6.9 confirm the earlier findings that investment in the tourism sector and in the non-tourism construction, human capital, and the rate of labour growth in the models have a short-term effect on output growth whereas the others are only significant at the 10% level. The model 2 slightly better performs than the others in terms of R^2 . The Second explains 90% of the variation of per capita growth (or labour productivity) whilst the first and third ones explain 87% and 86% of the variation of per capita growth for the short run period respectively¹²⁵.

Given the results of the cointegration tests, the causality test are conducted by running the formal Granger causality and the Holmes-Hutton causality procedures in a bivariate causal model. In the long-run, the evidence suggests that there is unidirectional causality from investment in the tourism sector (TR), and investment in transport equipment (TER), to real GDP per worker (CAPL)¹²⁶.

In the same table, there is bi-directional causality between investment in non-tourism construction (CNTR) and real GDP per worker (CAPL). Also, there is a flow of causality from real GDP per worker (CAPL) to investment in the non-tourism sector (ANTR), and investment in machinery-transport equipment (MTR).

In the short run, the evidence of causality is from investment in the tourism sector (TR), investment in non-tourism construction (CNTR), to real GDP per worker (CAPL) and from real GDP per worker (CAPL) to investment in transport equipment (TER), investment in non-tourism sector (ANTR), and investment in machinery-transport equipment (MTR) (see Common Tables A.5.7, A.5.8, A.5.9, and A.5.10 in Appendix Chapter A).

¹²⁴ We applied the instrumental variable (IV) method to ensure OLS short-run estimates are not jeopardised by the presence of some contemporaneous effects (see Common Tables A.5.11 in Appendix Chapter A).

¹²⁵ The estimated forecast performance technique shows that model 2 has minimum forecast errors (i.e. model 1 is 0.0035, model 2 is 0.0016, model 3 is 0.0025).

¹²⁶ See Canning and Pedroni (1999) for a similar comment about the causality results in which evidence indicate that causality runs from investment to GDP, particularly in the long run period.

6.5 Conclusion

This chapter is an empirical attempt to shed light on which type of disaggregated investment could be relied on to provide the greatest stimulus to economic growth. We derived a disaggregated version of the Augmented Solow model in which the variables are considered as stochastic with unit roots. Our model is based upon the recent approach of testing the neoclassical growth model as first introduced by Benhabib and Spiegel (1994), and Temple (1998b) taking into account disaggregated capitals.

We empirically investigated the models by applying different cointegration techniques, and we found the evidence that the extended disaggregated version of the Augmented Solow model with a partition of capital into investment in the tourism sector and investment in non-tourism sector, can be used to investigate labour productivity movements for a single country using multivariate time series techniques. Secondly the models under study can be considered as an error correction mechanism.

In addition, the models (i.e. models 1, 2 and 3) appear to be consistent with annual data in terms of t-statistics and the results obtained from different techniques employed in this chapter suggest that the disaggregated investments rates such as investment in the tourism sector¹²⁷ and investment in construction are the most important factors among the others. They have both the long term and the short term effects on per capita output according well with the prediction of exogenous growth model in the case of Cyprus. On the other hand, the impact of investment in transport equipment, machinery-transport equipment, and all types of investment in the non-tourism sector are not strong enough when the Engle-Yoo, the Saikkonen, and the Inder methods apply for both the long term output level and output growth in the short-run period. It is noteworthy that model 2 is most likely to represent the Cypriot economy.

¹²⁷ Kammas and Salehi-Esfahani (1992) analysed the direct contribution of the tourism sector to the economy and found that the contribution of the tourism sector to the economy is much more than the contribution of the other sectors.

Finally, we analysed the causal relationship between GDP per worker and the disaggregate capitals to determine the direction of causality. The findings show that investment in the tourism sector and investment in non-tourism construction cause output growth in the short run period whilst investment in the tourism sector and investment in transport equipment contribute the output level in the long run period for the case of Cyprus.

6.6 Tables

Table 6.6.1 The Residual-based ADF Test for Cointegration

Cointegration Regression	R^2	$\bar{R}^2$	CRDW	Calculated ADF Residuals	Critical Value MacKinnon (5%)
Model 1 $LCAPL_t = f(LTR_t, LANTR_t, LHR_t, LNGD_t)$	0.98	0.97	2.34	-7.66 (0)	-5.66
Model 2 $LCAPL_t = f(LTR_t, LCNTR_t, LTER_t, LHR_t, LNGD_t)$	0.98	0.97	2.22	-6.75 (0)	-6.01
Model 3 $LCAPL_t = f(LTR_t, LCNTR_t, LMTR_t, LHR_t, LNGD_t)$	0.96	0.95	2.38	-7.56 (0)	-6.01

The reported critical value is obtained from MacKinnon (1991) and reported by MFIT 4.0. The number in parentheses indicates number of lags that were chosen by Schwarz Bayesian Criterion. This means that zero augmentation is necessary to be sufficient to secure lack of autocorrelation of the error terms for the relevant cointegration regressions. To conserve space, dummy variables (i.e. DUM64, DUM67, DUM73, DUM74) are not shown into the equations above.

Table 6.6.2 Engle-Granger Static Long-run Regressions

Explanatory Variables	Dependent Variable: $LCAPL_t$		
	Model 1	Model 2	Model 3
C	10.60 (32.23)	9.67 (43.13)	10.67 (29.91)
T	0.052 (24.93)	0.046 (30.45)	0.051 (24.74)
LTR_t	0.19 (5.94)	0.14 (3.97)	0.14 (4.67)
$LANTR_t$	0.20 (4.93)	-	-
$LCNTR_t$	-	0.15 (3.63)	0.14 (4.01)
$LTER_t$	-	0.027 (2.42)	-
$LMTR_t$	-	-	0.057 (2.15)
LHR_t	0.11 (6.44)	0.14 (7.66)	0.11 (5.68)
$LNGD_t$	-0.51 (-7.73)	-0.30 (-6.83)	-0.51 (-7.43)
DUM64	-0.12 (-5.32)	-0.13 (-4.98)	-0.13 (-5.31)
DUM67	0.061 (2.64)	0.053 (2.27)	0.060 (2.59)
DUM73	-	-0.10 (-4.53)	-
DUM74	-0.18 (-5.63)	-	-0.18 (-5.54)
R^2	0.98	0.98	0.96
$\bar{R}^2$	0.97	0.97	0.95
CRDW	2.34	2.22	2.38
ADF*	-7.66	-6.75	-7.56
C.V.	-5.66	-6.01	-6.01
SER	0.022	0.022	0.022
χ^2_{SC}	2.91 (prob = 0.088)	1.20 (prob = 0.272)	3.17 (prob = 0.075)
χ^2_{FF}	3.69 (prob = 0.055)	3.79 (prob = 0.052)	3.86 (prob = 0.051)
χ^2_{NORM}	1.82 (prob = 0.401)	2.58 (prob = 0.275)	1.38 (prob = 0.501)
χ^2_{HET}	1.11 (prob = 0.292)	1.20 (prob = 0.271)	0.66 (prob = 0.415)

Notes: t-statistics are in parentheses and all diagnostic pass at the 5% level of significance. Unreported diagnostics also suggest no evidence of misspecification at the 5% level of significance and the other notations are already mentioned in the previous chapters.

Table 6.6.3 The Johansen Maximum Likelihood (ML) procedure:

Cointegration likelihood ratio (LR) test to determine the number of cointegration vectors (r) based upon Maximal Eigen Value of Stochastic Matrix, Trace of Stochastic matrix, and the (T-P) version is for the small sample suggested by Reimers (1992).

Cointegration Regression	H_0	H_1	$\lambda_{\max}$	$\lambda_{\max}$ (T-P)	Critical Value at 5%	λ_{trace}	λ_{trace} (T-P)	Critical Value at 5%
Model 1	$r = 0$	$r = 1$	76.02	64.84	37.52	140.70	119.41	87.31
	$r \leq 1$	$r = 2$	36.88	31.45	31.46	64.67	55.16	62.99
	$r \leq 2$	$r = 3$	20.51	17.49	25.54	26.78	22.84	42.44
	$r \leq 3$	$r = 4$	6.07	5.17	18.96	6.26	5.34	25.32
	$r \leq 4$	$r = 5$	0.19	0.16	12.25	0.19	0.16	12.25
Model 2	$r = 0$	$r = 1$	77.21	63.58	43.97	189.43	155.64	114.90
	$r \leq 1$	$r = 2$	45.11	37.14	37.52	105.89	87.20	87.31
	$r \leq 2$	$r = 3$	24.07	19.77	31.46	47.50	39.12	62.99
	$r \leq 3$	$r = 4$	14.47	11.92	25.54	23.43	19.30	42.44
	$r \leq 4$	$r = 5$	7.43	6.12	18.96	8.95	7.37	25.32
	$r \leq 5$	$r = 6$	1.51	1.24	12.25	1.51	1.24	12.25
Model 3	$r = 0$	$r = 1$	115.72	95.29	43.97	241.83	199.15	114.90
	$r \leq 1$	$r = 2$	45.19	37.21	37.52	106.01	87.30	87.31
	$r \leq 2$	$r = 3$	27.80	23.17	31.46	49.91	41.11	62.99
	$r \leq 3$	$r = 4$	17.16	14.31	25.54	22.11	18.21	42.44
	$r \leq 4$	$r = 5$	4.87	4.05	18.96	4.94	4.06	25.32
	$r \leq 5$	$r = 6$	0.77	0.64	12.25	0.77	0.64	12.25

r indicates the number of cointegrating relationship. $\lambda_{\max}$ is the maximum eigen value statistics and λ_{trace} is the trace statistics. The (T-P) version is the corrected statistics for small samples suggested by Reimers (1992). VAR 2 based on SBC is used in the Johansen procedure and unrestricted intercept and unrestricted trend in the VAR model are not rejected in all cases. DUM64, DUM67, DUM73, and DUM74 are considered as exogenous $I(0)$ variables. The critical values are obtained from Osterwald-Lenum (1992).

Table 6.6.4 The Johansen Method

Coefficient in the long run cointegration relationship between output and its determinants: coefficients normalised on output, to -1.

Explanatory Variables	Dependent Variable: LCAPL _t		
	Model 1	Model 2	Model 3
LTR _t	0.16 (2.58)	0.24 (2.05)	0.16 (2.08)
LANTR _t	0.27 (2.08)	-	-
LCNTR _t	-	0.16 (1.75)**	0.21 (2.13)
LTER _t	-	0.12 (1.68)**	-
LMTR _t	-	-	0.13 (1.18)*
LHR _t	0.30 (5.48)	0.32 (4.11)	0.26 (6.50)
LNGD _t	-0.32 (-2.12)	-0.59 (-6.57)	-0.34 (-5.23)

Notes: t-statistics are in parentheses. One (*) star shows that they are not significant at conventional levels, two (**) stars indicate that they are significant at the 10% level and others are significant at the 5% and 1% levels.

Table 6.6.5 Test of Parameter Restrictions: The Johansen Approach.

MODEL 1		
Parameter Restrictions	Chi-squared test statistics	Critical Value at 5%
$a_2 + a_3 + a_4 + a_5 + a_6 = 1.0$	10.56 (1)*	3.84
MODEL 2		
$b_2 + b_3 + b_4 + b_5 + b_6 = 1.0$	5.62 (1)*	3.84
MODEL 3		
$c_2 + c_3 + c_4 + c_5 + c_6 = 1.0$	9.02 (1)*	3.84

Notes: One star (*) shows that χ^2 -test rejects the null hypothesis that sum of the coefficients is equal to 1 for all models.

Table 6.6.6 Elasticity estimates: The Engle-Yoo Approach

Engle-Yoo Three Step Correction Approach			
Variable	Model 1	Model 2	Model 3
C	10.67 (17.49)	9.81 (24.12)	10.88 (16.48)
T	0.050 (12.82)	0.046 (16.41)	0.052 (13.00)
LTR _t	0.25 (3.88)	0.18 (2.69)	0.19 (3.27)
LANTR _t	0.26 (2.00)*		
LCNTR _t		0.19 (2.49)	0.20 (2.78)
LTER _t		0.028 (1.76)*	
LMTR _t			0.056 (1.69)*
LHR _t	0.11 (3.37)	0.14 (4.02)	0.12 (3.29)
LNGD _t	-0.49 (-3.91)	-0.28 (-3.41)	-0.45 (3.48)
DUM64	-0.12 (-2.70)	-0.09 (-2.18)	-0.11 (-2.44)
DUM67	0.053 (1.78)*	0.057 (1.73)*	0.062 (1.68)*
DUM73		-0.11 (-2.75)	-0.17 (-2.86)
DUM74	-0.17 (-2.82)		

Notes: t-values are shown in parenthesis. One star (*) indicates that they are significant at the 10% level and rests are significant at conventional levels (5% and 1%).

Table 6.6.7 Elasticity estimates: The Inder Approach

The Inder Approach			
Variable	Model 1	Model 2	Model 3
C	11.25 (16.38)	7.35 (6.88)	7.12 (5.83)
T	0.050 (15.54)	0.050 (17.21)	0.048 (16.23)
LTR _t	0.15 (2.05)	0.21 (2.94)	0.19 (2.42)
LANTR _t	0.08 (1.69)*		
LCNTR _t		0.16 (2.61)	0.16 (2.53)
LTER _t		0.021 (1.88)*	
LMTR _t			0.054 (1.71)*
LHR _t	0.13 (3.76)	0.16 (4.71)	0.17 (3.87)
LNGD _t	-0.25 (-3.87)	-0.26 (-3.61)	-0.27 (-2.58)
DUM64	-0.09 (-2.07)	-0.06 (-2.02)	-0.08 (-2.31)
DUM67	0.032 (1.45)**	0.017 (1.62)**	0.021 (1.65)**
DUM73		-0.12 (-4.22)	-0.14 (-2.48)
DUM74	-0.18 (-2.47)		

Notes: t-values are shown in parenthesis. Two stars (**) indicate that they are not significant at conventional levels (10%, 5% and 1%). One start (*) shows that they are significant at the 10% level and rests are significant at conventional levels.

Table 6.6.8 Elasticity estimates: The Saikkonen Approach

The Saikkonen Approach			
Variable	Model 1	Model 2	Model 3
C	9.31 (10.06)	10.61 (8.94)	8.67 (8.63)
T	0.043 (7.51)	0.049 (7.88)	0.042 (6.14)
LTR _t	0.18 (3.12)	0.19 (2.49)	0.17 (2.25)
LANTR _t	0.16 (1.96)**		
LCNTR _t		0.12 (2.21)	0.14 (2.43)
LTER _t		0.025 (1.86)**	
LMTR _t			0.051 (1.82)**
LHR _t	0.15 (3.52)	0.13 (2.57)	0.14 (4.59)
LNGD _t	-0.23 (-2.18)	-0.48 (-2.05)	-0.42 (2.07)
DUM64	-0.11 (-3.67)	-0.08 (-2.29)	-0.09 (-3.24)
DUM67	0.036 (1.67)*	0.015 (1.63)*	0.041 (1.61)*
DUM73		-0.17 (-2.02)	-0.18 (-2.03)
DUM74	-0.16 (-2.59)		

Notes: t-values are shown in parenthesis. Two stars (**) indicate that they are not significant at conventional levels (10%, 5% and 1%). One start (*) shows that they are significant at the 10% level and rests are significant at conventional levels.

Table 6.6.9 Error Correction Modelling: Short run dynamics.

Explanatory Variables	Dependent Variable: ΔLCAPL_t		
	Model 1	Model 2	Model 3
C	0.052 (11.20)	0.048 (11.50)	0.047 (9.80)
ECT (-1)	-0.96 (-4.72)	-0.92 (-6.83)	-0.95 (-4.32)
ΔLTR_t	0.21 (4.03)	0.19 (5.42)	0.14 (2.97)
ΔLANTR_t	0.20 (1.83)*	-	-
ΔLCNTR_t	-	0.20 (5.24)	0.14 (2.84)
ΔLTER_t	-	0.03 (1.85)*	-
ΔLMTR_t	-	-	0.059 (1.81)*
ΔLHR_t	0.11 (1.86)*	0.11 (2.28)	0.10 (2.04)
$\Delta \text{LN GD}_t$	-0.40 (-5.58)	-0.25 (-3.70)	-0.23 (-2.93)
ΔDUM64_t	-0.12 (-8.05)	-0.15 (-9.22)	-0.13 (-7.09)
ΔDUM67_t	0.057 (3.44)	0.048 (3.49)	0.054 (3.09)
ΔDUM73_t	-	-0.076 (-3.62)	-
ΔDUM74_t	-0.16 (-6.64)	-	-0.026 (-3.68)
R^2	0.87	0.90	0.86
$\bar{R}^2$	0.83	0.87	0.81
DW	2.16	2.08	1.85
SER	0.021	0.018	0.022
χ^2_{sc}	0.94 (prob = 0.331)	0.47 (prob = 0.491)	0.52 (prob = 0.467)
χ^2_{fr}	3.57 (prob = 0.059)	3.52 (prob = 0.060)	3.02 (prob = 0.082)
χ^2_{norm}	1.77 (prob = 0.412)	0.67 (prob = 0.712)	3.30 (prob = 0.192)
χ^2_{het}	0.33 (prob = 0.564)	0.11 (prob = 0.918)	0.05 (prob = 0.814)

Notes: t-statistics are in parentheses and all diagnostic pass at the 5% level of significance. One star (*) indicates that the relevant variables are significant at the 10% level. It is worth emphasising that unreported diagnostics suggest no evidence of misspecification at the 5% level of significance.

CHAPTER 7 Conclusion

7.1 Conclusion

This thesis aimed to conduct empirical analyses, using the most recent methodological advancements, to investigate the determinants of economic growth in the case of Cyprus. We have reformulated and empirically tested neoclassical growth model (i.e. the Solow and two different version of the Augmented Solow growth models) in order to find the determinants of economic growth and the relationship between the factors, influencing the rate of economic growth. In this chapter, we summarize the contents and findings extracted from all chapters included in the thesis and present an overall conclusion.

In chapter 2, we surveyed both empirical and theoretical developments in the growth literature. The interrelated studies of the literature were briefly reviewed under three headings: exogenous growth theory, endogenous growth theory, and a comparison of their strengths and weaknesses in the light of modelling and empirical findings. In general, the nexus between theory and empirical studies in explaining economic growth seemed to be relatively weak. In addition, evidence suggested that poor countries were likely to remain poor. In other words, poor countries did not seem to catch up with rich ones, which was called non-convergence. This contradicted the neoclassical models in which poorer countries tended to grow faster to their steady-state level of income, which might stem from differences with respect to macroeconomic stability and technologies. On the other hand, the new growth models still had some problems in providing robust answers on the determinants of economic growth. However, the new growth models have made contribution regarding the policy implications, particularly for developing countries, in spite of a number of criticisms. The evidence suggested that human capital and education policy, trade policies and government investment policies generated better ideas and indications for economic growth in developing countries, even though endogenous growth models are shaped by knowledge rather than capital as the source of sustainable growth.

