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Financial Development and Growth: Testing a Dynamic Stochastic General Equilibrium Model via Indirect Inference

by

Katerina Raoukka

Economics Section
Cardiff Business School
Cardiff University

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CARDIFF UNIVERSITY

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Financial Development and Growth: Testing a Dynamic Stochastic General Equilibrium Model via Indirect Inference

Abstract

Macroeconomics research has made a quantum leap in the past decade in establishing a new workhorse model for open economy analysis. The unique characteristic of this literature is the introduction of the financial system in a dynamic general equilibrium (DGE) model which is based on microfoundations. Its introduction in a DGE model is essential to explain empirical facts such as growth differences across countries. The aim of this thesis is to show whether the behavior of growth can be explained by financial development within a classical approach. The model's ability to explain growth by setting financial development as a causal factor is tested against the model's performance to explain growth via setting the human capital as a causal factor. The question proposed and answered in this thesis is the following: Can an increase in productivity be produced by a development in the financial system or in the educational system and if so, is growth determined by this increase in productivity? The empirical performance of DSGE models is under scrutiny by researchers. This thesis is introducing the reader to a fairly new and unfamiliar testing procedure; indirect inference which is fully explained and applied. The idea of the thesis is to provide a better identified model compared to the already established econometric models on the financial development and growth nexus. The procedure followed is firstly to set up a well-established microfounded model and then to connect it to the theory via an establishment of the time series properties of various macroeconomic variables. The results based on 10 sample countries indicate that setting financial development as a causal factor explains the data behavior of macroeconomic variables better than a model which considers human capital as a driver of economic growth.

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Non-Technical Summary

Macroeconomics research has made a quantum leap in the past decade in establishing a new workhorse model for open economy analysis. The unique characteristic of this literature is the introduction of the financial system in a dynamic general equilibrium (DGE) model which is based on microfoundations. The financial system is captured by the ratio of private credit to the gross domestic product (GDP). Its introduction in a DGE model is essential to explain empirical facts such as growth differences across countries. The aim of this thesis is to show whether the behavior of growth can be explained by financial development within a classical approach. The model's ability to explain growth via financial development is tested against the model's performance to explain growth via educational investment captured by the ratio of government spending in education to GDP.

Specifically, a dynamic stochastic general equilibrium (DSGE) model is built to examine the theory supporting that a productivity burst can lead to temporary or permanent effect on growth and other macroeconomic variables. It is already empirically well-established that increases in productivity lead to higher growth levels and rates. The question proposed and answered in this thesis is the following: Can an increase in productivity be produced by a development in the financial system or in the educational system and if so, is growth determined by this increase in productivity? Lucas' critique (Lucas, 1976) began a new strand of research for building macroeconometric models. Previous model formulations were judged on the basis of not being structural as well as for incorporating ungrounded identifying restrictions (Sims, 1980). Dynamic stochastic general equilibrium (DSGE) models emerged in the hope to overcome these shortcomings. The empirical performance of DSGE models is under scrutiny by researchers. There is no settlement on the best way to evaluate a

DSGE model especially after the Bayesian methods of estimation were introduced. Moreover, macroeconomic data are generally non-stationary and in order to test models researchers used techniques such as the HP-Filter or the Band Pass to remove the trend. However, the stationarised data has been judged for drifting away from the theories used in these models. This thesis is introducing the reader to a fairly new and unfamiliar testing procedure; indirect inference. It aims to explain its application on DSGE RBC models and its suitability when working with non-stationary data. Ten countries are examined in a 'one size fits all economy'. The 10 countries used are small open economies and thus the rest of the world is taken as given. The interaction with the rest of the world comes in the form of the current account and is derived explicitly from the agent's optimisation decisions.

The model uses quarterly data on all countries under examination. It is highly non-linear and it is solved numerically after calibration. Impulse response functions are produced to show the permanent effect of a one percent increase in productivity on other macroeconomic variables such as consumption and trade variables with an aim to show the position of a new equilibrium producing business cycle. The fact that productivity is set up to be affected by the financial system (or by the education system) is enlightening to the idea that economic growth may be explicable by financial development within an RBC context.

The method of 'bootstrapping' is used to supply further testing of the model's performance. Firstly, the errors of the model are estimated or calculated and then, they are used in the procedure of simulating the model in a repetitive nature as to create a 'satisfactory' large number of potential scenarios for the economy over the period of the actual sample. A time series equation for growth is estimated using the actual data. The produced simulations are used to re-estimate the growth equation to provide a sampling range for the estimates of this equation. If the model is correct, then at a probability or 'confidence' of 95% the actual estimates lie within the sampling range and aid in deciding whether to reject or accept the null hypothesis of the model being correct.

The results are in favour of the McKinnon (1976) and Shaw (1976) hypothesis that financial development explains economic growth behavior better compared to educational development. The possibility of other factors or the case of a vice versa result is not excluded under the restriction of different sample dates and countries. The idea of the thesis is to provide a better identified model compared to the already established econometric models on the financial development and growth nexus. The procedure followed is firstly to set up a well-established microfounded model and then to connect it to the theory via an establishment of the time series properties of various macroeconomic variables. Finally, the model is tested against the established facts by the method of indirect inference. Briefly, this method involves mimicking the economic environment in a stochastic framework to examine whether the data regression coefficients lie within the acceptance region of 95% confidence limits created by the coefficients of the model. The contribution of this thesis is thus focused on testing two well-known theories by using a unique innovative method drifting away from the simple econometric models.

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Chapter 1

Introduction

The issue of causality between financial development and growth is theoretically controversial. There is a priory a number of possibilities concerning this causal relationship including the possibility of no causality. The possibility of no causality implies that neither of the two has a considerable effect on each other and any observable relationship is a result of both growing at the same time but independently. Another possible statement is that financial development follows economic growth which implies that growth is a causal factor for financial development and the latter is thus demand driven. On the contrary, financial development can be a determinant of economic growth which implies a line of causation running from financial development to real development. Lastly, financial development can also be viewed as an impediment to economic growth. The current financial turmoil led to the idea that the financial sector is a transmitter of shocks rather than an absorber of shocks (Arcand, Berkes, and Panizza, 2011). Under this hypothesis, financial development can still be considered a determinant of growth but the focus lies on its potentially destabilising effects on economic growth. Unfortunately, there is no simple procedure to determine which of these views is empirically adequate. The econometric problems (some of which include measurement error, reverse causation and omitted variables) occurring when testing for the relationship as well as the causality between financial development and growth have proven to be an obstacle in even falsifying some of these views (Beck, 2008). The common ways used to test any causal relationship between financial development and growth have been the use of simple, linear or non-linear regressions usually cross country ones and more rarely panel regressions with no identification structure. Theoretical endogenous growth models have been used to test the relationship claiming that financial intermediation can result in higher equilibrium growth rates but these models fail to account for causality (Bencivenga and Smith, 1991).

The aim of this thesis is to analyse the problems of the up to date empirical research on the finance-growth nexus and to use an innovative way of testing whether financial development is a causal factor for growth. The standard neoclassical theory assumes that financial systems function efficiently where financial factors are often neglected from the analyses. Growth theory views economic growth as the result of innovation, human capital and physical capital accumulation while providing little or no attention to the financial sector. There is a general agreement that long-term sustainable economic growth depends on the ability to enhance physical and human capital accumulation which result in the use of productive assets more efficiently and ensure that the whole population has access to these assets. This thesis takes the stance that this investment process is supported via the level and the growth of financial development. To support this view, human capital theory is used as a competing theory of growth and is tested against the financial development theory. The null hypothesis is therefore that financial development is a causal factor of growth and it is this hypothesis that the second part of this thesis examines.

The objective of the thesis is to bridge the gap between theory and empirics in macroeconomics. This is a three-stage process. First, I build two micro-founded theoretical models; one for financial development and one for human capital. In the first one I assume that productivity and growth are driven by financial development and that human capital is demand following. In the latter model, the assumption is that the human capital is the causal factor instead while financial development is demand following. Second, the facts are established in terms of the time series properties of various macroeconomic variables. The final stage is testing both models against the stylised facts of the world using rigorous bootstrapping methodology called indirect inference. This procedure involves replicating the stochastic environment to see whether the regression coefficients in the data lie within 95% confidence limits, for those coefficients, implied by the model.

This thesis constitutes a contribution to the application of the indirect inference methodology. Although DSGE models have been under test for many years, the theory of financial development and/or human capital has not been tested in such a way before. This work has two main original pieces. The first one is the introduction of human capital and financial development in a DSGE model to be tested via indirect inference. The second is the use of a panel vector error correction model (PVECM) as an auxiliary model -which is represented by PVAR in levels-. The thesis abstracts from the usual simple growth regressions that have been used over the years for testing the relationship and/or the causality between financial development and/or human capital and growth. This thesis provides two core contributions. Firstly, it uses indirect inference within the concept of financial development theory and human capital theory -independently-. This becomes an original way of 'solving' the identification problem by setting a well-defined structural DSGE model. Secondly, the auxiliary model deviates from the simple VAR representation of the DSGE towards a relatively more complicated panel procedure using a PVECM to deal with non-stationary data.

The thesis is organised as follows. The second chapter familiarises the reader with the literature on growth theories and how these have evolved over time to include financial development and human capital accumulation as important determinants of the growth process. It is also an introduction to the underlying concepts of models embodying a real business cycle (RBC) framework which is used in subsequent chapters of the thesis to evaluate the impact of human capital and financial development through productivity shocks emerging from the these two theories independently. This chapter provides a trace to the developments in the literature which add government expenditure, taxes, money, and open economy extensions. This chapter finishes by reviewing the role of financial development and human capital in growth models. A short literature and empirical review is given on the use of public government expenditure as a proxy for human capital since this variable will be used in subsequent chapters as the variable which represents human capital.

The third chapter provides the answer behind the existence of financial intermediaries.

The reason why financial intermediaries exist is obvious only after the functions of the financial system are described. The chapter provides the reader with a definition of financial development as provided by relevant studies and shows the role of financial development in a simple AK model while outlining the functions of the financial system to relate each function to economic growth. This chapter is also a description of the most commonly used indicators providing their advantages and disadvantages. The indicators are separated according to size, access and depth to familiarise the reader with the concept of financial development. The main aim of this chapter is to offer the reader the reason why private credit to GDP is used as an indicator for financial development in this thesis. The main conclusion is that financial institutions are given the role of an intermediary between the saver and the lender and the functions of a financial system aid in materialising long term projects which have an impact on productivity and thus growth. It is this impact that subsequent chapters will try to test and analyse.

Chapter four gives an extensive review of the empirical work from 1969 to 2011. The reader is introduced to the three main types of regressions in order to establish a relationship between financial development and economic growth; cross country with or without panel techniques, time series, and microeconomic-based techniques. Since relationship never implies causality this chapter also provides a short review of the studies focusing on causality and on one country cases. The chapter concludes by describing the econometric caveats of all three approaches which act as an incentive for the unique testing method used in the subsequent chapters.

Chapter five takes the reader back to 19676 when Lucas' critique began a new strand of research for building macroeconometric models. Previews model formulations were judged on the basis of not being structural as well as for incorporating ungrounded identifying restrictions. Dynamic stochastic general equilibrium (DSGE) models emerged in the hope to overcome these shortcomings. There is however no settlement on the best way to evaluate a DSGE model. Moreover, macroeconomic data are generally non-stationary and in order to test models researchers used techniques such as the HP-Filter or the Band Pass to remove the trend. However, the stationarised data has been judged for drifting away from the theories used in these models. This chapter is introducing the reader to a fairly new and unfamiliar testing procedure; indirect inference with an aim to explain its application on DSGE RBC models and its suitability when working with non-stationary data. It provides reasons for the superiority of indirect inference compared to other methods of testing such as the Likelihood Ratio and the Del Negro-Schorfheide measure and explains its usefulness when working with non-stationary series. This chapter discusses the use of DSGE-VAR as a toolkit for evaluating DSGE models. This is a useful guide for the reader to follow the next chapters when a PVAR (panel vector autoregression) is used to represent the model outlined in Chapter 6.

The sixth chapter provides theoretically coherent micro-foundations for macroeconomic models and construct an econometrically testable dynamic general equilibrium open economy model. The model is a prototype RBC model enriched by the inclusion of a representative agent framework as in McCallum (1989). The model is based on optimising decisions of rational agents, incorporating financial development and/or human capital accumulation. The chapter describes the method of calibration. The specific model is calibrated using quarterly data for ten countries. The computer algorithm and the simulation procedure is explained. The main aim is to evaluate how the model economy will behave over time when it is hit by multiple shocks and graphically describe the motion of variables after a productivity shock (Impulse Response Functions, IRFs) which is done at the end of this chapter.

In Chapter 7, the testing procedure described in Chapter 5 is used to test the model outlined in Chapter 6. The chapter introduces the reader to the data used, describes the auxiliary model and analyses the results. The reader is introduced into PVAR regressions and is provided with an explanation for the reasons a PVAR is the chosen auxiliary model. The chapter explains the Wald Statistic, the transformed Wald and the M-metric and empirically evaluates the auxiliary model. It also provides the reader with the results and a discussion. The conclusion is that a model where the causal factor is financial development is better at explaining data behavior compared to a model with human capital as the causal factor. To show the magnitude of this conclusion, IRFs are provided representing the behavior of the variables after a shock to the financial sector. This chapter also provides robustness tests. Policy implications in this framework arise in the form of a guide towards deeper financial systems and are discussed in Chapter 7.

The final chapter presents the main findings of this thesis.

