REPUBLIC OF TURKEY
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AN ECONOMIC GROWTH ANALYSIS FOR EURO AREA COUNTRIES BY PANEL DYNAMIC ORDINARY LEAST SQUARES METHOD

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MSc. THESIS
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GöksuASLAN

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LIST OF SYMBOLS

A	Effectiveness of labour
AL	Effective labour
c*	The consumption per unit of effective labour
c_i	Country specific effects
δ_i	The rate of capital depreciation
E_{it}	The labour augmenting level of productivity
f(k)	The intensive form production function
f'(k)	The marginal product of capital
g_i	The exogenous growth rate of augmenting technology
$g_i t$	Potentially heterogeneous country specific deterministic trend
GW	Warranted rate of growth of income
I_{it}	The rate of physical capital investment
IT	Italy
K	Capital
K/AL	Amount of capital per unit of effective labour
K/Y	The ratio of capital output
L	Labour
lny_{it}	Log per capita income over time periods t=1,…,N
$ln(I/Y)_{it}$	The log investment shares over the same time periods and countries
n_i	The exogenous growth rate of labour
s	Rate of saving
S_i	Rate of saving
t	Time
u_{it}	white noise error term
v	Capital/production ratio
w*	Wage rate
$\dot{X}$	A variable implies a derivative respect to time
Y	Output
Y/AL	Output per unit of effective labour
Y(t)	Production function
y*	The level of output per unit of effective labour on the balanced growth path

LIST OF ABBREVIATIONS

ADF	Augmented Dickey Fuller
AT	Austria
BE	Belgium
CY	Cyprus
DE	Germany
DF	Dickey Fuller
DOLS	Dynamic Ordinary Least Squares
DFGLS	GLS transformed Dickey-Fuller
EA	Euro Area
EE	Estonia
ES	Spain
ERS	Elliot, Richardson and Stock
FI	Finland
FR	France
GDP	Growth Domestic Product
GLS	Generalized Least Squares
GR	Greece
IE	Ireland
KPSS	Kwiatkowski–Phillips–Schmidt–Shin
LSDV	Least Squares Dummy Variable
LU	Luxembourg
MT	Malta
NL	Netherlands
NP	Ng and Perron
PWT	Penn World Table
PP	Phillips-Perron
PT	Portugal
SI	Slovenia
SK	Slovakia

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ABSTRACT

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Euro Area consists of the European Union countries which use a single monetary unit, Euro. Even if they are in the same monetary union, they might have differences about their economic growth path. We studied with a view to define these differences between Euro Area countries, and to obtain an overall econometric model for their economic growth identifiers. Therefore, to estimate an overall econometric model, we based the Augmented Solow Growth Model on that the permanent changes in investment shares should be associated with permanent changes in per capita income.

On the basis of this economic theory, for the purpose of understanding how the investment shares on GDP affect the economic growth of Euro Area countries, real GDP per capita growth rate series as dependent variable and investment shares on GDP series as explanory variable have been used. The data of each Euro Area country have been taken from PWT version 7.1 for 1999-2010 time perod, annually .

In this study, it is aimed to find a significant long-run cointegrating relationship between economic growth and investment share on GDP, for Euro Area countries.

Firstly, the concept of economic growth has been explained. From accumulation oriented growth models to Keynesian approaches and Neoclassical growth models; specifically Solow growth model, the economic growth models and their evolutions have been viewed.

As empirical presentation of our model, Augmented Solow Growth model has been explained through the studies of Mankiw and Pedroni. It has been showed how the reduced form equation of Augmented Solow Growth model is obtained.

In order to make more precis the econometric analysis, the concepts about our analysis, have been described, such as nonstationarity, unit root, cointegration, panel data.

The analyses have been realized MS Excel and E-views programmes. The panel data has been organized with MS Excel, tests for unit root, cointegration and random or fixed effects and finally model estimation have been carried out with E-views.

In the long-run, there exists a significant cointegrating relationship between economic growth and investment share on GDP for 12 countries of the Euro Area.

Key words: Euro Area, economic growth, GDP, investment rate, panel data, cointegration, panel DOLS

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ÖZET

EURO BÖLGESİ ÜLKELERİ İÇİN EKONOMİK BÜYÜMENİN DİNAMİK PANEL EN KÜÇÜK KARELER YÖNTEMİ İLE ANALİZİ

Göksu ASLAN

İstatistik Anabilim Dalı

Yüksek Lisans Tezi

Tez Danışmanı: Doç. Dr. Filiz KARAMAN

Euro Bölgesi tek bir para birimi kullanmakta olan Avrupa Birliği ülkelerinden oluşmaktadır. Her ne kadar aynı parasal birlik içinde yer alsalar da ekonomik büyümeleri farklılık gösterebilecektir. Çalışmamızın amacı Euro Bölgesi ülkelerinin ekonomik büyümeleri arasında farklılıkları inceleyerek, ekonomik büyümelerinin belirleyicileri için toplam bir model elde etmektir. Bu amaçla, yatırım oranlarındaki kalıcı değişimlerin kişi başı gayri safi yurt içi hasıladadaki değişimler ile ilişkili olduğunu savunan genişletilmiş Solow büyüme modelini temel aldık.

Ekonomik teoriyi baz alarak, yatırım/GSYH oranının Euro bölgesi ülkelerinin ekonomik büyümelerini nasıl etkilediğini incelemek amacıyla, bağımlı değişken olarak kişi başı reel GSYH, bağımsız değişken olarak yatırımın/GSYH oranı kullanılmıştır. Tüm Euro Bölgesi ülkeleri verisi, 1999-2010 dönemi için yıllık olarak PWT (Penn Dünya Tablosu) versiyon 7.1'den alınmıştır.

Çalışmada, Euro Bölgesi ülkeleri için, ekonomik büyüme ile yatırım/GSYH oranı arasında uzun dönemli anlamlı bir eşbütünleşik ilişki kurmak amaçlanmıştır.

Öncelikle, ekonomik büyüme olgusu açıklanmıştır. Birikime dayalı büyüme modellerinden Keynesian yaklaşımlara, ve Neoklasik büyüme modellerine kadar, özellikle Solow büyüme modeli olmak üzere büyüme modelleri ve gelişimleri gözden geçirilmiştir.

Modelimizin ampirik tanıtımı amacıyla, geliştirilmiş Solow büyüme modeli Mankiw ve Pedroni'nin çalışmaları yoluyla açıklanmış ve genişletilmiş Solow büyüme modelinin indirgenmiş denklem formunun nasıl elde edildiği gösterilmiştir

Ekonometrik analizi daha açık bir hale getirmek için, durağan olmama, birim kök, eş bütünleşme, panel veri gibi analiz ile ilgili tanımlar açıklanmıştır.

Panel veri MS Excel ile düzenlenmiş ve birim kök, eş bütünleşme testleri, model tahmini ve sabit etkiler ile rassal etkilerin testleri E-views programları ile gerçekleştirilmiştir.

Uzun dönemde, 12 Euro Bölgesi ülkesi için, ekonomik büyüme ile yatırım/GSYH oranı arasında uzun dönemli anlamlı bir eşbütünleşik ilişki bulunmuştur.

Anahtar Kelimeler: Euro Bölgesi, ekonomik büyüme, GSYH, yatırım oranı, panel veri, kointegrasyon, panel dinamik en küçük kareler yöntemi

CHAPTER 1

INTRODUCTION

1.1 Literature Review

In this study, as to find long-run identifiers of economic growth for Euro Area countries, before defining a growth model, we had a quick look at economic growth theories in the second chapter; from accumulation oriented growth models to Keynesian approaches and Neoclassical growth models.

In the third chapter, through the studies of Pedroni and Mankiw, our empirical method has been denoted explaining how the reduced form equation of the augmented Solow growth model is obtained.

1.2 Objective of the Thesis

In this study, firstly it is aimed to find long-run identifiers of economic growth for Euro Area countries. Our aim is to find a significant long-run coingtegrating relationship between economic growth and investment share on GDP, for Euro Area countries. For this purpose, as to define how does the investment share on GDP affect economic growth in Euro Area, this cointegrating relationship has been analysed on the basis of the augmented Solow growth model.

1.3 Hypothesis

As for the augmented Solow growth model, permanent changes in investment shares should be associated with permanent changes in per capita income; we did analyses as to find a significant cointegrating relationship between two variables for Euro Area countries.

In the fourth chapter, the concepts have been explained about our model and our analyses. As nonstationary, unit root, cointegration, panel data and estimation methods have been viewed. Because, these associated permanent changes that we want to estimate, they have to be nonstationary and cointegrated.

In fifth chapter, econometric application for Euro Area has been realized. Logarithmic transformations; unit root and cointegration tests; fixed and random effects tests have been realized. For our estimation, the annual panel data for 17 Euro Area countries have been chosen for 1999-2010 time period from PWT version 7.1 [1]. For balanced panel estimation, the data of the 12 countries of the Euro Area has been used. Real GDP per capita series (Chain Series-at 2005 constant prices) as dependent variable and the corresponding investment share on GDP series have been used as explanatory variable.

After realizing all tests, we estimate the augmented Solow model, following the approach of Mankiw et al. (1992) by using dynamic ordinary least squares estimator, as to obtain an overall econometric model for their economic growth identifiers.

In the long-run, for 12 countries of the Euro Area, according to our estimated pooled equation, economic growth of these countries can be explained with their investment shares on GDP. The estimated investment shares on GDP elasticity is 0.4239 in the pooled estimation.

CHAPTER 2

ECONOMIC THEORY

2.1 Economic Growth

The increase in the amount of the goods and services produced by an economy over time is called as economic growth [2]. Economic growth which is measured as the rate of increase in real gross domestic product, real GDP, is concerned with the long run trend in production concerning the structural causes as technological growth and factor accumulation. Economic growth has traditionally been attributed to the accumulation of human and physical capital, and increased productivity arising from technological innovation. Economic growth was also the result of developing new products and services, which have been described as “demand creating” [3].

The concern about economic growth often focuses on the desire to improve a country’s standard of living. If the population grows along with economic production, increases in GDP do not necessarily result in an improvement in the standard of living. When the focus is on standard of living, economic growth is expressed on a per capita basis.The level of real GDP per capita, the ratio of real GDP to the population of the country, gives us the average standard of livingof the country. In assessing the performance of the economy from year to year, economists focus, however, on the rate of growth of real GDP – GDP growth. Periods of positive GDP growth are called expansions. Periods of negative GDP growth are calledrecessions. A high saving rate can sustain a higher level of output per capita, as capital accumulation per individual also increases.[4].

The basic problem of growth theory is to describe the behaviour of an expanding economy over time

2.2 Theories of the Economic Growth

2.2.1 Accumulation Oriented Models

2.2.1.1 Classical Economic Growth Model

According to classical economists, the economic growth of nations have been explained through the class structure of capitalist economy, by individuating three classes as workers, capitalists and rentiers. These classes have their own specific role in economic process. Workers have own labour, rentiers have own land and capitalists produce by employing labour from workers and renting land from rentiers. These agents behave to get as much as possible from the resources they own. If savers are also entrepreneurs, savings are directly transformed into investment, if savers are not entrepreneurs savings are indirectly transformed through the capital market [5].

The classes behave specifically, as workers consuming all their income; capitalists save and invest the entire amount of profits [6].

According to Classical economists, all savings are transformed in to investment through the capital market.

The rate of profits determines the interest rate [7]. Accordingly, this interest rateis determined by the wage rate depending on the condition of the labour market [8].

The wage rate determines the rate of population growth according to Classical economists: a wage rate higher than the natural one, i.e. that one which maintains constant population [9], yields a population increase [10].

Therefore, Smith explains the demographic law as a technological rule for producing labour as any good: '… the demand for men, like that for any other commodity, necessarily regulates the production of men; quickens it when it goes on too slowly, and stops it when it advances too fast' [11], anticipating Malthus [12].[1]

Two kinds of models are possible to be considered within the Classical framework:

Ricardian model stresses the tendency towards the stationary state due to the existence of scarce natural resources, and the Smithian and Marxian tradition which stresses the

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[1] Malthus thought that the dangers of population growth progress towards a utopian society: "The power of population is indefinetely greater than the power in the earth to produce subsistence for man"

progressive nature of economic growth. The models can be defined by the assumptions that capital and labour are employed in fixed proportions, capitalists anticipate wages, which are entirely consumed by workers, rentiers consume all rents and capitalists/entrepreneurs invest all profits. The labour supply can be ultimately increased indefinitely at the wage rate w^*, even though the Malthusian law mentioned regulates the rate of increase of population during any transitional phase.Following Smith it is assumed that the economy is growing and that the wage rate is at a level such to ensure a growth of population equal to the growth of demand for labour.The Ricardian model can be considered as a particular version of the basic Classical model, and it is characterised by the further assumptions that the set of available methods is constant over time and that land scarcity that goes with capital accumulation pushes output per worker down below what it is needed for reproduction. Otherwise, the Smithian-Marxian model is characterised by constant productivity of labour and capital. Thus, the growth rate of an economy is determined by the interaction between savings and population growth rate [5].

2.2.1.2 The Von Neumann Model

The Von Neumann model is a multisector linear model with only labour as the non-produced means of production and possibly with joint production.According to Von Neumann, the production is executed by means of physical capital and wage good capital and the aim of the productive activity is exclusively the accumulation of capital.Von Neumann considers the balanced growth equilibrium which describes that economy is growing at the maximum technical rate. Under very general conditions, there exists a semi-positive equilibrium vector of activity levels, a semi-positive equilibrium price vector and a non-negative rate of interest which is equal to the (maximum) rate of growth. These model can be viewed the first complete model which determines the growth rate endogenously [5].