Chapter 3 reviewed the history of the Cyprus economy, focusing on economic background, economic policy, economic growth and development plans, economic performance and macroeconomic indicators. Cyprus has overcome

many serious constraints and adversities to achieve relatively well advanced economic and social development. It was evident that the important driving forces behind the achievement of the country in the economic sphere were attributed, firstly, to the encouragement of the private sector which stimulated rapid growth. Secondly, highly educated and well trained human capital as well as the country's endowments have been utilised to contribute to Cyprus' recent success. Thirdly, the colonial rule left an everlasting heritage: which was the first international language of the world, the British judicial system and the administration for the civil service. Fourthly, political life was more stable than third world countries, reflecting a democracy.

In the first empirical analysis in chapter 4, we reformulated and empirically tested the implications of neoclassical exogenous growth models for the Cypriot economy over the period 1960-1995. The neo-classical growth models - the Solow and the Augmented Solow were investigated in a time series context by utilising multivariate time series techniques. The empirical results have shown that only the Augmented Solow model was consistent with annual time series data. The Solow model, on the other hand, was found incorrectly specified, due to omitted variable bias. The physical and human capital accumulation rates along with the rate of labour growth had both long-term and short-term effects on per capita growth and accorded well with the predictions of exogenous growth model.

Chapter 5 provided an extended version of the Augmented Solow growth model where openness and public infrastructure proxies were added by using advanced time series techniques to determine whether Cyprus' trade and public investment policies contributed to the economic growth. The findings confirmed that openness and public infrastructure were insignificant and inconsistent. This implies that these variables had no effect on the Cypriot economic growth. In other words, economic growth in Cyprus was not fuelled by openness and public infrastructure. This led to further investigation to find out what other factors could better stimulate economic growth.

In Chapter 6, the impact of different disaggregations of investment on economic growth based on the Solow growth model was investigated. The main aim was to

find out the relevant type of disaggregated investment which could better promote economic growth in the time-series context. In particular, we investigated the importance of investment in the tourism sector. The evidence found in this chapter indicated that the models appeared to be consistent with annual data. The results obtained from different techniques suggested that the disaggregated investments rates such as investment in the tourism sector, and investment in construction were the most important factors among the others. They had both long term and short term effects on per capita output. We also analysed the causal relationship between GDP per worker and the disaggregate capitals to determine the direction of causality. The findings showed that investment in the tourism sector and investment in non-tourism construction caused output growth in the short run period whilst investment in the tourism sector and investment in transport equipment contributed to the output level in the long run period for the case of Cyprus.

Appendix Chapter A provided some information about data source, data definition and the pair wise correlation among the variables used in the relevant models. The correlations among the variables did not matter in favour of multicollinearity problems except some minor problems.

In Appendix Chapter B, we discussed some advantages and disadvantages in small island economies in the light of economic growth. We found out that there existed some advantages to being small in many cases.

In Appendix Chapter C, we made an attempt to summarize and simplify the cointegration techniques used in the empirical applications in this thesis. The cointegration techniques allowed us to avoid spurious regression results when we use non-stationary data. These techniques also provided a possibility that enable us to test the validity of an econometric theory. For instance, if the long-run economic relationship existed, this implied that the cointegration regression captured the existence of an equilibrium relationship. In other words, cointegration test attempted to establish the nexus between the long-run movements in time-series context. Contrary to common belief, the concept of cointegration did not advocate that there existed clear-cut solution procedures in the construction and estimation of dynamic time-series models in economics.

7.2 Policy implications

Formulation of an economic policy package that is conducive to economic growth has always been the major concern of policy makers. Policy makers can select an appropriate policy or policies among alternative policy options based on empirical evidence. In our study on the Cyprus economy, we can derive a number of policy implications that may help to improve the performance of the Cyprus economy. Our analysis has been carried out at the aggregate level. We are aware of the fact that aggregate analysis cannot be used in policy formulation at the micro level but it definitely provides a general guidance in formulation of industrial policy and macroeconomic policies.

The findings of the study can be summarised as such: while international trade openness has no significant effect on growth, human capital, tourism investment and total infrastructure investment are found to be closely related to the output growth of the economy. The empirical evidence¹²⁸ just given carries a number of important economic policy implications that can be taken into consideration by policy makers as guidance in formulation of future economic policies.

First, the fact that investment in tourism is significantly related to the growth points the service sector as being a focus of future economic policy formulations. Considering remarkable level of schooling¹²⁹, per capita income, and the small size of the economy, it is not surprising that tourism plays an important role in economic growth. Because of the facts given above, comparative advantage of the Cyprus economy lays neither labour intensive light manufacturing sectors like textile, footwear or heavy manufacturing industries where economies of scale is important. Light manufacturing industries are labour intensive industries and thus, competition in international market depends on cheap labour. Although heavy manufacturing industries can be characterised as capital and skilled labour intensive, efficient production in these industries requires a big market to support

¹²⁸ Ghura and Hadjimichael (1996) use an extended version of the Augmented solow growth model and suggest a number of important policy implications that can be taken by policy makers for Sub-Saharan countries.

¹²⁹ Although the definition of human capital proxy is called third level (or tertiary enrolment rate), this does not only contain university enrolment rate but also post-secondary enrolment rate such as hotel and catering student enrolment rate. This may be a good reason behind this proxy why it supports development of the tourism sector.

the optimum scale, which is important to satisfy scale efficiency. Therefore, limited size of the market and labour, and high wages shows that the comparative advantage of Cyprus cannot be in these sectors. However, services sector and research and development intensive sectors (like tourism, banking, computer programming and software design) that need skilled labour and has high rate of return to support high wages seem the best candidate as an engine of long-run growth in Cyprus. Second, government education policy may be formulated to provide the high skilled labour needed for high-tech (i.e. high skill services such as financial sector¹³⁰) and tourism sector besides to provide general knowledge. Third, since the infrastructure of the economy may influence the type of investments that are undertaken as well as the pace of the economic growth, government policy on infrastructure should be formulated in a way that it is compatible with the points one and two above. In other words, as increase in total investment promotes growth, government should encourage not only government sector but also private sector development.

The insignificant signs on tariffs and openness imply that Cyprus economy is already a small open economy. It is well known fact that while protection has a detrimental impact on growth, openness removing the negative effects of protection will enhance the performance of the economy. One of the reasons why openness has insignificant effect on the Cyprus economy is that the economy is already an open economy.

¹³⁰ Unfortunately, there is no enough time series data to measure the contributions of financial sector whether can really stimulate economic growth in the case of Cyprus.

7.3 Suggestions and Recommendations for Further Studies

Considering the importance of services sector in determination of growth in Cyprus, value added of the further and detailed research on the relationship between services and growth in Cyprus case is very high.

As our analysis has also shown, more disaggregate analysis of the growth process will be very valuable to understand the contributions of different sectors and importance of sectoral interactions to economic growth. To this end, further disaggregation¹³¹ of services sector and manufacturing sector to their sub-sectors may provide more intuition about the sources of growth in Cyprus.

Although the Cyprus economy is a small island economy, concentration on tourism may have some implications about regional growth differences. It is worth looking at regional growth implications of policy suggestions derived from our analysis.

At the firm level, technical efficiency-growth relationship is another research area that may provide information whether there is a room for further improvement of economic performance.

Our study has concentrated on international trade openness only. The research on the impact of financial openness on growth might be interesting considering the relationship between service (i.e. banking) sector and growth.

On the eve of membership negotiations with the European Union, it will be important to search for the possible effects of integration on economic growth. Our study has already established that trade related effects of integration has no impact on economic growth but the effect of financial integration on growth waits for an answer. The convergence issue could also be an interesting future research. This can be empirically investigated to find out whether the EU countries and the Cyprus economy reach a common steady state growth path over time.

¹³¹ In this regard, it is important to mention that the study period is rather short for a definitive appraisal of the consequences of the regression results on economic growth. Longer time spans are essential for this purpose to obtain definitive results.

APPENDICES

APPENDIX CHAPTER A

Data Sources, Definitions, Construction of Correlation Matrices and The Common Tables

A.1 Introduction

This Appendix chapter provides information about data sources, data definitions and the pair wise correlations among the variables used in this study. We also estimate the long-run correlation coefficients to observe how the variables are correlated each other. In other words, our findings for the correlations among the variables do not suffer from multicollinearity problem. Finally, we present the common tables such as the ADF unit root test, the LR joint test, the Perron unit root test etc.

A.2 Data Sources

The data used for the study are annual observation for the period 1960 to 1995 and are extracted from various issues of the Department of Statistics and Research Institute, Ministry of Finance, Nicosia, Cyprus. The data for the years 1960 until mid-1974 refer to the whole country. From mid-1974 onward, the data refer only to the south part of Cyprus which is constitutionally recognized. It is worth to emphasize that northern part of Cyprus is excluded from the sample. The data are used in real terms and adjusted at constant prices of 1980. The classifications, concepts and methods in the presentation of the various series for the data are based on the latest U.N. system of National Accounts (1968 SNA).

A.3 Data Definitions

The following variables for Cyprus over the period 1960-1995 are converted in constant Cyprus pounds and adjusted at constant prices of 1980.

CAPL = Real gross domestic product (GDP) per worker at constant prices of 1980, (C£).

KR = The Real gross domestic fixed capital formation to GDP ratio is used as a proxy for the real investment to GDP ratio (investment share in GDP) at constant prices of 1980 (C£).

HR = Third level (or tertiary) enrolment rates: This proxy refers the ratio of the number of students enrolled at universities (abroad and home) and

at post-secondary institutes to the total number of workers. Post-secondary education institutes include the higher technical institute, the forestry college, the school of nursing, the Mediterranean institute of management, and the higher hotel and catering institute, which are below the university degree level. University education is mainly pursued abroad because the Cyprus University was established in the academic year 1992/93.

NGD = is the empirical counterpart of $(n + g + \delta)$. That is the sum of the labour growth rate plus the estimation technological progress rate plus the depreciation rate ($g + \delta = 0.05$ is assumed)¹³².

GIR = The ratio of general government fixed investment to GDP which is defined as proxy for public investment (infrastructure) at constant prices of 1980.

In fact, this variable exists in the original data set for the years between 1973- and onwards. The years between 1960 and 1972 are extracted from the government development expenditure figures.

OP = Openness index of Cyprus is defined as the ratio of the sum of real exports and imports to real GDP expressed in Cyprus Pounds at the constant prices of 1980 (C£).

MTAR = Import share of tariffs on intermediate and capital goods is defined as the ratio of imports duties to the value of imports expressed in Cyprus Pounds at the constant prices of 1980 (C£).

TR = Gross domestic fixed capital formation is used by type of construction in the tourism sector as proxy for investment in the tourism sector defined as the ratio of tourism investment to GDP.

$LNTR_t$ = The vector of non-tourism sector variables which can be decomposed of LANTR, LCNTR, LTER, and LMTR defined as follows:

LANTR = This is the combination of construction, machinery, and equipment. Here, Gross domestic fixed capital formation is used by type of construction, machinery and transport equipment in the non-tourism

¹³² We faithfully follow Mankiw et al. (1992) in assuming that $(g + \delta)$ is equal to 0.05.

sector as a proxy for investment in the non-tourism sector defined as the ratio of the non-tourism investment to GDP.

LCNTR = Gross domestic fixed capital formation is used by type of non-tourism construction as proxy investment in the non-tourism construction sector defined as the ratio of non-tourism construction to GDP.

LTER = Gross domestic fixed capital formation is used by type of transport equipment as proxy for investment in transport equipment unit defined as the ratio of transport equipment investment to GDP.

LMTR = Gross domestic fixed capital formation is used by type of machinery-transport equipment as proxy for investment in machinery-transport equipment unit defined as machinery-transport equipment investment to GDP.

Note that gainfully employed population is used as worker or labour force which is the full-time equivalent number of persons who work for the establishment including working proprietors, working partners, unpaid family workers, and persons on short-term or paid leave. The persons work for military service are excluded.

A.4 Correlation Matrices: Constructing of the Long-run Correlation Coefficients

We would like to note that one of the assumptions of the classical linear regression model is that there is no perfect multicollinearity. In other words, no exact linear relationship exists among explanatory variables included in a multiple regression. Firstly, one of the classic symptoms of multicollinearity is high R^2 but few significant t-ratios. Secondly, the other classic symptom of multicollinearity is high pair wise correlations among explanatory variables and this is our main aim in this part. Of course, there are other indicators that provide us with some clue about the existence of multicollinearity such as examination of partial correlations, computing subsidiary, or auxiliary regressions and using the variance inflation factor (VIF)¹³³.

¹³³ See Gujarati (1999) for more details.

In fact, multicollinearity is the existence of a strong relation among some or all explanatory variables of a regression. It does not affect the best-unbiased estimator of the OLS but since coefficients have large standard errors, they tend to be insignificant, thus, making precise estimation difficult (Gujarati, 1999; p.319).

Table A.4.1 represents model 1 in chapter 4 gives the matrix of correlation coefficients of the variables in logarithms. As this table shows, the pair wise correlations between the variables are reasonably normal. It is worth emphasizing that we expect to have low correlation between the explanatory variables and high correlation between the dependent (CAPL, the ratio of GDP to labour) and the explanatory variables. Table A.4.2 provides the pair wise correlations among the logs of four variables (i.e. CAPL is dependent) with respect to model 2 in chapter 4. It can be seen that per labor growth and human capital proxy are highly positively correlated about 0.85 as expected with regard to the theory behind multicollinearity. In the same table, other pair wise correlations are reasonably fine and they do not provide any probability in terms of multicollinearity. Table A.4.3 and A.4.4 also present the matrix of simple correlation coefficients of the variables in logarithms for model 1 and 2 in chapter 5 respectively. Findings in these tables are come out as expected except the correlation between openness proxies (OP, MTAR) and human capital proxy is uniformly high (i.e. 0.67–0.71). Table A.4.5, A.4.6 and A.4.7 report the pair wise correlations among the variables are used for the disaggregated Augmented Solow model in chapter 6. In these tables, high correlation coefficients between the investment ratios should be noted that these ratios are used as disaggregated investment and regrouped investment. Hence, the correlation between explanatory variables such as TR and CNTR, TR and ANTR are expected to be highly correlated. However, these kind of disaggregating and regrouping¹³⁴ data do not influence our findings in which investment ratios positively affect economic growth.

In summary, we can conclude that the correlations among the variables under study do not suffer from multicollinearity problem since our estimated results are acceptable from statistical point of view.

¹³⁴ See Jalilian and Odedokun (2000) to get more details.

Table A.4.1. Correlation Matrix: Model 1 in Chapter 4

	CAPL	KR	NGD
CAPL	1.00		
KR	0.54	1.00	
NGD	-0.41	-0.12	1.00

Table A.4.2. Correlation Matrix: Model 2 in Chapter 4

	CAPL	KR	HR	NGD
CAPL	1.00			
KR	0.54	1.00		
HR	0.85	0.24	1.00	
NGD	-0.41	-0.12	-0.29	1.00

Table A.4.3. Correlation Matrix: Model 1 in Chapter 5

	CAPL	KR	HR	NGD	GIR	OP
CAPL	1.00					
KR	0.54	1.00				
HR	0.85	0.24	1.00			
NGD	-0.41	-0.12	-0.29	1.00		
GIR	0.62	0.31	0.32	-0.26	1.00	
OP	0.82	0.18	0.67	0.21	0.10	1.00

Table A.4.4. Correlation Matrix: Model 2 in Chapter 5

	CAPL	KR	HR	NGD	GIR	MTAR
CAPL	1.00					
KR	0.54	1.00				
HR	0.85	0.24	1.00			
NGD	-0.41	-0.12	-0.29	1.00		
GIR	0.62	0.31	0.32	-0.26	1.00	
MTAR	-0.42	-0.31	-0.71	-0.47	-0.29	1.00

Table A.4.5. Correlation Matrix: Model 1 in Chapter 6

	CAPL	CNTR	TR	TER	HR	NGD
CAPL	1.00					
CNTR	0.79	1.00				
TR	0.76	0.97	1.00			
TER	0.34	0.10	0.13	1.00		
HR	0.85	0.51	0.53	0.38	1.00	
NGD	-0.41	-0.36	-0.27	-0.10	-0.28	1.00

Table A.4.6. Correlation Matrix: Model 2 in Chapter 6.

	CAPL	CNTR	TR	MTR	HR	NGD
CAPL	1.00					
CNTR	0.79	1.00				
TR	0.76	0.97	1.00			
MTR	0.59	0.10	0.18	1.00		
HR	0.85	0.51	0.53	0.62	1.00	
NGD	-0.41	-0.36	-0.27	-0.10	-0.28	1.00

Table A.4.7. Correlation Matrix: Model 3 in Chapter 6

	CAPL	TR	ANTR	HR	NGD
CAPL	1.00				
TR	0.76	1.00			
ANTR	0.82	0.97	1.00		
HR	0.85	0.53	0.57	1.00	
NGD	-0.41	-0.27	-0.29	-0.28	1.00

A.5 The Common Tables

Table A.5.1: The ADF (Augmented Dickey-Fuller) Test for Unit Roots:

Variables	Test statistics & Critical Values				Integration levels
	Levels		1 st differences		
	ADF	C.V. (5%)	ADF	C.V. (5%)	
LCAPL _t	-1.62(0)	-3.54	-6.78(0)	-2.95	I(1)
LKR _t	-2.85(1)	-2.94	-5.51(1)	-2.95	I(1)
LHR _t	-2.56(1)	-2.95	-3.41(0)	-2.95	I(1)
LNGD _t	-1.88(1)	-2.95	-4.36(1)	-2.95	I(1)
LGIR _t	-2.66(0)	-2.94	-7.20(0)	-2.95	I(1)
LOP _t	-0.38(2)	-2.95	-6.75(0)	-2.95	I(1)
LMTAR _t	-2.28(1)	-2.95	-5.07(0)	-2.95	I(1)
LTR _t	-1.26 (3)	-2.95	-3.76 (2)	-2.95	I(1)
LANTR _t	-2.75 (2)	-3.54	-3.59 (2)	-2.95	I(1)
LCNTR _t	-2.18 (2)	-2.95	-3.04 (2)	-2.95	I(1)
LTER [*] _t	-2.22 (11)	-2.99	-6.55 (1)	-2.95	I(1)
LMTR _t	-3.32 (0)	2.95	-6.92 (0)	-2.94	I(0)

The corresponding critical values for 36 number of observations at the 5% significance levels are obtained from Mackinnon (1991) and reported by MFIT 4.0. It is worth noting that the intercept and trend terms are in the ADF equations. The numbers in the parenthesis indicate that zero, one, two and three augmentations are necessary to be sufficient to secure lack of auto-correlation of the error terms with regard to the variables. We chose the Akaike Information Criterion to determine ADF values. LMTR_t, Machinery-Transport equipment is only found I(0). Star (*) shows that the level of LTER_t was found to be non-stationary when 11 lags were included in the regression [See Gemmell et al. (1998)].