Chapter 2

Financial Development and Human Capital in Growth Theories

2.1 Introduction

Motivated by the extreme income differences across countries, researchers urge to build economic models in order to explain the determinants of growth and the gap observed in the growth rates of developed and developing countries.[1] In the 1990s, research on growth expanded to include political economy factors and institutions. In the past two decades as household, firms and governments around the world became dependent on the resilience of the financial system, a voluminous theoretical and empirical research attempts to investigate the relationship and the causality between financial development and growth. Moreover, public spending on education is a major contributor to the development of human capital. The relationship between human capital and economic growth has been examined vigorously over the years. An initial analysis of broad statistics for all EU Member States and developing countries suggests a loose correlation between investment in human resources and growth in gross national product (GNP), but any clear causal relationship is difficult to be established. Much of this research draws on the seminal work by Becker (1964), Mincer (1974)

[1] Detailed examination on economic growth theories is given in Acemoglu (2007) while income differences are examined in Caselli (2004).

and many others. This body of work is founded on a microeconomic approach. Nevertheless the results have important macroeconomic implications. They highlight the strong links observed between education, productivity and output levels. Although some have questioned the direction of causality and argued that much education simply acts as a screening device to help employers to identify more able individuals, the general consensus seems to be that education does result in higher individual productivity and earnings (Barro and i Martin, 1995). Increased investment in education is shown to lead to higher productivity and earnings for the individual and thus such an investment results in significant social rates of return (Becker, 1964; Mincer, 1974).

Understanding the relationship between financial and the real sector as well as the relationship betwen investment in education and the real sector requires an examination on the background of the both theories. This chapter is organised as follows. Section 2.2 introduces a timeline of growth theories to demonstrate the creation of RBC models. Section 2.3 introduces the reader to the concept of business cycles and RBC. Section 2.4 briefly describes the connection between business cycles and growth. Section 2.5 gives a short survey on the extensions applied to the RBC model. Section 2.6 is a description of the role of financial development in growth theories and RBC framework. Section 2.7 is a similar description on the role of human capital in growth theories and gives a brief description of human capital indicators and empirical studies. The conclusions are described in Section 2.8.

2.2 Theories of Economic Growth

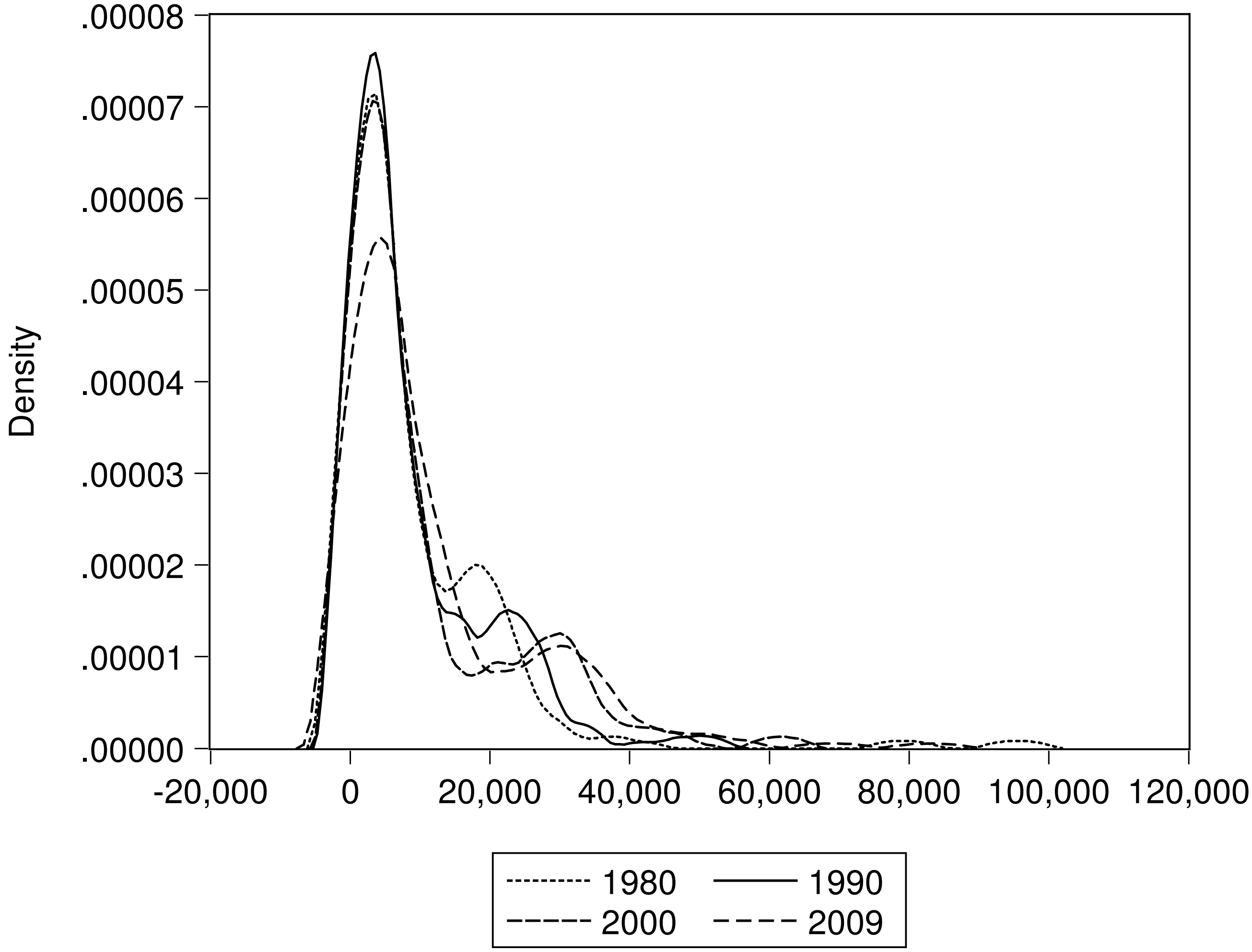
Since the days of Adam Smith, economists have persistently been preoccupied with the growth of nations. This subject is an enormous one. To do full justice to it would require great detail which falls outside the scope of this thesis. However, to include financial development and investment to education among the determinants of growth, one needs to comprehend the gravity that economists have given to the subject of output growth. Waves of research endeavour to shed a light on the determinants of growth as well as on the differences between the growth rates of countries. Years of research and voluminous studies attempt to solve the so called 'Mystery of Growth' (Helpman, 2004). Explanations of growth go back to the days of Thomas Malthus, David Ricardo, Trevor Swan and Robert Solow. Great names of the neo-classical growth models are among others that of Harrod (1948), Verdoorn (1956), Domar (1957), Inada (1963) and Kaldor (1961). The vast amount of interest on countries growth rates arises from the differences in incomes across countries. Figure 2.2.1 provides a first look at the differences in income. It plots estimates of the distribution of PPP-adjusted gross domestic product (GDP) per capita across the available set of countries in 1980, 1990, 2000 and 2009.[2] The rightwards shift of the distributions for 1980 up to 2009 shows the growth of average income per capita for the next 40 years.

There is a concentration of countries between \$20,000 and \$40,000. The density estimate for the year 2000 and 2009 shows the considerable inequality in income per capita today. Part of the spreading out of the distribution in Figure 2.2.1 is because of the increase in average incomes. It is more sensible to look at the log of income per capita, that grow over time, especially when growth is approximately proportional as suggested by Figure 2.2.2 below. It is evident from Figure 2.2.2 that the spreading-out is relatively limited. This is a sign that although the absolute gap between rich and poor countries has increased between 1980 and 2009, the proportional gap has increased on a lower scale.

It can be seen however, that the 2009 density for log GDP per capita is still more spread out than the 1980 density. Both of the figures show that there has been a noticeable increase in the density of relatively rich countries, as many countries still remain on the left part considered to be poor. These diagrams are explained by the stratification phenomenon which explains the tendency of some middle-income countries moving to the high income group while others remain static or even fall in rank and join the low income ones. The theories of growth can be divided into two categories. The first category is comprised of the supply side idea which supports that productive ideas become key innovations and lead to economic growth. The second category concentrates on entrepreneurship created from incentives to invest in research and development and in knowledge which increase productivity growth rates and economic growth. The second category is fairly 'modern' and attempts to give an explanation

[2]Details on the set of countries are found in Appendix A.

Figure 2.2.1: Estimates of the distribution of countries using PPP adjusted per capita data in 1980, 1990 ,2000 and 2009

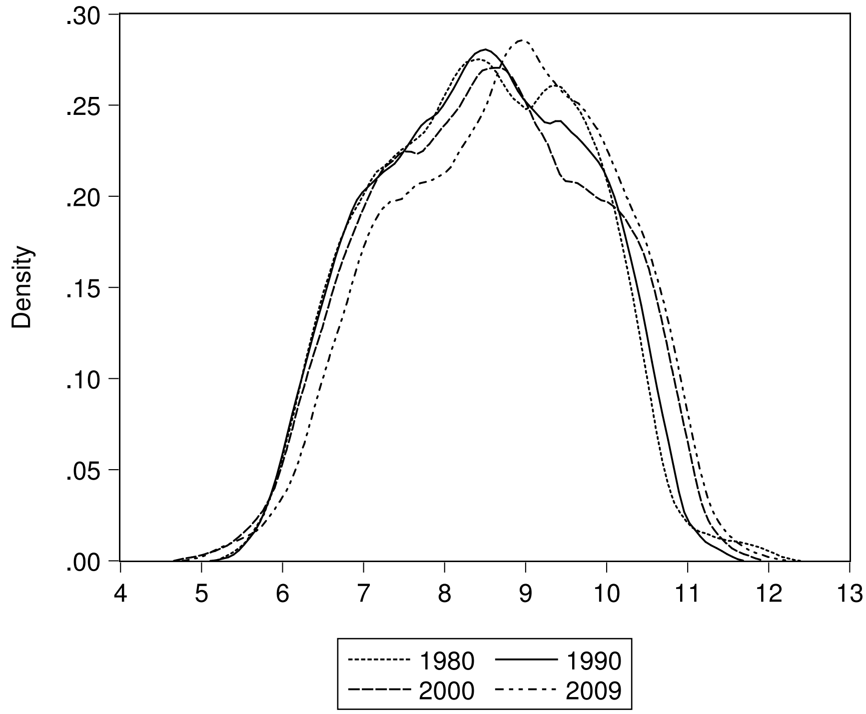


Source: World Bank Dataset

of economic growth by expanding the role of government institutions and finance.

Growth theory was developed in the 1950s and 1960s. Some of the earliest growth models are documented in Stiglitz and Uzawa (1969). The 1980s was a boom period for growth theories as the increased availability of data helped researches in building empirical models. The famous Solow (1956) model claims that the differences in factor accumulation between countries occur due to differences in saving rates. In a Solow growth model the labour force can enjoy 'capital deepening' which however runs into diminishing returns. Since accumulation on its own cannot lead to lasting economic growth Solow (1956) adds technological progress

Figure 2.2.2: Estimates of the distribution of countries using the log GDP per capita PPP adjusted data in 1980, 1990, 2000 and 2009



Source: World Bank Dataset

whose importance was measured in 1957. Although it is a relatively simple model, it reveals a number of useful insights about the dynamics of the growth process, and lays out the total factor productivity as the main driver of growth. Models that follow Solow's framework are built on the belief that economic growth arises due to the influences outside the economy and are thus called exogenous growth models. Inventions, innovation and knowledge are all exogenous forces outside the remit of this theory. According to this belief, given a fixed amount of labour and static technology, economic growth will cease at some point, as on-going production reaches a state of equilibrium based on internal demand factors. Although Solow's model was a leap from static models to dynamic models it lacks in many respects. Limitations of the exogenous growth models include failure to consider entrepreneurship and the strength of institutions as components in economic growth process. In addition, it does not explain how or why technological progress occurs.

These drawbacks welcomed a whole new and diverse body of theoretical and empirical work that emerged in the 1980s; the endogenous growth theory. The New Growth Theory developed models which endogenise technological progress and/or knowledge accumulation. In these models the choices of the public and private sector are uncovered and are considered the reason behind the various rates of growth of the residuals across countries. In such a framework technological progress is dependent upon other variables of the model and the changes in the saving rate can have growth effects on GDP per worker. Arrow (1962) introduced the learning-by-doing process applied on machine-producing industry. However this process can only explain a part of the growth drivers. Rebelo (1991) developed this theory through a model in which capital is linearly related to output. However, linearity poses problems when fixed factors are observed. Romer (1986) resolves the difficulty by introducing research and development. Knowledge accumulation leads to ideas which are non-rival and reflect increasing returns to scale. This occurs because ideas are expensive to produce and cheap to reproduce and through this mechanism research and development becomes a driver of sustained growth without relying on technological change.

Lucas (1988) uses a human capital accumulation model in the form of acquiring skills where linearities in the human capital producing sector allow for externalities in human capital which enhance growth. In these models technology is the same across countries and they differ in skill levels. Nevertheless, these models do not compensate technology which could lead to no production of knowledge. In the 1990s Schumpeterian growth models were developed motivated by the inability of the neoclassical models to account for the divergence of national growth rates. Endogenous technical change in such models is through creative destruction as in Aghion and Howitt (1992). Learning-by-doing and new innovations making old ones obsolete are the main drivers of growth. An agent's innovations are important to affect the whole economy. More specifically, competition between firms generates innovations which positively enter the productivity function and enhance economic growth. In a nutshell, these models emphasize that education, specific job training, basic scientific research and innovations are channels leading to growth.

Technically, the endogenous models of economic growth allow for policy to affect long run economic growth. Development economists consider the growth effects of human capital[3], government spending and taxation[4], trade policy[5] and financial markets[6]. In contrast to the traditional Keynesian macroeconomics, modern economics is based on dynamic equilibrium theory. Macro-economists went from the prototype models of rational expectations (Lucas, 1972) to more complex constructions like the economy in Christiano, Eichenbaum, and Evans (2005). These models have made a quantum leap in explaining growth through their main characteristic which is that they are based on microeconomic theory. The special characteristics of these models are the ability of agents to reoptimize subject to constraints such that the economy is always in equilibrium whether a short run or a long run.