In the modern endogenous growth literature (e.g. Lucas (1988), Jones and Manuelli (1990), Rebelo (1991)), some of the elements of this model have been used[13] [14] 15].

2.2.2 Keynesian Approach

2.2.2.1 Harrod-Domar Model

This model is the first economic growth model which analyses the problem of economic growth in a formal way. The consumption-saving decision is defined, as in the Keynesian approach, by an exogenously given propensity to consume; the investment decision is defined by the accelerator principle. The production is obtained only by means of physical capital and labour. From Keynesian assumption of fixed prices, firms choose the best technique at the given prices. The only one cost minimizing technique existing, implies that the capital/labour ratio and the capital/production ratio are uniquely determined. Harrod and Domar focus on the goods market equilibrium, rather than the general equilibrium on the goods and labour markets. If an economy is growing along a path with equilibrium on the goods market, it is said that this economy is its warranted growth path. Along this path, there is the equation$GW = s/v$ where GW is called the warranted rate of growth of income, s is the rate of saving and v is the capital/production ratio. The behavioural hypothesis on producers and the Keynesian multiplier yield that the warranted growth path is unstable. If the warranted growth path ensures also the full employment of labour - a possibility which is just accidental in this model - the economy is said to be on the golden age growth path [16] [17].

2.2.2.2 The Kaldor and Pasinetti Models

According to Kaldor; saving, investment, technical progress and population growth are not the causes of growth; these are just features of growth. He follows the Keynesian approach in conceiving the expansion of the economy is driven by psychological and social factors like "human attitude to risk-taking and money-making". He criticises Harrod's model on the ground that it explains only the growth of a cycle-less economy with full employment of savings rather than the actual rate of growth of a system that does not maintain a moving equilibrium. Kaldor sustained that in a system in which growth results from successive booms and slumps the actual trend is determined by the 'natural rate' of growth [18].

Because of the sociological factors underlying the phenomenon of growth, he maintains, following here the fundamental Schumpeterian intuition, that a satisfactory growth theory cannot be constructed without a business cycle theory [19].

He never develops in a formal way his position on economic growth, and his major contribution consists in solving in an original way the stability problem of the Harrod-Domar model. This is accomplished by allowing the possibility that the economy can growth along a natural growth path through adjustments in the rate of saving due to changes in the distributive shares between wages and profits and assuming that the population rate of growth is constant. The latter assumption is adopted only in his formal works, while in several non-technical articles he and other Post-Keynesian economists share the classical view that the rate of growth of population depends upon the wage rate and, therefore, upon the rate of growth of the economy [5].

Pasinetti has developed and pursued Kaldor’s approach; in emphasising the study of equilibrium paths have shifted attention from the original attempt to construct a growth theory out of a business cycle theory to the more traditional view of constructing a theory of the economic growth at the natural rate [20].

2.2.3 Neoclassical Growth Models

2.2.3.1 The Solow Model

Solow attempts to solve differently the stability problem of full-employment steady state and modifies the object of analysis with respect to the Keynesian growth theory, adopting a Neoclassical framework [21].

Constructing a theory of general full employment growth and ensuring the convergence of the economy towards the natural growth path are the most important problems. Growth theory has to explain the potential growth of economies, without paying attention, therefore, to cyclical trends of the economy and their possible effects on the long run trend of the economy [22].

Under the assumption of existing only capital and labour as factors of production, Solow defines the technology by means of a Neoclassical production function with constant returns to scale, productivity decreases with respect to physical capital and possibly labour-augmenting technical progress.Assuming that prices are flexible and therefore all markets are cleared, Solow aims to construct a model that conciliates full employment of resources with growth. The capital market equilibrium realizes when investments are equal to savings; the labour market equilibrium realizes when there is always full employment of labour. Based on Keynesian saving rule, production is distributed between savings and consumption.At the level of full employment, if savings are equal to investments, then there is the steady state in the economy. In the contrary, on the capital market price adjustments yield the equalisation between savings and investments and convenient changes of the per capita capital until the steady state is obtainedNeoclassical economists, assuming full employment of resources along the growth path, have ignored the problem of cyclic behaviour of economy [5].

While Kaldor aims to construct a growth theory which explains the actual rate of growth, Solow aims to construct a theory which explains the "evolution of potential output" [22].

2.2.3.2 The growth model à la Ramsey

Ramsey's approach is able to provide a positivetheory of growth like the traditional models, as Harrod-Domar's and Solow's ones. The decentralisation problem, moreover, has opened the way to the construction of growth models in which the equilibrium path is analysed independently of the optimal, centralised path. This frees the theory from the hypothesis of perfectly competitive markets or from the assumption of absence of external effects, and it is one of the most important contributions of the recent endogenous growth theory [5].

In the traditional growth models *à la* Ramsey (Cass (1965), Koopmans (1965)), the assumptions concerning the production function are the usual Neoclassical ones and the planner is endowed with a separable and stationary utility function and a constant discount rate. The optimal path, which dynamically has the structure of a saddle point, is unique and converges towards the steady state path. Along the optimal path the rate of saving changes over time and converges towards the long period level associated with the steady state [23] [24].

2.2.4 Endogenous growth models

Endogenous growth theory aims; first, to explain sustained growth which is not explained by Solow and Ramsey models, and second to have a rigorous model with all crucial variables for growth, as savings, investment, and technical knowledge. Because of this reason, the endogenous growth theory has adopted as reference theoretical structure Ramsey’s model in which saving is the outcome of a maximising agent and the equilibrium growth path is seen as the consumption/saving ratio chosen by rational agents by solving an intertemporal optimization problem [5].

The endogenous growth literature directs attentions to a necessary condition for perpetual growth which is that from the household's point of view the rate of interest should never be driven too low, and this is ensured if the productivity of accumulated factors does not decrease to zero as accumulation goes on [25].

On the contrary, if this case occurs, savings will be driven to a level that is not enough for fuelling sustained growth. In this perspective, the main object of the endogenous growth theory has been to develop economically meaningful ways of ensuring non-decreasing returns to scale with respect to the accumulated factors. This has been accomplished either by removing the scarcity of natural resources or by introducing technical progress. Labour has been straightforwardly transformed into a fully reproducible resource, human capital. As for technical progress, one the main feature of the endogenous growth theory is the capacity of endogenize the investment decision yielding technological progress which consists mainly in the introduction of new intermediate and/or final goods [26].

2.3 The Solow Growth Model

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2.3.1 Assumptions of The Solow Growth Model

The Solow model focuses on output(Y), capital(K), labour(L) and knowledge or effectiveness of labour(A) variables. The production function, where t denotes time, is:

$$Y(t)=F(K(t),A(t)L(t)) \quad (2.1)$$

It should be noted that time does not directly affect the output, but only through K, L and A; and that A and L are multiplicatively where AL which denotes as effective labor and technological progress enters as labor-augmenting or Harrod-neutral.[2] These features bring that output changes over time only if the inputs change; and that the entering way of A implies that the ratio of capital output K/Y, stabilizes in the long run. In model building, assuming that A and L multiples, makes the analysis simpler. The critical assumption of production function is that multiplying both capital and effective labor by any non-negative constant as c causes output to change by the same factor:

$$F(cK, cAL)=cF(K, AL) \text{ where } c \geq 0 \quad (2.2)$$

This constant returns assumption can be thought of as combining two assumptions. The first is that the economy is sufficiently large that the outputs can be doubled as the amounts of capital and labour doubles. The second assumption is that the other inputs are relatively unimportant. Under the assumption of constant returns, it is possible to show the production function in intensive form. Replacing $c=1/AL$ in equation (2.2) gives:

[2]Technological progress is *capital-augmented* when the knowledge enters in the form $Y=F(AK,L)$; is *Hicks-neutral* when the knowledge enters in the form $Y=AF(K,L)$.

$F(K/AL, 1)=(1/AL)F(K, AL)$ (2.3)

Where K/AL is the amount of capital per unit of effective labour and $F(K, AL)/AL$ is Y/AL, output per unit of effective labour. Defining $k=K/AL$, $y=Y/AL$ and $f(k)=F(k, 1)$, it can be rewritten (2.3) as:

$y=f(k)$ (2.4)

This demonstration shows that it is possible to write output per unit of effective labour as a function of capital per unit of effective labour. Behind the equation (2.4), there is the idea of dividing the overall economy into AL small economies, each with 1 unit of effective labour and K/AL units of capital. Under the assumption of constant returns, each small economy produces $1/AL$ as much as is produces in the undivided economy. Therefore, the amount of capital per unit of effective labour depends only on the quantity of capital per unit of effective labour, and not on the overall size of the economy. For calculating the total amount of output, the intensive-form production function can be multiplied by the quantity of effective labour as $Y=ALf(k)$. For the intensive-form production function, $f(k)$, there are the assumptions of $f(0)=0$, $f'(k)>0$, and $f''(k)<0$; where $f'(k)$ is the marginal product of capital.[3] These assumptions yield that the marginal product of capital is positive, but that it decreases as capital rises. Additionally, $f(\cdot)$is assumed to assure the Inada conditions (Inada, 1964).[4] These conditions imply that the marginal product of capital is very large when the capital stock is sufficiently small and that it becomes very small as the capital stock becomes large; ensuring that the path of the economy does not diverge. The Cobb-Douglas function is a specific example of the production function.

$$F(K, AL) = K^{\propto}(AL)^{1-\propto},\ 0 <\propto< 1 \quad (2.5)$$

The Cobb-Douglas function can be defined a good first approximation to actual production functions. Multiplying inputs by constant c, it is possible to check that the function has constant returns:

$$\begin{aligned} F(cK, cAL) &= (cK)^{\propto}(cAL)^{1-\propto} \\ &= c^{\propto}c^{1-\propto}K^{\propto}(AL)^{1-\propto} \\ &= cF(K, AL) \end{aligned} \quad (2.6)$$

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[3] $F(K, AL)=ALf(K/AL)$, $\delta F(K/AL)/\delta K=ALf'(K/AL)(1/AL)=f'(k)$

[4] $\lim_{k\to 0} f'(k) = \infty, \lim_{k\to\infty} f'(k) = 0$

Dividing the inputs by *AL*, the intensive form of the production function which can be found and have a positive first derivative and a negative second derivative:

$$f(k) = F\left(\frac{K}{AL}, 1\right) = \left(\frac{K}{AL}\right)^{\propto} = k^{\propto} \quad (2.7)$$

The other assumptions of the model are related to the changes of inputs over time; the variables are defined at every point in time. Labour and effectiveness of labour grow at constant rates:

$$\dot{L}(t) = nL(t) \quad (2.8)$$

$$\dot{A}(t) = gL(t) \quad (2.9)$$

Where n and g are exogenous parameters and a dot over a variable implies a derivative respect to time$\dot{X}(t)$ is shorthand for *dX(t)/dt*. These equations imply that *L* and *A* grow exponentially. Output is divided between consumption and investment. The fraction of output devoted to investment, s is exogenous and constant. Existing capital depreciates at rate δ:

$$\dot{K}(t) = sY(t) - \delta(\mathrm{t}) \quad (2.10)$$

For completing the description of the model, the sum of *n, g* and δ is assumed to be positive. The Solow model is simplified through most of ways, that there is only a single good; government is absent; fluctuations in employment are ignored; production is described by an aggregate production function just three inputs; and the rate of saving, depreciation, population growth and technological progress are constant [29].

2.3.2 Model Dynamics

Labour and knowledge evolution into production is exogenous. The behaviour of capital must be analysed in characterizing the behaviour of the economy [30].

The Dynamics of *k*

It's more useful to focus on the capital stock per unit of effective labour, *k*; because of the feature of economic growth over time. Where *k=K/AL*, the chain rule:

$$\dot{\mathrm{k}}(\mathrm{t}) = \frac{\dot{\mathrm{K}}(\mathrm{t})}{\mathrm{A}(\mathrm{t})\mathrm{L}(\mathrm{t})} - \frac{\mathrm{K}(\mathrm{t})}{[\mathrm{A}(\mathrm{t})\mathrm{L}(\mathrm{t})]^2}\left[\mathrm{A}(\mathrm{t})\dot{\mathrm{L}}(\mathrm{t}) + \mathrm{L}(\mathrm{t})\dot{\mathrm{A}}(\mathrm{t})\right]$$

$$= \frac{\dot{K}(t)}{A(t)L(t)} - \frac{K(t)}{A(t)L(t)}\frac{\dot{L}(t)}{L(t)} - \frac{K(t)}{A(t)L(t)}\frac{\dot{A}(t)}{A(t)} \quad (2.11)$$

If we substitute the facts from the equations (2.8) and (2.9), $\dot{L}/L$ and $\dot{A}/A$ are n and g; and from (2.10) $\dot{K}$, into (2.11); it can be obtained:

$$\dot{k} = \frac{sY(t) - \delta K(t)}{A(t)L(t)} - k(t)n - k(t)g$$

$$= s\frac{Y(t)}{A(t)L(t)} - \delta k(t) - nk(t) - gk(t). \quad (2.12)$$

Using the fact that *Y/AL* is given by *f(k),* lastly we obtain:

$$\dot{k} = sf\big(k(t)\big) - (n + g + \delta)k(t) \quad (2.13)$$

This equation is the key equation of the Solow model. According to this equation, the change rate of the capital stock per unit of effective labour is the difference between two terms. First term, *sf(k),* is actual investment per unit of effective labour: output per unit of effective labour is *f(k),* and the fraction of that output that is invested is *s*. The second term $(n + g + \delta)k$ is break-even investment, the investment amount that must be done just to keep k at its existing level. Some investment is needed to prevent *k* from falling, because of two reasons. First, depreciating capital must be replaced to keep the capital stock from falling; as the δk term in (2.13). Second, the quantity of effective labour is growing at rate *n+g*, the capital stock must grow at rate *n+g* to hold *k* steady; as the $(n + g)k$ term in (2.13). When actual investment per unit effective labour exceeds the investment needed to break even, *k* is rising; when actual investment falls short of break-even investment, *k* is falling; and when both are equal, *k* is constant.