Table A.5.2 The Johansen Maximum Likelihood Tests for the Order of Integration: MADF (Multivariate form of Augmented Dickey-Fuller)

Variables	Test Statistics & Critical Values				Integration Levels
	Levels		1 st difference		
	MADF	C.V. (5%)	MADF	C.V. (5%)	
LCAPL _t	1.54	12.25	17.19	9.24	I(1)
LKR _t	7.95	12.25	23.07	9.24	I(1)
LHR _t	3.05	12.25	9.35	9.24	I(1)
LNGL _t	4.33	12.25	17.03	9.24	I(1)
LGIR _t	4.77	12.25	20.55	9.24	I(1)
LOP _t	1.11	12.25	30.49	9.24	I(1)
LMTAR _t	5.59	12.25	15.28	9.24	I(1)
LTR _t	5.81	12.25	9.49	9.24	I(1)
LANTR _t	6.54	12.25	10.18	9.24	I(1)
LCNTR _t	5.71	12.25	9.98	9.24	I(1)
LTER _t	8.15	12.25	29.32	9.24	I(1)
LMTR _t	8.01	12.25	18.57	9.24	I(1)

The corresponding critical values at the 5% significance levels are obtained from Osterwald-Lenum (1992). It is worth noting that unrestricted intercept and unrestricted trend are included for the variables in levels and in differences respectively. VAR 2 based on AIC is used in the Johansen procedure. The MADF stands for the multivariate form of the Augmented Dickey-Fuller unit root test.

Table A.5.3 The DF Likelihood Ratio (LR) Joint Test For DSP vs. TSP

Variables	Test Statistics	Critical Value
		5% (n=36)
LCAPL _t	2.43	6.98
LKR _t	6.37	6.98
LHR _t	3.39	6.98
LNGLD _t	2.45	6.98
LGIR _t	2.84	6.98
LOP _t	6.27	6.98
LMTAR _t	2.85	6.98
LTR _t	3.46	6.98
LANTR _t	3.78	6.98
LCNTR _t	3.33	6.98
LTER _t	6.97	6.98
LMTR _t	6.96	6.98

The corresponding critical value is obtained from Dickey and Fuller (1981, p.1063, Table VI) for 36 observations. In all cases, an augmentation of one appeared to be sufficient to secure lack of auto correlation of the error terms. It is worth noting that the critical values for 36 observations do not exist in the original table tabulated by Dickey and Fuller (1981). Hence, we calculate the reported critical value approximately for 36 observations by using the original table.

Table A.5.4 The Perron Unit Root Test for Structural Break

Variable	Break Year	Test statistics		Critical Value (5%), $\lambda=0.4$
		Levels	1 st Differences	
LCAPL _t	1974	-1.51	-5.36	-3.58
LKR _t	1974	-2.04	-5.05	-3.58
LHR _t	1974	-0.08	-6.91	-3.58
LNGL _t	1974	-1.11	-6.24	-3.58
LGIR _t	1974	-1.98	-6.19	-3.58
LOP _t	1974	-1.91	-9.41	-3.58
LMTAR _t	1974	-2.37	-5.65	-3.58
LTR _t	1974	-2.74	-6.09	-3.58
LANTR _t	1974	-1.84	-6.97	-3.58
LCNTR _t	1974	-2.47	-6.50	-3.58
LTER _t	1974	-3.28	-6.62	-3.58
LMTR _t	1974	-3.17	-7.28	-3.58

We use the critical value reported by Rybinski (1994; 1995) instead of the original critical value reported by Perron. The corresponding break fraction for 36 number of observations are calculated easily with $\lambda = (T_b/T)$ (See Perron and Vogelsang, 1992). For 1974, the relevant break year fractions is $\lambda = 15/36=0.42$. In most cases, an augmentation of one appeared to be sufficient to secure lack of autocorrelation of the error terms.

Table A.5.5 The Zivot-Andrews unit root test for structural Break

Variable	Estimated Break Year T_b	Test statistics (t_α)		Estimated Value of λ
		Levels	1 st Differences	
LCAPL _t	1964	-1.68	-6.99	0.1388
LKR _t	1964	-2.30	-5.76	0.1388
LHR _t	1964	-1.48	-5.34	0.1388
LNGD _t	1964	-1.67	-5.66	0.1388
LGIR _t	1964	-2.66	-6.99	0.1388
LOP _t	1964	-3.47	-6.12	0.1388
LMTAR _t	1964	-1.88	-5.59	0.1388
LTR _t	1964	-1.22	-5.09	0.1388
LANTR _t	1964	-1.44	-5.67	0.1388
LCNTR _t	1964	-1.62	-5.11	0.1388
LTER _t	1964	-3.59	-6.19	0.1388
LMTR _t	1964	-3.81	-6.78	0.1388

This table presents the main results of estimating the relevant equation suggested by Zivot-Andrews (1992) (or Perron's model c) for values of λ which minimize the t-values for testing $\alpha=1$ over T-2 regressions. The null hypothesis of a unit root is rejected if $t_\alpha < t_\lambda$, where t_λ denotes the estimated date of break (critical value) reported by Zivot-Andrews (1992, p.257, table 4), t_α is estimated t-values and T_b is estimated break year. The corresponding critical value reported by Z-A is $t_\lambda=-5.08$ at the 5% significant level.

Table A.5.6 Testing for Weak Exogeneity using the Engle, Hendry and Richard (EHR) Framework and the Johansen Approach

Variable	Test For Weak exogeneity (EHR)		Test For Weak exogeneity (Johansen Approach)	
	Test-statistics	Conclusion	Test statistics	Conclusion
LKR _t	F(1,23)=0.87(.36)	Accept	$\chi^2(1)=2.23(.13)$	Accept
LHR _t	F(1,23)=1.72(.21)	Accept	$\chi^2(1)=2.45(.12)$	Accept
LNGD _t	F(1,23)=2.43(.13)	Accept	$\chi^2(1)=2.19(.14)$	Accept
LGIR _t	F(1,24)=2.06(.16)	Accept	$\chi^2(1)=0.37(.54)$	Accept
LOP _t	F(1,23)=2.43(.13)	Accept	$\chi^2(1)=2.39(.12)$	Accept
LMTAR _t	F(1,23)=3.01(.10)	Accept	$\chi^2(1)=0.41(.52)$	Accept
LTR _t	F(1,25)=0.48(.42)	Accept	$\chi^2(1) = 1.19 (.27)$	Accept
LANTR _t	F(1,25)=1.03(.32)	Accept	$\chi^2(1) = 0.98 (.32)$	Accept
LCNTR _t	F(1,23)=0.07(.79)	Accept	$\chi^2(1) = 0.14 (.71)$	Accept
LTER _t	F(1,23)=3.07(.10)	Accept	$\chi^2(1) = 0.71 (.39)$	Accept
LMTR _t	F(1,23)=0.08(.93)	Accept	$\chi^2(1) = 0.06 (.80)$	Accept

This table shows the results that the hypothesis of weak exogeneity can not be rejected at the conventional level for all explanatory variables under the study. The tabulated test statistics of F-test are F(1,23)=2.94; 4.28, F(1,24)=2.93; 4.26, and F(1,25)=2.92; 4.24 at the 10% and 5% level respectively. Table also indicates the results that the hypothesis of weak exogeneity cannot be rejected at the 5% or 10% level for the explanatory variables. The tabulated test statistics of $\chi^2(1)$ is 3.84 for the Johansen Approach.

Table A.5.7 Selection of Lag Lengths Using The Final Prediction Error (FPE)

Dependent Variable	Independent Variable	m^*	n^*	FPE (m^*)	FPE (m^*, n^*)
DLCAPL	DLKR	1	2	2.83×10^{-3}	2.63×10^{-3}
DLKR	DLCAPL	2	2	1.11×10^{-2}	0.90×10^{-2}
DLCAPL	DLTR	1	1	3.22×10^{-3}	2.39×10^{-3}
DLTR	DLCAPL	4	2	7.40×10^{-2}	7.50×10^{-2}
DLCAPL	DLANTR	1	1	2.73×10^{-3}	3.22×10^{-3}
DLANTR	DLCAPL	3	1	6.39×10^{-2}	6.05×10^{-2}
DLCAPL	DLCNTR	1	1	3.22×10^{-3}	2.83×10^{-3}
DLCNTR	DLCAPL	4	1	5.56×10^{-2}	5.93×10^{-2}
DLCAPL	DLTER	1	1	3.18×10^{-3}	3.22×10^{-3}
DLTER	DLCAPL	2	2	2.45×10^{-1}	2.41×10^{-1}
DLCAPL	DLMTR	1	1	3.22×10^{-3}	3.41×10^{-3}
DLMTR	DLCAPL	1	1	3.28×10^{-2}	3.13×10^{-2}
DLCAPL	DLHR	1	1	3.22×10^{-3}	2.10×10^{-3}
DLHR	DLCAPL	1	1	1.014×10^{-2}	1.008×10^{-2}
DLCAPL	DLNGD	1	1	3.22×10^{-3}	2.12×10^{-3}
DLNGD	DLCAPL	1	1	9.40×10^{-3}	7.45×10^{-3}

Notes: If $FPE(m^*, n^*) < FPE(m^*)$, Y Granger-causes X.

m^* denotes maximum lag on dependent variable.

n^* denotes minimum lag on independent variable.

Table A.5.8: Vector Autoregressive Models: The Granger and The HH Causality Tests.

Dependent Variable	Independent Variable	Degrees Of freedom ^a	Wald Test	Sim's LR Test	m [*]	n [*]	HH Multiple-rank F-test	Causal Inference
DLCAPL	DLKR	2	5.46 [*]	5.70 [*]	1	2	1.14 (2,28) ^b	KR → CAPL
DLKR	DLCAPL	2	0.23	0.29	4	2	0.23 (1,26) ^b	CAPL → KR
DLCAPL	DLTR	1	13.18 [*]	12.04 [*]	1	1	4.43 [*] (1,32) ^b	TR → CAPL
DLTR	DLCAPL	2	0.23	0.29	4	2	0.23 (1,26) ^b	NC
DLCAPL	DLANTR	1	0.25	0.27	3	1	2.52 (1,30) ^b	NC
DLANTR	DLCAPL	1	5.48 [*]	5.53 [*]	1	1	2.62 (1,32) ^b	CAPL → ANTR
DLCAPL	DLCNTR	1	6.42 [*]	6.40 [*]	1	1	8.67 [*] (1,32) ^b	CNTR → CAPL
DLCNTR	DLCAPL	1	1.25	1.51	4	1	0.59 (1,26) ^b	NC
DLCAPL	DLTER	1	2.30	2.43	1	1	0.68 (1,32) ^b	NC
DLTER	DLCAPL	2	4.26	4.68 ^{**}	2	2	4.11 [*] (2,29) ^b	CAPL → TER
DLCAPL	DLMTR	1	0.02	0.03	1	1	0.024 (1,32) ^b	NC
DLMTR	DLCAPL	1	3.45 [*]	3.58 [*]	1	1	0.38 (1,32) ^b	CAPL → MTR
DLCAPL	DLHR	1	19.47 [*]	16.57 [*]	1	1	4.42 [*] (1,32) ^b	HR → CAPL
DLHR	DLCAPL	1	2.08	2.20	1	1	0.039 (1,32) ^b	NC
DLCAPL	DLNGD	1	18.80 [*]	16.11 [*]	1	1	1.68 (1,32) ^b	NGD → CAPL
DLNGD	DLCAPL	1	10.47 [*]	9.89 [*]	1	1	0.01 (1,32) ^b	CAPL → NGD

Notes: ^{*} indicates significance at the conventional levels (5% and 1%).
^{**} indicates significance at the 10% level.
^a χ^2 degrees of freedom for both Wald and Sims's LR tests.
^b degrees of freedom for HH multiple-rank F-test.
NC no causality.

Table A.5.9 Results based on log-levels data: The Wald and Sim's LR test

Dependent Variable	Independent Variable	Degrees Of freedom ^a	Wald Test	Sims's LR Test	m [*] (b)	n [*] (b)	FPE (m [*])	FPE (m [*] , n [*])	Causal Inference
LCAPL	LKR	2	9.24 [*]	9.42 [*]	2	2	2.71 x 10 ⁻³	2.24 x 10 ⁻³	KR → CAPL
LKR	LCAPL	1	0.51	0.59	3	1	1.07 x 10 ⁻²	1.09 x 10 ⁻²	NC
LCAPL	LTR	3	17.7 [*]	16.19 [*]	1	3	2.94 x 10 ⁻³	2.32 x 10 ⁻³	TR → CAPL
LTR	LCAPL	1	1.24	2.92	5	1	6.83 x 10 ⁻²	7.24 x 10 ⁻²	NC
LCAPL	LANTR	2	1.81	1.92	1	2	2.56 x 10 ⁻³	2.94 x 10 ⁻³	NC
LANTR	LCAPL	2	6.59 [*]	6.75 [*]	1	2	6.71 x 10 ⁻²	5.81 x 10 ⁻²	CAPL → ANTR
LCAPL	LCNTR	2	6.41 [*]	6.58 [*]	1	2	2.94 x 10 ⁻³	2.83 x 10 ⁻³	CNTR → CAPL
LCNTR	LCAPL	2	7.64 [*]	8.23 [*]	3	2	5.93 x 10 ⁻³	5.24 x 10 ⁻³	CAPL → CNTR
LCAPL	LTER	1	4.48 [*]	4.58 [*]	1	1	2.94 x 10 ⁻³	2.73 x 10 ⁻³	TER → CAPL
LTER	LCAPL	1	2.46	2.68	1	1	2.03 x 10 ⁻¹	2.02 x 10 ⁻¹	NC
LCAPL	LMTR	1	0.19	0.21	1	1	2.94 x 10 ⁻³	3.11 x 10 ⁻³	NC
LMTR	LCAPL	2	15.6 [*]	14.28 [*]	1	2	2.96 x 10 ⁻²	2.01 x 10 ⁻²	CAPL → MTR
LCAPL	LHR	3	13.1 [*]	12.68 [*]	1	3	2.94 x 10 ⁻³	2.58 x 10 ⁻³	HR → CAPL
LHR	LCAPL	2	2.85	3.18	2	2	8.8 x 10 ⁻¹	9.11 x 10 ⁻¹	NC
LCAPL	LNGD	2	7.14 [*]	7.26 [*]	1	2	2.94 x 10 ⁻³	2.77 x 10 ⁻³	NGD → CAPL
LNGD	LCAPL	2	11.3 [*]	11.20 [*]	2	2	8.95 x 10 ⁻³	7.26 x 10 ⁻³	CAPL → NGD

Notes: If $FPE(m^*, n^*) < FPE(m^*)$, Y Granger-causes X.
m^{*} denotes maximum lag on dependent variable.
n^{*} stands for minimum lag on independent variable.
^a χ^2 degrees of freedom for both Wald and Sim's LR tests.
^b degrees of freedom for FPE.
NC no causality.

Table A.5.10 Summary of Causality Results

Log-differences			Log-levels	
FPE	χ^2 -Test	HH Multiple-Rank F-Test	FPE	χ^2 -Test
KR $\rightarrow$ CAPL	KR $\rightarrow$ CAPL	KR – CAPL NC	KR $\rightarrow$ CAPL	KR $\rightarrow$ CAPL
CAPL $\rightarrow$ KR	CAPL – KR (NC)	CAPL – KR (NC)	CAPL – KR NC	CAPL – KR NC
TR $\rightarrow$ CAPL	TR $\rightarrow$ CAPL	TR $\rightarrow$ CAPL	TR $\rightarrow$ CAPL	TR $\rightarrow$ CAPL
CAPL – TR (NC)	CAPL – TR (NC)	CAPL – TR (NC)	CAPL – TR (NC)	CAPL – TR (NC)
ANTR – CAPL (NC)	ANTR – CAPL (NC)	ANTR – CAPL (NC)	ANTR – CAPL (NC)	ANTR – CAPL (NC)
CAPL $\rightarrow$ ANTR	CAPL $\rightarrow$ ANTR	CAPL – ANTR (NC)	CAPL $\rightarrow$ ANTR	CAPL $\rightarrow$ ANTR
CNTR $\rightarrow$ CAPL	CNTR $\rightarrow$ CAPL	CNTR $\rightarrow$ CAPL	CNTR $\rightarrow$ CAPL	CNTR $\rightarrow$ CAPL
CAPL – CNTR (NC)	CAPL – CNTR (NC)	CAPL – CNTR (NC)	CAPL $\rightarrow$ CNTR	CAPL $\rightarrow$ CNTR
TER – CAPL (NC)	TER – CAPL (NC)	TER – CAPL (NC)	TER $\rightarrow$ CAPL	TER $\rightarrow$ CAPL
CAPL $\rightarrow$ TER	CAPL $\rightarrow$ TER	CAPL $\rightarrow$ TER	CAPL $\rightarrow$ TER	CAPL – TER (NC)
MTR – CAPL (NC)	MTR – CAPL (NC)	MTR – CAPL (NC)	MTR – CAPL (NC)	MTR – CAPL (NC)
CAPL $\rightarrow$ MTR	CAPL $\rightarrow$ MTR	CAPL – MTR (NC)	CAPL $\rightarrow$ MTR	CAPL $\rightarrow$ MTR
HR $\rightarrow$ CAPL	HR $\rightarrow$ CAPL	HR $\rightarrow$ CAPL	HR $\rightarrow$ CAPL	HR $\rightarrow$ CAPL
CAPL $\rightarrow$ HR	CAPL – HR (NC)	CAPL – HR (NC)	CAPL – HR (NC)	CAPL – HR (NC)
NGD $\rightarrow$ CAPL	NGD $\rightarrow$ CAPL	NGD – CAPL (NC)	NGD $\rightarrow$ CAPL	NGD $\rightarrow$ CAPL
CAPL $\rightarrow$ NGD	CAPL $\rightarrow$ NGD	CAPL – NGD (NC)	CAPL $\rightarrow$ NGD	CAPL $\rightarrow$ NGD

Notes: CAPL; Real GDP per worker, KR total investment to GDP, TR; Investment in tourism to GDP, ANTR; Investment in non-tourism to GDP, CNTR; Investment in non-tourism construction, TER; Investment in transport equipment to GDP, MTR; Investment in machinery-transport equipment to GDP, HR; Tertiary enrollment to GDP, NGD; the rate of labour growth plus technological efficiency plus depreciation rate, and NC; No causality.

Table A.5.11 Instrumental Variable (IV) Estimation Method

Model	Chapter	Test statistics	
		ECT(-1)-OLS	ECT(-1)-IV
Model 1	4	-0.61 (-3.63)	-0.59 (-2.61)
Model 2	4	-0.94 (-6.39)	-0.91 (-3.39)
Model 1	5	-0.83 (-5.63)	-0.80 (-4.53)
Model 2	5	-0.79 (-6.49)	-0.73 (-3.41)
Model 1	6	-0.96 (-4.72)	-0.95 (-4.02)
Model 2	6	-0.92 (-6.83)	-0.88 (-4.74)
Model 3	6	-0.95 (-4.32)	-0.93 (-5.19)

ECT(-1) denotes the error correction term. OLS and IV represent the ordinary least squares and the instrumental variable estimations respectively. The numbers in the parentheses show t-statistics which are all significant at the conventional levels (5% and 1%). Since we take the contemporaneous effects into consideration within the short-run models, we report the relevant t-statistics and coefficient estimates of error correction terms for the IV estimation method compared to the results estimated by the OLS (see also Ghatak et al, 1997).