In the 1970s people got more interested in understanding the macroeconomic fluctuations observed in the economy. The idea of Keynes that short run fluctuations were due to changes in aggregate demand could not explain the stagflation observed at the time. In 1982, Kydland and Prescott gave a role to technology in growth and considered this, along with market failures the contributors to short run business cycles. Kydland and Prescott (1982) along with Long and Plosser (1983) revealed a new class of models where the focus is on the behavior of economic aggregates over the course of the business cycle caused by real factors. The Real Business Cycle (RBC) methodology involves a general equilibrium model where money is of little importance and changes in productivity known as technology shocks drive the aggregate behavior and cause cycles. These models use calibration to create an artificial data that mimics observed business cycles and became important as they focus on the off steady state high frequency behavior of the economic aggregates. RBC models can be solved numerically to yield stationary laws of motion for the endogenous variables as functions of the state variables (Uhlig, 1997). This only happens if these models are transformed into stationary variant. This stationary economy is then simulated and the properties of the data

[3]Pioneering papers include Azariadis and Drazen (1990); Becker, Murphy, and Tamura (1990); Stokey (1990); Chamley (1991)

[4]Such models were extended by Jones and Manuelli (1990); King and Rebelo (1990); Easterly and Rebelo (1992)

[5]Trade policy and economic growth are examined by Grossman and Helpman (1989, 1990); Rivera-Batiz and Romer (1991)

[6]An examination on the relationship between financial development and growth was initiated by McKinnon (1973); Shaw (1973); Greenwald and Stiglitz (1991)

drawn from the model are compared with the real data properties.

Albeit a great amount of papers exist, and a vast amount of models are built, neither exogenous or endogenous models give a vibrant answer on what determines economic growth or why are some countries so much richer than others. The resultant literature brought to the attention of all the importance of geography, culture and history (Acemoglu, Johnson, and Robinson, 2001), of the quality of macroeconomic policies (Frankel and Romer, 1999) and the role of financial, political or economic institutions.

2.3 The Real Business Cycle Framework

In most industrialized countries it is often observed that aggregate economic activity is characterized by recurrent expansion and contraction. Lucas (1977) defines business cycles as the repeated fluctuations of output about the trend. The economy is thought to be on a slowly moving path (a trend) and fluctuations are the deviations from this path. This behavior is also distinguished by the co-movement of various economic activities such as the outputs of different sectors. Business cycles are thus phenomena characterized by their behavior through time. Any model of business cycles attempts to provide an explanation to this behavior by searching for the causes that give rise to these characteristics.

The Great Depression of the early 1930s convinced economists that they cannot explain business cycles with the use of microeconomic theory alone. The stagflation of the 1970s led to the breakdown of the traditional Philips curve theory and to the questioning of the appropriateness of the 1950s Keynesian IS-LM approach. The Keynesian framework was no longer a suitable model for shedding a light on the business cycle phenomenon observed. Lucas (1976) critique also emphasised how inappropriate such models are for providing unambiguous answers to policy changes. Keynesian models were based on the assumption of market failures and thus could not provide an overview of the fluctuations in the case of perfect markets. Sims (1980) and Sargent (1980)[7] pioneered a modern macroeconomic analysis

[7]Sims (1980) and Sargent (1980) were against the quantitative macro models which were not micro founded. They considered micro foundations important in estimation and identification issues.

set up to avoid these imperfections. The solution came in the early 1980s by Kydland and Prescott (1982) and Long and Plosser (1983). They attempted to present reasoning behind the fluctuations noticed in the economy by observing the attitude of the main aggregate macroeconomic variables when there is a change in technology, in policies and/or in tastes and preferences.

In contrast with the 19th century idea of business cycles, the modern theory emphasises the role of external factors instead of internal factors when accounting for the oscillations of economic aggregates. The RBC theory supports the idea that economic fluctuations are primarily a source of real factors. The two basic characteristics of RBC theory are firstly the unimportance of money in business cycles and secondly the specifications of rational agents responding optimally to real but not nominal shocks create business cycles. The RBC methodology requires the use of dynamic general equilibrium models with rational expectations and also the calibration of parameters in order for the model to fit the data. McCallum (1990) and Plosser (1989) give extensive reviews on the methodology and describe a number of disadvantages but support the idea that this approach better describes some of the essential empirical regularities observed in economic fluctuations. The basic RBC framework is comprised of many identical infinitely lived agents maximizing their utility subject to production possibilities and resource constraints. There is a single commodity in the economy produced by a constant returns to scale production technology. The production function is comprised of labour in terms of work effort and capital which depreciates with time. The feasibility of production is affected by technology changes which alter the economic environment and agents need to adapt to it. The consumer has to choose work, leisure, investment and consumption. A main assumption made is that agents are forced to form expectations of future events that may affect the way they allocate resources and time. The restriction placed on the constraints is that the sum of time spent working and on leisure is less than or equal to a specific amount of time in the period.

Agents' aim is to smooth consumption over time and take productivity changes as an incentive to re-adjust their savings, investment, work and leisure according to the prices of these factors and the productivity of labour. So the agent will invest in productive periods and use capital in unproductive periods. These adjustments agree with the stylized facts about business cycles. Consumption, investment and employment are considered procyclical in the sense that the increase in booms and decrease in recessions. Investment is three times more volatile than output and total hours worked has almost the same volatility as output. The real wage is less volatile than output. All macroeconomic aggregates are defined by large and positive persistence. This persistence helps in making business cycles predictable. Predictability is also enhanced because the structural equations of the model are derived by optimizing technique and thus the parameters of the model such as technology and preferences are regarded as structural indeed. Thus with common agents in the economy, it is easy to predict how they will choose to respond in changes of the economic environment. Therefore, the shocks that create the business cycles become clear. This is important in policy making.

However, a drawback of RBC models is their failure to reproduce some stylized facts such as positive autocorrelations of the gross national product growth in the U.S as well as the trend reverting component that has a humped-shaped impulse response function. In fact, another source of exogenous engine of growth is needed to explain the fluctuations observed in the economy.[8] It could be that monetary factors, government policy and exchange rates are the omitted variables that would explain the business cycles without the need of such huge technology shocks. Gabisch and Lorenz (1989) contend that such phenomena as the business cycles should not be considered to be a consequence of stochastic exogenous factors like technology. Moreover business cycle models have been judged for their focus on fluctuations and ignorance of growth. Kydland and Prescott (1982) integrate growth and business cycles to explain the cyclical variances of the essential economic time series given quarterly data for the U.S.

[8]More specifically Hansen and Wright (1992), describe the importance of large external shocks if the U.S data for the labour market is to be reproduced by these models.

2.4 Real Business Cycles and Economic Growth

The post war evidence from the U.S economy and most industrialized countries is that per capital values of output, consumption and capital grow continually over time which is against the neoclassical model conclusions that in the absence of productivity shocks, per capita values cease to grow and rest to steady state values. Solow (1956) concluded that the major factors determining growth were productivity and technology. However growth and business cycles were studied independently. It is a common procedure by researchers to think of business cycles and growth separately and to characterize the latter as the deviations from the smooth, deterministic trend that is taken to be a proxy for growth. Growth theory focused on the factors determining long-run behavior while business cycle theory on the short run fluctuations. Hicks (1965) stressed that there is no logic to conclude that what determines the trend and the fluctuations is any different. More specifically, Nelson and Plosser (1982) argue that output per capita behaves as if a random walk process and thus shocks to productivity have a permanent effect. Moreover, productivity grows over time and thus output, consumption and capital per capita will tend to do the same. A permanent technological progress is expressed as labour augmenting shifts in productivity. King, Plosser, and Rebelo (1988) and King, Plosser, Stock, and Watson (1991) show that in the case of a stochastic technological progress, output, consumption and investment per capita will all contain some element of random walk or stochastic trend. This implies that each permanent shock creates a new growth path. A permanent change in productivity leads to a series of dynamic responses. What follows after a permanent change in productivity, leads to the conclusion that the fluctuations observed are a result of the same factors that create growth.

Kydland and Prescott (1982) pioneered the connection between economic growth and business cycles. An essential difference between their model and the standard growth models is the introduction of multiple time periods needed to build new capital goods.[9] Only once the capital goods are finished they can enter in the production capabilities of the economy.

[9]Kydland and Prescott (1982) assume that it takes around four quarters to build new capital goods.

A central component of their model is the non-time-separable utility function.[10] This assumption creates greater volatility in the hours worked as it implies a greater intertemporal substitution of leisure. If the consumer works a lot today, in the future he appreciates leisure more. It is difficult for RBC models to have an analytical solution due to the non-linearity in the dynamic system of equations arising especially between the multiplicative elements in the Cobb-Douglas production function and the additive terms in the law of motion of capital stock (Campbell, 1994). Thus a linear approximation method needs to be applied. The solution given by Kydland and Prescott (1982) is to linearise the first order conditions using an approximation. After calibration and simulation their paper proved that a number of business cycle fluctuations can be mimicked quite well using a model with no money or government.[11] One of the criticism their paper faced was that the variability of hours worked tends to be low relative to the data.

Hansen (1985) and Rogerson (1988) introduce indivisibility in the labour supply decision so that agents have a choice to work full time or not at all in response to a stochastic technology shock. The choice of entering and leaving the working pool creates a continuous variation of hours worked creating an increased volatility as a response to productivity shifts in contrast to the standard model. The introduction of heterogeneity across agents in the economy is another way to increase the volatility and response of hours worked. Different skill levels may lead to incorrect, lower estimates of aggregate labour supply elasticity. The heterogeneity approach is used in Cho and Rogerson (1988), King, Plosser, and Rebelo (1988) and Rebelo (1991), Krusell, Smith, and Jr. (1998). Although most models concentrate on one sector economy, multiple sectors economy framework has been used by Long and Plosser (1983). In a multi-sector economy, the agents allocate their savings in the consumption of many various goods. This helps explain the persistence and the co-movement observed in business cycles under the assumption of constant relative prices. Black (1987) asserts that

[10]Further discussion on non-separable utility function is given in McCallum and Nelson (2000), McCallum (2001) and Ireland (2004).

[11]The main reason for calibration is that the discounted dynamic programming problem used to get the policy functions is too complicated to allow for a closed form solution. Pagan (1994) claims that calibration involves quantitative research in which a theoretical model is taken seriously instead of using a special technique for estimating the parameters of the model.

the multi-sector extension of the neoclassical model, can explain unemployment. When a shock to preferences or technologies occurs, there is a need for labour and capital to move between sectors. Since human and physical capital are highly specialized, this re-allocation is costly and time consuming and as a result unemployment is likely to rise.

An alternative approach analysed by King, Plosser, and Rebelo (1988), Gomme (1993), Ozlu (1996) and Baranano (2001b,a) among others is to integrate the analysis of cycles with endogenous growth. The idea in these models is to allow for human capital to be produced using physical and human capital in the production technology. In such cases, a permanent effect in productivity results in more output and this leads to more resources being devoted to human capital. This alteration in the allocation decisions lead to greater level of technology and more growth in the economy. A productivity shock in such models leads to complex changes in work effort and thus consumption. An understanding of these models is a step closer to understanding the growth and fluctuations relationship.

2.5 Further Extensions to the RBC Framework

2.5.1 Government

Government has no role in the standard RBC model with complete markets and no externalities. However, government spending and taxes are an important source of real disturbances to the economy. Changes in the government spending create a demand side shock to the model. Mankiw (1989) contends that an increase in government spending increases the demands for goods. To keep the economy at equilibrium the real interest rates are required to increase. Due to intertemporal substitution effects noticed in RBC methodology, the agent will choose to increased current working hours relative to the future when faced with the increased interest rates. This increases the equilibrium output and employment. Adding the government's actions in the model helps analyst the effects of fiscal policy changes. Arrow (1962), Brock (1975) and Romer (1986, 1987) follow this line of research. More specifically, in their models, the government's actions are taken in the agent's decision problem. Government spending can have a negative wealth effect reducing consumption and leisure and increasing work and output. Increased government spending may also lead to a temporary intertemporal substitution away from consumption and investment inducing work effort and output. Fiscal shocks' effect on the labour market dynamics are examined by Christiano and Eichenbaum (1992)[12] , Braun (1994), McGrattan (1994)which enhance the model's ability to fit the US data originally tested by Kydland and Prescott (1982).

2.5.2 Money

RBC framework has focused mainly on models without a role for money.[13] King and Plosser (1984), Kydland (1989), Eichenbaum and Singleton (1986) and Cooley and Hansen (1989) introduce money and examine the implications of this in real business cycle model. Money is introduced as something that agents wish to hold positive amounts of. King and Plosser (1984) add money and banking into a real business cycle theory and create a model of money, inflation and growth. Money in the utility is introduced by Sidrauski (1967) where the equilibrium consists not only of paths for consumption, capital, employment etc. but also for money balances. Clower (1967) as well as Cooley and Hansen (1989) introduce cash-in-advance models to emphasize the weathered system of barter. The cash-in-advance constraint is binding only in the case of consumption. Investment and leisure are treated as credit goods. Any unexpected inflation drives consumers away from the use of money and thus towards leisure and investment. There has always been a controversy on the role of money since it is not perfectly understood (Plosser, 1989).

2.5.3 Open Economy

Growth and fluctuations may be subject to changes in the ability to lend and borrow internationally. Extending the model as an open economy model, the country is affected not

[12] Traditionally, the weakness of RBC models has been their ability to explain the weak correlation between hours worked and wages. Christiano and Eichenbaum (1992) argue that neglecting the role for government expenditure shocks RBC models cannot correctly explain the labour market dynamics.

[13] King (1981) demonstrates that in a Lucas (1973) framework, real output and monetary information should be uncorrelated.

only by its own productive capabilities but also by the rest of the world. Examination of open economies shows that equilibrium consumption paths are less variable while investment is more volatile as capital is allocated to the country with the most favourable technology conditions. Backus and Kehoe (1992) provide a background on the international aspects of the business cycles. Mendoza (1991) is the first to one to have applied the Kydland and Prescott (1982) model on a small open economy. The model manages to replicate some of the stylized facts which usually are (a) the positive correlation between national savings and investment,[14] (b) the worsening of the net foreign asset position of the country after an increase in output and (c) the current account and the trade balance move counter cyclically. Other papers such as Lundvik (1992), Backus, Kehoe, and Kydland (1992), Correia, Neves, and Rebelo (1995), Mendoza (1995), McCurdy and Ricketts (1991) all follow the same idea introduced by Mendoza (1991) to enhance the ability of the model to explain the stylized facts.