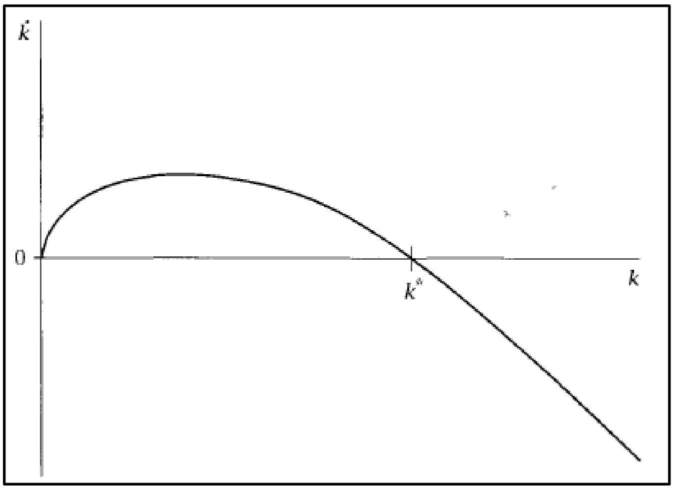

Figure 2.1The phase diagram for *k* in the Solow model

Figure 2.1 shows that $\dot{k}$is a function of *k*. If k is less than *k**, actual investment exceeds break-even investment, and $\dot{k}$ is positive; if *k* exceeds *k**, $\dot{k}$is negative, if *k* equals *k**, $\dot{k}$ is zero. Therefore, *k* converges to *k**.

The Balanced Growth Path

Under the assumption of respectively growing of labour and knowledge at rate *n* and *g*, the capital stock, *K*, equals *ALk*; where *k* is constant at *k**, K is growing at rate *n+g*. Under the assumption of constant returns, when both capital and effective labour grow at rate *n+g*, the output, *Y*, grow at this rate. Thus, capital per worker, *K/L*, and output per worker, *Y/L* are growing at rate *g*.

According the Solow model, the economy converges to a balanced growth path where each variable of the model grows at a constant rate. The growth rate of output per worker is determined only by the technological progress rate, on the balanced growth path. The growth rate of output and capital are approximately equal and are larger than the growth rate of labour.

The Impact of a Change in the Saving Rate

The division of the government's purchases between consumption and investment goods, the division of its revenues between taxes and borrowing, and its tax treatments of saving and investment are all likely to affect the fraction of output that is invested. Then, the effects of a change in the saving rate must be examined. The increase in *s* causes the actual investment line upward, then *k** rises. At first, *k* is equal to the old value of k^*, when k begins to rise until it reaches the new value of k^*, where it remains constant [30].

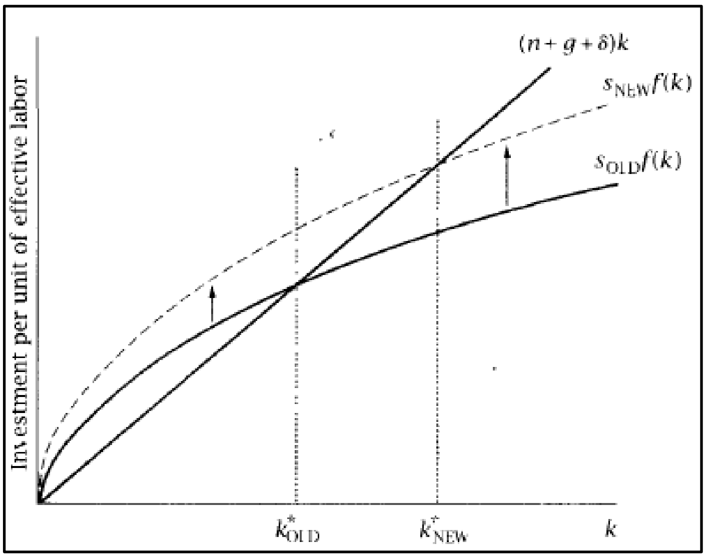

Figure 2.2 The Effects of an Increase in the Saving Rate on Investment

A permanent increase in the saving rate causes a temporary increase in the growth rate of output per worker; k increases to the point where the additional saving is devoted entirely to maintaining the higher level of k. Under the assumption, s increases and remains constant thereafter; k rises gradually from the old value of k^* to the new value; the growth rate of output per worker jumps upward from its initial level g, and gradually returns to its initial level. A change in the saving rate has a level effect but not a growth effect; the balanced growth path of economy and the level of output per worker at any point in time are changed by a change in the saving rate, but not the growth rate of output per worker on the balanced growth rate. In the Solow model only changes in the rate of technological progress have growth effects; while other effects have only level effects.

For introducing households into the model, the behaviour of consumption must be examined rather than the behaviour of output. Consumption per unit effective labour equals output per unit of effective labour, $f(k)$, times the fraction of that output that is consumed, $1-s$.

Where c^* which denotes consumption per unit of effective labour on the balanced growth path, equals output per unit of effective labour, $f(k^*)$, minus investment per unit of effective labour, *sf(k*).* Actual investment equals break-even investment,$(\mathrm{n}+\mathrm{g}+\delta)\mathrm{k}^*$:

$$\mathrm{c}^* = \mathrm{f}(\mathrm{k}^*) - (\mathrm{n}+\mathrm{g}+\delta)\mathrm{k}^* \tag{2.14}$$

k^*which is determined by s, n, g and δ; can be written as a function of these parameters, as $\mathrm{k}^* = \mathrm{k}^*(\mathrm{n}+\mathrm{g}+\delta)$. From the equation (2.14):

$$\frac{\partial \mathrm{c}^*}{\partial s} = \left[\mathrm{f}'\left(\mathrm{k}^*(\mathrm{s},\mathrm{n},\mathrm{g},\delta)\right) - (\mathrm{n}+\mathrm{g}+\delta)\right]\frac{\partial \mathrm{k}^*(\mathrm{s},\mathrm{n},\mathrm{g},\delta)}{\partial s} \tag{2.15}$$

The increase in *s* raises k^*. In the long run, the difference between$\mathrm{f}''(\mathrm{k})$ and$(\mathrm{n}+\mathrm{g}+\delta)$ define if the increase raises or lowers consumption. When k rises, investment per unit of effective labor must rise by $(\mathrm{n}+\mathrm{g}+\delta)$ times the change in k for the increase to be sustained. When $\mathrm{f}'(\mathrm{k})$ is less (higher) than $(\mathrm{n}+\mathrm{g}+\delta)$ there is not enough (more than enough) additional output to maintain the higher capital stock level, consumption lowers (rises). Consumption equals output less break-even investment on the balanced growth path, where c is the distance between *f(k)* and $(\mathrm{n}+\mathrm{g}+\delta)\mathrm{k}$.

Where $\mathrm{f}'(\mathrm{k}^*)$and $(\mathrm{n}+\mathrm{g}+\delta)$ are equal, in other words where *f(k)* and $(\mathrm{n}+\mathrm{g}+\delta)\mathrm{k}$ lines are parallel at $k=k^*$; a marginal change in s does not affect the consumption in the long run and consumption is at its maximum possible level among balanced growth paths. This value of k^* is known as the golden-rule of the capital stock [30].

2.3.3 In the Long Run

The long run effect of a rise in saving on output, where $y^*=f'(k^*)$ is the level of output per unit of effective labour on the balanced growth path:

$$\frac{\partial y^*}{\partial s} = f'(k^*)\frac{\partial k^*(s,n,g,\delta)}{\partial s} \tag{2.16}$$

To find long run effect of a rise in saving rate on output, it is necessary to find$\partial k^*/\partial s$ By the condition of$\dot{k} = 0$, k^* is:

$$sf'(k^*((s,n,g,\delta)) = (n+g+\delta)k^*(s,n,g,\delta) \tag{2.17}$$

The derivatives of two sides through *s*:

$$sf'(k^*)\frac{\partial y^*}{\partial s} + f'(k^*) = (n+g+\delta)\frac{\partial k^*}{\partial s} \tag{2.18}$$

That can be rewritten, omitting the arguments of k* for simplifying:

$$\frac{\partial k^*}{\partial s} = \frac{f(k^*)}{(n+g+\delta)-sf\prime(k^*)} \tag{2.19}$$

By substituting (2.19) into (2.16):

$$\frac{\partial y^*}{\partial s} = \frac{f\prime(k^*)f(k^*)}{(n+g+\delta)-sf\prime(k^*)} \tag{2.20}$$

By multiplying both sides by *s/y** to convert to an elasticity, and by substituting for *s*, using $sf(k^*) = (n + g + \delta)k^*$, the expression can be interpreted simpler.

$$\frac{s}{y^*}\frac{\partial y^*}{\partial s} = \frac{\propto_K(k^*)}{1-\propto_K(k^*)} \tag{2.21}$$

Under the assumption of competitive markets and without externalities, capital earns its marginal product, thus the share of total income that goes to capital on balanced growth path is *k*f'(k*)/f'(k*)* or *αK(k*).* With this estimate, the elasticity *f* output with respect to the saving rate in the long run is about one-half. So, significant changes in saving have only moderate effects on the output level on the balanced growth path [31].

CHAPTER 3

EMPRIRICAL SECTION

3.1 Augmented Solow Growth Model

3.1.1 The Study of Mankiw

The paper of Mankiw, Romer and Weil examines whether the Solow growth model is consistent with the international variation in the standard of living. It shows that an augmented Solow model that includes accumulation of human as well as physical capital provides an excellent description of the cross-country data. The paper also examines the implications of the Solow model for convergence in standards of living, that is, for whether pour countries tend to grow faster than richer countries. The evidence indicates that, holding population growth and capital accumulation constant, countries converge at about the rate the augmented Solow model predicts. Their paper argues that the predictions of the Solow model are to a first approximation, consistent with the evidence. They have found that saving and population growth affect income in the directions that Solow predicted. They use the data from the Real National Accounts recently constructed by Summers and Heston (1988). The data set includes real income, government and private consumption, investment and population for almost the entire world other than the centrally planned economies [32].

3.1.2 The Studies of Pedroni

In the study of Pedroni, it has been demonstrated that how such nonstationary panel techniques can be used to investigate the distribution of coefficients which reflect key structural parameters of the production function in a way that accounts for the possibility of intangible social capital, barriers to production and multiple regimes in explaining persistent per capita income disparities across countries; in a framework which permits to link directly to a notion of conditional convergence. The results add to a growing empirical literature that points to the importance of relaxing the traditional assumption of a common linear production function, and argues that an appeal to unobserved factors alone is unlikely to suffice as a substitute for heterogeneity of the production function.

Empirical Strategy

According to the Solow growth model, in the long run steady state, permanent changes in the savings rate will be associated with permanent changes to the level of per capita income and that the relationship is determined by the capital share parameters of the Cobb-Douglas production function.Considering that the share of investment is best measure for saving rates, if the pattern of time series variations in the investment is informative, it should be observed for instances in which permanent variations of the investment share. There is the potential to define any permanent co-movement in per capita income. To model these permanent changes in investment shares, when they occur is to treat them as changes to the expected long run values; the investment shares series behave a non-mean reverting[5] unit root process. Since, ultimately investments shares must be bounded by the resources available to an economy. It is convenient to think as a feature which describes the local behaviour of the series and from these samples. [33]

In Pedroni's study, they find this to be the case for many countries, and they use this criteria to select countries from within the Summers and Heston panel. To observe investment share series with permanent movements that can be well-approximated by a unit root process. Since the neoclassical model in conjunction with this econometric technique explains that these permanent changes to investment shares can help to uncover the parameters of the production function when they are associated with permanent changes in output, the empirical strategy is to look for instances in which this pattern has occurred in the Summers and Heston panel [34].

Between per capita incomes and investment shares, it should be expected to find coingtegrating relationships; because according to the Solow model, permanent changes to investment shares should in turn be associated with permanent changes to the level of

[5] In statistics, regression to the mean is the phenomenon that if a variable is extreme on its first measurement, it will tend to be closer to the average on its second measurement and paradoxically, if it is extreme on its second measurement, it will tend to have been closer to the average on its first.

per capita income. When the level of per capita effective human capital or other intangible capital inputs are relatively stable across countries, or evolve relatively smoothly over the long run, then these features will be absorbed into the fixed effects or heterogeneous deterministic trends for our panel specification, depending on the case. In such cases, the steady state relationship between per capita income and investment shares characterized by the cointegrating relationship traces out the implied curvature of the production function for each country as determined by the capital share parameters of the tangible and intangible capital inputs [33].