A.6 Conclusion

We used annual data for our study over the period 1960-1995 and did not face any limitations in collecting the data set. It is important to stress that we could not obtain the proxy for public infrastructure therefore; the government development expenditure figures are used for this purpose.

We then checked whether there exists multicollinearity problem in our data set. It should be noted that the correlations among the variables under this study do not matter in favor of multicollinearity problem except some minor problems. These kind of problems are inevitable due to the form of disaggregating or regrouping data.

Finally, we presented the results of the different techniques under heading of the common table in which the estimated findings are for all empirical chapters.

APPENDIX CHAPTER B

Smallness, Characteristics and Constraints of Small Island Economies: A Review of The Literature

B.1 Introduction

Small island countries attracted much interest after their gaining independence in the late 1950s and the early 1960s. A large number of small countries and territories were formed with the decolonisation process of the British Empire in 1960s. Afterwards, Commonwealth Secretariat showed special interest by organizing a seminar in 1963 on the problems of smaller territories at the Institute of Commonwealth studies of the University of London. The main concern was designed to overcome the development problems of smaller states, which prevent them to achieve their development objectives.

Small Island economies (SIEs) have long been characterised by their small size and narrow resource base where by these factors are also considered as the constraints and obstacles to their economic growth. The constraints become even stricter when there is inefficiency or bad public administration in employing these limited resources, which in fact, affect the nature of their growth and development.

Besides smallness and narrow resources, there are other factors that can easily slow down their economic growth or development, such as the effects of international debt¹³⁵, the unsatisfactory performance for the promotion of the private sector¹³⁶, lack of aid-donors, high import demand, terms of trade problem¹³⁷, excessive money creation¹³⁸, the problem of labour migration, and transport cost due to remoteness.

Notwithstanding there exist special problems or characteristics in small island economies, they find themselves more concentrated on products in which they have a comparative advantage. For instance, Mauritius: sugar production and export, Fiji: sugar and tourism, the Caribbean islands: tourism and banana, Malta: textiles and shipping, Lesotho and Botswana: mines (especially, diamond) and Cyprus: tourism and financial services (i.e. off-shore banking).

¹³⁵ See Kaminarides and Nisan (1993).

¹³⁶ See Cole (1993).

¹³⁷ See Briguglio (1993).

¹³⁸ See Caram (1993).

The chapter is organized as follows: Section B.2 explains the definition of smallness and the evaluation of interest for small states. Section B.3 discusses the difference between small islands and small states. Section B.4 indicates the general characteristics of small islands. In section B.5, the economic implications are presented. Section B.6 compares the growth rates between the Cyprus economy and some small states economies. Finally, section B.7 provides some conclusions.

B.2 The definition of ‘Smallness’ and the evolution of interest for small states

‘Smallness’ is only one of many characteristics of small countries. The phenomenon of smallness has been widely discussed since the late 1950s by both development economists and social scientists. These small countries attracted much interest after their gaining independence in the late 1950s and the early 1960s. Mainly, the economic, demographic, sociological and political implications of size and development were examined (Chenery, 1960; Benedict, 1967).

In this case, it is important to define smallness, the cut-off point at which a country can be classified as ‘small’. The first attempt to question the size of the nation, ‘smallness’ was made in the International Economic Association Conference in 1957¹³⁹. The conference is called *The Economic Consequence of the Size of Nations* and the ‘smallness’ criterion was based on the population size of 15 million downwards. Although the main emphasis was on the developed countries, the paper by Kuznets (1971) in particular laid the foundation of the statistical work on the implications of country size in developing countries.

Since Kuznets (1971), there had been an increase in the studies to test the economic effects of size. Chenery (1960) found out that size is a good indicator on economic structure to develop industrialization. Like most economists of the 1960s, it was believed that industrialization was an engine to economic growth and small states were disadvantaged due to their size and production composition¹⁴⁰.

¹³⁹ The proceedings of this conference are in Robinson (1960).

¹⁴⁰ The production composition was on primary production (i.e. agricultural products).

On the other hand, there were some other statistical studies which found the opposite (Chenery and Taylor, 1968; Kuznets, 1971; later in international trade). In their statistical work, they investigated the influence of country size for economic growth and found no relationships between economic size and income per head or rate of growth. The contribution of Kuznets (1971) showed that the size of a nation is not a constraint. Therefore the access to international trade via openness regimes is an important and viable potential for many economies including the small ones¹⁴¹.

A large number of small countries and territories were formed with the decolonisation process of the British Empire in the 1960s. Commonwealth Secretariat therefore showed special interest by organizing a seminar in 1963 on the problems of smaller territories at the Institute of Commonwealth Studies of the University of London (Selwyn, 1975; Commonwealth Secretariat, 1985).

The concern of United Nations for small states was not comprehensive in 1945 as there were only three island states (Cuba, Haiti, and Dominican Republic) among the twelve small states, which became member for United Nations. However, with the admission of Cyprus¹⁴² in September 1960, the number of small islands expanded in UN (Kaminarides, 1989).

Commonwealth Secretariat's concern continued and another conference was initiated in 1977 in Barbados. The main concern was on 'small state' and other specially disadvantaged states. A programme was designed to overcome the development problems of small states, which prevent them to achieve their development objectives. The smallness criterion was again on population and around one million population requirement was set to identify the small countries that would benefit from the programme.

In recent years, besides an increase in the criterion of 1 million to 5 million, the Commonwealth Secretariat became extensively interested in other measures of smallness to identify small countries. These countries are thus defined from a

¹⁴¹ In recent years, the cases of Mauritius, Singapore and Cyprus can be given as good examples.

¹⁴² Cyprus is an island in the Mediterranean with 9250 sq km area and 500,000 inhabitants in 1960.

composite measure, which incorporates population, area and income, and further classified into different categories such as low, middle and high-income countries.

Another conference on development issues of the island states in the Pacific and Indian oceans convened in 1979 by the Development Studies Centre of Australian National University. Smallness was discussed in terms of the problems of small island states. They took the main characteristics of the small states, such as size of population, geographical size and gross domestic product (GDP) as criteria. Smallness in human resources is associated with the size of population and physical area with the inadequacy of natural resource endowment. GNP or GDP as a rough measure give an indication for the size of domestic market (Dommen and Hein, 1985a:20).

However, some economists propose the use of population size and gross domestic production (GDP) for defining small countries and reject the surface area as a significant factor (Lall and Ghosh, 1982:144-5). They also acknowledge that due to economies of scale particularly in manufacturing, the small countries are disadvantaged compared with the larger ones. Thus smallness is seen as constraint in achieving a success in development.

In spite of its shortcomings, most studies have used population as a measure of size. Hein (1985:116) on the other hand disagrees that the use of a single variable for defining small states is inadequate. That is because of the existence of other appropriate relative variables, which could affect the development of small countries and do not necessarily arise out of size alone.

In a study by Milner & Westaway (1993), the effects of remoteness among the other variables and population size are tested for a large sample of developing economies for 1973-1985. They consider a number of variables which are constraints for growth. They put forward their hypotheses about the influence of country size on the medium-term growth under four headings (i.e. capital shallowing, restricted structural change, barriers to international “catching up” and limited domestic technical diffusion).

Before we discuss the results, it would be helpful to define these hypotheses as they would be useful when we will be explaining the characteristics of small

states. The meaning of capital shallowing is that the small or remote states are disadvantaged due to the high costs of capital. Structural change allows the shift among the low productivity sectors to the greater potential ones as is in the case of large countries which are likely to enjoy the economies of scale. “Catching up” is the ability to “import” technological improvements in which the small states are likely being disadvantaged. Lastly, limited domestic technological diffusion is hypothesised to consider the lower scope for growth by internal technological diffusion.

The results from Milner and Westaway (1993) study showed no link between medium term growth and a range of attributes of country size and performance. Some evidence is recorded that certain sources of growth are affected by country type. For example, the effects of “capital shallowing” and greater barrier to inter country technological spillover in agriculture are existent in small states. The important conclusion from this study focuses on the role of international trade and they pointed out that “these effects are likely to be weaker as openness increase” (Milner and Westaway, 1993:211).

Openness is the most important common characteristics of small island economies and it is related with trade policies where affects economic growth or development. The nexus between openness and economic growth have long been analysed in the relevant literature. In the case of Mauritius, the impact of trade policy (openness) on economic growth was investigated by Ghatak and Milner (1997) and find that openness and human capital are the main factors to increase economic growth. The other paper, was provided Ghatak and Fethi (1999), examine the relationship between openness and economic growth. In this paper, openness has a negative impact (or adverse effect) on economic growth due to the political and economic isolation of northern Cyprus.

Turning to the definition of being small, Kaminarides (1989:xvi) contributes to the definition of smallness theoretically that “small country is one that is small enough so that the quantity of goods and services it produces is too small to affect their prices. In other words, the small country, from a micro point of view, is a “price-taker.” At the macro-economic level, smallness might be defined as such

that the country's expansion or contraction will not influence the overall economic activity in the rest of the world". He notes that the classical criteria of smallness are population, area and the size of the economy measured by the GDP are all acceptable, but no limits of these measures are mentioned. The main theme behind this definition is one of the important characteristics of small states, which is defined as the narrow production capacity.

The above section aimed to define the smallness and the evolution of the interest for small states. Some variables to define smallness were proposed by different researchers, institutions and studies were aimed to see whether there is any size effect in development. However we can conclude that there is still no single, universally accepted definition of 'smallness' and it is now widely accepted that the size is not a constraint for development.

B.3 Smallness and islandness

Another debate questioned the validity of grouping island as distinct from small states. Selwyn (1980) argues explicitly that there is no need to classify islands in a separate group since this is not useful for the purpose of analysis and prescriptions. He emphasizes that many of the characteristics of small states also belong to the characteristics of small islands.

In addition, Khatkhate & Short (1980) implicitly mention that there is little to distinguish islands from other "mini" or small states as far as the monetary policy is concerned. The high degree of openness of mini economies or islands prevents the policy makers to adopt macroeconomic stabilisation policies to reduce the country's vulnerability to external shocks.

Indeed, in a number of respects, both small islands and small states, which are landlocked¹⁴³, have wide variations among themselves. For example, per capita income, land area and population size or density differ in these two groups and there are wide variations in the same groups. The most important common characteristics of these economies are their openness. Furthermore, in the case of small islands, their location and remoteness are in away with both advantages and

¹⁴³ Streeten (1993) points out that "landlock small countries suffer from depending on their neighbours for access to the sea".

disadvantages. Even though they suffer from high transportation costs¹⁴⁴, mostly they could enjoy the benefits that they have a comparative advantage. For instance, Mauritius: sugar production and export, Fiji: sugar and tourism, the Caribbean islands: tourism and banana, Malta: textiles and shipping, Seychelles: tourism and industrial fisheries, Lesotho and Botswana: mines (especially, diamond), and Cyprus: tourism and financial services (i.e. off-shore banking).

B.4 The general characteristics of small islands

We now summarise the special constraints faced by small island economies and then continue with the economic implications at a greater detail.

As far as definition of “small island” is concerned, again there is still no consensus even though there is a growing debate. Dolman (1985:40) simplifies this problem and pointed out that “the definition of a small island is a matter of interpretation rather than fact”. The special constraints or problems faced small island states can be classified under two headings; economic and natural ones (Dolman, 1985; Commonwealth Secretariat, 1985; Jacobs, 1989):

B.4.1 Economic Problems

- Small island states suffer from diseconomies of scale in the provision of large-scale production.
- Many small islands have serious balance of payment problems¹⁴⁵ emerging from stagnating export performance and earnings, while at the same time imports of foods, energy, and consumer goods are growing.
- They depend on a very narrow range of agricultural products such as sugar, fruit and vegetables for exports that could be disadvantage in the international trade.
- Some small economies are dependent on the operations of a few large companies, often foreign-owned. These companies are mostly active in

¹⁴⁴ Armstrong et al. (1993) present a research project on transport costs for the case of Isle of Man and conclude that transport costs are real problems for its development.

¹⁴⁵ Helleiner (1982) examines small countries that face the difficulties to adjust sharp deteriorations in their balance of payment.

mining, tourism, and financial services in operating on highly privileged terms.

- They depend on limited access to capital market and a heavy dependence on aid¹⁴⁶ and external institutions.
- Distance to and from markets, high external and sometimes internal transport costs and the need for transshipment of goods entail considerable costs, low frequencies of movement and much time.
- Most Small Islands are located in remote distances and some suffer from political vulnerability due to their location. For example, Cyprus is the only island where UN peacekeeping forces are in operation due to the communal crises, which improved the communal unrest in the country (Harden, 1985; Bray, 1986; Clarke and Payne, 1987; Christofides, 1991).

B.4.2 Natural problems

- They generally suffer from narrow resource bases. Many have severe limitations in natural resource endowments in terms of commercially exploitable minerals. There is scarcity in human resources (skilled) too.
- Some island states are prone to natural disasters that destruct their economies. Cyclone, hurricane and typhoons cause devastating effects on crop production, thus food security.

In particular, the small island countries of the south Pacific are highly vulnerable to natural disasters. Such disasters mentioned above, can easily damage to a country's productive base. Benson (1997) and Fairbairn (1997) attempt to explore some of economic consequences of natural disasters for some pacific island economies (i.e. Fiji, Western Samoa and Papua New Guinea).

¹⁴⁶ See Baker (1990) and Bertram (1993) to get more details about the relationship between foreign aid and development in small island economies.

B.5 Economic Implications

In this section, we aim to discuss the economic problems at a greater length. In particular, we examine some studies, which analyse the economic problems of small island economies.

A small domestic market of small island economies is the result of not only the small population size but also the small income generating society (Jambiya, 1993:68). Therefore these countries are likely suffer from the diseconomies of scale in the large-scale production of certain industries. This is particularly applicable to manufacturing industry in which economies of scale are important due to the high technology requirement. Some economists believe that there is a minimum size below which it is not viable for small states to establish such industries (Lall and Ghosh, 1982:143-164).

On the other hand, an interesting perspective is put forward by Streeten (1993) that being small is not always a constraint, but advantageous in the sense that these countries could single out the ability of economies of scale to adjust to sudden changes. He provides the examples of Botswana and Malta for this purpose.

In reality, most small island states, either due to the inability to exploit economies of scale or the consequence of their narrow resource base, they “concentrated” on a few products, thus few industries. This is called the concentration phenomenon (Lloyd and Sundrum, 1982:17-38). In extreme cases, in some islands, there exists only one major activity, which is recognised popularly as “sugar” economies, “petroleum” economies or “tourism” economies. For example in the cases of Mauritius, sugar traditionally has been the main export of the country that constituted 8% of GDP and about 28% of export earnings.¹⁴⁷

Product, as well as export concentration is the consequence of narrow resource base and there is a need for specialization to secure scale economies in production, marketing, transportation and distribution facilities (Persaud, 1989:15-20).

¹⁴⁷World Bank (1992:349).

Nevertheless, the concentration could also bring some disadvantages that is a higher degree of vulnerability to external shocks. The problem in this case is aggravated by having main production on agricultural or mineral sectors. They are more vulnerable due to the unstable world prices.

Diversification¹⁴⁸ is proposed to diminish the effects of the external shocks. Due to the limited narrow base, the importance of service industries increased in small island economies, in particular in the tourism and financial services. For example, Mauritius diversified its sugar economy to tourism and manufacturing activities and this was reflected to the figures in recent years. Manufactured exports in 1991 accounted for about 11 percent of GDP and almost 50 percent of gross domestic earnings (The World Bank, 1992:349).

It is always expected that tourism is a well strategy for the development of small economies, however this service sector has its proponents and opponents. Those people who support a tourism-led growth strategy argue that, given the market size and the paucity of natural resources in small economies, the services sector, and especially tourism, is the key area, which offers good prospects for economic progress (Dommen and Hein, 1985b).

In the cases of Cyprus, tourism has become one of the most important sectors of the economy. Kammes and Salehi-Esfahani (1992) analyse the direct contribution of tourism to gross domestic product (GDP), employment and foreign exchange earnings. They mention that the tourism sector recently has grown more rapidly than any other sector in the economy, and tourism receipts have surpassed the income from exports for both the agriculture and the manufacturing sectors. They also point out that tourism not only has created jobs for 20 percent of the population but also led to a major boom in the construction industry on the island. Finally, they briefly consider the indirect linkage and leakage effects of tourism on other types of economic activity as well as some environmental and social considerations related to tourism in Cyprus.

The comparative advantage theory developed by Hechsher-Ohlin-Samuelson supports the tourism-led growth strategy by pointing out some countries have

¹⁴⁸ See Elek, A., Hill, H. et al. (1993) and Fairbairn and Kakazu (1985) for more information.

comparative advantage in certain industries and this is very important in the case of small islands where there is the abundance of the combination of sun and sea which promotes the tourism sector.

As Balassa (1978:184) points out, the “small service based economies of Malta, Panama and Cyprus have been service oriented since the 1960s”.

Nevertheless, the role of tourism is not without risk because the industry is highly sensitive to external factors. This is even worst when the sole earning is from tourism revenues as it is occurred in the case of most small island economies. Oglethorpe (1985) examines the role of tourism in the development of the Maltese economy. Malta state was formed with the decolonisation after World War II. He points out that the dependent nature of tourism in Malta has not contributed positively to the economic development of the island. He also adds that tourism in Malta faced a serious problem in the international markets because of dependence upon the UK tourist markets and Maltese politician’s attitude to tourism.

According to Chen-Young (1982:221-229), there is the need to adopt policies which might improve the economic benefits and reduce the social costs in tourism activities since there is no alternative rather than the tourism-led development strategy for small island economies. Using the data for Jamaica, he criticizes the heavily dependence on transnational corporations and foreign airlines which are all subject to substantial fluctuations. However, the data he reveals that the industry yielded significant benefits to the economy in terms of employment and foreign exchange earnings.

Dieke (1993) also points out that there is number of policy objectives associated with successful tourism in the Gambia such as effective public sector, efficient organizational and management framework, the combinations of sand-sea-sun and friendly behaviour of the country’s people. These are the good indicators to achieve remarkable successes in this sector.

Turning to the manufacturing industry, there is a view that emerged on the role of promoting manufacturing industry in small island economies to reduce the vulnerability to external shocks. This could include the clothing, footwear, leather

goods and furniture. Mainly the protectionist policies of government could promote this industry from external competition.

Demetriades, Al-Jebory and Kamperis (1993:259-268), in their study assess the contribution of manufacturing to the economy of Cyprus between 1960 and 1989. They utilize an econometric model to estimate dynamic multipliers in the economic growth and foreign exchange net inflows. Due to narrow resource base, they find that the country was disadvantaged and had to import most of the intermediate goods essential for the manufacturing industry.