2.6 The Role of Financial Development in Growth Theories

The relationship between financial development and growth is under scrutiny ever since the first money was discovered in Lydia. Back in 33 AD, Rome banks experienced the first case of bank run and its people wavered between supporting a banking system to be controlled by the government or by the private sector. It has been since that many are against the way a banking system is established. In the 19th century, Bagehot (1873) and Schumpeter (1912) emphasized that financial development belongs in the factors determining growth through the funding of innovative investments enhanced by banks which is important for the level and growth rate of the national income. Schumpeter (1912) stated that the first thing an entrepreneur wants is credit. In a simple capitalist system, the bank becomes the producer

[14] Obstfeld (1986) claims that in a non-stochastic dynamic model with perfect capital mobility, persistent productivity shocks create a correlation between savings and investment. Finn (1990) however, contends that correlation between savings and investments mainly depends on the stochastic process of underlying technological disturbances.

of this commodity. The idea that financial development and especially credit matter for growth was firstly pointed out by Schumpeter (1912). He supports that entrepreneurs need credit in order to finance ideas and realisation of new production technologies. Banks are considered as the most important channel through which financial intermediating activities are supported and enhance growth. Along the lines of Schumpeter follows Gurley and Shaw (1955) by proposing that economic development includes not only goods but also finance. Written by Keynes (1930) "bank credit is the pavement along which production travels, and the bankers if they knew their duty, would provide the transport facilities to just the extent that is required in order that the productive powers of the community can be employed at their full capacity". When the financial services become responsible for giving access to credit, they also become dominant in increasing productivity and enhancing economic growth. Such ideas led to Patrick (1966) "supply-leading hypothesis" which supports that a transfer from the traditional non-growth sectors to the modern sectors of the economy and the promotion of entrepreneurial response in these modern sectors gives a role to finance. Financial intermediaries have the role of transferring these resources from one sector to the other and enhance the Schumpeterian idea of innovation financing.

Not everyone however shares the same opinion. Robinson (1952) avowed that it is actually the augmented economic growth of an economy that creates a demand for financial services such that "where enterprise leads, finance follows". This demand-following hypothesis gives growth a pivotal role in influencing the development of the financial sector and is initiated by Patrick (1966). In his view, the lack of financial institutions in underdeveloped countries is an indication of a lack of demand for these kind of services. Savers and investors in the real economy are in need of the related financial services offered by the spur of financial institutions. The financial system thus grows with the aid of the economic environment and by changes in the tastes and preferences. Gurley and Shaw (1961), Meier and Seers (1984), Lucas (1988) and Jung (1986) endorse this view. On the other extreme, some see any role of finance at all.

The followers of the Modigliani and Miller (1958) theorem believe that, in a perfect information world, with efficient markets and no transaction costs, the value of a firm does not depend on the way the firm is financed.[15] Development economists such as Stern (1989) do not mention finance in their pioneering works of development economics (Meier and Seers, 1984). However, turbulent economic developments in Asia, Japan and recently in the U.S and Eurozone economies have renewed the issue of importance of financial systems especially on a macro level. Establishing a stable financial system has become the centre of attention in policy making.[16] Whilst a vast amount of literature emphasizes the positive impact of finance in economic growth and development, after the credit crunch research has also expanded on the negative consequences of 'too much finance' (Arcand, Berkes, and Panizza, 2011).[17] Even earlier, researchers considered finance to have a negative role in the process of growth (Morck and Nakamura, 1999; Morck, Stangeland, and Yeung, 2000). Minsky (1975), claims that an economy can easily move from a sound to a fragile financial system and support that an economic crisis can occur from such instability. Followers of this idea believe in the intervention of central banks and government spending to avoid booms and busts created by financial risky behavior. [18]

The theory and the vast amount of empirical work attempts to answer questions such as why and to what extent does society need finance; does finance do more harm on growth and welfare than it does good; do all countries need sound financial systems? The results are at least ambiguous as there is no 'one size fits all' solution. The effect of finance on growth does not seem to be uniform across countries and time (Demetriades and Hussein, 1996; De Gregorio and Guidotti, 1995; Odedokun, 1996). Law and Demetriades (2005), show that financial depth[19] has no effect on growth in countries with poor institutions. Rousseau

[15]The Modigliani-Miller irrelevance theorem states that in a perfect world, investment decisions are not dependent on financial considerations. Only in the rise of asymmetric information and the need for a relation between the borrowers and the lenders the theorem becomes of less importance. Fama (1980) also contends that in a world of equal access to capital markets, banks' decisions have no effect on price or output under general equilibrium.

[16]The Bank of England in 2010 announced plans for a reform of the UK regulatory framework to include an independent Financial Policy Committee on the belief that agents need to have confidence that the system is safe and stable, and the functions are proper in providing critical services to the wider economy.

[17]In particular, Arcand, Berkes, and Panizza (2011) show that finance has a negative effect on output growth if the credit to the private sector is equal or more than 100% of GDP.

[18]See Mankiw (1986) for more details.

[19]Throughout the thesis, financial depth refers to the ratio of private credit to GDP

and Wachtel (2002) find that finance does not affect growth in countries with extremely high inflation.[20] De Gregorio and Guidotti (1995) show that in high-income countries financial depth enters growth regressions positively and significantly over the 1960-1985 period but that the correlation between financial depth and growth becomes negative for the period 1970-85. They suggest and Levine (2001) agrees that as financial development increases, its effect on growth diminishes. Wachtel and Rousseau (2006) also find a vanishing effect of financial development and growth and claim that credit to the private sector has no statistically significant impact on GDP growth over the period 1965-2004. A possible explanation of this puzzling relationship between financial depth and growth is that in times of prosperity, the lenders and the borrowers are both rich and happy and the positive effect of finance on growth is more evident than in times of economic regress where people are reminded that financiers are like short-term greedy speculators. The non-monotonic relationship was theoretically built by Patrick (1966) in an attempt to explain that the 'demand following hypothesis' (aggregate growth brings demand for financial services) applies to the early stages of economic development and the 'supply leading hypothesis' (the functions of financial intermediaries aid in increasing growth) at later stages. Thus initially causality runs from finance to growth and as this relationship is established, the increased growth creates causality from growth to finance. Cameron (1967) explains how financial systems can be both growth-inducing and growth-induced but he focuses more on the quality and the efficiency of these services. Despite the abundance of cross country, time series and panel studies, the econometric difficulties (Beck, 2008) allow only a small amount of convincing documentation of a direct relationship between financial intermediation and the economic growth.

In the era of pre-1970s the neoclassical consumer and producer make consumption and investment decisions without any explicit reference to finance. The 'First Theorem of Welfare Economics' is using a model which has no place for money or for finance. In the 1960s the idea that financial development comes after economic growth dominated. Gerschenkron (1962) shared the view of 'economic backwardness'. His theory gives a role to the banking sector according to the countries initial degree of economic development. Countries such as

[20] This is evident in countries with double digit inflation.

Russia were considered a backward country as it needed a sound financial sector in order to increase efficiency of the industrial sector. Empirically the first work was done by Goldsmith (1969) identifying the financial development process and the necessary conditions in which a financial system can 'deepen' over time. The contribution of financial development in growth is through an expansion of financial intermediaries and the introduction of non-financial intermediaries. Goldsmith (1969) claims that, the positive effect of financial development and growth comes from the increased efficiency and volume of investment.[21]

The financing of investment thus became an important issue. The complementarity hypothesis by McKinnon (1973)[22] and the financial deepening hypothesis by Shaw (1973) are designed to give an end to the concept of financial repression and provide ways of financing productive project investments. McKinnon (1973) and Shaw (1973) in contrast to the neo-classical view state that a high real interest rate could increase savings and bank credit.[23] They argue that interest rate liberalization and abolition of financial repression policies promotes economic growth. McKinnon (1973) concentrates on the less developed countries and explains that internal financial investment (i.e. self finance) and the deposit rate are essential for promoting investment since investment cannot occur without sufficient saving accumulation in the form of deposits. Shaw (1973) on the other hand focuses on more financially advanced economies and builds a theory for supporting financial deepening and external finance.[24] This view is known as 'debt-intermediation' (Ang, 2008) and suggests that financial intermediaries promote investment through borrowing and lending. The two theories, although different, claim that investment of projects can be financed partly internally and partly externally. Models of growth following similar ideas to McKinnon and Shaw include those of Kapur (1976), Mathieson (1980), Fry (1988) and Pagano (1993).

The 1980s was a wave of neo-structulist ideas and arguments against the McKinnon and

[21] Goldsmith (1969)assigns less importance to the volume of investment relative to its efficiency. See Goldsmith (1969) pp.391-401.

[22] The complementarity theory states that in an uneven financial system, money and investment are complementary.

[23] McKinnon and Shaw go against the idea of Keynes (1936) and Tobin (1965) that financial repression accelerates economic growth.

[24] This is known as inside money approach. Inside money is backed by the internal debt of the private sector. In contrast, outside money is backed by government loans and banks make no loans to the private sector. Fry (1988) gives a formal definition of the two theories.

Shaw hypothesis. Neo-structural economists van Wijnbergen (1982, 1983), Taylor (1983), Buffie (1984) built models contradicting McKinnon and Shaw. Their models differ in that economies are assumed to be 'ruled' by competitive non-financial intermediaries or 'curb markets'.[25] Since curb markets are not as restricted in terms of reserve requirements their functions as transmitters of credit to investors is more efficient. However, in the case of an increase in bank deposit rates consumers have the choice to shift towards bank deposits and away from curb loans which eventually results in a fall to the supply of loanable funds and thus investment and growth. As such, this school of thought claims that financial liberalization could instead harm growth if curb markets exist.[26] Stiglitz (1989) also supports this view by expanding the discussion on the financial markets' failure. The Stiglitz and Weiss (1981) model describes how a high market clearing interest rate can attract bad borrowers or give incentives for investing in riskier projects (adverse selection). Mankiw (1986) presents a model of financial collapse incurring because changes in the interest rate could increase the risk of the borrowers. This may lead to bank losses and in combination with restrictive monetary policy it could lead to financial crisis. Asymmetric information as pointed out by Diamond (1984) makes it difficult for banks to function efficiently without monitoring costs.

The positive role of financial development is mostly discussed in the 1990s with the introduction of more complex endogenous growth models (Greenwood and Jovanovic, 1990; Bencivenga and Smith, 1991, 1993). Such models seek for the possibility of financial conditions to explain the sustainability of growth observed. The main argument is that financial systems generate an external effect on investment compensating for the decrease in the marginal product of capital. Berthelemy and Varoudakis (1995) build a model of reciprocal externalities between the financial sector and the real sector in an endogenous model of a learning-by-doing framework with the assumption of a positive relationship between financial development, the efficiency of capital and thus growth. Most of the research follows an AK model framework like the one presented in Romer (1986).[27] Bencivenga and Smith (1991)

[25] Curb markets are defined as unrecognised money markets.

[26] More details on the Neostructuralist and other criticisms of the financial liberalization policies in the 1980s are given in Eschenbach (2004).

[27] An AK model implies a production function of the form $y = AK^{\alpha}$ and implies constant returns to capital.

build a model which gives the agents the choice of holding a liquid (safe and unproductive) and an illiquid type (risky and productive) of asset. Financial intermediation allows for savings to be channelled into the illiquid assets and therefore increase growth. An influential work by King and Levine (1993b) develops a Schumpeterian model of technological progress similar to Romer (1991) or Grossman and Helpman (1991). Financial intermediaries are a channel for entrepreneurs to undertake innovative activity, which affects growth through productivity enhancement. Greenwood and Jovanovic (1990) internalize financial development by building a model giving an endogenous role for finance and growth. Saint-Paul (1992) analyses the indirect effect of finance on growth by evaluating the effects of financial markets on technological choice and division of labour. When technology becomes risky, that is where financial intermediation aids in financing it.

The (un)importance of stock markets in growth studies goes back to the 1930s. It is claimed that stock market growth gives a choice of substituting away from bank loans and towards stocks. Kindleberger (1978) and Keynes (1936) support that stock markets are a cause of instability in the economy as they create harmful speculative attacks. The developing countries which have a relatively immature stock market system are more susceptible as lack of transparency and irrational speculation leads to asset price bubbles. In the 1990s, Atje and Jovanovic (1993) provide a positive role for stock markets in a Greenwood and Jovanovic (1990) framework. Stock market in this case acts as an insurer against idiosyncratic risk and provides information over profitable investment projects. Levine (1991) also includes stock markets in an endogenous growth model to show how it accelerates growth through their liquidity levels. Stock markets could reduce firm capital reduction and thus unnecessary technology shocks.

The introduction of stock markets in growth theories gave rise to another debate. In the 1990s studies focused on the relative advantages of a bank-based financial system (German and Japan) and a market based financial system (England and United States). A bank-based financial country is usually financially less developed compared to a market-based country. This is probably due to the extreme reliance of firms on the banks for credit. The argument for bank-based systems is the secrecy of information over investments. The free rider problem (see Stiglitz, 1985b) is avoided and investors have more incentives to expand resources in accessing information. The firms are closely related to the banks making investigation and supervision of managers easier compared to a market based economy. Hostile takeovers are less evident in such systems because of the small number of shareholders and the large share stakes they own. Moreover, banks are responsible for longer term loans and this can be a source of growth. However, the banks have a huge influence on firms which could lead to negative consequences for growth. The market-based system supporters claim that banks can extract rents from the firms under their supervision in the sense that firms have to somehow pay for their greater access to credit. This potentially reduces firms' incentives to invest and impede growth (Weinstein and Yafeh, 1998). Market-based financial systems allow for funds to be raised not through a bank but through more liquid and efficient stock markets. In such systems, firms are owned by a large number of shareholders with small share stakes and takeovers occur more frequently. Gray, Merton, and Bodie (2007) argue that it is of no importance whether a country belongs in any of these two categories. The main point is that financial structure provides services necessary and sufficient to increase economic growth.