Accordingly, the empirical reduced form equation takes the form:

$$lny_{it} = c_i + g_i t + \beta_i \ln{(I/Y)_{it}} + \varepsilon_{it} \quad (3.1)$$

Where lny_{it} is log per capita income over time periods $t=1,\ldots,T$ and countries $i=1,\ldots,N$, $\ln{(I/Y)_{it}}$is the log of investment shares over the same time periods and countries, $c_i$is the country specific effects and$g_i t$is potentially heterogeneous country specific deterministic trends. The approach is robust to the violation of strong assumptions in the literature, including the assumption that regressors and omitted initial conditions are exogenous, and that countries behave close to their steady state positions at all points in time and the panel technique does not require transitional dynamics to be similar among countries. Since the residuals of the cointegrating relationship are stationary mean zero processes, this implies that any differences among the residuals are temporary. This corresponds closely to Bernard and Durlauf's concept of time-series forecast convergence, except that we are applying the idea here to the residuals of a steady state relationship rather than raw per capita income data [35]. The definition becomes appropriate for conditional convergence in a non-stationary panel in that the cointegrating relationship picks out those features upon which it is necessary to condition in order for per capita outputs to be conditionally convergent in the sense that any remaining differences are only transitory.

In the non-stationary panel framework, the combination of the extra dimension and the long run properties of the cointegrating relationship provide to use statistical proxies such as the fixed effects and heterogeneous trend components which can serve to capture a broad class of the unobserved mechanisms, thus it will be possible to study the distribution of the structural parameters of the production function in a way that is robust to the presence of these features. To obtain estimates for the cross country distribution of the structural parameters, we need to see how the reduced form coefficients relate to the structural parameters, by examining the relationship between the reduced form equation (3.1) and the augmented Solow model in a panel setting.

The typical augmented Solow model growth model specifies an aggregate Cobb-Douglas production function as below:

$$Y_{it} = K_{it}^{\propto_i} X_{it}^{\varphi_i} (E_{it} L_{it})^{1-\propto_i-\varphi_i} \quad (3.2)$$

The share parameters are common across countries *i=1,…,N*; in the typical augmented Solow model.

Where $X_{it}$is an intangible capital input, and E_{it} is the labour augmenting level of productivity. Labour and productivity can be shown as:

$$L_{it+1} = (1 + n_i)L_{it},\ E_{it} = (1 + g_i)E_{it} \quad (3.3)$$

Where n_i and $g_i$are the exogenous growth rates of labour and augmenting technology. According to the accumulation equation, physical capital grows as:

$$K_{it+1} = I_{it} + (1 - \delta_i)K_{it},\ I_{it} = S_i Y_{it} \quad (3.4)$$

Where δ_i is the constant rate of capital depreciation and I_{it} is the rate of physical capital investment determined in the Solow model as a share of output given by the saving rate S_i .

The augmented model with endogenous intangible capital can be shown as:

$$X_{it+1} = I_{it}^{x}(1 - \delta_i^{x})X_{it},\ I_{it}^{x} = S_i^{x} X_{it} \quad (3.5)$$

Where δ_i^xdepreciation rate of the intangible capital stock, and δ_i^x which is a constant fraction of output, determines the investment rate in this stock; these two parameters are permitted to vary across countries. For the steady state value of log per capita income, $lny_{it} = lnY_{it} - lnL_{it}$, the model can be solved in terms of log investment shares, $ln(I/Y)_{it} = lnS_i$:

$$lny_{it} = lne_{i0} + \varphi_i(1 - \alpha_i)^{-1} lnx_{it}^{*} - \alpha_i(1 - \alpha_i)^{-1}\ln(n_i + g_i + \delta_i) + g_i t + \alpha_i(1 - \alpha_i)^{-1}\ln(I/Y)_{it} \quad (3.6)$$

as an approximation when the values of and are relatively small. Here $e_{i0}$is the initial condition for labour augmenting technology, and $\ln x_{it}^{*} = \ln X_{it} - \ln E_{it} - \ln L_{it}$ is the steady state value of the intangible capital stock in log per capita efficiency units.

Alternatively, note that the steady state relationship can also be expressed in terms of the rate of savings, δ_i^x, for the intangible capital stock, so that;

$$\ln y_{it} = \ln e_{i0} + \varphi_i(1 - \alpha_i - \varphi_i)^{-1}\ln S_{it}^{*} - (\alpha_i + \varphi_i)(1 - \alpha_i - \varphi_i)^{-1}\ln(n_i + g_i + \delta_i) + g_i t + \alpha_i(1 - \alpha_i - \varphi_i)^{-1}\ln(I/Y)_{it} \quad (3.7)$$

To obtain a general treatment, it is worth considering how the reduced form equation (3.1) can best be interpreted depending on the nature of X_{it}.

Specifically, this will depend on how the unmeasured intangible capital stocks are accumulated. In particular, there exist two distinct categories for such unmeasured capital inputs, as the accumulation of human capital is accomplished at the expense of some fraction of income andas differing from this to the extent that the accumulation of such capital stocks tends to be accomplished more generally by means other than at the expense of some fraction of measured income. It does not mean that the accumulation of this intangible capital stock is exogenous orindependent of income, or that it occurs without effort or sacrifice. Rather, the key distinguishing feature of thissecond class of intangible capital is that it does not specifically require a fraction of income to be set aside. Thismay be typical of many, though not necessarily all, forms of social capital; i.e.development of trust or property rights, or common social values are examples of this type of intangible capitalstock, which evolve gradually over long periods of time and enhance the productivity of other measured inputs, butdo not necessarily require a fraction of measured income to be set aside in order to beaccumulated. Most likely, theaccumulation of these forms of social capital require effort in the form of investment, but perhaps these efforts are atthe expense of personal resources that are not a part of aggregate measured income.The reason it is important to bear in mind the distinction between these two different types of intangiblecapital assets is because they affect the structural interpretation of the parameters of the panel specification that isgiven in terms of measured aggregate per capita income and investment shares of tangible physical capital. Incomparing equation (3.6) with the reduced form specification (3.1), this form relates the omitted intangiblecapital input in terms of its steady state stock value, measured in per log capita efficiency units,$\ln x_{it}^{*}$. In this case,the fixed effects,c_i, as picking up the effect of this unmeasured capital stock under certainscenarios. For example, if the level of such capital measured in efficiency units is relatively stable over the length ofthe sample for any one country, then it will only impact the level of per capita income after we have conditionedupon the measured physical capital investment shares, $\ln(I/Y)_{it}$, and any country specific trend growth rates, $g_i t$.If the long runvalue is relatively constant for any one country, it can be thought of simply dropping the *t*index, from the steady statespecification, so that this could be represented simply as $\ln x_{it} = \ln\tilde{z}_i^*$for some unknown country specific value$\tilde{z}_i^*$ .In this case, these country specific values will be absorbed into the fixed effects along with other relatively constant country specific factors, so that$c_i = \ln e_{i0} + \varphi_i(1-\alpha_i)^{-1}\ln\tilde{z}_i^* - \alpha_i(1-\alpha_i)^{-1}\ln(n_i + g_i + \delta_i)$. In this sense, theunmeasured capital stock behaves no differently than the population growth rate, n_i, which, even though it may betime varying, is relatively stable and only impacts the country specific intercept of the log linear steady staterelationship. In fact, more generally the conditions under which this category of unmeasured capital stock will beaccounted for in the panel regression is even broader, and does not require that it be constant for the duration of thesample. Provided that this capital stock evolves relatively smoothly, even if it does change over the sample, itwill be absorbed into a combination of the fixed effects and country specific trend terms $g_i t$. If all unmeasuredintangible capital were of this form, then the reduced form specification could be interpreted in terms of equation (3.6),in which case the slope coefficient for the measured share of physical capital investment would be a function solelyof the production function share parameter for physical capital, such that $\beta_i = \alpha_i(1-\alpha_i)^{-1}$.More generally, however, it is expected that other forms of intangible capital exist which do notnecessarily follow this behaviour, and which require that a fraction of measured income be dedicated in order to accumulate the stock. Most notably human capital hasconventionally been modelled in this way, and presumably there may be some forms of unmeasured social capital that also better fit this description. In this case, theaccumulation equation (3.4) applies, and the long run values for the stocks,$\ln x_{it}^*$, of this capital type need not necessarily be stationary around trend even when measured in log per capita efficiency units. The reason for thisstems from the fact that the accumulation of this type of capital depends on a fraction of measured income, which inturn depends on the rate of measured physical investment shares. In this case, the more appropriate steady statespecification for per capita incomes is in the form of equation (3.7), which specifies the relationship in terms of therate of savings,$\ln S_{it}^*$, of the intangible capital, rather than the stock value. The important point to notice is that inthis case the interpretation of both the intercept and the slope coefficient changes in the panel specification. If all unmeasured intangible capital stocks were in this form, then the fixed effects, c_i, absorb the country specific rate ofsavings for the intangible capital stock such that $c_i = \ln e_{i0} + \varphi_i(1 - \alpha_i - \varphi_i)^{-1}\ln S_i^* - (\alpha_i + \varphi_i)(1 - \alpha_i - \varphi_i)^{-1}\ln(n_i + g_i + \delta_i)$, and in this case the slope coefficient for the measured share of physical capital investment would be a function ofboth the physical capital and intangible capital share parameters such that $\beta_i = \alpha_i(1 - \alpha_i - \varphi_i)^{-1}$.In the most general case, it might be expected that some of both types of categories are likely to make up thestock of unmeasured intangible capital stocks. In this case, it can be thought of a more finely specified productionfunction that includes both types of intangible capital, one of which requires a fraction of measured income in order to accumulate and another which does not. Now the fixed effects absorb the impacts that both of these types ofintangible capital inputs have on the level of per capita income after conditioning on measured physical capitalinvestment shares and any country specific trend growth rates, $g_i t$. But the slope coefficient on measured physical capital investment shares still depends only on production function share parameters of the capital stock types whichare accumulated by using a fraction of measured income, such as human capital and possibly some components ofsocial capital. The key point in this discussion is that the cointegrated panel specification is sufficiently general to handle a number of different possibilities regarding the nature of the unmeasured intangible capital stock, but it is important to interpret the meaning of the slope coefficients accordingly. Similarly, the inclusion of theheterogeneous deterministic trend terms permits the panel specification to be sufficiently general to accommodate mechanisms that might explain the cross country dispersion of per capita incomes in terms of differing rates ofproductivity. For example, if country specific barriers to the adoption of global technologies impact the level ofproductivity, then this will be absorbed into the fixed effects, c_i . More generally, if such barriers impact the rate of technological adaptation, then this will be absorbed into the country specific trend rates $g_i\, t$. This is as importantdistinction relative to conventional dynamic panel approaches. As Durlauf and Quah (1999) point out, conventionaldynamic panel approaches tend to inadvertently estimate higher frequency short run relationships among thevariables, while relegating the long run relationships to the fixed effects. This does not occur in our nonstationarypanel data setting, which explicitly extracts the long run relationship among the variables in the form of thecointegrating vectors which include the slope coefficients [33].

CHAPTER 4

METHODOLOGY

4.1 Concepts about Nonstationary Models

4.1.1 Stochastic Process

A random stochastic process is a collection of random variables ordered in time. When Y denotes a random variable and if it is continuous, it is denoted as *Y(t)*, if it is discrete, it is denoted as Y_t [36].

4.1.2 Stationary Process

A stochastic process is said to be stationary if its mean and variance are constant over time and the value of the covariance between the two time periods depends only on the distance or gap or lag between the two time periods and not the actual time at which the covariance is computed. If a time series is stationary, its mean, variance and autocovariance (at various lags) remain the same no matter at what point we measure them, that is, they are time invariant. Such a time series will tend to return to its mean, mean reversion, and fluctuations around this mean will have broadly constant amplitude. A non-stationary time series has a time-varying mean or a time-varying variance or both. If a time series is non-stationary, then it is possible to study its behaviour only for the time period under consideration. It is not possible to generalize to other time period.There is a special type of stochastic process, namely, a purely random, or white noise, process. A stochastic process is purely random if it has zero mean, constant variance σ^2, and is serially uncorrelated [37].

4.1.3 Nonstationary Process

A nonstationary time series will have a time-varying mean or a time-varying variance or both. There are two types of random walk: random walk without drift (no constant or intercept term), random walk with drift (constant term is present).

Random Walk without Drift

The series $Y_t$is said to be a random walk if

$$Y_t = Y_{t-1} + u_t \tag{4.1}$$

Where u_t is a white noise error term with 0 mean and σ^2. In the random walk model, the value of Y at time t is equal to its value at time (t-1) plus a random shock; thus it is a an AR(1) model; it can be thought as a regression of Y at time t on its value lagged one period. From (4.1);

$$Y_1 = Y_0 + u_1$$

$$Y_2 = Y_1 + u_2 = Y_0 + u_1 + u_2$$

$$Y_3 = Y_2 + u_3 = Y_0 + u_1 + u_2 + u_3$$

If the process started at some time 0 with a value ofY_0, then

$$Y_1 = Y_0 + \sum u_t \tag{4.2}$$

Therefore,

$$E(Y_t) = E(Y_0 + \sum u_t) = Y_0 \tag{4.3}$$

It can be shown as

$$\mathrm{var}(Y_t) = t\sigma^2 \tag{4.4}$$

The mean of *Y* is equal to its initial value, which is constant, but as *t* increases, its variance increases indefinitely, thus violating a condition of stationary; in other words the random walk model without drift is a nonstationary process. In practice, Y_0 is often set at zero, in which case $E(Y_t) = 0$. Random walk model is said to have an infinite memory, it means that this model is persistent for random shocks (i.e., random errors).

When the model is written as

$$(Y_t - Y_{t-1}) = \Delta Y_t = u_t \tag{4.5}$$

whereΔ is the first difference operator. While Y_t is nonstationary, its first difference is stationary; in other words the first differences of a random walk time series are stationary.

Random walk with drift

$$Y_t = \delta + Y_{t-1} + u_t \quad (4.6)$$

whereδ is the drifter parameter. This model is also known as AR(1).