Indeed, the vulnerability to external shocks and the high cost of diversification exacerbates the balance of payments problem of small islands economies. The growth of imports, thus an increase in balance of payments deficits in these countries is financed from growing volumes of aid, remittances¹⁴⁹ from abroad and invisible export earnings (i.e. tourism revenues).

For instance, tourism in the case of the Republic of Maldives became an important source of income after financial organizations and development banks sent the money (i.e. aid or loan) for investments in tourist facilities. The share of GDP of the Maldives in 1983 was 14% which made tourism the third largest sector as far as contribution to GDP was concerned. Balance of payment deficit also was covered by net foreign exchange rate earnings from travel that rose from US\$ 7.8 m in 1979 to US\$ 18.1 m in 1983 (Sathiendrakumar and Tisdell, 1989).

In the case of Cyprus, for example, as a result of limited technological content through the problems of production and the economy, it was seen that there was a structural problem in the balance of payments in the late 1950s and the early 1960s. With the exception of 1987 and 1988, Cyprus has consistently suffered from a current account deficit since 1967. Due to the increase in tourism revenues, this problem has been partly compensated until 1989 (The Economist Intelligence Unit, Cyprus, Country Profile, 1991-92).

Lall and Ghosh (1982) examine the options available for small economies in overcoming the constraints arisen from economies of scale or technological

¹⁴⁹ See Sofer (1993) for more details about remittances how important they are in the small island economies.

incapacity. They emphasized the role of exports in the industrial development of small economies and suggested that obtaining necessary technological skills will create penetration into the foreign markets. In other words, being compatible with endogenous growth theory which necessitates the import of foreign technology and know-how, small island economies need to improve their technological ability to achieve success in the world markets.¹⁵⁰

The main theme behind the import of foreign technology (capital accumulation) is the notion that the role of human capital is important in producing or discovering new ideas¹⁵¹. Both physical and human capital accumulation¹⁵² are crucial because without entrepreneurial know-how (or managerial expertise), technology may not be fully utilized.

Unfortunately, many small islands suffer from the scarcity of both physical and human capital accumulation that is essential in the economic growth. Cyprus is advantageous with the skilled and capable entrepreneur. Hudson and Dymitou-Jensen (1989) modelled the Cyprus economy and stressed the importance of human capital behind the success of the country's development.

Cypriots developed a comparative advantage using their labour force, location and attractive climate and beaches. Particularly, they utilised all of the country's assets with highly educated human capital to stimulate economic growth in Cyprus. These factors mentioned above enable such poorly endowed country to create 'an economic miracle', despite its short independence life and major structural breaks caused by either intercommunal conflict or war (Hudson and Dymitou-Jensen, 1989).

Ultimately, we attempted to identify the constraints which are faced by small island economies and to explain the forces behind the 'economic miracle', especially, in the small countries (i.e. Cyprus, Hong Kong and Mauritius).

¹⁵⁰ The case of Singapore applies.

¹⁵¹ New Growth Theories are explained in the second chapter: Literature Review.

¹⁵² In the case of Cyprus, human capital plays an important role to stimulate economic growth. In terms of university degrees per capita, Cyprus ranks third after the USA and Canada.

B.6 A Comparison of Cyprus Productivity Growth With Some Small States

The Cyprus economy can easily be affected by the economic improvement in the world economy due to its open character. This applies to the rate of growth of GDP, import demand in the economic partners of Cyprus, production cost in the development sectors, and prices in international markets. Apart from this, the Cyprus economy was also adversely affected by intercommunal conflict and the war during 1963-67 and 1974 respectively. In this section, the annual real growth rate of output per worker and the labour productivity growth rate of the Cyprus economy is compared with favourably many small state economies.

Table B.6.1 lists the most rapidly growing small state economies among the countries in the Summer-Heston data set, using the data on output per worker with 1985 international dollar prices. As can be seen in the Table, East Asian small state economies are at the top. For city-states such as Hong Kong and Singapore, the rapid growth is likely to be related with absence of a rural area, and of food production (i.e. agriculture) for domestic consumption, which is an obstacle to total growth. It is worth noting that Botswana has the highest growth rate in Africa and Malta has the highest growth rate of any European country. In the same Table, Cyprus with its growth rate of 4.73 is in the sixth fastest grower among the rest of small state economies. The reason behind these countries' success is that they have a comparative advantage. For example, Cyprus: tourism and financial services, Malta: textiles and shipping, Lesotho and Botswana: diamond and workers' remittances, Seychelles: tourism and industrial fisheries, Mauritius: tourism, sugar production and export. Table B.6.1 is also tabulated for the years 1976-1990 to avoid Cyprus's war period. Having cut the problematic years out of the sample, the Cyprus economy was the first fastest grower among the others.

One can ask the question, do poor countries grow faster than rich ones? The answer for this particular question still is controversial in the literature¹⁵³. To our knowledge, poor countries are less likely to grow quickly than rich ones. In other words, they do not seem to catch up the advanced developed countries such as the

¹⁵³ See Sala-i-Martin (1996) about the discussion on convergence concept.

USA. However, small states or islands can grow faster than the advanced developed countries because of their comparative advantages.

To sum up, the table illustrates that the small states economies have been relatively well off. It is worth emphasizing that such small countries like Cyprus and Botswana did very well in terms of growth rate due to the comparative advantages, which are known as economic forces behind the success of their economic development.

**Table B.6.1 Some Small States and Cyprus:
Annual real growth rates of
output per workers**

Country	Growth Rate 1960-1990
Botswana	6.32
Hong Kong	5.91
Taiwan	5.86
Singapore	5.52
Malta	4.83
Cyprus	4.73
Lesotho	4.65
Seychelles	4.56
Mauritius	2.14
Country	Growth Rate 1976-1990
Cyprus	6.25
Taiwan	6.06
Seychelles	6.03
Hong Kong	5.92
Malta	5.14
Botswana	4.74
Singapore	4.24
Mauritius	2.67
Lesotho	2.27

Notes: The data used for Table B.6.1 was extracted from Summer-Huston data set¹⁵⁴, which is also known as 'The Penn World Table (Mark 5)'.

¹⁵⁴ See Temple (1999:9) for constructive criticisms about the quality of the output data.

B.7 Conclusion

We attempted to define and discuss some concepts that have been adequately considered in small island economies' literature. An important issue, which is at the heart of the case for special problems and policies in small countries, is associated with smallness or small size. So far, it can be concluded that there is still no single, universally accepted definition of 'smallness' or 'small size' and it is now widely accepted that size is not a constraint or drawback for economic growth or development in small island economies.

The growth experiences in small developing countries suggest that the most important sources of growth are associated with human sources (i.e. human capital), national sources (i.e. physical capital) and national cohesion. In order to succeed the well-defined economic growth or development, efficient public administration should be formulated that small island economies do not face administrative disadvantages.

Apart from administrative disadvantages in small island economies, it is widely accepted that there are some other disadvantages or obstacles for the relevant economies such as lack of international trade, the effects of international debt, balance of payment problems, vulnerability of external shocks, less diversity (or concentration phenomenon) in raw materials and natural resources and lack of international aids.

Even though small countries suffer from various handicaps, drawbacks and obstacles, they could reap the benefits using their own comparative advantages such as tourism, industrial fishery, financial service, sugar production, clothing and textile. These comparative advantages make small island economies to grow faster than larger countries. As a consequence, it can be said that there are also advantages to being small in so many cases.

APPENDIX CHAPTER C Methodology

C.1 Introduction

This chapter presents recent econometric methodologies (cointegration techniques) that are employed in this thesis. The methodologies utilised throughout this chapter are based on a time series approach. The concept of cointegration has become the most important recent development in empirical modelling in time series studies in the early 1980s. Before cointegration was introduced to the literature, economic time series data were assumed to be stationary. However, time series data can be non-stationary (trended) and this kind of data can be regarded as potentially a major problem for applied econometric studies. It is well known that trends may cause some problems (i.e. spurious regression). Some authors have suggested a remedy, namely, to difference a series successively until stationarity is achieved.¹⁵⁵

This causes a loss of some valuable long-run information in the relevant data. However, a breakthrough in time series econometrics came out with the concept of cointegration. Cointegration analysis simply determines the long-run relationships between observed time series variables where the residuals measure short run disequilibria. For the first time, the concept of cointegration was introduced by Engle and Granger (1987). In their seminal paper, they provided a theoretical base for representation, testing, estimating and modelling of cointegrated non-stationary time series variables. Since then there has been an explosion of research on cointegration and related subjects.

The premise of cointegration analysis has received a great deal attention on three points in the recent literature: stationarity, spurious regression and error-correction mechanism. Stationarity is the key point of the concept of cointegration and such series¹⁵⁶ should at least have constant unconditional mean and variance over time while the value of covariance depends only on the gap between periods. In fact, the mean, variance, autocovariances are independent of time (i.e. remain constant

¹⁵⁵ Box and Jenkins (1970) emphasize that a non-stationary series can be a stationary one by successive differencing of the series. However, Sargan (1964), Hendry and Mizon (1978) and Davidson et al. (1987) have criticized this specification in terms of differenced variables only for the benefits of the long-run relationship.

¹⁵⁶ See Granger and Newbold (1974), Nelson and Kang (1984) and Nelson and Plosser (1982) for the importance of the stationarity assumption and the econometric implications of non-stationarity.

over time). However, a non-stationary series can be transformed into a stationary one by successive differencing of the series. It is obvious that the properties of a stationary series and a non-stationary series are quite different (Hall and Henry, 1988: 48).

It is still possible to run regressions, even if time series do not satisfy the stationarity assumption. However these regressions could simply be spurious (or economically meaningless) and this leads us to the concept of “spurious regression”. In this respect, spurious regression results usually arise when the regression variables are non-stationary. Since many macroeconomic time series data are typically non-stationary, this is a case of particular interest to applied economists (see Hendry, 1980). Another drawback for time series data is to have trends and these series have to be detrended before any sensible regression analysis is performed. It is already known that this is done by successive differencing. Box and Jenkins (1970) and Granger and Newbold (1974) advocate the idea of differencing the economic series data to remove non-stationarity. This approach, however, disregards potentially important long-run relationships among the levels of the series postulated by economic theory.

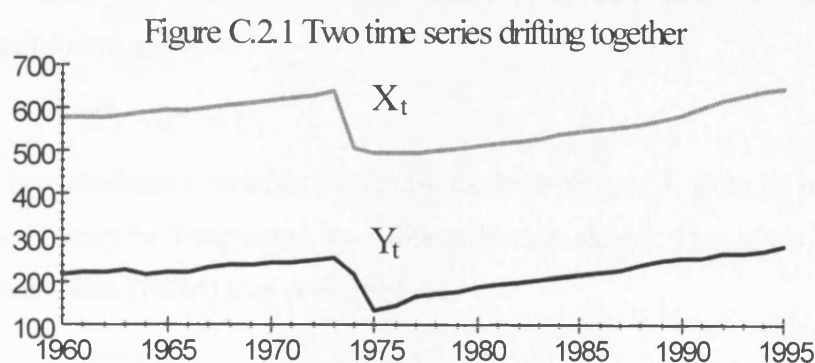
For the first time, this problem was anticipated by Sargan (1964) who used a class of mechanism that later would be known as “error-correction mechanism (ECM)”. Actually, Phillips (1954) developed a class of ECM and Sargan (1964) was the first to apply this to economic data. The name ECM was first introduced by Davidson et al. (1978), which is one of the best-known applied examples of ECM.

This chapter is not only concerned with single equation techniques, but also with system-based methods, such as the Johansen cointegration approach. The remainder of this chapter shows how cointegration analysis relates to the existing time series econometrics literature, together with non-stationarity and spurious regression. Subsequently, we define and explain the nature of cointegration in section C.2. In section C.3, we discuss several alternative tests for the existence of unit roots. Section C.4 deals with whether the variables under study, are difference stationary process (DSP) or trend stationary process (TSP) since it is important to know the type of trend (i.e. stochastic or deterministic). Section C.5

explains the existence of possible cointegration relationships. Section C.6 discusses the Johansen full information Maximum likelihood (FIML) method and the Reimer method, which is suggested for small sample sizes. In section C.7, we define the concept of exogeneity. The Engle, Henry and Richard (EHR) framework and the Johansen approach for weak exogeneity are explained and discussed. In section C.8, we present an error correction modelling (ECM) proposed by Engle and Granger (1987). Section C.9 discusses alternative approaches such as the Engle-Yoo three-step modelling approach (EYM), the Saikkonen time domain approach and the Inder Fully modified unrestricted ECM approach. Section C.10 presents the nature of causality and discusses the tests for causality such as Final Prediction Error (FPE)s, The Granger Causality (G-C) test, the Holmes–Hutton (HH) test and Sim’s LR test. The final section C.11 draws some concluding remarks.

C.2 The Nature of Cointegration

Let us assume that the variables X_t and Y_t in figure C.2.1 are non-stationary as they are both subject to a positive trend. In the figure, they seem to be drifting together in the time. These variables are likely to be integrated of the same order and the differences between them do not indicate a clear tendency to increase (or to decrease).



The concept of cointegration suggests that, even though the series X_t and Y_t in the above figure are non-stationary, they do not drift apart in time. If there is such a long-run relationship between X_t and Y_t , this means that deviations from the long-

run path are stationary and these variables are said to be cointegrated. The concept of cointegration was first introduced into the literature by Granger (1981) and the formal definition was developed by Engle and Granger (1987). The definition of cointegration is as follows:

Definition C.2.1: Given two series, X_t and Y_t are both integrated to the same order, d , and if a linear combination of X_t and Y_t is integrated to the order b where $d \geq b \geq 0$, then the two series are said to be cointegrated of order d and b denoted by $X_t, Y_t \sim CI(d, b)$. This constitutes cointegration between the variables is known as the cointegrating vector¹⁵⁷.

Now, assuming that economic theory suggests a long-run relationship (or an equilibrium relationship) between X_t and Y_t in the following form:

$$X_t^* = \alpha Y_t \quad (C.2-1)$$

Where X_t^* is the long-run equilibrium path (i.e. expected or target long-run path) of X_t . If target X_t say, X_t^* follows an equilibrium path at each instant, the equation C.2.1 will be as follows:

$$X_t^* - \alpha Y_t = 0 \quad (C.2-2)$$

In brief, one would not anticipate X and Y adjust in accordance with this equilibrium at every point in time, and so, even if equation C.2.1 correctly specifies an equilibrium relationship, equation C.2.2 does not hold at all instant. We then write equation C.2.2 to take into account that the condition is out of equilibrium as below.

$$X_t^* - \alpha Y_t = U_t \quad (C.2-3)$$

Where stochastic variable U_t represents deviations of X_t from its long-run path X_t^* (or U_t may be interpreted as a disequilibrium error). This gives error correction mechanism (ECM) that is defined as:

$$ECM = X_t - X_t^* = X_t - \alpha Y_t = U_t.$$

¹⁵⁷ It is important to stress that the notion behind cointegration can be explained by considering the case $d=b=1$. This is the case used in the definition above [See Charemza and Deadman, (1997:125)]. In multivariate case, maximum number of cointegration vectors can be $r=P-1$ where p represents the number of variables. This is shown by Johansen (1988) that there might be more than one cointegrating vector in the multivariate case.

If we reformulate the equation above, we can have the following:

$$X_t = \alpha Y_t + U_t \quad (\text{C.2-4})$$

Where $U_t \sim I(0)$.

In the framework of cointegration, U_t in equation (C.2-4) stands for deviations from the long-run equilibrium path¹⁵⁸. In fig C.2.1, U_t is the difference between, X_t and Y_t (i.e. $U_t = X_t - \alpha Y_t$). This indicates the definition of error correction mechanism in cointegration framework. The ECM constructs a case of systematic disequilibria adjustment process through which X_t and Y_t are prevented from 'drifting too far apart'. Charemza and Deadman (1997:131) point out that cointegrated series imply that there is some adjustment process, which prevents the errors in the long-run relationship becoming larger and larger. Engle and Granger (1987) also show that any cointegrated series have an error correction representation. The reverse is also true. This shows an important correspondence, which exists between cointegrated system and EC processes. For any set of cointegrated series, the relationship between them may be expressed by an EC representation. This is often called the Granger Representation Theorem (GRT)¹⁵⁹.

As a consequence, if X_t and Y_t are cointegrated, the following requirements should exist:

- (a) The two series should be integrated¹⁶⁰ of the same order.¹⁶¹
- (b) There should exist a linear combination of the two series, which is integrated of order zero, denoted as $U_t = (X_t - \alpha Y_t) \sim I(0)$.

In practice, it is often desirable to formulate cointegration hypothesis between more than two variables. Therefore, higher order is also possible and allowed under the general definition of cointegration.

¹⁵⁸ See also Granger (1993) for more details.

¹⁵⁹ See Charemza and Deadman (1997), Engle and Granger (1987), Granger and Weiss (1983) and Hylleberg and Mizon (1989) for more information about GRT.

¹⁶⁰ Integration is the representation of a process as a sum of past shocks. This process is said to be integrated of order $D(I(d))$. If the process are differenced as d times, the resulting process will be stationary (Denoted $I(0)$).

¹⁶¹ Nelson and Plosser (1982) and Peron (1988) show that most macroeconomic series are non-stationary and integrated of order one.

However, if the number of variables involved in the long-run relation increases, the problem becomes more complicated than the two variable case. In a multivariate case, it is possible for the variables to be integrated of different orders and the error term U_t to be stationary. Charemza and Deadman (1997) point out that if variables in the long-run relationship are of a different order of integration and the order of integration of the dependent variable is lower than the highest order of integration of the explanatory variables, there should be at least two explanatory variables integrated of this highest order if the necessary condition for stationary of the error term is to be met.

In addition, the existence of cointegration leads to some causal implications and statistically significant error-correction term introduces an additional channel in which Granger-causality could be detected. If two variables are cointegrated, causality must run in, at least, one direction between the variables¹⁶².

C.3 Unit Root Test: Test for order of Integration

To examine stationarity (or non-stationarity) in an applied time series study, some tests should be employed for unit roots. The existence of unit roots is related to non-stationarity. As it is demonstrated below, a number of alternative tests are available for the presence of unit roots (testing for the order of integration) whether a series is stationary. The integration analysis is based on the following key definition proposed by Engle and Granger (1987):

Definition C.3.1: A non-stationarity series, which can be transformed to a stationarity series by differencing d times, is said to be integrated of order d . A time series X_t , integrated of order d is denoted $X_t \sim I(d)$. For instance, if $X_t \sim I(1)$, the first differences of X_t achieve stationarity with $\Delta X_t = X_t - X_{t-1}$. This process is termed first order differencing and the resulting series are called first differences.

The relevant tests for the presence of unit roots or testing for integration level in an applied time series data fall into the following categories: visual inspection of the series and of the sample autocorrelations of the series, integration Durbin-Watson (IDW) statistic test, and regression-based t test such as the Dickey- Fuller

¹⁶² See Granger (1988) for further information.