Financial development has gained a role in growth studies, either positive or negative through the last four decades. This led to confusion over the definition of financial development, its functions, its indicators and its channels to growth. The next chapter describes these in detail in the hope to give a clear image as to why financial development has a role in growth theories, which instruments are best to describe it and what are the functions that give an importance of financial development to growth.

2.7 The Role of Human Capital in Growth Theories

Education has gained a role in growth ever since the era of Plato and has been regarded as one of the key and leading determinants of economic growth since the time of Adam Smith. Marshall (1890) stated that investing in human beings is the most valuable capital of all. In the 1960s the impact of education on economic growth became an issue attracting researchers and policy makers as Schultz (1961), Becker (1964) and Mincer (1974) developed a comprehensive theory of human capital. Schultz (1961) claimed that much of the increase in American real growth income per capita was due to the growth in human capital evident in the first half of the twentieth century. Back then, the belief that education is related and often causes growth assigned a significant role to human capital formation especially to the investment in education made by governments. Economic history concentrating on economic backwardness considered a poorly educated and trained population translating into low productivity levels, low labour mobility, slow innovative processes and thus to a reduced ability of governments to alleviate poverty or create higher economic growth rates and levels. The argument that a knowledge-based economy leads to innovation and growth through a high skilled workforce, has led to an increased spending on public education. Especially for developing countries, spending on education by the government is considered as a panacea for many problems (Cochrane, 1986). The main problem assigned with giving a role to human capital in economic growth is the way it is measured.

2.7.1 Human Capital Proxies

The range of possible proxies for human capital is large and falls outside the scope of this thesis. Nevertheless, since the following chapters use government spending on education to GDP as a proxy a small review on the measurement issues is required. As research expanded, multiple proxies were created to capture human capital. Usually, the proxies used however do not reflect human capital as described in endogenous growth models. Most of the research had used proxies such as literacy rates, primary school enrolment and average years of education.

Adult Literacy Rates

Studies by Azariadis and Drazen (1990) and Romer (1990) have used adult literacy rates as an indicator of human capital. This variable is usually defined by the World Bank Development Indicators (WBDI) as the ability to read, write and understand a short simple statement presented in everyday life. It is measured as the percentage of the population aged 15 and above who are literate. Although literacy rate is an essential component of the human capital stock it neglects any investment which occurs over and above the basic literacy. This implies that investment on the acquisition of numeracy, scientific and technical knowledge is not included in this measure and is thus also excluded as a parameter for increasing productivity.

School Enrolment Ratios

Others such as Mankiw, Romer, and Weil (1992), Barro (1991) and Levine and Renelt (1992), use schooling enrolment ratios as an indicator of the human capital stock. This proxy measures the number of students enrolled at a grade level relative to the total population of the corresponding age group. Firstly, this variable usually ignores primary and tertiary education and by using it, the true variation in educational achievements across different countries is underestimated. Secondly, this is a current and a flow variable. The students enrolled in schools are not yet part of the labour force and thus offer nothing to the production of the economy. It is a measure of the human capital acquired by students who may (or may not) enter the labour force at some point in the future. Thirdly, the accumulated human capital stock depends on the lagged values of school enrolment ratios and any changes in the enrolment rates have an effect on GDP at a long lag. The availability of data only allows for a limited number of lags to be used in regression analysis and this makes regression results unreliable. Finally, reverse causality is one of the most common problems in growth regressions. Causality may run from GDP per capita to enrolment so that as the economy grows, the returns to schooling increase and the enrolment rates rise. As Hanushek and Kimko (2000) state, enrolment ratios are poor measures of human capital especially in periods of educational and demographic changes.[28]

Average years of schooling

Average years of schooling are usually the most used indicators partly because they are relatively widely available (Barro and Lee, 1993; Krueger and Lindahl, 2000; Hanushek and Woessmann, 2007). On the micro level, Mincer, 1974 showed that one additional year of education raises earnings by 10%. Data on this variable are considered better suited to examine the effects of schooling on economic growth (Benhabib and Spiegel, 1994; Cohen

[28]For an extensive review on the proxies of human capital see van Leeuwen and Foldvari (2008)

and Soto, 2001; de la Fuente and Domenech, 2002). By using this variable, the problem of reverse causality becomes less severe (Temple, 2001a). However, Cohen and Soto (2001) claim that the years of education have been estimated with measurement error. Barro and Lee (1993) construct a data set for this measure which is however limited to the adult population excluding the labour force. Their data set also suffers from poor coverage. Secondly, it excludes adult training and lifelong learning which are usually considered to be essential especially in rapidly technologically advanced economies. Thirdly, hours spent in school each day and the mandatory age until which a student is required to stay at school differs between countries. These are factors which influence the years of schooling without reflecting the skills and the abilities of the students. This leads to incorrect results since it implies that productivity differentials between workers are proportional to their years of schooling. This is in contrast with the microeconomic literature (Psacharopoulos, 1994) which claims that there are decreasing returns to schooling. Finally, not all teaching courses are equally important for the acquisition of skills which will lead to innovation of new technologies. No comparison can easily be done on the productivity of human capital across countries. Using the years of schooling as a proxy leads to conclusions such as 'An extra year of schooling in Ghana leads to the same increase in productive human capital as a year of schooling in Japan'. Thus the years of schooling in this respect is not an indicator of the quality of education.

Quality Indicators and Public Spending on Education

Barro (1991) uses student-teacher ratios in a cross country study as a proxy of quality of education. Barro and Lee (1996) use data on educational expenditure per student and teaching salaries among others to capture the quality of educational inputs. These are judged by Hanushek and Kim (1995) to be poor measures of educational quality. They, along with Barro (1999), Hanushek and Kimko (2000), develop an average score on mathematics and science score tests across countries. Average years of schooling is also mostly considered an indicator capturing the time spent on human capital and thus better suits models following Lucas (1988) method. One of the most common quality indicators is the expenditure on education by the government (Baldacci, Clements, Gupta, and Cui, 2008). The problem with this variable is that not all financing is done at national level. For example, in Japan in the beginning of 1900s sums of money by the government were spent on regional levels.[29] A major advantage of this variable is the easiness of collecting it compared to the others since it is mostly well documented. Moreover, it is preferred because it is a measure not only of the quality but also of the value of the education provided. This variable highlights the importance of incentives, raises certain equity issues and questions about the appropriate role of government in the provision of education. The choice of this variable becomes important in studies which include developing countries where spending of government on education is essential for the creation of incentives towards education.

2.7.2 Theory of Human Capital and Economic Growth

A relatively more important role of education to growth has been given with the emergence of the 'new growth theory' in the late 1980s. Pioneered by Lucas (1988) human capital is considered to be one of the factors of production. In this model, the rate of growth of human capital depends on the time required for individuals to gain skills. The rate of growth of income per capital subsequently depends heavily on the rate of growth of human capital. In such cases where human capital is another factor of production, investing a part of savings in education aids in increasing the rate of economic growth in an economy (Jorgenson and Fraumeni, 1989). Long-run growth is partly determined endogenously via more investment in human capital and partly endogenously via the Solow residual. Lucas (1988) has given the agent a labour-leisure choice and a learning-by-doing technology. The human capital accumulation can be created via a formal training which implies some time off work, lower leisure and consequently leads to a loss in production. Alternatively, the agent can gain knowledge through a learning-by-doing procedure which does not lower production. This training has a linear technology which constitutes the driving force of economic growth.

Schultz (1988) considers human capital as a cause to disequilibrium in society but it can also bring adjustment of to such equilibrium. The economies of scale caused by human capital

[29] More details on the data and its problems are given in Chapter 7.

formation lead to a shift of resources which at some point eliminate the return to scale. The literature born by Lucas (1988) extended the idea of externalities associated with human capital accumulation. Investment in human capital brings about external effects which are essential aspects of reality (Lucas, 2002). Lucas (1990) claims that the skills of the relatively more educated workers have an external positive effect on the rest of the workers. Allowing for such externalities can give a possible reason for income differences observed across countries. Jones and Williams (1998) contends that human capital induces research and development and enhances economic growth via innovation and new production lines.

Since Solow (1956) recognised the importance of skills in the production function researchers tried to account for heterogeneity across labour depending on its quality. Denison (1967) among others augmented labour input to reflect the differences in labour quality by adjusting for education and other factors. Since the wage is a reflection of the marginal productivity, differences in the wages reflected the differences in human capital. The neoclassical view of the human-capital-augmented growth uses a Cobb-Douglas production function as follows:

$$Y_t = AK_t^{\alpha}(u_t h_t L_t)^{(1-\alpha)} H^{\beta}_{t,i} \tag{2.7.1}$$

where Y_t is the level of output, K_t is the physical capital stock, L_t is the size of the labour force,H_i is the human per capital indicator for each agent i, u is the time devoted to innovative/productive activities, A_t is the level of technology and α,β are the weights/elasticities attached to physical capital, human capital and labour. There is another sector which determined the accumulation of human capital which is not used in the productive sector but is used instead in the production of extra human capital. The human capital formation is demonstrated by:

$$\dot{H}_t = H_t C\,(1 - u_t) - \delta H_t \tag{2.7.2}$$

where δ is the depreciation of human capital and$C(1-u_t)$represents the increase in the amount of human capital making C a parameter which determines the rate at which investments from the productive sector are converted into growth of human capital. The term in the brackets is the share of human capital that is not used in the production of the final good but is used to form new human capital. The growth of human capital independently of how well educated an agent is, takes the following form:

$$\gamma_H = \frac{\dot{H}_t}{H_t} = C\left(1 - u_t\right) - \delta \tag{2.7.3}$$

Putting together equations 2.7.1 and 2.7.3 one obtains the balanced growth path rate of GDP:

$$\gamma_y = \frac{\dot{y}}{y} = \frac{1 - \alpha + \delta}{1 - \alpha}\frac{\dot{H}}{H} \tag{2.7.4}$$

Equation 2.7.4 implies that the differences in the growth rates across countries are related to differences in the rate at which human capital is accumulated.

Romer (1991) introduces a new class of an endogenous growth model through which manifests the importance of human capital. This model has three sectors; a technology producing sector, an intermediate goods producing sector and a final output producing sector. The part of human capital not used in the production of the final good is instead used in the creation of new technologies. Thus, the level of human capital enters the productivity growth equation in a positive manner and becomes a central source of economic productivity. In other words, the growth of total factor productivity depends on human capital as follows:

$$\dot{A} = \psi H_A A \tag{2.7.5}$$

whereH_A is that stock of human capital used in the accumulation of technology. Human capital can affect productivity either due to direct effects of human capital on the production of technological innovation as in Romer (1991) or due to the effects it has on the adoption and implementation of new technologies aborted from abroad as in Nelson and Phelps (1965). In either case, the growth of total factor productivity is a positive function of the country's human capital level. The production function in a Romer style of growth theory is:

$$Y_t = H_y^{\alpha} L_t^{\beta} K_t^{(1-\alpha-\beta)} \tag{2.7.6}$$

where H_y^{α} is an exogenous variable representing the human capital not used in the technology sector but only in the final goods producing sector. In other words, once the agent has gained the knowledge to apply new technologies he uses it in the production of the final good. The endogeneity of this model stems from the fact that research on innovations positively affects growth and at the same time innovations increase the productivity of researchers in the future. The growth rate of output is presented by:

$$\gamma_y = \frac{\dot{y}}{y} = \frac{\dot{A}}{A} = \psi H_A \tag{2.7.7}$$

This relationship supports that output growth is a function of the growth and level of human capital. Both of these models imply that differences in knowledge occur between countries because the knowledge embodied in people through education differs across countries. This thesis uses the Romer (1991) idea since the aim is not so much to explain differences in growth rates but to explain growth itself. The way human capital affects productivity gives a possible explanation on the advances in knowledge and thus growth.

Rebelo (1991) extends Lucas (1988) model by introducing physical capital together with human capital in the production function. Caballe and Santos (1993) use the Lucas (1988) model excluding the external effect in production and human capital accumulation is a concave function of time devoted to education. Nelson and Phelps (1965) developed a model where the ability to adopt and implement new technology is a function of the human capital stock. In such a way, the speed of diffusion of new technologies and products depend on human capital and as such education gains an excessively important role in the growth of the economy. Many researchers including Arrow (1962), Chamley (1991), Grenier (1999), Chang, Gomes, and Schorfheide (2002) attempt to use models outlined by Lucas (1988) and Romer (1991) in order to highlight the importance of human capital. However, most of these endogenous growth models ignore some developing countries' characteristics such as the connection between opulence and poverty. The society is dual in the sense that is comprised by poor and rich individuals. The latter group has the ability to save and invest in physical and human capital while the former doesn't. Research thus extended to take into account dualism including Lewis (1954), Sen (1966), Dixit (1968), Banerjee and Newman (1998) and Gupta and Chakraborty (2006).

2.7.3 Public Spending on Education and Economic Growth: A Brief Review of the Empirical Work

A generalization easily made out of the theoretical research is that human capital is a major driver of growth and that government should allocate a greater amount of resources and funding in education. Countries with higher stock of human capital usually become technologically leaders and remain at that position as long as the level of human capital is maintained. However, whether human capital accelerates growth remains also a controversial issue mainly because of the difficulties in constructing an appropriate proxy for human capital as described in Section 1.7.1. Many studies have used cross section methodology in an attempt to relate human capital and growth. Barro (1991) using data on 98 countries concludes that school enrolment rates as a proxy for human capital have a positive impact on the growth rate of income per capita. Levine and Renelt (1992) on the other hand find that human capital enters the regression in a statistically insignificant way. Benhabib and Spiegel (1994), Self and Grosskopf (2000) and Pritchett (1996) also find no important relationship between human capital and economic growth. Several authors have reversed Benhabib and Spiegel's finding (Temple, 1999; Krueger and Lindahl, 2000; Temple, 2001b), showing that their results are due to miss-specification of the model, measurement error and unrepresentative observations. Hanushek and Kimko (2000) stress the importance of accounting for the quality of human capital. They find a strong link between cognitive skills and economic growth. Other studies such as Barro and i Martin (1995) support the Romer (1991) approach by including interaction terms between initial GDP and human capital as well as various human capital variables in their cross-country regressions for a mixed sample of developed and developing countries. The conclusion is that a higher level of human capital lowers the cost of adopting new innovative ideas from abroad and some human capital variables are positive and statistically significant.