When it is written as

$$Y_t - Y_{t-1} = \Delta Y_t = \delta + u_t \quad (4.7)$$

It shows that Y_t drifts upward or downward, depending on δ being positive or negative.

For the random walk with drift model:

$$E(Y_t) = Y_0 + t \cdot \delta \quad (4.8)$$

$$var(Y_t) = t \cdot \sigma^2 \quad (4.9)$$

The mean as well as the variance increases over time, again violating the conditions of (weak) stationary. Therefore, random walk model, with or without drift is a nonstationary process [38].

4.1.4 Unit Root Stochastic Process

Random walk model is as below:

$$Y_t = \rho Y_{t-1} + u_t \qquad -1 \leq \rho \leq 1 \quad (4.10)$$

If ρ is in fact 1, there is unit root problem, that is, a situation of nonstationarity; we already know that in this case the variance of Y_t is not stationary. The name unit root is due to the fact that $\rho = 1$.[6] The terms nonstationary, random walk and unit root can be treated as synonymous.If $|\rho| \leq 1$, that is if the absolute value of ρ is less than one, then it can be shown that the time series Y_t is stationary.[7] In practice, it is important to find out if a time series possesses a unit root [39].

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[6]If $\rho = 1$, it can be written as $Y_t - Y_{t-1} = u_t$.Using the lag operator L, than$LY_t = Y_{t-1}$, $L^2Y_t = Y_{t-2}$, and then it can be written as$(1-L)Y_t = u_t$. The term unit root refers to the root of the polynominal in the lag operator. When we set $(1-L) = 0$, we obtain $L = 1$, because of this the name unit root.

[7]If in (4.10), it is assumed that the initial value of $Y(= Y_0)$ is zero, $|\rho| \leq 1$, and $u_t$is white noise and distributed normally with zero mean and unit variance, then it follows that $E(Y_t) = 0$ and $var(Y_t) =$

Augmented Dickey-Fuller (ADF), GLS transformed Dickey-Fuller (DFGLS), Phillips-Perron (PP), Kwiatkowski, et. al. (KPSS), Elliot, Richardson and Stock (ERS) Point Optimal, and Ng and Perron (NP) unit root tests can be used for whether the series (or its first or second difference) is stationary [40].

4.1.5 Trend Stationary and Difference Stationary

If trend in a time series is completely predictable and not variable, it is a deterministic trend, if it is not predictable, it is a stochastic trend. For time series Y_t, the definition is as bellow:

$$Y_t = \beta_1 + \beta_2 t + \beta_3 Y_{t-1} + u_t \quad (4.11)$$

Where u_t is a white noise error term and where *t* is time measured chronologically.

If$\beta_1 = 0$, $\beta_2 = 0$, $\beta_3 = 1$ we will have:

$$Y_t = Y_{t-1} + u_t \quad (4.12)$$

If we write as

$$\Delta Y_t = (Y_t - Y_{t-1}) + u_t \quad (4.13)$$

Then, it becomes stationary. A random walk model without drift is a difference stationary process.

If $\beta_1 \neq 0$, $\beta_2 = 0$, $\beta_3 = 1$we will have:

$$Y_t = \beta_1 + Y_{t-1} + u_t \quad (4.14)$$

$$(Y_t - Y_{t-1}) = \Delta Y_t = \beta_1 + u_t \quad (4.15)$$

This trend is called as a stochastic trend; which is a difference stationary process because the non-stationary inY_t can be eliminated by taking first differences of the time series.

If$\beta_1 \neq 0$, $\beta_2 \neq 0$, $\beta_3 = 1$, we will have:

$$Y_t = \beta_1 + \beta_2 t + u_t \quad (4.16)$$

as a trend stationary process.

Random walk with drift and deterministic trend: If $\beta_1 \neq 0$, $\beta_2 \neq 0$, $\beta_3 = 1$,then:

$1/(1-\rho^2)$. Since both these are constants, by the definition of weak stationary, Y_t is stationary. On the other hand, if $\rho = 1$, Y_t is random walk or nonstationary.

$$Y_t = \beta_1 + \beta_2 t + Y_{t-1} + u_t \quad (4.17)$$

When we write this equation as below:

$$\Delta Y_t = \beta_1 + \beta_2 t + u_t \quad (4.18)$$

Where Y_t is non-stationary.

If $\beta_1 \neq 0$, $\beta_2 \neq 0$, $\beta_3 < 1$;then we can show the deterministic trend with stationary AR(1) component:

$$Y_t = \beta_1 + \beta_2 t + \beta_3 Y_{t-1} + u_t \quad (4.19)$$

which is stationary around the deterministic trend [41].

4.1.6 Integrated Variables

Integrated Stochastic Process

If a non-stationary time series has to be differenced *d* times to make it stationary, that time series said to be integrated of order d. An integrated time seriesY_t of order *d* is denoted as$Y_t \sim I(0)$ [42].

Spurious Regression

Supposing two random walk models:

$$Y_t = Y_{t-1} + u_t \quad (4.20)$$

$$X_t = X_{t-1} + v_t \quad (4.21)$$

Under the assumption of that $u_t \sim N(0,1)$, $v_t \sim N(0,1)$, and that they are serially uncorrelated as well as mutually uncorrelated; and that the initial values of *Y* and *X* were zero. When we make a regression $\mathrm{Y_t}$on $\mathrm{X_t}$, we can see that the coefficients are significant even if there is not any relationship between two variables. This situation is called as the spurious regression [43].

4.1.7 Cointegration

Cointegration can be called as a regression of a unit root time series on another unit root time series. Supposing two time series individually have a unit root, in other words they are both *I(1)*, if we regress $\mathrm{Y_t}$ on $\mathrm{X_t}$,as below:

$$\mathrm{Y_t} = \beta_1 + \beta_2 \mathrm{X_t} + \mathrm{u_t} \quad (4.22)$$

If we write it as:

$$u_t = Y_t - \beta_1 - \beta_2 X_t \tag{4.23}$$

Where u_t is stationary. Although Y_t and X_t are individually *I(1)*, they have stochastic trends, their linear combination is *I(0)*. In this case, the two variables are called as cointegrated. Economically, two variables are cointegrated if they have a long-term, or equilibrium, relationship between them. A regression such as (4.22)is known as a cointegraing regression and the slope parameter β_2 is known as the cointegrating parameter [44].

Cointegration for the series in the group can be tested with Johansen, Engle-Granger, or Phillips-Ouliaris tests [45].

4.2 Panel Data and Panel Data Estimation Methods

4.2.1 Panel Data

Panel data involve observations that possess both cross-section and within-cross section identifiers.

There exist three types of data for empirical analysis: time series, cross-section, and panel data. A time series is a set of observations on the values that a variable takes at different times. Such data may be collected at regular time intervals, such as daily, weekly, monthly, quarterly, annually, decennially or with the advent of high-speed computers, data can now be collected over an extremely short interval of time, such as the data on stock prices, which can be obtained literally continuously (the so-called real-time quote). Although time series data are used heavily in econometrics, they present special problems, as most empirical work based on time series data assumes that the underlying time series is stationary. Cross-section data consist of one or more variables collected at the same point in time. When describing cross sectional data it is useful a subscript to denote the entity; for example, Y_i referred to the variable *Y* for the variable i^{th} entity. Cross-sectional data also, have their own problems, specifically the problem of heterogeneity.Panel data (also called longitudinal data) refers to data for *n* different entities observed at *T* different time periods. In short, panel data have space as well as time dimensions. When describing panel data, we need an additional notation to keep track of both the entity and the time period, by using two subscripts. Thus, Y_{it} denotes the variable *Y* observed for the i^{th} of n entities in the t^{th} of T periods. Panel data consist of observations on the same *n* entities at two or more time periods *T*. If data set contains observations on the variables *X* and *Y*, then the data are denoted

$$(X_{it}, Y_{it}), i = 1, \dots, n \text{ and } t = 1, \dots, T \quad (4.24)$$

Where the fist subscript, *i*, refers to the entity being observed and the second subscript, *t*, refers to the date at which it is observed. A balanced panel has all its observations, that is the variables are observed for each entity and each time period. A panel that has some missing data for at least one time period for at least one entity is called an unbalanced panel. It is possible to observe more variation in behaviour across time and individual using panel data, compared to time series or cross section data [46].

Moreover, it is possible to allow observable and unobservable individual heterogeneity in econometric model, as fixed and random effects models.

4.2.2 Panel Unit Root

Panel unit root testing has additional complications as compared with time series unit root testing. First, panel data generally introduce a substantial amount of unobserved heterogeneity, rendering the parameters of the model cross section specific. Second, in many empirical applications it is inappropriate to assume that the cross section units are independent. To overcome these difficulties, variants of panel unit root tests are developed that allow for different forms of cross sectional dependence. Third, the panel test outcomes are often difficult to interpret if the null of the unit root or cointegration is rejected. Fourth, with unobserved nonstationary common factors affecting some or all the variables in the panel, it is also necessary to consider the possibility of cointegration between the variables across the groups (cross section cointegration) as well as within group cointegration. Finally, the asymptotic theory is considerably more complicated due to the fact that the sampling design involves a time as well as a cross section dimension. Furthermore, a proper limit theory has to take into account the relationship between the increasing number of time periods and cross section units [47].

In the panel context, Levin, Lin and Chu, Breitung, Im, Pesaran and Shin, Fisher-type tests using ADF and PP tests (Maddala and Wu, and Choi) panel unit root tests are carried out [48].

4.2.2.1 Panel Unit Root Testing

Assuming that time series $\{y_{i0}, \ldots, y_{iT}\}$ on the cross section units *i=1, …,N* are generated for each , by a sample first-order autoregressive, AR(1) process:

$$y_{it} = (1 - \alpha_i)\mu_i + \alpha_i y_{i,t-1} + \varepsilon_{it} \quad (4.25)$$

where the error terms, ε_{it} are i.i.d across i and t, can also be written as Dickey-Fuller (DF) regression:

$$\Delta y_{it} = -\phi_i \mu_i + \phi_i y_{i,t-1} + \varepsilon_{it} \quad (4.26)$$

Where $\Delta y_{it} = y_{it} - y_{i,t-1}$and $\phi_i = \alpha_i - 1$. When we write the model in mean-deviations as $\bar{y}_{it} = \alpha_i \bar{y}_{i,t-1} + \varepsilon_{it}$, where $\bar{y}_{it} = y_{it} - \mu_i$, DF regression in mean-deviations can be written as:

$$\bar{y}_{it} = \alpha_i \bar{y}_{i,t-1} + \varepsilon_{it} \quad (4.27)$$

The null hypothesis is:

$$H_0 = \phi_1 = \cdots = \phi_N = 0,$$

where all time series are independent random walks. There exist two alternatives:

$$H_{1a} = \phi_1 = \cdots = \phi_N \equiv \phi, \phi < 0$$

$$H_{1b} = \phi_1 < 0, \ldots, \phi_{N_0} < 0, N_0 \leq N.$$

Under H_{1a} it is assumed that the autoregressive parameter is identical for all cross section units [49]. This is called the homogeneous alternative. H_{1b}assumes that N_0 of the $N(0 < N_0 \leq N$ panel units are stationary with individual specific autoregressive coefficients. This is referred to as the heterogeneous alternatives [50]. For the consistency of the test it is assumed that $\frac{N_0}{N} \to k > 0$as $N_0 \to \infty$. Differentpanel testing procedures can be developed depending on which of the two alternatives is being considered. The panel unit root statistics motivated by the first alternative, H_{1a}, pools the observations across the different cross section units before forming the “pooled” statistic, whilst the tests developed againstthe heterogeneous alternatives, H_{1b}, operates directly on the test statisticsfor the individual cross section units using (standardized) simple averages ofthe underlying individual statistics or their suitable transformations such asrejection probabilities. Despite the differences in the way the two tests viewthe alternative hypothesis both tests can be consistent against both types ofthe alternatives.

When the null hypothesis is rejected one can only conclude that a significant fraction of theAR(1) processes in the panel does not contain unit roots [47].

The pooled log-likelihood function of the individual DF regression:

$$\ell_{NT}(\phi,\theta) = \sum_{i=1}^{N}\left\{-\frac{T}{2}log2\pi\sigma_i^2 - \frac{1}{2\sigma_i^2}\sum_{t=1}^{T}\left(\Delta y_{it} + \phi_i\mu_i - \phi_i y_{i,t-1}\right)^2\right\} \quad (4.28)$$

where$\phi = (\phi_1, \dots, \phi_N)'$, $\theta = (\mu_i, \sigma_i^2)'$ and $\theta = (\theta_1, \dots, \theta_N)'$. In the case of homogeneous alternatives, H_{1a}, where $\phi_i = \phi$, the maximum likelihood estimator of ϕ is:

$$\hat{\phi}(\theta) = \frac{\sum_i^N \sum_{t=1}^T \sigma_i^{-2}\Delta y_{it}(y_{i,t-1}-\mu_i)}{\sum_i^N \sum_{t=1}^T \sigma_i^{-2}(y_{i,t-1}-\mu_i)^2} \quad (4.29)$$

Under the alternative hypothesis the particular estimates of μ_i and σ_i^2chosen naturally depend on the nature of the alternatives envisaged. Under homogeneous alternatives, $\theta_i = \phi < 0$, the ML estimates of μ_i and $\sigma_i^2$are given as non-linear functions of $\hat{\phi}$. Under heterogeneous alternatives μ_i and σ_i^2 can be treated as free parameters and estimated separately for each *i*. Levin, Lin and Chu avoid the problems associated with the choice of the estimators for $\mu_i$and base their tests on the t-ratio of ϕ in the pooled fixed effects (FE) regression [49].

$$\Delta y_{it} = \alpha_i + \phi_i y_{i,t-1} + \varepsilon_{it}, \varepsilon_{it} \sim (0, \sigma_i^2) \quad (4.30)$$

The t-ratio of the FE estimator of ϕ is:

$$T_\phi = \frac{\sum_i^N \hat{\sigma}_i^{-2}\Delta y_i' M_T y_{i,-1}}{\sqrt{\sum_i^N \hat{\sigma}_i^{-2}(y_{i,-1}' M_T y_{i,-1})}} \quad (4.31)$$

Where$\Delta y_i = (\Delta y_{i1}, \Delta y_{i2}, \dots, \Delta y_{iT})'$, $y_{i,-1} = y_{i0}, y_{i1}, \dots, y_{i,T-1}$, $M_T = I_T - \tau_T(\tau_T'\tau_T)^{-1}\tau_T'$, τ_T is a Tx1 vector of ones:

$$\hat{\sigma}_i^2 = \frac{\Delta y_i' M_i y_i}{T-2} \quad (4.32)$$

Where $M_i = I_T - X_i(X_i'X_i)^{-1}X_i'$and $X_i = \tau_T, y_{i,-1}$.