(DF) (1979), the Dickey-Pentula (DP) (1987), Phillips-Perron (PP) (1988) and Perron (1989). Among these tests, the DF test, in particular, has received the most attention in the applied econometrics literature. The first two procedures provide rough idea about the relevant issue. In this thesis, our attention will be mainly centred on the DF test (or ADF test)¹⁶³.

C.3.1 The DF-ADF Test: Dickey-Fuller And Augmented Dickey Fuller

In order to investigate the stationary properties of the relevant data set, DF and ADF tests are employed. The purpose of ‘augmenting’ the Dickey-Fuller (DF) regression is to achieve white noise errors. When the order of augmentation is zero, the ADF is the same as the DF test. The DF-ADF test of unit roots (Dickey and Fuller 1979; 1981) is widely regarded as one of the most reliable test for integration level. If a time series is stationary, this means that its mean, variance, and autocovariances are independent of time. When these properties are changing over time, the time series has a unit root. To put it another-way, a ‘shock’ or ‘innovation’ has a sustained effect in the unit root case and this effect diminishes with time in the stationary case (see Holden and Perman 1994:53).

Now assume that we wish to test the hypothesis that an annual series X_t is integrated of order one by considering the following model:

$$X_t = \gamma X_{t-1} + \varepsilon_t \quad t = 1, 2, \dots, n$$

Where ε_t represents a sequence of uncorrelated stationary error terms with zero mean and constant variance.

If $\gamma < 1$, X_t is a stationary series, otherwise (if $\gamma = 1$) X_t is said to have a unit root meaning that it is a non-stationary series [see also Harvey, 1990:12-14, Charemza and Deadman, 1992:124-131, Madalla, 1992:581-2, Madalla and Kim, 1998:49, Granger and Newbold, 1986:8-10]. The model above is a first order autoregressive process [AR(1)] and its coefficient γ is one or less for most economic time series (see Perman 1991). This process may not be economically

¹⁶³ The DF test does not take account of possible autocorrelation in the error process. Dickey and Fuller (1981) suggest a simple solution for this weakness of the DF test using lags for the left hand size variables as additional explanatory variables to eliminate the autocorrelation problem and this procedure is called the Augmented Dickey-Fuller (or ADF) test.

sensible if $\gamma > 1$. As can be seen in the DF integration level testing, we usually test the null $\gamma = 1$ against the one-tailed alternative $\gamma < 1$. The autoregressive model above with $\gamma = 1$ is known as ‘difference stationary process (DSP)’ and such a model with $\gamma = 1$ is said to be integrated of order one. To estimate the model by OLS with the hypothesis of $\gamma = 1$ by using the standart t-test is more likely to be biased. This may be because of the standard assumption of normality, which collapses when the series has a unit root (see Charemza and Deadman, 1992:131).

An appropriate method of testing the order of integration of X_t in equation (C.3.1-1) was suggested by Dickey and Fuller (1979), which is known as Dickey-Fuller (DF) test. The DF test based on the estimation of the following regression equation:

$$\Delta X_t = \gamma X_{t-1} + \varepsilon_t \quad (\text{C.3.1-1})$$

If $\gamma = 0$, then X_t is said to have a unit root (non-stationary). The alternative hypothesis is $\gamma < 0$ implies that the series is stationary. This is a one-sided test as the sign is expected to be negative and significantly different from zero. In other words, the DF test consists of testing negativity of γ in the OLS regression of (C.3.1-1).

The null hypothesis $\gamma = 0$ implies a non-stationary X_t series. Rejection of the null hypothesis $\gamma = 0$ in favour of the alternative $\gamma < 0$ implies that X_t is integrated of zero (i.e. $X_t \sim I(0)$).

If the null hypothesis cannot be rejected, for example, the variable X_t is integrated of order higher than zero or is not integrated at all, the next step, obviously, would be to test whether the order of integration is one. The DF equation, then becomes as follows:

$$\Delta \Delta X_t = \gamma \Delta X_{t-1} + \varepsilon_t \quad (\text{C.3.1-2})$$

and in the same way, our interest is in testing the negativity of γ . We can continue this process until we realise that X_t cannot be made stationary by differencing. For example, if the null hypothesis is rejected against alternative $\gamma < 0$, the series ΔX_t is stationary and this situation is denoted as $X_t \sim I(1)$. If the null hypothesis cannot

be rejected, we may subsequently test whether $X_t \sim I(2)$. In practice, it is unusual for economic series to be integrated of an order greater than two.

The DF test can also be used for testing the order of integration of a variable generated as a stochastic process with drift. This is achieved by test on the following equations:

$$\Delta X_t = \gamma X_{t-1} + \alpha + \varepsilon_t \quad (\text{for level}) \quad (\text{C.3.1-3})$$

$$\Delta \Delta X_t = \gamma \Delta X_{t-1} + \alpha + \varepsilon_t \quad (\text{for first differences}) \quad (\text{C.3.1-4})$$

Where γ is a constant representing drift. In practice, it is unclear whether one should use the DF regression with or without a constant term¹⁶⁴.

Statistical inference about a stochastic trend is usually combined with a deterministic trend, that is a mixed stochastic–deterministic process. In this case, the straightforward modification of the Dickey-Fuller equation which accounts for both drift and a linear deterministic trend is the following:

$$\Delta X_t = \gamma X_{t-1} + \alpha + \delta t + \varepsilon_t \quad (\text{for level}) \quad (\text{C.3.1-5})$$

$$\Delta \Delta X_t = \gamma \Delta X_{t-1} + \alpha + \varepsilon_t \quad (\text{for first differences}) \quad (\text{C.3.1-6})$$

In the above process, it is assumed that the expected value of ε_t is zero and the stochastic process is ε_t white noise, but these conditions may be relaxed to allow for autocorrelation in the series of ε_t . If the ε_t 's are autocorrelated, the process will still be non-stationary.

A drawback of the original DF test is that it does not take into account of possible autocorrelation in the error process ε_t . If ε_t is autocorrelated (or it is not white noise) then the OLS estimates and its variants are not efficient. A simple solution proposed by Dickey and Fuller (1981) is to use lagged left-hand side variables as additional variables to eliminate the autocorrelation problem.

This is known as the Augmented Dickey-Fuller test (ADF) and can be reformulated as follows:

¹⁶⁴ Charemza and Deadman (1994: 4/17) mention that 'it is better to start with DF test without constant, and if the null hypothesis is not rejected, move to the DF test with constant'.

$$\Delta X_t = \gamma X_{t-1} + \sum_{i=1}^p \beta_i \Delta X_{t-i} + \alpha + \delta_t + \varepsilon_t \quad (\text{for levels}) \quad (\text{C.3.1-7})$$

Where ΔX_t are the first differences of the series, p is the number of lags and t is time. A practical rule for establishing the number of lags for ΔX_{t-i} (or the value of P) is that it should be relatively small in order to save degrees of freedom, but large enough to secure the lack of autocorrelation of the error term¹⁶⁵. For example, if $p=2$, and the Durbin-Watson autocorrelation statistic is low, this indicates first order autocorrelation. To remedy this, we can increase p with the hope that such autocorrelation will disappear (see Charemza and Deadman, 1997).

A series is stationary if the coefficient on the lagged variable (i.e. X_{t-1} in eqn (C.3.1-8)) is negative and significantly different from zero. In order to check for higher orders of integration, equation (C.3.1-8) has to be written in the appropriate order of difference of the series and this can be formulated as follows:

$$\Delta \Delta X_t = \gamma \Delta X_{t-1} + \sum_{i=1}^p \beta_i \Delta \Delta X_{t-i} + \alpha + \varepsilon_t \quad (\text{for first difference}) \quad (\text{C.3.1-8})$$

Again, we use this regression to test $\gamma=0$ against $\gamma<0$. If $\gamma=0$ is rejected then the X_t series is stationary. In brief, the DF-ADF test regressions are estimated to add as many terms of differenced variables as is necessary to obtain white noise residuals (or residuals are non-autocorrelated).

C.3.2 The MADF Test: Multivariate Form of the ADF Test

Multivariate form of the Augmented Dickey-Fuller test (MADF)¹⁶⁶ introduced by Johansen (1988) and Johansen and Juselius (1990) with the null hypothesis of stationarity rather than the usual non-stationary null. It is important to stress that time series data are often assumed to be non-stationary (see Nelson and Plosser, 1982) and a stationary cointegration relationship(s) need(s) to be found in order to avoid the problem of spurious regression. However, it is clear from the literature that the ADF and other unit root tests suffer from poor size and power properties

¹⁶⁵ The number of P is increased up to the point that the null hypothesis of no autocorrelation is accepted for the residuals from the regression.

¹⁶⁶ See Harris (1995) for more information about MADF.

(i.e. the tendency to over-rejected the null when it is false). Multivariate ADF test using the Johansen procedure has a well defined limiting distribution and this test does not suffer from parameter instability.¹⁶⁷

This test can be conducted as follows:

$$X_t = \Pi_1 X_{t-1} + \dots + \Pi_k X_{t-k} + \mu + e_t \quad \text{for } t=1, \dots, T \quad (\text{C.3.2-1})$$

Where X_t is a vector of P variables; e_t is an independent normal error with mean zero and covariance matrix Π ; X_{t-k} is fixed; and μ is intercept vector.

Economic time series are often non-stationary and systems such as the above vector autoregressive representation (VAR) can be written in the conventional first difference form¹⁶⁸:

$$\Delta X_t = \Gamma_{k-1} \Delta X_{t-k+1} + \Pi X_{t-k} + \mu + e_t \quad (\text{C.3.2-2})$$

where $\Gamma_i = -(I - \Pi_1 \dots \dots \dots \Pi_{ii})$ for $i = \dots, k-1$, and

$$\Pi = -(I - \Pi_1 \dots \dots \dots \Pi_k)$$

Equation C.3.2-2 includes only one level term (namely, ΠX_{t-k}). The matrix Π contains information about the long-run relationship between the various variables in data vector.

There are three cases:

- (a) If the matrix Π has rank zero, then all variables X_t are integrated of order one or higher and the VAR has no long-run properties;
- (b) If Π has rank P (i.e. full rank), the variables in X_t are stationary;
- (c) If Π has rank r (i.e. $0 < r < p$), Π can be decomposed into two distinct $(P \times r)$ matrices α and β such that $\Pi = \alpha \beta'$.

These tests can also be used to determine if a single variable is stationary by including only the variable in X_t and the relevant hypothesis is conducted as follows:

¹⁶⁷ Hendry and Mizon (1990) illustrate that conventional ADF test generally suffer from parameter instability and insufficient power.

¹⁶⁸ This form is also called vector error correction model (VECM).

We test $H_0:r=0$ against $H_1:r=1$. In the level, acceptance of the null hypothesis implies that the variable X_t is integrated of zero (i.e. $X_t \sim I(0)$). In differences, rejection of the null hypothesis that the variable X_t is integrated of one (i.e. $X_t \sim I(1)$).

C.3.3 The Perron Unit Root Test: Structural Break Test

The potential existence of structural changes (or breaks) in a time series has been argued that can easily affect the integration level of the series and makes the Dickey-Fuller and the Augmented Dickey-Fuller tests unreliable. Perron (1989; 1990) and Perron and Vogelsang (1992) show that a structural break in the mean of a stationary variable is more likely to bias the DF-ADF tests towards the nonrejection of the null of a unit root in the process. In brief, a structural break in the mean level is a type of exogenous intervention to the series. Perron (1990) argues that ignoring these effects can lead to an ‘inadequate model specifications’, ‘poor forecast’, ‘spurious unit roots test results’ and ‘improper policy implications’. So, Perron propose an integration level test for structural break known as the Perron test and provides the appropriate values¹⁶⁹.

This test can be regarded as an improvement in the direction of searching and creating more informative economic time series. If a spurious unit root is found which means the structural break changes the integration level of the series in question, the next step should be to remove this effect by applying the Perron integration level test. It is worth emphasizing that this test is not for testing the presence of a structural break. In fact, we conduct this test whether or not the order of integration is changed by the structural break.

Perron (1990) suggests two types of model: the ‘additive outlier’ model (AOM) and the ‘innovation outlier’ model (IOM). The former is recommended for series exhibiting a ‘sudden’ change in mean while the latter is suggested for a ‘gradual’ change (see also Perron and Vogelsang; 1992). In our empirical chapters, we decided to conduct the ‘additive outlier’ model, because it can be hypothesised that the effect of the war is sudden. Hence, we assumed that there might be a

¹⁶⁹ Rybinski (1995) also provides the appropriate critical values for small samples.

structural break in 1974 in the examined series. This test is carried out in two steps. In the first step, we estimate residuals using OLS as follows:

$$X_t = \mu + \delta DU_t + e_t \quad (\text{C.3.3-1})$$

Where $DU_t = 1$ if $t > T_b$ and 0 otherwise. T_b is the point where the break occurs. In the second step, we run the following modified regression by using OLS. The test of negativity of γ is checked by using appropriate critical values reported in Rybinski's paper (1994; 1995):

$$\Delta e_t = \sum_{i=0}^K \phi_i (DUTB)_{t-i} + \gamma e_{t-1} + \sum_{i=1}^K \alpha_i \Delta e_{t-i} + \varepsilon_t \quad (\text{levels}) \quad (\text{C.3.3-2})$$

$$\Delta \Delta e_t = \sum_{i=0}^K \phi_i (DUTB)_{t-i} + \gamma \Delta e_{t-1} + \sum_{i=1}^K \alpha_i \Delta \Delta e_{t-i} + \varepsilon_t \quad (\text{first differences}) \quad (\text{C.3.3-3})$$

Where $(DUTB)_t = 1$ if $t = T_b + 1$ and 0 otherwise, T_b is the break year, $DUTB$ is dummy variable for the break year, e_t is residual obtained from equation (C.3.3-1) using OLS and ε_t is an error term.

C.3.4 The Z-A Test: Zivot-Andrews Structural Break Test

Perron's methodology and his findings have recently been criticized and re-evaluated by Zivot and Andrews (1992) and others¹⁷⁰. Zivot and Andrews argue that Perron's procedure involves 'data peeking', 'data pinching', and 'data mining' by assuming that the date of the break is known a priori. They use the idea of Christiano (1992) to select the break point as the outcome of an estimation procedure and change the structural form of Perron's (1989) conditional unit root test as an unconditional unit root test. In the Z-A approach, the null hypothesis is that the series under study has a unit root without a structural break and it is tested against the alternative hypothesis of trend stationarity with a one-time break in the intercept and slope of the trend function at an unknown a point in time. The Z-A variant of the sequential ADF test for a unit root with a structural break can be represented by the following equation:

¹⁷⁰ Unlike the Perron's (1989) assumption where the break point is uncorrelated with data, Christiano (1992) argues that the break point should be treated as being correlated with data.

$$\Delta X = \mu + \theta DU_t + \beta t + \gamma DT_t + \alpha X_{t-1} + \sum_{i=1}^K \delta_i \Delta X_{t-i} + \varepsilon_t \text{ (level)} \quad (\text{C.3.4-1})$$

$$\Delta \Delta X = \mu + \theta DU_t + \gamma DT_t + \alpha \Delta X_{t-1} + \sum_{i=1}^K \delta_i \Delta \Delta X_{t-i} + \varepsilon_t \text{ (first differences)} \quad (\text{C.3.4-2})$$

Where Δ is the difference operator, X stands for the series under consideration, $DU=1$ and $DT=t-T_b$ if $t < T_b$ and 0 otherwise. T_b is the time of the break which ranges from 1 to T , where T is the number of observations.

In equation (C.3.4-1) and (C.3.4-2), DU_t and DT_t are employed to account for a potential break in the time series. The main idea of the ZA procedure is that it chooses the break fraction¹⁷¹ $\lambda = T_b / T$, so as to minimize the one-sided t-statistics for testing the null hypothesis that $\alpha = 1$ over all $T-2$ regressions. We can not reject the null hypothesis of a unit root if $t_\alpha < t_\lambda$ where t_λ denotes the 'estimated break point' (critical value) reported by Z-A (1992:257:Table 4) (see also Serletis, 1994).

In short, by capturing the influence of a potential break in the time series, the Z-A test is able to show that its test statistic is more reliable than those recommended by Dickey and Fuller (1979) and Perron (1989).

C.4 The DF-LR Joint Test (or F-test): DSP vs. TSP¹⁷²

This test is used to examine the type of trend¹⁷³ whether it is stochastic or deterministic in time series data. Nelson and Plosser (1982:152) mention that economics time series are more likely to have stochastic trends characteristics than deterministic time trends (see also Perman, 1991:9). Actually, it is important to know the type of trend in the time series while cointegration analysis deals with

¹⁷¹ The break fraction λ ranges from $2/T$ to $(T-1)/T$ which is estimated from the data (See Ghatak, 1997).

¹⁷² Madalla (1992:259-262) says that 'in practice it is best to use DF-LR test to check whether data are of DSP or TSP type. Nelson and Plosser (1982) also use the test developed by Dickey and Fuller (1979).

¹⁷³ Madalla (1992) points out that there should be a clear distinction between what are called Difference stationary process (DSP) and deterministic stationary process (TSP). The first assumes the presence of a stochastic trend whilst the second assumes the presence of a deterministic trend.

the relationship between the variables that have stochastic trends rather than deterministic (See Granger 1987 and Cuthbertson et al. 1992).

We therefore employ the Dickey-Fuller Likelihood Ratio (LR) joint test (or F-test) to check the relevant series if they are Difference Stationary Process (DSP) or Trend Stationary Process (TSP) (See Dickey and Fuller 1979; 1981). 'Differencing' for stochastic process has been suggested to eliminate the trend and make them stationary. So, we test null Hypothesis of DSP, $H_0: \beta_1 = 0$ and $\alpha_1 = 1$ against the alternative of TSP by using the following equation (See also Maddala and Kim, 1998:88):

$$\Delta X_t = \beta_0 + \beta_1 t + \alpha_1 X_{t-1} + \sum_{i=1}^n \alpha_i \Delta X_{t-i} + \varepsilon_t \quad (\text{C.4-1})$$

where ε_t is a zero mean, serially uncorrelated and mutually independent disturbance term. β_0 , β_1 , α_1 and α_2 are all parameters estimated by OLS regression and t is a time trend. We then use the formula taken from Dickey and Fuller (1981:1071) to obtain F-values as follows:

$$F_{test} = \frac{RRS_R - RRS_U}{2 \left(\frac{RSS_U}{n-k} \right)} \quad (\text{C.4-2})$$

Where RSS_R is restricted residual sum of squares, RSS_U is unrestricted residual sum of squares, n is number of observations and k is number of parameters used in the relevant equation. RSS_R value is estimated using alternative hypothesis regarding to Equation (C.4-1) whereas RSS_U value is estimated using null hypothesis regarding to the same equation.

It is important to stress that in some cases, the test statistics might seem too high to be able to claim that we have a pure DSP process. For such cases, Charemza and Deadman (1992:139) argue that 'statistical inference about a stochastic trend is often combined with a deterministic trend'. Alternatively, it suffices to say that a mixed (or stochastic-deterministic) process is also possible (see Charemza and Deadman, 1997:90).