Mankiw, Romer, and Weil (1992) conclude that overall, their results strongly support the augmented Solow model. Their human capital variable enters significantly in the three OECD country samples they use, and adding human capital improves the overall fit of each of the three regressions. However, the explanatory power of their model for OECD countries is poor, and their results are biased towards Lucas methodology due to the choice of human capital indicator (Klenow and Rodriguez-Clare, 1997). In order to avoid the restriction of identical production functions for all countries panel data regressions are used. Islam (1995) implemented a panel data covering 1960-1985 with fixed effects using the human capital augmented Solow production function. His results show a negative and insignificant effect of the human capital variable on growth especially in OECD countries; a common characteristic of many regressions on OECD countries.

Concentrating on the spending of education and its relationship with growth, the empirical work provides mixed answers not only on the relationship but also on the causality issue. The main cause of this result arises in the models where public spending on education is a driver of growth and taxes are used for financing expenditures. These studies usually find a non-monotonic relationship between expenditures and growth. This is because, while as public spending on education increase growth, the taxes reduce growth and the net effect is ambiguous (Blankenau and Simpson, 2004). Blankenau, Simpson, and Tomljanovich (2007) use endogenous growth theory and find a non-monotonic relationship between public education expenditure and growth due to tax structures and parameters of production technologies. Becker, Murphy, and Tamura (1990) claim that education expenditures are an important determinant of growth for 100 countries examined for a period starting from 1960. O'Neil (1995) states that convergence in education levels result in a reduction in income dispersion. Worldwide however, income has diverged even if education levels converge because of returns to education being in favour of the developed countries. Sylwester (2000) finds that public education expenditures are positively correlated with future economic growth. Chakraborty (2005) and Dahlin (2005) find that investment in education is beneficial for the economy not only at a macro but also at a micro level.

A positive relationship between public expenditure and growth is also indicated in Jorgenson and Fraumeni (1992) for the U.S economy, Aziz, Khan, and Aziz (2008) for Pakistan and Chandra (2010) for India. Public spending is at times more important at initial levels of education since the cost of living when attending a university even if the fees are paid has a negative effect on the incentive to acquire higher education. Fiszbein and Psacharopoulos (1993) conduct a study for the case of Venezuela and find that indeed, public investment in primary education has relatively higher effects compare to the effect of investment in higher levels to education. Nurudeen and Usman (2010) and Belgrave and Craigwell (1995) find a negative impact of educational expenditures on growth. Attempts to determine causality between education expenditure and economic growth led to the application of Granger Causality tests. An increase in the human capital may increase economic growth and vice versa. Evidence of such a bi-directional causality is provided by Asteriou and Agiomirgianakis (2001) and Self and Grabowski (2003).

2.8 Conclusions

This chapter has familiarised the reader with the underlying concepts of models embodying a RBC framework. It started with a background summary of economic growth models explaining the urge of researchers to explain economic growth. It described the failure of the Keynesian models in the 1970s and the birth of RBC models. It described the relationship between RBC and growth focusing, summarised the extensions of RBC models and introduced the reader to the role of financial development and human capital in economic growth models which becomes the main subject in subsequent chapters of the thesis when trying to test whether any of these roles are justified. The reader is introduced to the evolution of the importance of financial development in growth theories. It went back to Modigliani theorem and reached to King and Levine to show that the role of financial development in growth has puzzled and led many researchers to model the behavior of growth by internalising financial factors. It then traced the developments in the literature in terms of addition of human capital in growth models and described proxies which have been used to capture the effect of investment in education. This chapter elucidated the roles of financial sector and investment in education through simple theoretical models and laid the foundations of the vast body of research in financial development and human capital and their relationship with growth.

Chapter 3

Financial Development: Definitions, Functions and Indicators

3.1 Introduction

Researchers have not yet established a common definition of financial development. Different definitions would lead to different indicators used as proxies capturing the level of financial development. The reason why financial intermediaries exist is obvious only after the functions of the financial system are described. The functions of the financial system become the incentive to build models testing the relationship between financial development and growth. The models aim to show whether the functions are fulfilled and how they feed back to growth. Section 3.2 gives a brief definition of financial development as provided by relevant studies. Section 3.3 shows the role of financial development in a simple AK model and then outlines the functions of the financial system to relate each function to economic growth. Section 3.4 describes the most commonly used indicators providing their advantages and disadvantages. The main aim of this sector is to offer the reader the reason why private credit to GDP is used as an indicator for financial development in this thesis. The conclusions are in Section 3.5.

3.2 Financial Development: Definition

Financial development is given multifarious definitions. It is considered as the actions taken to ameliorate, develop and sometimes change the way that people manage money, capital or credit. Financial development consists of the development of financial intermediaries and of the financial system. The lucid definition of financial intermediaries is that they are firms that borrow from consumer/savers and lend to companies that need resources for investment. However, the simple intermediation between the saver and the investor is no longer so simple. Credit default swaps, asset-backed securities and collateralised debt obligations are some of the recent financial innovations which add to the complexity of the financial system.

A financial system is a network of complex and interconnected financial institutions, markets, instruments and services which facilitate the transfer of funds (Financial Report, 2008). It consists of the savers, the intermediaries, the instruments and the ultimate user of funds. It therefore includes all whether its banks or stock markets or financial institutions. The OECD defines the financial system as "*... institutional units and markets that interact, typically in a complex manner, for the purpose of mobilizing funds for investment, and providing facilities, including payment systems, for the financing of commercial activity*".[1] The institutional units and markets interact within the system, for the purpose of mobilizing funds for investment, and providing services such as payment systems, for the financing of commercial activity. In general the financial system, including banks and stock markets is a mechanism through which funds flow from the group with surplus funds to the one that has a shortage of funds.

Gertler and Rose (1991) have characterized financial development as the evolution from self-finance to external finance, through the development of markets for direct credit as well as the increased access to world capital markets, and the narrowing of the spread between loan and deposit rates, along with a rise in the riskless rate. Fitzgerald (2006) contends that financial development involves the establishment and expansion of institutions, instruments and markets that lead to effective financial markets capable of providing deep and broad

[1] The definition provided by OECD is found in the glossary of statistical terms in the IMF, 2004 Compilation Guide on Financial Soundness Indicators.

access to capital and financial services. The Solow-Swan model provides no role for financial markets since in a perfect competition world with transparency and no private information. However, the role of financial institutions arises when frictions are introduced. Their functions abet to mitigate the effects technological friction and incentive problems.[2]

3.3 Financial Intermediaries: Functions

3.3.1 Role of financial development through a simple AK model

To capture the effects of the financial system and its development consider a simple, closed economy, AK representative agent model with a production function of a single good

$$y_t = Ak_t \tag{3.3.1}$$

wherey_t and k_t denote output and capital stock respectively. With no population growth and with capital depreciation at the rate δ, gross investment is

$$I_t = k_{t+1} - (1 - \delta)\, k_t \tag{3.3.2}$$

The investment is set equal to the gross savings and thus

$$I_t = \theta s y_t \tag{3.3.3}$$

where θ is a portion of the savings. The rest, $1 - \theta$, is 'lost' in the process of financial intermediation. Using 3.3.1 and setting the economy on its steady state, the rate of growth of output is

$$g_y = A\theta s - \delta \tag{3.3.4}$$

The steady state growth rate is a product of the savings rate, the marginal productivity

[2]See Sinha (2001) for more details on these frictions.

of capital and the fraction of savings not used in the intermediation process. Financial development increases A through enhancing the efficiency of capital accumulation. This is also emphasised by Goldsmith (1969) who finds that the observed positive relationship between financial development and growth occurs mainly due to a more efficient use of the capital stock enhanced by the development of a financial 'superstructure'. Financial intermediaries also create a path for savings which aids in increasing the private savings rate s and θ which in turn increase the growth rate of output g_y.[3]

3.3.2 The functions of the financial system

Through the years the functions of the financial system have been altered by the complicated instruments that have been introduced. The activities of the financial system have been extended beyond the Schumpeterian idea. As seen from the AK model above, finance affects growth through the three variables of interest, A, θ, s. The functions of the financial intermediaries alter each of these variables in a way which feeds back to growth.[4]

Mobilization of savings

Mobilization of savings greatly affects technological progress according to Bagehot (1873). Financial intermediaries funnel savings to the firms through the process of transforming savings into investment. In an era of no channel for savings, credit unavailability stalled improvements. In the simple model described in Section 2.3.1, $(1-\theta)$ is the fraction of savings that goes to the banks in the form of a spread between the lending and the borrowing rates. This in effect gives to the financial system an important role as the means through which better technologies are adopted and growth is boosted. The parameter $1-\theta$ reflects the transaction costs which is determined by the real costs of financial intermediation. A more efficient transformation of savings into investment leads to a lower loss of resources θ and thus more savings can be channelled to productive investments.

[3] The model illustrated follows Pagano (1993) and De Gregorio and Guidotti (1995). Although it is simple, it captures most of the applications. Others such as Santomero and Seater (1999) use it to derive the optimal size of the financial system.

[4] A detailed description of the functions of financial intermediaries is given in Levine (1997).

Individual savings may not be sufficient to fund a borrower. Mobilization of savings gives the opportunity for investors to hold diversified portfolios; it increases asset liquidity and thus improves resource allocation (Sirri and Tufano (1995)). Endogenous growth models assume that savings directly influence the equilibrium income levels and growth rates (Greenwood and Jovanovic, 1990; Bencivenga and Smith, 1991). This promotes the idea that financial markets are able to impact the real economy. De Gregorio (1996) asserts that mobilizing savings increases the availability of credit and also helps to finance human capital i.e. the investment in education and health. As the financial system expands and its efficiency increases, the prospects of higher returns on investment increase. Whether this increase in efficiency is capable of positively affecting s is ambiguous. Prospects of higher returns may also reduce savings because future consumption can be achieved by increasing present consumption and thus reducing savings. If however, the mobilisation of savings increases the savings available for investment, growth is enhanced which in turn enhances deeper financial development. However, mobilization of savings is costly since it involves the process of collecting savings and facing informational asymmetries (Carosso, 1970; Levine, 1997).

Acquisition of information and allocation of capital

After pooling savings, the financial intermediaries ensure the allocation of capital to the most profitable projects (i.e. to the projects where the marginal product of capital is highest). Savers may not have the time nor the means needed to acquire information on firms and on the economic environment. High information costs prevent capital from flowing to its highest value use. Financial intermediaries such as banks and fund managers exist to collect and process the kind of information needed on behalf of the investors (Diamond, 1984; Boyd and Prescott, 1985). Tobin and Brainard (1962) emphasize that evaluation of investment projects by financial intermediaries helps to avoid moral hazard and thus makes it easier for the 'good' borrowers to borrow funds at a lower interest rate. It is more likely that financial markets fund new and risky investment projects when information is transmitted easily leading to even more efficient allocation of services. Specialised screening of the quality of borrowers is an effective remedy against the problem of adverse selection in credit markets created when lending of savings are not intermediated (Stiglitz and Weiss, 1981).

According to a model built by Harrison, Sussman, and Zeira (1999), bank competition can reduce the transaction costs $(1-\theta)$ which are assumed to be created by the geographical distance between the bank and the entrepreneur. A higher economic growth induces the profit margins of financial intermediation and increases the entry of more banks. The competition created increases the ability of banks to specialise on raising useful information for an efficient allocation of funds. The distance between the banks and investment projects is reduced, intermediation costs fall and economic growth is enhanced.

Stock markets can also perform the duty of collecting information and allocating capital efficiently. According to Levine (1997: 695) "large, liquid stock markets can stimulate the acquisition of information", that in turn enhances growth (Merton, 1987). When individuals trade in markets which are larger and more liquid they are motivated to spend resources in evaluating firms and gain profit. [5] Liquidity acts as an incentive for investing a larger share of savings in long-term projects which are riskier but more profitable. Liquidity allows agents to bring forward consumption without eliminating investments projects but instead by transferring assets to other agents. This implies that investment on projects continues and this raises the productivity of capital, A. Stock market liquidity helps in fostering corporate governance and hence reduce moral hazard; qualities important for growth. If managerial compensation is directly linked to stock market performance, either through contracts or stock ownership, managers have an incentive to select and implement actions that increase shareholder wealth. However, as Stiglitz (1985a) states, stock markets are not always helpful in the sense that they reveal information through the prices which are available to all (free rider problem). This discourages agents from spending their time on finding information. Galor and Zeira (1993) refer to capital market imperfections which repress investment in human capital. A suboptimal allocation of resources occurs if financial intermediaries do not intervene to efficiently allocate resources and ensure gains from such an investment.

[5] Liquidity is given many definitions. A microeconomic aspect of liquidity is the provision of insurance against uncertain timing of consumption. Agents' intertemporal consumption plans may alter by selling or buying assets.

Acquisition of information by financial intermediaries has been closely related to productivity growth by Greenwood and Jovanovic (1990). In their model, capital can be invested into a safe, low-return technology or a risky, high-return technology. The latter is affected by either an aggregate shock or a project specific shock. The role of the financial intermediaries is to disentangle these two effects and using their large portfolios they choose the technology that is best for the realization of the aggregate productivity shock. Collecting information and screening selected investment projects becomes an important determinant in enhancing the profitability of investment. The average capital productivity of the projects selected efficiently by the intermediaries is considered to be greater than the productivity of those projects that have not been effectively screened. The function of financial intermediaries to evaluate and select investment projects drives out of the market the unprofitable ones. Thus the total productivity, A increases which in turn enhances growth.

Transformation and management of risk

During the recent financial crises, the transformation and management of risk became a key function of financial institutions and essential for societies. Traditionally, as described by Gurley and Shaw (1955) financial markets are the driving force of investment into the projects which are riskier, offer higher returns and at the same time are disliked by savers. Financial markets provide savers with a large choice of instruments that allows diversification of risk. Investing in an individual project is always more risky than investing in a wide range of projects whose returns are independent. Banks, stock exchanges and other financial institutions help to diversify portfolios and hedge against risk and thus permit investments on riskier projects to take place. This applies to firms, industries, and nations. Obstfeld (1994) observes that the opportunity to share risk through capital markets increases incentives to invest in riskier and thus more profitable investments.