The construction of a test against H_{1b} is less clear because the alternative consists of a set of inequality conditions. Im, Pesaran and Shin suggest the mean of the individual specific t-statistics [50] [51]:

$$\bar{\tau} = \frac{1}{N}\sum_{i=1}^{N}\tau_i \quad (4.33)$$

Where

$$\tau_i = \frac{\Delta y_i' M_T y_{i,-1}}{\hat{\sigma}_i (y_{i,-1}' M_T y_{i,-1})^{1/2}} \quad (4.34)$$

is the DF t-statistic of cross section for *i*.

Maddala and Wu [52] and Choi [53] independently suggested a test against the heterogenous alternative H_{1b} that is based on the p-values of the individual statistic as originally suggested by Fisher [54]. Let $\pi_i$denote the p-value of the individual specific unit root test applied to cross-section unit *i*. The combined test statistic is:

$$\bar{\pi} = -2 \sum_{i=1}^{N} \log(\pi_i) \quad (4.35)$$

4.2.3 Panel Cointegration

The estimation of long-run relationships has been the focus of extensive research in time series econometrics. In the case of variables on a single cross-section unit the existence and the nature of long-run relations are investigated using cointegration techniques developed by Engle and Granger [55], Johansen [56] [57] and Phillips [58].

So far the focus of the panel cointegration literature has been on residual based approaches, although there has been a number of attempts at the development of system approaches as well. Having established a cointegration relationship, the long-run parameters can be estimated efficiently using techniques similar to the ones proposed in the case of single time series models. Most approaches employ a homogenous framework, that is, the cointegration vectors are assumed to be identical for all panel units, whereas the short-run parameters are panel specific. The residual based tests were developed to ward against the "spurious regression" problem that can also arise in panels when dealing with *I(1)* variables. Such tests are appropriate when it is known a priori that at most there can be only one within group cointegration in the panel. System approaches are required in more general settings where more than one within group cointegrating relation might be present, and/or there exist unobserved common I(1) factors. [47]

Pedroni suggest two different test statistics for the models with heterogeneous cointegration vectors. Pedroni considers two different classes of test statistics: (i) the “panel statistic" that is equivalent to the unit root statistic against homogeneous alternatives and (ii) the “Group Mean statistic" that is analogous to the panel unit root tests against heterogeneous alternatives [59].

Other residual-based panel cointegration tests include the recent contribution of Westerlund [60] that are based on variance ratio statistics and do not require corrections for the residual serial correlations. Gutierrez compares the power of various panel cointegration test statistics; he shows that in homogeneous panels with a small number of time periods Kao's tests tend to have higher power than Pedroni's tests, whereas in panels with large T the latter tests performs best [61]. Both test outperform the system test suggested by Larssen et al. [62].

4.2.3.1 Panel Cointegration Testing

Pedroni suggests two different test statistics for the models with heterogeneous cointegration vectors. Where $\hat{u}_{it} = y_{it} - \hat{\delta}_i' d_{it} - \hat{\beta}_i' x_{it}$ denote the OLS residual of the cointegration regression, Pedroni considers two different classes of test statistics: (i) the “panel statistic” that is equivalent to the unit root statistic against homogeneous alternatives and (ii) the “Group Mean statistic” that is analogous to the panel unit root tests against heterogeneous alternatives. [47]

The two versions of the t statistic:

Panel version:

$$Z_{Pt} = \left(\tilde{\sigma}_{NT}^2 \sum_{i=1}^{N} \sum_{t=1}^{T} \hat{u}_{i,t-1}^2 \right)^{-1/2} \left(\sum_{i=1}^{N} \sum_{t=1}^{T} \hat{u}_{i,t-1} \hat{u}_{it} - T \sum_{i=1}^{N} \hat{\lambda}_i \right) \tag{4.36}$$

Group-mean version:

$$\tilde{Z}_{Pt} = \sum_{i=1}^{N} \left(\hat{\sigma}_{ie}^2 \sum_{t=1}^{T} \hat{u}_{i,t-1}^2 \right)^{-\frac{1}{2}} \left(\sum_{t=1}^{T} \hat{u}_{i,t-1} \hat{u}_{it} - T \hat{\lambda}_i \right) \tag{4.37}$$

Where $\hat{\lambda}_i$ is a consistent estimator of the one-sided long run variance $\lambda_i = \sum_{j=1}^{\infty} E\left(e_{it} e_{i,t-j}\right), e_{it} = u_{it} - \delta_i u_{i,t-1}, \delta_i = E(u_{it} u_{i,t-1})/E(u_{i,t-1}^2), \hat{\sigma}_{ie}^2$ denotes the estimated variance of $e_{it}$and $\tilde{\sigma}_{NT}^2 = N^{-1} \sum_{i=1}^{N} \hat{\sigma}_{ie}^2$. Pedroni presents values of μ_p, σ_p^2 and $\tilde{\mu}_p$, $\tilde{\sigma}_p^2$ such that $(Z_{Pt} - \mu_p \sqrt{N}/\sigma_p)$ and $(\tilde{Z}_{Pt} - \tilde{\mu}_p \sqrt{N}/\tilde{\sigma}_p)$ have standard normal limiting distributions under the null hypothesis [59].

4.2.4 Panel Models

4.2.4.1 Random Effects Model

Random coefficients model allows slopes to vary over i

$$Y_{it} = \alpha_i + \beta_i X_{it} + u_{it} \tag{4.38}$$

Where α_i is purely random (usually i.i.d $((0, \sigma_\alpha^2))$. Regressor X_{it} must be exogenous corrects standard errors for equivalently correlated clustered errors. The random effects model corresponds to a usual GLS regression model.

4.2.4.2 Panel Data with Two Time Periods: "Before and After" Comparisons

When data for each stale are obtained for T=2 time periods. It is possible to compare values of the dependent variable in the second period to values in the first period. In other words, analysing changes over time, thereby eliminating this source of omitted variable bias [63].

4.2.4.3 Fixed Effects Regression Model

Fixed effects regression is a method for controlling for omitted variables in panel data when the omitted variables vary across entities but do not change over time. Unlike the "before and after" comparisons, fixed effects regression can be used when mere are two or more time observations for each entity. The fixed effects regression model has n different intercepts, one for each entity. These intercepts can be represented by a set of binary (or indicator) variables. These binary variables-absorb the influences of all omitted variable that differ from one entity to the next but are constant over time.

The fixed effects regression model

The fixed effects regression model with one regressor is

$$\mathrm{Y_{it}} = \beta_1 \mathrm{X_{1,it}} + \alpha_\mathrm{i} + \mathrm{u_{in}} \tag{4.39}$$

Where $\alpha_\mathrm{i}, \dots, \alpha_\mathrm{n}$ are treated as unknown intercepts to be estimated, one ofor each entity. The interpretation ofα_i as an entity specific intercept in (4.39) comes from considering the population regression linefor the i^{th}entity; this population regression line, β_1, is the same for all entities, but the intercept of the population regression line varies from one entity to the next. The intercept α_i can be thought of as the effect of being in entity *i*, the terms $\alpha_i, \dots, \alpha_n$ are also known as entity fixed effects. The variation in the entity fixed effects comes from omitted variables that vary across over entities but not over time.

The fixed effects regression model is:

$$Y_{it} = \beta_1 X_{1,it} + \dots + \beta_k X_{k,it} + \alpha_i + u_{in} \quad (4.40)$$

where i=1,…,n and t =1,…,T, $X_{1,it}$ the value of the first regressor for entity i in time period t, $X_{2,it}$ is the value of the second regressor, and so forth, and $\alpha_i, \dots, \alpha_n$ entity-specific intercepts. Equivalently, the fixed effects regression model can be written in terms of a common intercept, the *X*'s and *n-1* binary variables representing all but one entity.

$$Y_{it} = \beta_0 + \beta_1 X_{1,it} + \dots + \beta_k X_{k,it} + \gamma_2 D2_i + \gamma_3 D3_i + \dots + \gamma_n Dn_i + u_{in} \quad (4.41)$$

Where $D2_i = 1$ if i=2 and $D2_i = 0$ otherwise, and so forth.

Regression with Time Fixed Effects

As fixed effects for each entity can control for variables that are constant over time hut differ across entities, so can time fixed effects control for variables that are constant across entities but evolve over time.

The time fixed effects regression model with a single X regressor is

$$Y_{it} = \beta_1 X_{it} + \lambda_t + u_{it} \quad (4.42)$$

This model has a different intercept, λ_t, for each time period, which can be tought of as the effect on Y of year t,the terms $\lambda_i, \dots, \lambda_t$ are known as time fixed effects. The variables in the time fixed effects come from omitted variables[8]that, vary over time but not across entities.

The time fixed effects regression model can be presented using T-1 binary indicators:

$$Y_{it} = \beta_0 + \beta_1 X_{it} + \delta_2 B2_t + \dots + \delta_T BT_t + u_{it} \quad (4.43)$$

Where $\delta_2, \dots, \delta_T$ are unknown coefficients and where $B2_t = 1$, if t =2 and $B2_t = 0$ otherwise, and so forth.As in the time fixed effects regression model, in this version of the time fixed effects model the intercept is included, and the first binary variable, $B2_t$ is omitted to prevent perfect multicollinearity.

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[8]Omitted variables are variables which have significant influence on dependent variable and so should be in the model, but are excluded.

Both Entity and Time Fixed Effects

If some omitted variables are constant over time but vary across entities, while others are constant across entities but vary over time, then it is appropriate to include both entity and time effects.

The combined entity and time fixed effects regression model is

$$Y_{it} = \beta_1 X_{it} + \alpha_i + \lambda_T + u_{it} \qquad (4.44)$$

Where α_i it the entity fixed effect and λ_t is the time fixed effect. This model can equivalently represented using *n-1* entity binary indicators and *T-1* time binary indicators, along with an intercept:

$$Y_{it} = \beta_0 + \beta_1 X_{it} + \gamma_2 D2_i + \cdots + \gamma_n Dn_i + \delta_2 B2_t + \cdots + \delta_T BT_t + u_{it} \qquad (4.45)$$

where$\beta_0, \beta_1, \gamma_2, \dots, \gamma_n, \delta_2, \dots, \delta_T$ are unknown coefficients.

The combined entities and time fixed effects regression model eliminates omitted variables bias arising both from observed variables that are constant over time and from unobserved variables that are constant across entities. The time fixed effects model and the entity and time fixed effects model are both variants of the multiple regression model. Their coefficients can be estimated by OLS by including the additional time binary variables. Alternatively, in a balanced panel the coefficients on the *X*'s can be computed by first deviating *Y* and the *X*'s from their entity and time-period means, then estimating the multiple regression equation deviated *X*'s. This algorithm which is commonly implemented in regression software packages eliminates the need of constructing the full set of binary indicators. Another equivalent approach is to deviate*Y*, the *X*'s and the time indicators. Lastly, if *T=2*, the entity and time fixed effects regression can be estimated using "before and after" approach, including the intercept in the regression [64].

4.2.4.4 Random or Fixed Effects and Testing

The fixed effects model is more convenient for macroeconomic analysis for two reasons. First, if the individual effect represents omitted variables, it is highly likely that these country specific characteristics are correlated with the other regressors. Second, it is also fairly likely that a typical macro panel will contain most of the countries of interest and, thus, will be less likely to be a random sample from a much larger universe of countries [65].

Fixed Effects Testing

After estimating the unrestricted specification that includes the effects of interest, this test provides to test the joint significance of the fixed effects estimatesin least squares specifications. The unrestricted specification is a two-way fixed effects estimator, the joint significance of all of the effects as well as the joint significance of the cross-section effects and the period effects separately are tested.

There exist three sets of tests. The first set consists of two tests ("Cross-section F" and "Cross-section Chi-square") that evaluate the joint significance of the cross-section effects using sums-of-squares (F-test) and the likelihood function (Chi-square test). The corresponding restricted specification is one in which there are period effects only [66].

Random Effects Testing

A central assumption in random effects estimation is the assumption that the random effects are uncorrelated with the explanatory variables. One common method for testing this assumption is to employ a Hausman test to compare the fixed and random effects estimates of coefficients [67]. To perform the Hausman test, the model should be estimated with random effects specification [68].

4.2.4.5 Pooled Equation

Pooled (or population average) regression estimate an equation with a common intercept and common slope for all individual, beside the single equations for each individual. These single equations can be estimated with individual-specific fixed or random effects and with or without individual-specific time trends. It is convenient to estimate panel data with common relationship across country, because also it is possible to see country-specific effects identification [69].