C.5 The Engle and Granger Cointegration test

Cointegration test (or technique) has been introduced to obtain evidence for a long-run relationship along with legitimate standard diagnostic tests. In the relevant literature, there are several techniques in order to test the cointegration regression.

Mainly, these are two-fold. The first group of tests are known as the 'residual-based tests which are based on the residuals of single and static cointegration regression. The most widely used residual-based cointegration test is the residual-based DF-ADF tests suggested by Engle and Granger (1987)¹⁷⁴. This test uses a single equation, assuming that there is only one endogenous variable and all other variable are exogenous [see also Phillips and Ouliaris (1990)].

The Engle and Granger (E-G) (1987) approach has received a great deal of attention in recent years. One of the advantages of this approach is that the long-run equilibrium relationship can be modelled by a straightforward regression involving the level of the relevant variables (see Inder, 1993). Holden and Thomson (1992:26) point out that “this approach is attractive for two reasons: first, it reduces the number of coefficients to be estimated and so, minimize the problem of multicollinearity. Second, the first step can be estimated by OLS”. However, it is criticised in a few aspects. First, cointegration test must be invariant to be a selected variable for normalisation. For example, when two variables are used in a model, the regression of say, y_t on x_t and x_t on y_t will produce two different error terms (e_1 and e_2) in which one would indicate cointegration between variables, but the other would show no cointegration in the relationship (see Ender, 1995). The second one is associated with the procedure that the E-G approach assumes only one cointegration vector, however there might be more than one or more cointegration vectors. Harris (1995) points out that single equation estimation potentially leads to inefficient results. To put it differently, he means that if there is more than two variables in the model, there

¹⁷⁴ Haug (1993) suggests that Engle-Granger's residual-based ADF test indicates the least size distortion among seven different residuals-based tests based on Monte Carlo analysis. See McKinnon (1991) and Engle and Granger (1987) for the critical values of the residual-based ADF cointegration test.

might be more than one disequilibrium which influences the dynamics in the error correction mechanism (ECM).

This approach can be carried out in two steps. In the first one, long-run relationship (co-integration regression) is estimated by OLS (Equation C.2-4). In the second step, the residual U_t from Equation (C.2-4) are taken and then the ADF test is applied as follows:

$$\Delta \hat{U}_t = \alpha_t \hat{U}_{t-1} + \sum_{i=1}^K \alpha_i \Delta \hat{U}_{t-i} + \varepsilon_t \quad (\text{C.5-1})$$

Here, we test $H_0: \alpha = 0$ against $H_1: \alpha < 0$ using the appropriate critical value from (McKinnon, 1991). We can test the null hypothesis that the residual in cointegration regression is non-stationary. A sufficient condition for a joint cointegration among the variables in a long-run regression is that error term U_t should be stationary (or $U_t \sim I(0)$). The residual-based ADF test statistics for U_t ensures that we reject the null hypothesis of non-stationary (or no cointegration) at 5% significant level for the equation (C.5-1).

It is worthwhile stressing that the Engle-Granger method does not prove whether the relation is really a long-run one. This is an assumption which cannot be statistically verified. Charemza and Deadman (1997) point out that a long-run equilibrium relationship should be supported by the relevant economic theory in which the theory suggests a suitable assumption about a long-run relationship.

C.6 The Johansen Full Information Maximum Likelihood (FIML) Test

This cointegration test is known as ‘system based’ test, which is applied within systems of equations. This procedure can easily tackle these shortcomings explained above and assumes that all the relevant variables are endogenous. In this case, a unique cointegration vector assumption of the single equation residual-based DF-ADF test is no longer valid. If there are P variables, there can be at most $r = P-1$ cointegration vectors. The Johansen approach allows the estimating of all possible cointegrating vectors between the set of variables. Let a VAR model be as follows:

$$X_t = \Pi_1 X_{t-1} + \dots + \Pi_K X_{t-K} + \mu + e_t \quad (\text{for } t=1, \dots, T) \quad (\text{C.6-1})$$

Where $X_t, X_{t-1}, \dots, X_{t-K}$ are vectors of current and lagged values of P variables which are $I(1)$ in the model; $\Pi_1, \dots, \Pi_K$ are matrices of coefficients with $(P \times P)$ dimensions; μ is an intercept vector¹⁷⁵; and e_t is a vector of random errors. The number of lagged values, in practice, is determined in such a way that error terms are not significantly autocorrelated. Adding $X_{t-1}, \dots, X_{t-K}$ and $\Pi_1 X_{t-2}, \dots, \Pi_{K-1} X_{t-K}$ to both sides and rearrange term the VAR model will be in the following form¹⁷⁶:

$$\Delta X_t = \Gamma_1 \Delta X_{t-1} + \dots + \Gamma_{K-1} \Delta X_{t-K+1} + \Pi X_{t-K} + \mu + e_t \quad (\text{C.6-2})$$

where $\Gamma_i = -(I - \Pi_1 - \dots - \Pi_i)$; ($i=1, 2, \dots, K-1$); $\Pi = -(I - \Pi_1 - \dots - \Pi_K)$ and I is the identity matrix. The rank of the matrix of coefficient, Π gives the number of long-run relationships between the variables of the system. Three possible cases are stated by Johannes and Juselius (1990):

- If the ranks equal $P[r(\Pi) = P]$ meaning that Π has full rank, then any linear combination of $I(1)$ series is stationary.
- If the rank equals zero ($r(\Pi) = 0$, i.e. Π is a null matrix), then there is no cointegration relationship. Although a long-run relationship seems to be unlikely, a short-run relationship may be identified by the first differences.
- If the rank is between zero and P ($0 < r(\Pi) < P$), then there are matrices α and β with $(p \times r)$ dimension, so that it is possible to represent $\Pi = \alpha \beta'$. Matrix β is called the 'cointegrating matrix' whereas matrix α is referred to as the 'adjustment matrix' or the 'feedback matrix'. Matrix β has the property to transform $\beta' X_t$ into a stationary process even though X_t is not in the equilibrium relationship. The rank of Π is the number of cointegrating relationship(s) (i.e. r) which is determined by testing whether its Eigen values (λ_i) are statistically different from zero. Johansen (1988) and Johansen and Juselius (1990) propose that using the Eigen values of Π ordered from the largest to the smallest is for computation of the maximal-

¹⁷⁵ μ is a vector of $I(0)$ variables which represent dummy variables as well. This ensures that errors e_t are white noise.

¹⁷⁶ This form of the equation is also called vector error correction (VECM).

eigen value and trace statistics. The maximal-eigen value statistics (λ_{max}) is computed by the following formula:

$$\lambda_{max} = -TL_n(1 - \lambda_{r+1}) \quad r = 0, 1, 2, \dots, n-2, n-1.$$

Where T is sample size. This statistic tests that there are r number of cointegrating vectors against the alternative that $r+1$ exist. The null and alternative hypotheses are:

$$\begin{array}{ll} H_0: r = 0 & H_1: r = 1 \\ H_0: r \leq 1 & H_1: r = 2 \\ H_0: r \leq 2 & H_1: r = 3 \\ \dots & \dots \end{array}$$

The trace statistic is computed by the following formula:

$$\lambda_{trace} = -T \sum \ln(1 - \lambda_i), i = r+1, \dots, n-1 \text{ and the hypotheses are :}$$

$$\begin{array}{ll} H_0: r = 0 & H_1: r \geq 1 \\ H_0: r \leq 1 & H_1: r \geq 2 \\ H_0: r \leq 2 & H_1: r \geq 3 \\ \dots & \dots \end{array}$$

At the beginning of the procedure, we test the null hypothesis that there are no cointegrating vectors. If it can be rejected, the alternative hypothesis (i.e. $r \leq 1$, ..., $r \leq n$) are to be tested sequentially. If $r=0$ cannot be rejected in the first place, then there is no cointegrating relationship between the variables, and the procedure stops.

Asymptotic critical values are obtained from Osterwald-Lenum (1992). The maximum-eigen value static is a test of the significance of the largest λ_r where the trace statistic tests the null against the unrestricted alternative. These two statistics do not always produce the same results.

Despite its theoretical advantages and superiority, this method is, in practice, subject to various shortcomings. First, given the small sample size, the method cannot be regarded as an appropriate one since the point estimates obtained for cointegrating vector, β , may not be particularly meaningful.

To remedy this problem, Reimers¹⁷⁷ (1992) suggests that in the case of small samples, the Johansen procedure over-rejects when the null is true. Thus, the number of parameters to be estimated in the model are also taken into account and an adjustment is made for degrees of freedom replacing T by $(T-P)$, where $P = nk$, n is the number of variables and k is the number of lags in the model. In practice, first, $P = nk$ is the number of estimated parameters and T is the number of usable observations (Banerjee et al. 1993:286). Second, for the small sample studies, it is important to use an appropriate lag length to ensure that residuals are white noise, however using too many lags¹⁷⁸ reduces the power of the statistics. In addition, setting the length of lags is also closely related to the issue of using deterministic components such as intercept, trend or dummy variables. Omitting such variables would be reflected in the error terms and a residuals misspecification problem would arise. This situation influences the estimates of the cointegration rank and makes it difficult to interpret the existing cointegration relationships (see also Harris, 1995). Third one is related to the studies which particularly use both the Johansen and the E-G cointegration analysis consequently. In fact, the E-G (1987) provides (assumes) only one cointegrating vector whereas the Johansen (1988) provides $r = P-1$ cointegrating vectors at most, where P is the number of variables in a VAR model.

It is worth emphasizing that the statistical properties of the Johansen procedure are generally better than the E-G procedure. However, they are grounded within different econometric methodologies and thus cannot be directly compared. In this regard, the Johansen method can be used for single equation modelling as an auxiliary tool, testing the validity of the endogenous-exogenous variable division. This may also be referred as a conformation test of the single equation model. In this sense, Charemza and Deadman (1992:201-2) suggest that it might be more appropriate to use the system-based cointegration test as an auxiliary tool, testing the validity of the residual-based test results.

¹⁷⁷ Doornik and Hendry (1994) point out that this procedure is still unclear whether is the preferred correction.

¹⁷⁸ Charemza and Deadman (1992) report that there is always some limit on the number of variables which can be included in a VAR model as well as on the maximum number of lags.

In this chapter, we also used a number of tests employing Johansen procedure such as coefficients normalized on output testing procedure and exogenous-endogenous modelling testing procedure. The former is used whether the estimated coefficients provide expected signs and magnitude compared with the relevant theory. The latter is used whether the model(s) under inspection is (are) exogenous or endogenous growths modelling (see also Coe and Moghadam, 1993).

C.7 The Nature Of Exogeneity

The concept of exogeneity is an old and controversial issue in the relevant literature. This issue stems from Cowles foundation approach developed by the econometricians at the Cowles foundation at the University of Chicago during the late 1940s and early 1950s. In this approach, the data are assumed to have been generated by a system of simultaneous equations. However, it was criticized in recent years on three main grounds: the first is the endogenous-exogenous division of the variables. In this respect, structural (or Cowles commission) econometrics distinguishes between the endogenous and exogenous variables of an econometric model. It is pointed out that those variables are called endogenous explained by the structure of the model and all the remaining variables are the exogenous variables. The second is that many variables are excluded to achieve identification from the equation in which they should be included into the equation. This is known as the Liu critique (1960). The third is that the coefficients in the simultaneous equations models cannot be assumed to be independent of changes in the exogenous variables. This is called the Lucas Critique (1976). In other words, simultaneous equations estimation is based on the forecast effects of changes in the exogenous variables on the endogenous ones.

There are two main concepts of exogeneity that are usually distinguished: the first is predeterminedness: a variable is predetermined in a particular equation if it is independent of the contemporaneous and future errors in that equation. The second is strict exogeneity: a variable is strictly exogenous if it is independent of the contemporaneous, future, and past errors in the relevant equation.

Notwithstanding the concept that predeterminedness and strict exogeneity are more precise than the traditional division (classification) of variables into endogenous-exogenous, it is still not certain enough to deal with all the potential ambiguities in explaining econometric variables. There is no explicit way why a variable under study is exogenous.

Engle, Hendry, and Richard (EHR) (1983), are not satisfied with the previous definitions of exogeneity and proposed three more concepts: In turn, these are weak, strong and super exogeneity.

Weak exogeneity: The concept of weak exogeneity is regarded to the problem of static inference in an econometric model that is estimation. Let a variable Y_t can be regarded as weakly exogenous for a set of parameters of interest, say Φ , if the marginal process for Y_t contains no useful information for the estimation of Φ , this is if an inference for Φ can be efficiently and conditionally made on Y_t alone and its marginal process contains no relevant information. This concept can also be formulated in another way [see Spanos (1986) and Urbain (1992)].

Strong exogeneity: the concept of strong exogeneity is related to the problem of dynamic inference in an econometric model that is estimation. In this case, if Y_t is weakly exogenous and this variable is not preceded by any of the endogenous variables in the system, Y_t is defined to be strongly exogenous. However, if we consider the definition of Granger-Causality, suppose that X_t is a Granger-cause for Y_t and if Y_t depends on X_{t-1} , so Y_t is not strong exogenous. In other words, if X_t is weakly exogenous and X_t is not caused in the sense of Granger by any of the endogenous variables in the system, then X_t is defined to be strongly exogenous.

Super exogeneity: The concept of super exogeneity is related to the Lucas critique and structural invariance. If X_t is weakly exogenous and the parameters in the system remain invariant to changes in the marginal distribution of X_t , then X_t is said to be super exogenous. It is important to note that weak exogeneity and super exogeneity are the conditions required for efficient, estimation, and policy purposes respectively. In this sense, Leamer (1985) points out that weak exogeneity is not a necessary condition for super exogeneity. Moreover, he adds

that his definition of exogeneity is the same as the definition of super exogeneity by EHR without the requirement of weak exogeneity.

C.7.1 The Engle-Hendry-Richard (EHR) Approach

Engle et al. (1983) propose three concepts of exogeneity (i.e. weak, strong and super) which is related to the particular aspects of the specification of econometric model. They also emphasize that the invariance property is used to explain the concept of super exogeneity. Exogeneity modelling can be used as an attempt to clarify whether the statistical data employed in studying economic growth allow us to model the GDP growth rate without modelling the determining variables (i.e. investment).

If a certain explanatory variable is not weakly exogenous, it should be modelled within the system. This means that some of the imposed zero restrictions may not be valid. The aforementioned linear growth models treat the regressors as if they are exogenous for the parameters of interest.

Let us consider the following model:

$$DY_t = \alpha DX_t + \beta Z_t + \varepsilon_t \quad (\text{C.7.1-1})$$

Where DY_t is real output growth, DX_t is the variable assumed to be weakly exogenous, Z_t is a vector of other regressors, ε_t is the independently distributed normal disturbance term, and α and β are estimated parameters.

If we assume DX_t is normally distributed, its marginal distribution is totally characterized by its mean and variance (i.e. μ and σ). According to Engle et al. (1983), DX_t is said to be weakly exogenous for α if μ and σ do not enter Equation (C.7.1-1) explicitly. If DX_t is weakly exogenous for α and α is structurally invariant to μ and σ , DX_t is then said to be super exogenous for α . In other words, super exogeneity requires that α can be consistently and efficiently estimated using Equation (C.7.1-1) alone. The value of α will be invariant to structural changes (or policy interventions) that alter the data generating process of DX_t .

Engle and Hendry (1993) propose a set of statistical procedures, which can be used to test for weak exogeneity and invariance. These techniques allow us to

carry out policy evaluation within a formal model. To employ Engle and Hendry's (1993) framework to Equation (C.7.1-1), we need to use a set of instruments (Z_t) in which the mean DX_t can be estimated as $\mu_t = Z_t\theta$ from the least square regression $DX_t = Z_t\theta + V_t$. V_t is an error term which is assumed to be independently and normally distributed with mean zero and finite variance σ . If ε_t and V_t are jointly homoscedastic under the null hypothesis of exogeneity, a test for the weak exogeneity of DX_t is to augment to Equation (C.7.1-1) with μ as an additional regressor and test for its significance.

The test for super exogeneity (or the invariance property) of DX_t , μ and μ^2 should be added to Equation (C.7.1-1) for a joint significance test. In brief, a test for the assumption of weak exogeneity of DX_t and its regression coefficient which is formulated in testing DY_t is the test of significance of the coefficient μ . On the other hand, the super exogeneity test is given for DX_t , which examines the joint significance of μ and μ^2 by using F-test. In this test, variable 'X' refers to the explanatory variables used in this study.

C.7.2 The Johansen Approach

The Johansen procedure for testing exogeneity (i.e. weak) is originally proposed by Johansen (see Johansen 1992; Johansen and Juselius 1992). This concept then is developed by Hunter (1990; 1994). He discusses the issue of cointegrating exogeneity as well as determining valid conditions for its testing. In this case, we try to test for weak exogeneity in a simple cointegrating VAR. To formulate a framework for testing exogeneity, we assume an element of ΔX_t to be weakly exogenous in the following equation:

$$\Delta X_t = \Gamma \Delta X_{t-1} + \dots + \Gamma_{K-1} \Delta X_{t-K+1} + \Pi X_{t-K} + \mu + \psi D_t + \varepsilon_t \quad (\text{C.7.2-1})$$

Where $t = 1, \dots, T$. The series are cointegrated when the following condition is satisfied:

$$\Pi = \alpha\beta' \quad (\text{C.7.2-2})$$

Where matrix Π contains long-run relationship, β is a matrix of long-run coefficients and α (weight matrix) represents the speed of adjustment to disequilibrium.

We assume an element of ΔX_t to be weakly exogenous with respect to parameters β_{ij} of corresponding cointegrating vector if corresponding coefficients of weight matrix are equal to zero when following hypothesis:

$H_0: \alpha_i = 0$ is satisfied.

The testing procedure consists in comparing the unrestricted cointegrated VAR system (i.e. Equation C.7.2-1) with the restricted one under null hypothesis.

For instance, suppose that $r=1$, and we have the variable set $X_t - X_t = [X_{1t}, X_{2t}, X_{3t}]$ and $\alpha = [\alpha_{11}, \alpha_{21}, \alpha_{31}]$. Then, the first term in α represents the speed of adjustment of the dependent variable ΔX_{1t} in the first equation of VAR towards the single long-run cointegrating relationship ($\beta \Delta X_{1t-1} + \beta \Delta X_{2t-1} + \beta \Delta X_{3t-1}$), while α_{21} indicates how fast ΔX_{2t} responds to the disequilibrium changes represented by the cointegration vector and α_{31} stands for the speed at which ΔX_{3t} adjusts. In this framework, if α_{31} is zero, this means that the equation for ΔX_{1t} contains no information about the long-run β because the cointegration relationships do not enter into the equation. Thus, it can be said that the variable ΔX_{1t} is weakly exogenous to the system and can take its place on the right-hand side of VAR.

It is an important point to note that there is also a simple way to test the assumption of weak exogeneity using error correction modelling. Engle and Granger (1987) argue that this simple way of checking weak exogeneity of, say, explanatory variable X_t for the long-run and short-run parameters of interest is to estimate an ECM for X_t and test the statistical significance of error correction term using the t-test. If the t-test is significant, then X_t can no longer be treated as weakly exogenous.