Interest rate movements as well as currency movements create uncertainty for investors. King and Levine (1993b) suggest cross-sectional risk diversification as a boosting factor for innovation and thus technological change and economic growth. Innovations are risky and most of them fail. However, the diversification of risk through the investment of many different innovation based enterprises allows the investment in projects which would otherwise be considered risky. Being able to hedge against shocks related to projects leads to more specialised investment reduces direct exposure towards uncertainty and increases economic welfare and growth.[6] Nevertheless, even though a reduced risk pattern theoretically increases savings, s, it is possible for an increase in the flow of savings into higher risk-higher return projects to occur without stimulating an increase in current savings.[7]

A common type of risk is that of liquidity. Financial institutions are able to hedge liquidity risk. Liquidity is necessary for investors because of the uncertainty in converting assets into medium of exchange any time desired in the future. According to Diamond and Dybvig (1983), financial intermediaries effectively match the different maturity periods of loans and provide liquidity. Liquidity is linked to economic growth since it allows financial intermediaries to provide medium to long term capital for investment and liquidity for savers (Levine, 1991). Projects with high returns need a commitment of capital for a long time but savers are not willing to keep their savings for such a long time. They want to be able to draw their savings or move them into another investment if they see that it is worth doing so. Liquid capital markets permit savers to hold assets that they can easily sell when they want to access their savings (Bencivenga and Smith, 1991). According to Demirguc-Kunt and Levine (2008), banks are able to offer liquid deposits to savers and undertake liquid, low-return investments thus providing demand deposits supplying insurance to savers against liquidity risk and contemporaneously encouraging long-run investments in high return projects. Financial intermediaries can thus affect the rate of technological change and promote technological innovation because of long term commitments to research and development. Thus, in such a case, financial development promotes economic growth through its effect on A.

Besides liquidity risk, insurance markets, banks and securities markets mitigate the effects

[6] More details of the effect of risk diversification on the economic welfare are given in Obstfeld (1994), van Wincoop (1999) and Obstfeld and Rogoff (2000).

[7] It can also reduce the effect on precautionary savings. In general, the effect of risk diversification on savings is not clear and it depends on the risk properties of the utility function. Not having the choice to do so implies expectation of elimination of physical investment, and leads to increased investments in short-term projects.

of idiosyncratic risk; the risk related to individual projects, firms, countries etc. Financial intermediaries provide risk diversification services and trading pooling which positively affects the savings rate as well as the output growth rate.

External Finance

Financial intermediaries provide the possibility to divert away from self-finance and moving towards external finance and thus help in increasing investment. The provision of external funds dates back to the industrial revolutions. Although back then, the size of production was relatively modest and physical capital was cheap, loans from friends or relatives were an essential form of finance. In the 21st century, a rise in the wealth of nations requires a large injection of capital. Access to external credit facilitates the production processes bringing them to an economically efficient scale. The entrepreneur can borrow against future income streams and this limits the constraint to invest in more expensive and efficient physical capital. External finance helps to invest in innovative ideas which in the long term encourage production and economic growth. Empirical evidence shows that firms are able to gain access to external finance in countries with a relatively more sound legal system (La-Porta, de Silane, Shleifer, and Vishny, 1997).[8] Rajan and Zingales (1998) show that financial development causes a reduction in the cost of raising external funds relative to the cost of raising internal funds.[9]

Facilitating transactions

Financial intermediaries have the ability to make economic exchange less costly. Financial sector facilitates transactions in the economy as it is the means through which payments are made and received. Business transactions are viable due to guaranteed payments. Gurley and Shaw (1961) state that, transforming primary securities into indirect securities, is a basic

[8] More evidence on the importance of external finance is given in (Demirgüç-Kunt and Maksimovic, 1998; Ayyagari, Demirguc-Kunt, and Maksimovic, 2010).

[9] In any other case external funds are costlier because outsiders have less control over the borrowers' incentives and actions and because they have little or no information on what the borrower is planning to do with the funds (Jensen and Meckling, 1976; Myers and Majluf, 1984)

function of the financial system. Smith (1776) contended that lower transaction costs allow for greater specialization which is valuable to higher productivity, successful innovations and thus growth. The argument was backed by the introduction of money in lieu of barter which reduces transactions costs and improves productivity as it is considered a widely accepted medium of exchange. Financial development makes the trading of goods and services between businesses and households easier.[10]

Going back to the classic Lombard Street by Bagehot (1873), the importance of the banking system in economic growth is conveyed through the idea that identifying and funding the efficient and productive investment ideas can stimulate innovation and growth. The idea is simple; the entrepreneur has innovative ideas for producing a commodity or a service. He first wants credit. He has to become a debtor and have the purchasing power needed to produce his ideas. The banker becomes the judge and decides whether it would be wise and efficient to give this power to the entrepreneur. Once the credit flows to the investor, it is up to him to allocate it efficiently as to materialise the idea which will in the future feedback to growth. Lowering transaction costs enables individuals to specialize in the invention for which they are more productive (Lamoreaux and Sokoloff, 1996). Cooley and Smith (1991), argue that financial systems can promote the accumulation of human capital by encouraging access to money to be used in the accumulation of skills. In an AK model like the one described above, human labour does not enter the production function, but a more productive and high skilled labour increases the efficiency and productivity of the physical capital, A.

Savings, Borrowing and Interest Rate

As mentioned previously, financial intermediaries can affect economic growth through an impact on the savings rate s. The sign of the effect is however ambiguous as it may increase it or reduce it. As financial markets expand, firms become more insured against shocks and consumers access credit easier and cheaper. A relatively developed financial system reduces the wedge between the interest rate paid by firms and received by households. The savings

[10] Money is a medium of exchange that helps in avoiding the problem of double coincidence of wants as described by Brunner and Meltzer (1971) or Ostroy and Starr (1988).

are affected but the direction of the effect is ambiguous. Financial intermediaries react as a transmitter of funds from those who save to those that dissave. In the case of shortage in loan supply, the households become liquidity-constrained. Jappelli and Pagano (1994) show that this may lead to an increase in the savings rate if applied to an overlapping generations model where young households do not have the option of dissaving. According to equation 3.3.1 this leads to an increase in the growth rate of output g_y. This however implies that liberalisation of consumer credit leads to a reduction in savings and growth rate. In other words, financial development affects growth negatively. Another way borrowing constraints can affect growth is given by De Gregorio (1996). He argues that in the case where households borrow to cover consumption and the accumulation of human capital the effect on growth is unclear. Faced with a liquidity constraint, this borrowing increases savings s, but reduces the productivity of investment, A because it depends on the skills earned during realising the education investment. Hence, the effect on growth will depend on whether the household self-finances education. McKinnon (1973) and Shaw (1973) assert that financial repression keep the interest rate paid to savers at low levels compared to the one prevailing under perfect competition, $A - \delta$. In an imperfect capital market if the saving rates rise in line with the interest rates then savings will be lowered and growth will be depressed.

3.4 Financial Development: Indicators

The research on finance and growth has not yet agreed on the indicators of financial development. The characteristics of a financial system are the level, the efficiency, the composition of financial intermediation and the access to financial systems. The idea is to find indicators that describe the degree of financial development through these characteristics. The level of financial intermediation refers to the size of a financial system. According to the World Bank, the size of the financial system can be measured among others by the amount of funds that it allows to be processed and intermediated and the economic resources it employs. In general a large financial system allows economies of scale to be exploited through the fixed costs in the operation of financial intermediaries and this helps in fulfilling the function of allocating capital efficiently. The size may refer to the amount of people involved in financial intermediaries. The greater the number of people involved, the better the information produced and thus a positive externality for growth is initiated (Greenwood and Jovanovic (1990); Bencivenga and Smith (1991)). The larger the banking system, the more capital can flow from savers to investors. This is because a large financial system better allows firms to borrow and take advantage of the profitable investment opportunities. Moreover, a larger financial system ameliorates intertemporal risk sharing (Allen and Gale, 1976) as it is more efficient in reallocating and transforming risk.

The efficiency of a financial system is related to the quality of financial intermediation. In other words, the efficiency of a financial system depends on how well can financial intermediaries compete and perform so that the functions of the financial system are fulfilled. More specifically, one of the most important functions is collecting information on behalf of investors or screening agents and their investments. One needs to be careful when evaluating the efficiency of the financial systems since any asymmetric information, externalities and imperfect competition can lead to non-optimal level of investment, inefficient capital allocation and bank runs which all can negatively affect growth rates. Legal systems and governmental bodies could ensure the efficiency of the financial market.

The composition of financial intermediation refers to the form of delivery of the financial services in the economy. Economies such as Germany and Japan are bank-based while others such as England and the United States are market-based. In bank-based economies the banks play a major role in fulfilling the functions of the financial system. In market-based economies, securities markets are more essential for the transmission of funds to society. Jacklin (1987) notes that banks have no advantage over markets and can thus be replaced by markets. When exploring the relationship between finance and growth and such economies, the stock market indicators are of more importance.

Access to finance may refer to practical issues such as the easiness with which one can reach a bank, an ATM. It also refers however to the easiness with which people from different backgrounds and income levels have access to credit and other banking and non-banking services. Some contend that it is natural for financial development to have a disproportionate effect on poor people because information asymmetries create credit binding constraints for the poor. However, the poor may have innovative enough ideas which they cannot materialise because they lack the resources to find internal finance and the political connections to reach external finance.[11]

Most of the indicators, if not all, are expected to have a positive correlation with growth to capture the idea that a relatively high degree of financial development is an indication that the financial systems fulfil their functions through their services. This, in the long run contributes positively to the growth and welfare of a country by enhancing the access to financial services (Beck, Feyen, Ize, and Moizeszowicz, 2008; Beck, Demirguc-Kunt, and Singer, 2011).[12]

3.4.1 Size Indicators

One of the oldest and most common indicators of the size of the financial markets, usually due to its availability, is the liquid liabilities to GDP described as M2/GDP and used by McKinnon, 1973 or as M3/GDP and M4/GDP. It equals currency plus demand and interest-bearing liabilities of banks and other financial intermediaries divided by GDP. It is a wide measure in the sense that it includes all banks and non-bank financial institutions. Monetary aggregates in general are considered by the McKinnon-Shaw framework as a sign of high capital market development. A monetised economy reflects a relatively developed capital market (Calderón and Liu, 2002). Many researchers including Goldsmith (1969); King and Levine (1993a); Ram (1999); Pelgrin and Schich (2002) use this indicator as a proxy of the depth of financial development. The reasoning behind this variable is that economic efficiency could rise if this ratio helps in reducing the financing costs and the risks involved in investment or if the production function of the financial sector exhibits increasing returns to scale. 3.4.1 shows the money supply in selected countries according to their income. While

[11] More details on the proportionate effect of financial development and growth are given in Banerjee and Newman, 1993; Galor and Zeira, 1993; Aghion and Bolton, 1997.

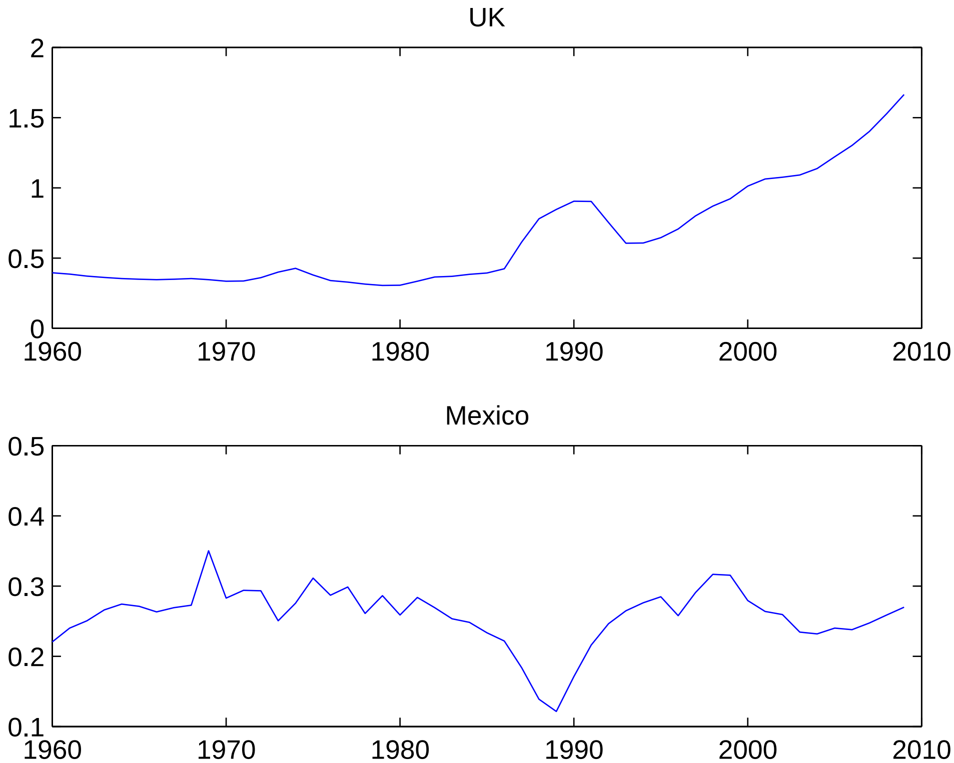
[12] See Figure A.2.1 and Table A.4 in Appendix A for more information on the correlation between the financial development indicators.

some countries have financial systems smaller than $1 billion, others have systems smaller than $10 billion. Most of the developing countries excluding India have very small financial systems.