Pooled regression can be shown as:

$$Y_{it} = \alpha + \beta X_{it} + u_{it} \tag{4.46}$$

Pooled models can be estimated by least squares methods.

4.2.5 Estimators

The pooled model, with individual-specific fixed effects and with individual deterministic trend, can be estimated by LSDV or DOLS [70]. But, so as to simplify, we use the estimator as panel DOLS.

The issues involved in panel cointegration vector estimation and testing parallels that in the single equation environment. For a single equation, OLS is a consistent estimator of the cointegrating vector but its asymptotic distribution depends on the long-run covariance between $u_{it}$and v_{it}. This nuisance parameter dependency invalidates standard hypothesis testing in the OLS framework without modifications. DOLS, dynamic generalized least square (GLS), and fully modified OLS are examples of such modifications. Similarly, in panel data, Phillips and Moon [71] and Pedroni [72] show that for fixed *N*, the pooled OLS estimator is a consistent estimator of the cointegrating vector as $T \rightarrow \infty$ and can be used in a first pass in getting point estimates. In panel data, however, the problems of second-order asymptotic bias and nuisance parameter dependence are compounded and are potentially more serious in the sense that the bias accumulates with the size of the cross-section. In particular, OLS estimator for the pooled cross section time series data follows that the distribution for a Wald statistic for testing linear restrictions becomes even less useful as the cross-sectional dimension of the panel grows as it too can diverge [73].

Kao and Chiang compared the small-sample performance of panel DOLS and panel fully modified OLS with fixed effects in the case of a single regressor and they found that panel DOLS performed much better than panel fully modified OLS in removing finite sample bias [74].

4.2.5.1 Dynamic OLS

The panel dynamic ordinary least square (DOLS) estimator of a homogeneous cointegration vector for a balanced panel of N individuals observed over *T* time periods. Allowable heterogeneity across individuals includes individual-specific time trends, individual-specific fixed effects and time-specific effects. The estimator is fully parametric, computationally convenient, and more precise than the single equation estimator [73]. Panel DOLS which is suggested by Saikkonen [75],is fully parametric and computationally convenient alternative to the panel 'fully modified' OLS estimator proposed by Phillips and Moon [71] and Pedroni [72].

The sequential limit distribution by first letting $T \to \infty$for fixed N, and thenletting $N \to \infty$as proposed by Phillips and Moon [71].Here, panel DOLS has a limiting Gaussian distribution and as in the fixed N case, the Wald statistic has a limiting chi-square distribution. In the absence of linear trends in the cointegrating regression, the sequential limiting normality of the estimator is theoretically interesting but has less practical import because the limit distribution of the test statistics is identical to the$T \to \infty$ distribution with fixed N. However, when linear trends are present, the sequential limit theory produces considerable simplifications. Here, the estimator of the cointegration vector and the time-trend slope coefficients remain correlated for fixed N as $T \to \infty$but are asymptotically uncorrelated when $T \to \infty$then $N \to \infty$. As single equation cointegration vector estimators are super consistent, it is natural to ask what is to be gained by using the panel estimator. The answer is that super consistency means that convergence towards the asymptotic distribution occurs at rate T but it says nothing about the sampling variability of the estimator for a fixed value of T. In fact, the statistical properties of single-equation cointegration-vector estimators can be quite poor when applied to sample sizes associated with macroeconomic time series typically available to researchers (e.g. Stock andWatson, [76]). Moreover, even limited amounts of heterogeneity in the short-run dynamics across individuals can generate considerable disparities in single-equation DOLS estimates of the true homogeneous cointegration vector. In these situations, combining cross-sectional and time-series information in the form of a panel can provide much more precise point estimates of the cointegration vector with reasonably accurate asymptotic approximations to the exact sampling distribution [73].

The DOLS estimator is based on the error decomposition and the regression is:

$$y_{it} = \beta' x_{it} + \sum_{k=-\infty}^{\infty} \gamma_k' \Delta x_{i,t+k} + v_{it} \tag{4.47}$$

wherev_{it} is orthogonal to all leads and lags of Δx_{it}.

DOLS Estimator with fixed effects and heterogeneous trends

Both individual-specific fixed effects and heterogeneous time trends are admitted into the specification. The equation for both individual-specific fixed effect and heterogeneous time trends is:

$$y_{it} = \alpha_i + \lambda_i t + \underline{\gamma}' \underline{x}_i + \delta_i \underline{z}_i + u_{it} \tag{4.48}$$

The time series average of equation (4.48) yields:

$$\frac{1}{T}\sum_{t=1}^{T} y_{it} = \alpha_i + \lambda_i\left(\frac{T+1}{2}\right) + \underline{\gamma}'\frac{1}{T}\sum_{t=1}^{T}\underline{x}_i + \delta_i\frac{1}{T}\sum_{t=1}^{T}\underline{z}_i + \frac{1}{T}\sum_{t=1}^{T}u_{it} \quad (4.49)$$

Where $\frac{1}{T}\sum_{t=1}^{T} t = (T+1)/2$. To control for the fixed effects subtract equation (4.49) from (4.48) to get

$$\tilde{y}_{it} = \lambda_i\tilde{t} + \underline{\gamma}'\underline{\tilde{x}}_i + \delta_i\underline{\tilde{z}}_i + \tilde{u}_{it} \quad (4.50)$$

Where a "tilde" denotes the deviation of an observation from its time series average as:

$$\tilde{y}_{it} = y_{it} - \frac{1}{T}\sum_{t=1}^{T} y_{it}$$

$$\tilde{x}_{it} = x_{it} - \frac{1}{T}\sum_{t=1}^{T} x_{it}$$

$$\tilde{z}_{it} = z_{it} - \frac{1}{T}\sum_{t=1}^{T} z_{it}$$

$$\tilde{u}_{it} = u_{it} - \frac{1}{T}\sum_{t=1}^{T} u_{it}$$

$$\tilde{t} = t - \frac{T+1}{2}$$

To set up panel DOLS, where $\underline{\lambda}_N = (\lambda_1, \lambda_{2,} \dots, \lambda_N)'$is the trend-slope coefficients vector and $\beta = (\underline{\gamma}', \underline{\lambda}'_N, \underline{\delta}'_1, \dots, \underline{\delta}'_N)'$ is the grand coefficient vector:

$$\begin{array}{lcllllllllll} \underline{\tilde{q}}'_{1t} & = & (x'_{1t} & \tilde{t} & 0 & \dots & 0 & \underline{\tilde{z}}'_{1t} & 0' & \dots & \underline{0}')' \\ \underline{\tilde{q}}'_{2t} & = & (x'_{2t} & 0 & \tilde{t} & \dots & 0 & \underline{0}' & \underline{\tilde{z}}'_{2t} & \dots & \underline{0}')' \\ \vdots & & & & & \vdots & & & & & \\ \underline{\tilde{q}}'_{Nt} & = & (x'_{Nt} & 0 & 0 & \dots & \tilde{t} & \underline{0}' & \underline{0}' & \dots & \underline{\tilde{z}}'_{Nt})' \end{array} \quad (4.51)$$

The panel DOLS estimator of β is:

$$\underline{\beta}_{NT} = \left[\sum_{i=1}^{N}\sum_{t=1}^{T}\underline{\tilde{q}}_{it}\underline{\tilde{q}}'_{it}\right]^{-1}\left[\sum_{i=1}^{N}\sum_{t=1}^{T}\underline{\tilde{q}}_{it}\underline{\tilde{y}}_{it}\right] \quad (4.52)$$

CHAPTER 5

APPLICATION FOR EURO AREA COUNTRIES

5. PanelDynamic Ordinary Least Squares Estimation

The balanced panel DOLS is realized to estimate coefficients of the long run real GDP per capita growth rate. After the logarithmic transformations, unit root and cointegration and random or fixed effects tests are realized.

The panel DOLS estimator of a homogeneous cointegration vector for a balanced panel of N individuals observed over T time periods. The pooled estimation has been carried out with country-specific fixed effects and individual deterministic trend.

The nonstationary panel estimation by using dynamic ordinary least squares estimator method is carried out. The pooled model is implicitly assuming that the coefficients (including the intercepts) are the same for all the individuals.

5.1 The Data

For the non-stationary panel estimation, the annual panel data has been chosen from PWT data (version 7.1) from 1999 to 2010 and for 17 Euro Area countries (Austria, Belgium, Cyprus, Estonia, Finland, France, Germany, Greece, Ireland, Italy, Luxembourg, Malta, Netherlands, Portugal, Slovakia, Slovenia and Spain). But primarily, for balanced panel estimation, because of the number of observations, Cyprus, Estonia, Malta, Slovakia and Slovenia have been ignored from the analysis.Because of launching and using of the Euro by 11 countries (Austria, Belgium, Finland, France, Germany, Ireland, Italy, Luxembourg, Netherlands, Portugal, and Spain), our estimation period starts from 1999. Among the analysed countries, only Greece has been admitted in 2001 into the Euro Area. While we use the ratios for analyses, this difference can be treated as negligible. But, the other countries (Cyprus, Estonia, Malta, Slovakia, Slovenia) which have been admitted into the Euro Area between 2007 and 2011, have been ignored from the analysis; therefore their data will not be sufficient and significant for our estimation.

Real GDP per capita growth series(Chain Series-at 2005 constant prices) as dependent variable and the corresponding investment share on GDP series have been used as explanatory variable.

5.2 Unit Root Tests

The presence of the unit root for log real GDP per capita, *ln(Y)* and log investment share on GDP series, *ln(I/Y)* series has been tested. Im, Pesaran, Shin; ADF Fisher and PP Fisher tests have been carried out for the individual unit root process and Levin, Lin, Chu and Breitung tests have been carried out for the common unit root process.

As to give an idea about nonstationarity of *ln(Y)* and *ln(I/Y)* series of the countries, the results of Im, Pesaran and Shin test for *ln(Y)* and *ln(I/Y)* can be seen in Table 5.1 and 5.2. The results of the other individual unit root process tests, common unit root process tests and overall tests summary are given in Appendix-A.

Table 5.1Im, Pesaran and Shin Test for *ln(Y)* series

Method	Statistic	Prob.
Im, Pesaran and Shin W-stat	0.16811	0.5668

Intermediate ADF test results

Cross section	t-Stat	Prob.	E(t)	E(Var)	Lag	Obs
Austria	-3.1718	0.1452	-2.173	1.453	1	10
Belgium	-2.6686	0.2668	-2.173	1.453	1	10
Finland	-3.7786	0.0670	-2.173	1.453	1	10
France	-2.2140	0.4345	-2.173	1.453	1	10
Germany	-2.7294	0.2495	-2.173	1.453	1	10
Greece	0.2517	0.9933	-2.173	1.453	1	10
Ireland	0.0193	0.9872	-2.173	1.453	1	10
Italy	-1.6370	0.7030	-2.173	1.453	1	10
Luxembourg	-2.5095	0.3189	-2.173	1.453	1	10
Netherlands	-3.3159	0.1215	-2.173	1.453	1	10
Portugal	-3.1464	0.1503	-2.173	1.453	1	10
Spain	-0.4737	0.9605	-2.173	1.453	1	10

Table 5.2 Im, Pesaran and Shin Test for *ln(I/Y)* series

Method	Statistic	Prob.
Im, Pesaran and Shin W-stat	-1.20798	0.1135

Intermediate ADF test results

Cross section	t-Stat	Prob.	E(t)	E(Var)	Lag	Obs

Austria	-2.1263	0.4732	-2.173	1.453	1	10
Belgium	-3.7845	0.0665	-2.173	1.453	1	10
Finland	-1.6321	0.7052	-2.173	1.453	1	10
France	-3.1439	0.1508	-2.173	1.453	1	10
Germany	-2.5072	0.3197	-2.173	1.453	1	10
Greece	-1.9117	0.5751	-2.173	1.453	1	10
Ireland	-1.8691	0.5983	-2.173	1.453	1	10
Italy	-1.4494	0.7765	-2.173	1.453	1	10
Luxembourg	-1.8384	0.6133	-2.173	1.453	1	10
Netherlands	-2.0877	0.4903	-2.173	1.453	1	10
Portugal	-2.3830	0.3646	-2.173	1.453	1	10
Spain	-6.3866	0.0030	-2.173	1.453	1	10

The countries must be eliminated if they have stationary series, according to the unit root test results. According to the results of these unit root tests, twelve countries (Austria, Belgium, Finland, France, Germany, Greece, Ireland, Italy, Luxembourg, Netherlands, Portugal and Spain) have a nonstationary behaviour. Furthermore, for balanced panel estimation, the countries which have not enough observation have been ignored primarily. These countries are Cyprus, Estonia, Malta, Slovakia and Slovenia.

In Table 5.1 and 5.2, there exist the results of Im, Pesaran, Shin tests for ln(Y) and ln(I/Y) series. According to these tests results, all the countries in interest, have nonstationary ln(Y) and ln(I/Y) series. Then, we can search a cointegrating relationship between two series.

5.3 Cointegration Tests

According to the Solow model, the permanent changes in investment shares should be associated with permanent changes in per capita income, which should be reflected as a cointegrating relationship between the two variables [33].

To estimate the panel regression, we have to find a cointegrating relationship between these variables. Therefore, the cointegration tests have been carried out by E-views programme.

For both real GDP and investment share on GDP serieswhich have nonstationary behaviour, cointegration tests have been carried out.