C.8 Error Correction Modelling: The EG Two Step Modelling (EGM)

Engle and Granger Two step procedure is suggested by Engle and Granger (1987) and this procedure (method) has received a great deal of attention in recent years.

This method allows us to model a long-run equilibrium relationship (or a cointegration regression) employing a straightforward regression for the levels of the relevant variables. Actually, this modelling procedure is carried out in two steps.

In the first step, all dynamics (differences and lags) are omitted and the long-run equation is estimated using OLS. Let us consider the following equation using the two variables for simplicity.

$$X_t = \alpha Y_t + U_t \quad (\text{C.8-1})$$

where both X_t and Y_t are integrated of order one. In this framework, a necessary condition is related to the estimated residuals (error terms) from Equation (C.8-1) should be stationary. Thus, the estimated long-run relationship is said to be satisfactory. The second step is related to understand short-run behaviour (short-run model) within an error correction model (ECM) by OLS. An important theorem is known as the Granger representation theorem (GRT) says that if X_t and Y_t are cointegrated, then the relationship between them can be expressed as an ECM. In order to understand the properties of ECMs, the estimated residuals $(X_t - \alpha Y_t) = \hat{U}_t$ from the first step long-run regression (C.8-1) may then be imposed on the following short-run model with the remaining parameters being consistently estimated by the OLS.

$$\Delta X_t = \alpha_1 \Delta Y_t + \alpha_2 (X_t - \alpha Y_t)_{t-1} + \varepsilon_t \quad (\text{C.8-2})$$

Where ε_t is the error term in the ECM and $(X_t - \alpha Y_t)$ is error correction term or residuals from Equation (C.8-1). It is worth emphasizing that estimated coefficient α_2 in the short-run Equation (C.8-2) should be negative and statistically significant (coefficient α_2 should be between 0 and -1).

According to the GRT, negative and statistically significant α_2 is necessary condition for the variables in hand to be cointegrated. In practice, this is regarded as extra evidence and confirmation for the existence of cointegration found in the first step. It is also significant to stress that there is no doubt about a spurious regression in the second step since the variables are stationary. In short, Equation (C.8-1) is estimated by OLS and test for stationarity of the error terms in the first

step. In the second step, if the null hypothesis of no cointegration is rejected, estimated residuals ($\hat{U}_t$) from Equation (C.8-1) are placed into the short-run Equation (C.8-2) to find out short-run dynamics.

C.9 Elasticity Estimates of Multivariate Modelling Approach: Alternative Approaches

In this section, we employ three methods; in turn, The Engle-Yoo three step correction method (approach), The Saikkonen time domain correction method (approach) and The Inder fully modified error correction method (approach) to obtain unbiased long-run elasticity estimates.

C.9.1 The Engle-Yoo Three Step Modelling (EYM): Three-Step Correction Approach

Engle-Yoo (1991) suggests a ‘three step’ correction approach to overcome the two main disadvantages of the classical two-step EG procedure. These are: (i) notwithstanding the long-run static regression gives consistent estimates; they may not be fully efficient. (ii) Due to the non-normality of the distribution of the estimators of the cointegrating vector, no sensible judgments can be made about the significance of the parameters.

The three-step approach corrects the parameters estimates of the first step, thus, standard tests such as t-test can be applied¹⁷⁹. This approach is carried out as follows: In the first step, we estimate a standard cointegrating regression of the form (C.8-1), where U_t is the OLS residuals to give first step estimates of α , namely, $\hat{\alpha}$. In the second step, we estimate dynamic model (C.8-2) using the lagged residuals, $(X_t - \alpha Y_t)_{t-1} = \hat{U}_{t-1}$ from the cointegrating regression as an error correction term. In the third step, we regress error terms (which is taken from dynamic model) on the error correction term multiplied by the coefficients of the relevant explanatory variables in the following equation:

¹⁷⁹ See Engle, Granger and Yoo (1991), and Cuthbertson et al. (1992) for more details.

$$\varepsilon_t = \psi(-\alpha_2 Y_t) + V_t \quad (\text{C.9.1-1})$$

The appropriate correction for the first step estimates $\hat{\alpha}$ and the third-step estimates ψ can be formulated as below:

$$\alpha_{COR} = \hat{\alpha} + \psi \quad (\text{C.9.1-2})$$

Finally, the corrected standard errors for α_{COR} are given by the standard errors for ψ in the third step and the standard errors for $\hat{\alpha}$ in the first step.

Engle and Yoo (1991) compares the EG two-step procedure with the Johansen ML procedure and they point out that the Johansen procedure has some advantages over the standard EG technique. However, three-step estimator achieves the same limiting distribution as the Johansen approach in an additional OLS regression from the two-step estimates.

C.9.2 The Saikkonen Method: Time Domain Correction Approach

This method is related to remove the asymptotic inefficiency of the least square estimators by using all the stationary information (i.e. lags, leads and differences) of the system to explain the short-run dynamics of the cointegration regression. As long as stationary information increases in a model, this may reduce the relevant error covariance matrix of the cointegration regression and hence, improve the asymptotic efficiency (Saikkonen, 1991:14).

Banerjee et al. (1986) mention that omitting the lagged terms in small samples may create biased results in the estimated parameters. This led many researchers to make an attempt to get rid of the bias by using dynamic components in the form of lags, leads and differences (see Inder 1993; Phillips and Loretan (1991); and Saikkonen 1991). Among them, Saikkonen (1991) proposes a new asymptotically efficient estimator, which is quite straightforward to estimate unbiased and efficient results using OLS without any initial estimation. In practice, this approach takes the place in the following simplified version:

$$X_t = \alpha_0 + \alpha_1 Y_t + \alpha_2 \Delta Y_{t-1} + \alpha_3 \Delta Y_{t+1} + u_t \quad (\text{C.9.2-1})$$

This is a time domain correction framework and met by adding ΔY_{t-1} and ΔY_{t+1} to the classical Engle–Granger type static long-run equation where Δ is the first difference operator.

C.9.3 The Inder Fully Modified Estimator: Unrestricted ECM Correction Approach

The Engle and Granger (1987) two-step procedure has some drawbacks in terms of ignoring dynamics and possibility of endogeneity of the variables. In this respect, some authors, for example, Banerjee et al. (1986) emphasize that although the dynamics are asymptotically irrelevant in the first step, omitting lagged terms may lead to substantial bias in finite samples. Others, in particular, Park and Phillips (1988) focus on the fact that the OLS estimator in the first step has an asymptotic distribution, which is non-normal and related to nuisance parameters. This makes estimation difficult and t-statistics may not even be valid asymptotically.

Because of these critics, Banerjee et al. (1986) and many others suggest that long-run estimated parameters in an unrestricted error correction model (ECM) form embody all the dynamics. Stock (1987) also advocates that this estimator provides the properties of nonlinear least square (NLS). On the other hand, Phillips and Hansen (1990) suggest that using semi-parametric correction to the OLS estimator, it leads a normal distribution asymptotically. Their study is based on results in Park and Phillips (1988) and it is called the fully modified OLS estimator.

Inder (1993) finds out that Phillips and Hansen's (1990) approach is biased in favour of modified OLS and he proposes the unrestricted ECM estimator which is better than modified OLS. Inder also demonstrates that semi-parametric corrections approach can be applied to ECM estimator, which gives a fully modified unrestricted ECM estimator and is asymptotically optimal. In addition, Inder shows that the effects of endogeneity and distribution of the ECM estimator are minimal.

To model fully modified unrestricted ECM estimator, Inder uses the following equation, which suggests the semi-parametric corrections could also be applied to unrestricted ECM estimator.

$$Y_t = \beta_1 + \beta_2 X_t + W_t \quad (\text{C.9.3-1})$$

where the parameter β_2 measures the long-run impact of X on Y , and W_t is an I(0) disturbance.

Inder (1993) then uses the idea who was proposed by Bewley (1979) that the Equation (C.9.3-1) can be estimated by using instrumental variables (IV) with instruments for ΔX_t and ΔY_t being X_{t-1} and Y_{t-1} . The Equation (C.9.3-1), thus will turn into the following form:

$$Y_t = \beta_1 + \beta_2 X_t + \gamma_1 \Delta Y_{t-1} + \gamma_2 \Delta X_{t-1} + \varepsilon_t \quad (\text{C.9.3-2})$$

In the first step, having run the Equation (C.9.3-2), we obtain unrestricted ECM estimates of β_2 and the coefficients of dynamics. In the second step, we regress estimated residuals ε_t from Equation (C.9.3-2) on X_t in order to find the fully modified OLS estimator of γ_2 . The procedure in the second step can also be defined as follows:

$$\hat{\varepsilon}_t = Y_t - \hat{\gamma}_1 \Delta Y_{t-1} - \hat{\gamma}_2 \Delta X_{t-1} \quad (\text{C.9.3-3})$$

It is an important point to note that test of hypothesis about γ_2 can be based on the appropriate t-statistics that come from the fully modified estimates in the second stage.

C.10 The Nature of Causality:

Final Prediction Error (FPE), Granger-Causality (G-C), Holmes-Hutton (H-H), and Sim's LR test:

In economics, systematic testing and determination of causal directions only become possible after an operational framework is developed by Granger (1969) and Sim (1972). Granger and Sim's approach start from the premise that the past and the present may cause the future but the future cannot cause the present or the past (Granger, 1980).

In econometrics, the most widely used operational definition of causality is the Granger definition of causality, which is defined as follows:

For instance; X is a Granger cause of Y (denoted as $X \rightarrow Y$), if the present value of Y can be predicted with better accuracy by using the past values of X rather than by not doing so, other information being identical (Charemza and Deadman, 1997:165).

If event S occurs after event F , it is assumed that S cannot cause F . at the same time, if S occurs before F , it does not necessarily mean that S causes F . For example, the weatherman's prediction occurs before the rain. This does not imply that the weatherman causes the rain. In practice, we observe S and F as time series and we would like to know whether S precedes F , or F precedes S , or they are contemporaneous.

In the literature, there exists a number of tests for determining Granger causality in a bivariate system. Among them, Guilkey and Salemi (1982) and Geweke-Meese-Dent (1983) recommend the use of the ordinary least squares version of the Granger test, because it has eased implementation, power and robustness in finite samples.

Four findings are possible in a Granger causality test:

- (a) Neither variable "Granger-causes" the other. In other words, independence is recommended that when the sets of X and Y coefficients are not statistically significant in both regressions.
- (b) Unidirectional causality from X to Y : that is X causes Y , but not vice verse.
- (c) Unidirectional causality from Y to X : that is, Y cause X , but not vice verse.
- (d) X and Y Granger cause each other. This means that there is a feedback effect or bilateral causality between X and Y (Miller and Russek, 1990; Gujarati, 1999).

Since we have explained cointegration analysis and defined the concept of standard causality testing procedure, we can emphasize the relationship between Granger causality and error-correction mechanism. There exist a number of studies about this relationship between the relevant issues. For example, Granger (1988) argues that causality test based on traditional time series techniques (i.e.

Granger and Sim's tests) can reach incorrect conclusions about causality when time series are cointegrated. Bahmani-Oskooee and Alse (1993: 536) also emphasize that standard Granger or Sim's test is only valid if the original time series, say, X and Y are not cointegrated. However, this is because the error correction terms are not included in the standard Granger or Sim's test.

Before the appearance of error correction modeling, Granger causality is detected by Granger and Sim's tests. ECM is an alternative test to detect the direction of causality in the literature (See Masih and Masih, 1996). Error correction mechanism and cointegration analysis provide additional channels through which causality can be detected. In this regard, if the variables are cointegrated, there must be causation in at least one direction (Granger, 1988). Cointegrated variables allow us to examine Granger-causality via an error-correction mechanism. But if they are not cointegrated, this means that there is no long-run causal relationship between them.

Final Prediction Error (FPE), Granger-Causality (G-C), Holmes-Hutton (H-H), and Sim's LR test are explained in the following section:

Akaike's minimum final prediction error (FPE) criterion alongside Hsiao's synthesis is used to choose the optimal lag-lengths both in lag-levels and lag-differences (see Giles et al. 1993). Akaike's minimum FPE can be formulated as follows:

$$FPE(m) = \frac{T + K}{T - K} \frac{SSR(m)}{T} \quad (C.10-1)$$

where T is the sample, and $k = m+1$ if the variables under study are not cointegrated; $k=m+2$ if they are cointegrated (the error correction term should be added to the equation); $SSR(m)$ is the sum of the squared residuals. When $m=m^*$ in Equation (C.10-2), we change n to find out the value $n=n^*$ so as to minimize $FPE(m^*,n)$ in which $k=m^*+n+2$ (in the cointegrated case). If $FPE(m^*,n^*) < FPE(m^*)$, this means that Y Granger-Causes X . The value of m and n are related to Equation (C.10-2).

We then adopt the Granger-causality test to determine the direction of the causality between the variables. Besides this, we also apply the Holmes-Hutton

(1988, 1990a, 1990b) causality test to confirm the results obtained from the Granger-Causality tests.

The Granger model is premised on the maintained hypothesis of correct functional form (i.e. linear), homoscedasticity and normality of the error term. Holmes and Hutton (HH) argue that violation of these conditions can influence causality conclusions. They thus, suggest an alternative procedure for causality testing based on rank ordering of each variable. That is, they recommend ranking each variable and using the rank value of each observation in causality testing. The causality conclusion, achieved by using the Granger testing procedure applied to the rank ordering of the variables, is robust over alternative distribution of the error structure and invariant to monotonic transformations of the variables.

The HH testing procedure is the rank ordering and regress it against the current value of hypothesis dependent variable. The rank order is obtained from the first difference of each series, and each lagged variable is ranked separately. A null hypothesis of no causality is rejected if an F-statistic based on the estimated coefficients of the lagged causal variable is statistically significant. The HH procedure generates a multiple-rank F-test. We know that causality should exist in at least one direction in the I(1) variables regarding to Granger Representation Theorem (GRT).

We therefore construct the specification of both Granger and HH models using the vector autoregressive (VAR) model in terms of the levels and the first differences of the variables under consideration. It is important to stress that we exclude the error correction term from the relevant models due to the cointegration procedure used in bivariate analysis. These two models are conducted as follows:

Granger (1969):

$$DLX_t = \alpha + \sum_{i=1}^m \beta_i DLX_{t-i} + \sum_{j=1}^n \gamma_j DLY_{t-j} + u_t \quad (Y \rightarrow X) \quad (C.10-2)$$

$$DLY_t = c + \sum_{i=1}^q d_i DLY_{t-i} + \sum_{j=1}^r e_j DLX_{t-j} + v_t \quad (X \rightarrow Y) \quad (C.10-3)$$

Holmes-Hutton (1988):

$$R(DLX)_t = \alpha + \sum_{i=1}^m \beta_i R(DLX_{t-i}) + \sum_{j=1}^n \gamma_j R(DLY_{t-j}) + \varepsilon_t \quad (Y \rightarrow X) \quad (C.10-4)$$

$$R(DLY)_t = c + \sum_{i=1}^q d_i R(DLY_{t-i}) + \sum_{j=1}^r e_j R(DLX_{t-j}) + w_t \quad (X \rightarrow Y) \quad (C.10-5)$$

where $DLX_t = \ln(X_t) - \ln(X_{t-1})$ and U_t , V_t , ε_t and w_t are serially uncorrelated random disturbances with zero mean. In all cases, G-C and H-H tests are associated with tests on the significance of the γ 's and the e 's conditional on the optimal lag lengths, m , n , q , and r . Here we test to see if Y Granger causes X (or if Y HH causes X using a multiple rank F-test) by utilizing the following hypothesis:

H_0 : $\gamma_1 = \gamma_2 = \gamma_3 = \dots = \gamma_n = 0$ is rejected against the alternative

H_1 : not H_0

Similarly, we test whether X causes Y by testing the hypothesis below:

$H_0^* = e_1 = e_2 = e_3 = \dots = e_n$ is rejected against the alternative

$H_1^* = \text{not } H_0^*$

In this framework, having applied the final prediction error (FPE) procedure, we employ the Wald and Sim's LR tests to determine the direction of causality under OLS. These two tests are based on usual asymptotic χ^2 -distribution and degrees of freedom for HH multiple rank F-test. The Wald test and the HH multiple rank F-test are based on a test of zero restrictions on the independent variables in equations of (C.10-2), (C.10-3), (C.10-4), and (C.10-5). It is worth stressing that in order to obtain the results of the Sim's LR test, a simple logarithmic transformation can be used which converts wald statistics into LR test statistics. This transformation is also asymptotically based on χ^2 -distribution (See Giles et al. 1993:202; Sims 1980:17).

C.11 Conclusion:

The introduction and development of cointegration analysis have been a bridge between the economic theorists, applied economists and econometricians. Integrated and cointegrated model processes are the two main issues in the cointegration analysis. The former deals with the degree of integration of the time series data before a regression analysis is employed whilst the latter is concerned with estimating, testing and modeling long-run economic relationships using time series data.

Cointegration techniques allow us to avoid spurious regression results when we use non-stationary data. These techniques also provide a possibility which can enable us to test the validity of an economic theory. If the long-run economic relationship exists, this means that the cointegration regression is supposed to capture the existence of the equilibrium relationship. In other words, cointegration test attempts to establish the interrelationship between the long-run movements in economic time series. Contrary to common belief, the concept of cointegration does not advocate that there exists clear-cut solution procedure in constructing and estimating the dynamic time series models in economics.¹⁸⁰

One important point is also mentioned by Charemza and Deadman (1997). That is the relationship found by using cointegration test and this relationship cannot be proved that it is really a long-run one. On the contrary, this is an assumption supported by relevant economic theory and cannot be statistically verified. However, researchers are likely to support this existence whether the cointegration relationship is found or not (see Granger, 1986:226).

Another important point of the cointegration analysis is that it easily gives a simple framework for testing long-run economic relationships from the actual data. In the literature, cointegration analysis has been used for testing some economic theories such as permanent income hypothesis, rationality of

¹⁸⁰ See also Muscatelli and Hurn (1992) and Perman (1991) for various advantages and limitations as cointegration analysis is conducted in macroeconomic time series modeling.

expectations, market efficiency in different markets, purchasing power parity theorem and economic growth¹⁸¹.

In this chapter, following the unit root tests and the Engle-Granger cointegration analysis, the Johansen cointegration procedure is explained and discussed in detail. In this regards, we attempt to summarize and simplify¹⁸² the different techniques used in the concept of cointegration analysis in the sense of both the E-G and the Johansen procedures.

The empirical chapters (4, 5 and 6) utilize the relevant techniques explained in this chapter.

¹⁸¹ See Corbae and Ouliaris (1988); Taylor (1988); Kim (1990); Maddala (1992:559); Verne (1996) and Cellini (1997) for these issues which are applied in the cointegration analysis.

¹⁸² see McDermott (1990) for a non-mathematical introductory survey on cointegration.

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