According to the Pedroni Residual Cointegration test, if we look at the panel statistic values, there is significant cointegrating relationship between *ln(Y)* and *ln(I/Y)* series.[9]

Table 5.3 Pedroni Residual Cointegration Test Results

Pedroni Residual Cointegration Test

Series: LN_Y LN_IY

Null Hypothesis: No cointegration

Alternative hypothesis: common AR coefs. (within-dimension)

	Statistic	Prob.	Weighted Statistic	Prob.
Panel v-Statistic	11.31122	0.0000	8.371098	0.0000
Panel PP-Statistic	-3.356516	0.0004	-5.680396	0.0000
Panel ADF-Statistic	-1.847338	0.0323	-2.464942	0.0069

Alternative hypothesis: individual AR coefs. (between-dimension)

	Statistic	Prob.
Group PP-Statistic	-4.332273	0.0000
Group ADF-Statistic	-1.827492	0.0338

As we see in Table 5.3, with the null hypothesis of no cointegration, test results suggest the presence of cointegration at a significance level of 5%, both panel and group based. Consequently panel regressions can be estimated accounting for these cointegration relationships.

5.4 Testing Fixed and Random Effects

Fixed effects and/or random effects significance has been tested with F, Chi-squared and Hausman tests. According to these tests results, fixed effects are significant for our

[9]In an open economy where the government effect exists, aggregate output equals to aggregate expenditure, and this relationship can be shown as Y=C+I+G+(X-M), where Y is aggregate output, C is household consumptions, I is investment expenditures, G is government consumptions, (X-M) is net exports.

For this kind systems, There exist two general properties ; first, the productivity shock sets off transitional dynamics, as capital is accumulated and the economy moves toward a new seady state. During this transition, work effort and the great ratios (C/Y and I/Y) change temporarily. Second, there is a common stochastic trend in consumption, investment and output arising from productivity growth. In systems that incorporate both real and nominal variables, additional cointegrating relations may plausible arise [77].

However, cointegrating relationship between two variables has been tested,as in the recent works on Augmented Solow Growth Model.

model. Primarily, F and Chi-squared tests have been carried out as to test whether the fixed effects are significant or not. Test result can be seen below:

Table 5.4 Redundant Fixed Effects Tests

Test cross-section fixed effects

Effects Test	Statistic	d.f.	Prob.
Cross-section F	683.568178	(11,119)	0.0000
Cross-section Chi-square	599.299243	11	0.0000

In Table 5.4, there exist F and chi-squared statistics and their p-values; according to the results of F and Chi-squared tests, the fixed effects are significant.

Table 5.5 Correlated Random Effects-Hausman Test

Test cross-section random effects

Test Summary	Chi-Sq. Statistic	Chi-Sq. d.f.	Prob.
Cross-section random	0.098125	1	0.7541

In Table 5.5, there exists chi-squared statistic and its p-value of the correlated random effects, Hausman test.Aaccording to the test results, the random effects are not significant, for our estimation.

5.5 Estimation

After finding the cointegrating relationship between two variables, then we estimate the panel regression.For twelve countries which have non-stationary behaviour, we have estimated pooled DOLS, with country-specific fixed effects and deterministic individual trend added. Pooled DOLS estimation which has been done using E-views, can be seen below:

Table 5.6 Pooled OLS E-views Output

Dependent Variable: LN(Y)

Method: Pooled Least Squares

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	8.933658	0.070871	126.0547	0.0000
LN(IY)	0.423911	0.021661	19.57067	0.0000
AT_@TREND	0.021882	0.000265	82.72624	0.0000
BE_@TREND	0.013161	7.95E-05	165.6498	0.0000
DE_@TREND	0.015385	0.000223	68.86925	0.0000
ES_@TREND	0.009733	7.77E-06	1253.145	0.0000
FI_@TREND	0.019458	3.64E-05	534.7055	0.0000
FR_@TREND	0.007169	5.54E-05	129.3188	0.0000
GR_@TREND	0.033780	0.000412	81.94231	0.0000
IE_@TREND	0.026225	0.000740	35.42456	0.0000
IT_@TREND	0.002963	5.06E-05	58.52883	0.0000
LU_@TREND	0.021759	2.16E-05	1008.766	0.0000
NL_@TREND	0.015526	0.000220	70.42890	0.0000
PT_@TREND	0.012409	0.000544	22.80386	0.0000
Fixed Effects (Cross)				
AT_C	0.081059			
BE_C	0.033675			
DE_C	0.064584			
ES_C	-0.193028			
FI_C	-0.056173			
FR_C	0.050551			
GR_C	-0.401864			
IE_C	0.060347			
IT_C	-0.048891			
LU_C	0.740668			
NL_C	0.194785			
PT_C	-0.525712			

Effects Specification

Cross-section fixed (dummy variables)

F-statistic	1233.338
Prob(F-statistic)	0.000000

When we look at the pooled OLS results in Table 5.6, we are able to see that, our panel estimation is statistically significant. F-statistic value of the model is less than 0.05; then we can say that the pooled estimation is significant at %95 significance level.

Pooled equation model has been estimated as in the equation (4.33), $Y_{it} = \alpha + \beta X_{it} + u_{it}$.

$$\ln(Y)_{it} = 8.933658 + 0.423911 \ln(I/Y)_{it} + \varepsilon_{it}$$

Slope coefficient value is 0.423911. Based on the panel regression result, a 1 percent increase (decrease) in investment share on GDP is associated with a 0.4239% increase (decrease) in real GDP growth per capita.

In pooled estimation, unlike single equation time series estimations, it is assumed that the pooled estimation is independent from time series estimations.

Single equations for each country are estimated as:

$\ln\,(Y_{it}) = c_i + \alpha + g_i t + \beta_i \ln\,(I/Y)_{it} + \varepsilon_{it}$

wherec_i individual-specific fixed effects, α common intercept, $g_i t$ individual deterministic trend and βcommon slope coefficient. Estimated single equations with common slope coefficients are below:

*AT_ln(Y) = 0.081059 + 8.933658 + 0.423911*AT_ln(I/Y) + 0.021882**$g_{AT}t + \varepsilon_{it}$

*BE_ln(Y) = 0.033675 + 8.933658 + 0.423911*BE_ln(I/Y) + 0.013161*@*$g_{BE}t + \varepsilon_{it}$

*DE_ln(Y) = 0.064584 + 8.933658 + 0.423911*DE_ln(I/Y) + 0.015385**$g_{DE}t + \varepsilon_{it}$

*ES_ln(Y) = -0.193028 + 8.933658 + 0.423911*ES_ln(I/Y) + 0.009733**$g_{ES}t + \varepsilon_{it}$

*FI_ln(Y) = -0.056172 + 8.933658 + 0.423911*FI_ln(I/Y) + 0.019458**$g_{FI}t + \varepsilon_{it}$

*FR_ln(Y) = 0.050551 + 8.933658 + 0.423911*FR_ln(I/Y) + 0.007169**$g_{FR}t + \varepsilon_{it}$

*GR_ln(Y) = -0.401864 + 8.933658 + 0.423911*GR_ln(I/Y) + 0.033780**$g_{GR}t + \varepsilon_{it}$

*IE_ln(Y) = 0.060347 + 8.933658 + 0.423911*IE_ln(I/Y) + 0.026225**$g_{IE}t + \varepsilon_{it}$

*IT_ln(Y) = -0.048891 + 8.933658 + 0.423911*IT_ln(I/Y) + 0.002963**$g_{IT}t + \varepsilon_{it}$

*LU_ln(Y) = 0.740668 + 8.933658 + 0.423911*LU_ln(I/Y) + 0.021759**$g_{LU}t + \varepsilon_{it}$

*NL_ln(Y) = 0.194785 + 8.933658 + 0.423911*NL_ln(I/Y) + 0.015526**$g_{NL}t + \varepsilon_{it}$

*PT_ln(Y) = -0.525712 + 8.933658 + 0.423911*PT_ln(I/Y) + 0.012409**$g_{PT}t + \varepsilon_{it}$

When we look at the dynamic OLS results, also in connection with the economic theory, there exist a positive relationship between investment shares on GDP and real GDP per capita.Investment shares on GDP (*ln(I/Y)*) series is an important component for their economic growth (*ln(Y)*) series, even if there are decreasing returns to scale.

For single equations, any omitted factor that constant over time or evolve smoothly over time will be absorbed into country specific fixed effects, $c_i$and country specific deterministic trend, $g_i t$.

All countries have a trend effect in the same way, which is positive. The fixed effects absorb the impacts that both of these types of intangible capital inputs have on the level of per capita income after conditioning on measured physical capital investment shares and any country specific trend growth rates. The inclusion of the heterogeneous deterministic trend terms permits the panel specification to be sufficiently general to accommodate mechanisms that might explain the cross country dispersion of per capita incomes in terms of differing rates of productivity. Spain, Finland, Greece, Italy and Portugal have relatively lower intangible capital inputs, then other countries.

The slope coefficient on measured physical capital investment shares still depends only on production function share parameters of the capital stock types whichare accumulated by using a fraction of measured income, such as human capital and possibly some components ofsocial capital. The key point in this discussion is that the cointegrated panel specification is sufficiently general tohandle a number of different possibilities regarding the nature of the unmeasured intangible capital stock, but wemust take care to interpret the meaning of the slope coefficients accordingly.

However, in a panel DOLS model, we take into account that whether the pooled equation is statistically – obviously, also economically – significant or not.

Economically, when the share of investment in GDP increases, the real GDP growth rate also increases, according to the panel DOLS regression. The investment share on GDP has a positive effect on real GDP growth.

CHAPTER 6

RESULTS AND DISCUSSION

According to the pooled DOLS, in the long-run, we find that changes in investment share on GDP is associated with changes in real GDP growth per capita for selected Euro Area countries. We realize a panel DOLS as to estimate the coefficients of long-run growth identifiers of Euro Area countries. Based on the Augmented Solow Growth model, and on the knowledge that the permanent changes in the investment shares on GDP and real GDP growth per capita should be associated, we apply this model, for a specific area.

In single-equation vector point estimates, heterogeneity and persistence can have substantial variability, then these estimators can be sensitive to the particular time span of the observations as well as to the particular individual being studied. For these situations, panel DOLS estimators can be much more precise.

For the countries which have high public debt ratios Italy, Ireland, Greece, Portugal and Spain, their economic growth paths can be observed separately in another study. Their economic growth changes can be related with their debiting ratios.

Apropos of the differences on intangible capital; Finland, Greece, Italy, Portugal and Spain have relatively lower intangible capital inputs, then other countries. These countries which have negative country specific fixed effects, c_i, their intangible capital levels as the accumulation of human capital have negative effect on their economic growth paths for this period. Austria, Belgium, France, Germany, Ireland, Luxembourg, and Netherlands have relatively higher intangible capital levels, according to the their positive country specific fixed effects, c_i.

As for the estimated panel DOLS regression for Augmented Solow Growth model, using a panel of 12 countries of the Euro Area, with annual data from 1999 to 2010, the estimated investment shares on GDP elasticity is a 0.4239 in the pooled estimation. The increases in the investment shares on GDP, in other words in the propensities to invest have important effects on their economic growths. The increases in investments will have positive effects on the economic growth level.

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APPENDIX-A

SUMMARIES OF THE PANEL UNIT ROOT TESTS RESULTS

Panel unit root test: Summary
Series: LN_Y

Method	Statistic	Prob.**
Null: Unit root (assumes common unit root process)		
Levin, Lin & Chu t*	0.32204	0.6263
Breitung t-stat	3.45177	0.9997
Null: Unit root (assumes individual unit root process)		
Im, Pesaran and Shin W-stat	0.16811	0.5668
ADF - Fisher Chi-square	9.91008	0.7687
PP - Fisher Chi-square	3.76940	0.9967

** Probabilities for Fisher tests are computed using an asymptotic Chi-square distribution. All other tests assume asymptotic normality.

Panel unit root test: Summary
Series: LN_IY

Method	Statistic	Prob.**
Null: Unit root (assumes common unit root process)		
Levin, Lin & Chu t*	-1.4165	0.0783
Breitung t-stat	0.20335	0.5806
Null: Unit root (assumes individual unit root process)		
Im, Pesaran and Shin W-stat	-1.20798	0.1135
ADF - Fisher Chi-square	31.3279	0.0896
PP - Fisher Chi-square	12.0798	0.9557

** Probabilities for Fisher tests are computed using an asymptotic Chi-square distribution. All other tests assume asymptotic normality.

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Undergraduate	Econometrics	Istanbul University	2008
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WORK EXPERIENCE

Year	**Corporation/Institute**	**Enrollment**
2010-2013	Club Med	Sports-Animation
2008-2010	Playmaker Sport Event Company	Event Management
2007-2008	Garanti Bank	Long Term Internship

PUBLICATIONS

Papers

1. A Logistic Regression Application on Credit Scoring, 2012, n'denN'ye Gezinti Statistics Review.

Conference Papers

1. Calculation of Value at Risk on ISE100 index, by using Monte Carlo Simulation Method, with Karaman, F., 2011, 12thInternational Symposium on Econometrics Operations Research and Statistics.
2. Comparing Logistic Regression, Discriminant and CHAID Analyses on Credit Scoring Application, with Kayman,H. and Karaman, F., 2012, 13th International Symposium on Econometrics Operations Research and Statistics.
3. A Comparative Statistical and Econometric Analysis of Macroeconomic Variables for Greece, Spain, Portugal, Italy and Turkey, with Karaman, F., 2012, 13thInternational Symposium on Econometrics Operations Research and Statistics (Poster Session)

AWARDS

1. Obtained the first place in the Statistical Research Project Competition organized by "n'denN'ye Gezinti Statistics Review" with "A Logistic Regression Application on Credit Scoring" Project