Nevertheless, this indicator is considered a poor measure of financial development because it better mirrors the ability of the intermediaries to provide services rather than the ability to be a channel of funds, ease transaction, and improve information asymmetries (Khan and Senhadji, 2000). A country could be financially underdeveloped and still have a high ratio of money to GDP because money is used a store of value (Demetriades and Luintel, 1996). There is an extreme variability of this indicator across countries according to different monetary policy rules. For example, whilst countries like the United States have a ratio around 0.65-0.70 for the past 50 years, others like Zambia and Sudan have a ratio of around 0.20 and 0.01 respectively. A drawback of this indicator is demonstrated in 3.4.1. As Demirguc-Kunt (2006) put sit, ‘there are financial systems with trillions of USD and others with the size of a financial system equal to the size of a small bank in developed countries’. Although Mexico faced important changes of the financial system, the M2/GDP measure shows little variance over the long run. On the other hand, the explosion of consumer lending in 1994 in Mexico is poorly related with economic growth. As liquidity constraints for the consumers were relaxed, personal saving was declining. Thus, although monetary liquid liabilities are positively correlated with financial development, this does not imply the same for their relationship with growth. Thus this measure is disingenuous since the choice of the base year influences the results. Moreover, the UK indeed enjoyed financial liberalisation in the 1980s but it is not reliable to trust the indicator when it demonstrates the UK to be less financially developed between 1950 and 1980 or in 1995. The figures lead to the wrong conclusion that in 1970, Mexico had the same financial depth as the UK.

This measure is thus criticised for better capturing the degree of monetization rather than financial deepening. The main functions of a financial system are to channel funds and to provide liquidity. Fama (1980) argues that providing a medium of exchange is not necessarily related to growth compared to other abilities of the financial system. Monetary

Figure 3.4.1: Liquid Liabilities: UK and Mexico



aggregates could also lead to the conclusion that a low monetized economy is one with individuals economizing on their money holdings and could be an indicator of high degree of sophistication in the financial system. It is thus controversial whether monetary aggregates are a consistent indicator of financial development.

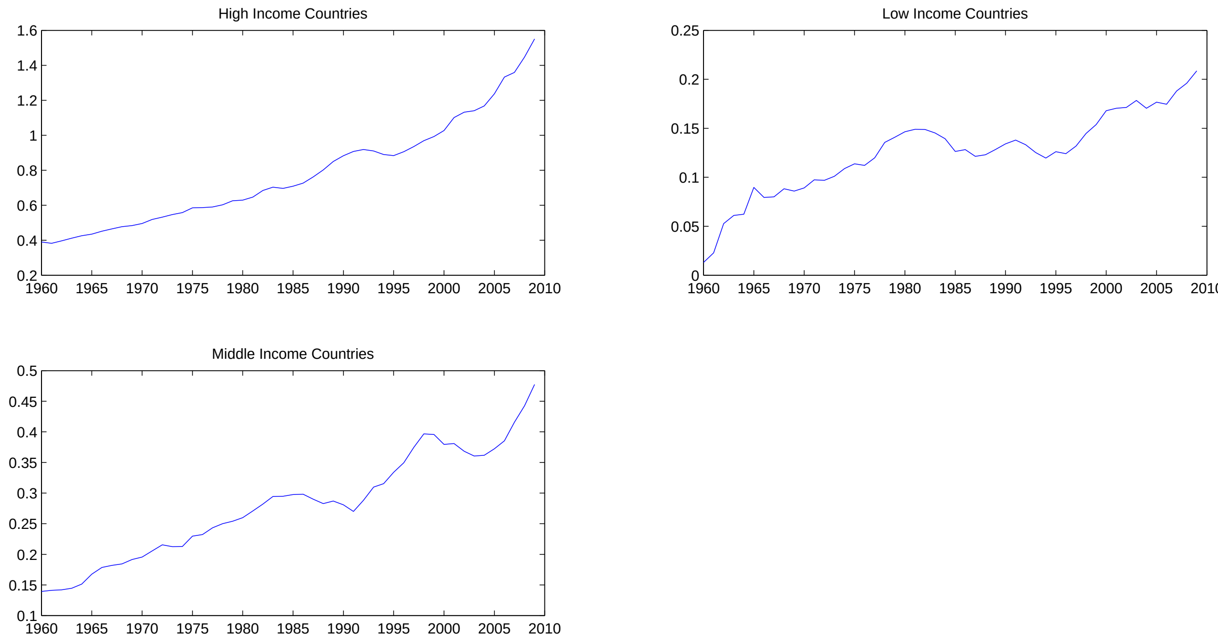
3.4.2 Financial Depth Indicators

One of the most important functions of the financial system is credit allocation. Some researchers concentrate on the ratio of bank credit to the private sector as a ratio of GDP. This excludes any credit provided from sources outside the banking system and it is thus a weaker indicator of financial development for industrial countries. King and Levine (1993a) used the ratio of proportion of credits channelled to private enterprises to total domestic claims and also the ratio of claims on the non-financial private sector to GDP. By doing this, the role of government in economic activity is neglected because an economy providing credits to the government does not have a strong objective to carry out the functions efficiently. A financial system providing credit to the government does not efficiently fulfil the roles of evaluating managers or selecting high return risky investments relative to a financial system which provides credit to the private sector. However, these indicators are also weak because they do not fully reflect on the level or depth of the financial services. A study by Leahy, Schich, Wehinger, Pelgrin, and Thorgeirsson (2001) on OECD countries shows that there is no statistically significant relationship between bank credit to GDP ratios and economic growth rates. Other studies such as Loayza and Ranciere (2004) include developing countries in their datasets find a robust relationship between bank credit ratios and growth even though their financial systems are not efficient.

An indicator which captures this asset side of the financial intermediaries is the ratio of credit to the private sector relative to the GDP (Levine and Zervos, 1998; Levine, Loayza, and Beck, 1999). The private credit by deposit money banks and other financial indicators is defined as claims on the private sector by deposit money banks and other financial institutions divided by GDP. It is relatively more informative than any money aggregate variable perhaps because it excludes the credit to the public sector and thus gives a more precise measure of the ability of the financial intermediaries to channel funds from one group to another (De Gregorio and Guidotti, 1995). It better reflects the actual volume of credit channelled into the private sector. This creates a direct link between the private credit, investment and growth. The positive relationship between the expansion of credit to the private sector and the economic growth of a country has been supported by King and Levine (1993a,b). A larger amount of credit channelled to the private sector in combination with the monitoring functions of the financial system, enhances investment in projects that can potentially contribute to the growth rate of the economy. The German economy is an example of a private credit system economy where investment financing is supported mainly by the long term loans expanded by large and private banks.

However, this indicator excludes the role of security markets as it does not take into account stock and bond markets. Many of the developing countries have recently experienced

Figure 3.4.2: Private Credit to GDP



a non-bank financial development with securities markets becoming more important and thus their role should not be ignored. Just like monetary aggregates, the private credit indicator also exhibits enormous variation across countries. On average, through the years of 1960 and 2009, countries like Ghana, Haiti and Syria have a private credit of less than 10 per cent of GDP while others like Switzerland and Japan and United States have more than 85 per cent of GDP. Also, as demonstrated by the late 2000 crisis, an exceptionally high level of private credit to GDP reflects excessive and imprudent lending by the banking sector (Arcand, Berkes, and Panizza, 2011). If private credit is expanded in an excessive rate and speed, risks are created at a microeconomic level (misallocation of credit) and macroeconomic level (leverage which creates susceptibility in adverse shocks).

Financial Systems Deposits to GDP is another widely used indicator of financial development. This is expressed as the ratio of all checking, savings and time deposits in banks and bank-like financial institutions to growth per capita. The ratio has a positive correlation with the income level of countries. This size indicator evaluates the size of deposits of the whole financial system to with respect to the economy of the country. A greater ratio is considered as a reflection to a larger banking system in the sense that more capital can flow from savers to investors through financial intermediaries. Other size indicators include Central Bank Assets to GDP and Money Bank Assets to GDP. These are indicators which give evidence of the importance of the financial services performed by these two types of financial institutions relative to the size of the economy. Another common indicator is the ratio of Commercial Bank to Central Bank Assets which primarily measures the extent to which funds are allocated in a productive manner. This measure is most widely used in studies of developing countries where the central bank plays a major role in the allocation of resources (King and Levine, 1993a).

3.4.3 Efficiency Indicators and Access Indicators

Financial efficiency is more difficult to be captured through indicators. An important aspect of efficiency is the extent to which banks can intermediate society's savings into credit for the private sector. Asymmetric information, externalities in financial markets and imperfect competition (Stiglitz and Weiss, 1992) are signs of inefficient investment and allocation of capital. These features could also lead to bank runs or frauds which impede growth. Efficiency could also be captured through the legal and institutional background of the country.

One indicator capturing efficiency is the Bank Credit to Bank Deposits is the claims on the private sector to deposits in deposit money banks. A low ratio is an indication that the financial system of the country does not attract deposits and thus a low share of them becomes credit for the private sector. The efficiency of financial development shows the correlation of loans provided by private banks with the loans provided by the central bank and the percentage of loans given to private non - financial companies in the number of all loans. However, taking as evidence from the currently funding instability in world economies, while a high loan-deposit implies efficiency, a 'too high' ratio can be a sign that money flows to the private sector through non-deposit sources. Demirguc-Kunt (2006) emphasizes the net interest margin and the overhead costs as indicators of efficiency. The net interest margin is a sign competition but also of lower interest rates in developed countries or macroeconomic volatility in emerging economies. High levels of overhead costs as a share of the bank's assets indicate lower levels of efficiency as it is a sign of high bank costs. This leads to another indicator; the inverse of the spread between banks' lending and deposit interest rates. A higher wedge between lending and deposit rates illustrates banking inefficiency. Usually poor countries have relatively high net interest margins, overhead costs and lending-deposit rate gaps.

Access to the financial system is captured by indicators such as number of ATMs, number of bank deposits, number of bank branches all relative to total population. Access to financial systems allows consumers to smooth consumption over time and stabilises consumer's income in the case of temporary shocks to wages and income. A commonly used indicator is the number of loans per capita. It is an indication of the use of credit services. However, the differences within income groups make it difficult for this variable to be considered as an indicator.[13] It is generally difficult to capture access to credit by a single or few indicators because it is affected by all other indications of a sound financial system as depth, efficiency and composition.

3.4.4 Stock Market Indicators

Although this thesis due to limited data availability concentrates on the depth of the financial development, mainly through the banking system, it is worth mentioning few of the indicators that describe the capital markets. Stock market capitalization to GDP is the most widely used indicator for the size of the stock market relative to the size of the whole economy. The activity of stock markets is measured by the stock market total value traded to GDP which is the total shares traded on the stock market relative to the size of the economy. Together with the stock market turnover ratio-the ratio of the value of total shares traded and market capitalization-these are liquidity indicators. Liquidity is considered the most essential function of the stock market since in economies where long-term commitment of capital is necessary liquid markets reduce the risk which threatens investment. A large liquid

[13] In Poland there are 770 bank loans per 1000 people but only 94 in Venezuela (Demirguc-Kunt, 2006).

market allows savers to buy equity and sell it quickly whenever they are found in need for their savings or in desire to alter their portfolios. Opening up a liquid trade and acting as a price determining mechanism for financial instruments, stock market spreads the risk between investors and capital raisers. This activity increases investment and reduces the cost of capital. This in turn ameliorates the allocation of capital, improves investment and enhances growth (Levine, 1997). A country with organised and liquid market is able to attract a FDI and portfolio investment leading to an increase in capital inflow and funds in the country to finance current account deficits. The liquidity offered is an encouragement for domestic investors to transfer their surpluses into long term capital and enjoy economies of scale. Merton (1987) declares that as markets become larger and more liquid, it becomes easier to acquire information and thus the incentive to invest increases since any private information can be translated into money. On the other hand, very liquid markets can also lead to investor myopia. The fact that they can sell an asset quickly when they are displeased means less commitment and incentive for corporate control or monitoring firms' performance and this can impede economic growth (Levine, 1997). The connection of these indicators with growth is that, high income countries tend to have relatively larger and more liquid stock exchanges.

3.5 Conclusions

This chapter started with a clear definition of financial development. It provided a detailed description of the functions of financial institutions through the building of a simple AK model. The reader is introduced to the indicators of financial development used by many researchers over the years and gives justifies the use of private credit to GDP ratio as the main indicator for this thesis by emphasising the disadvantages of other indicators. This chapter separated the indicators according to size, access and depth to familiarise the reader with the concept of financial development. The main conclusion is that financial institutions are given the role of an intermediary between the saver and the lender and the functions of a financial system aid in materialising long term projects which have an impact on productivity and thus growth. It is this impact that subsequent chapters will try to test and analyse.

Chapter 4

Financial Development and Growth: A Survey on the Empirics

4.1 Introduction

Theory suggests that effective financial markets and institutions enhance economic growth and the welfare of a country. Some researchers claim that countries which are relatively less financially developed are also relatively less economically developed. Others give no role of the financial system in the real sector of the economy. Either way, after the pioneering work of Goldsmith (1969), researchers attempt to prove any kind of relationship between the financial and the real sector.[1] Albeit a score of empirical studies investigating the relationship between financial development and economic growth, the result is ambiguous. The main empirical research focuses on three types of regressions in order to establish a relationship between financial development and economic growth; cross country with or without panel techniques, time series, and microeconomic-based techniques. The channels of transmission in explaining the finance-growth relationship differ across studies but most of them provide a positive link between financial development and growth.[2] Since relationship never implies causality, many studies also attempt to find a causal link between finance and growth using co-integration

[1] See Levine (1997, 2005) for extensive literature on the theory.

[2] Appendix C provides a review of the most cited papers in the literature of finance and economic growth.

techniques and Granger causality tests. Advances in computational capacity and increases in the availability of country and time data drove researchers away from cross country techniques towards Panel Data techniques to explore the relationship between financial and real sector. Section 4.2 provides a review of the empirical evidence of some cross country, time series and panel data studies. Section 4.3 gives a small review of the studies focusing on causality and on one country cases. Section 4.4 describes the econometric caveats of all three approaches. The conclusions are in Section 4.5.

4.2 Empirical Approach to the Finance-Growth Nexus

4.2.1 Cross Country Studies

The application of cross country techniques involves aggregating economic growth over long periods such as a decade or more and examining the relationship between measures of financial development and long run economic growth.[3] Goldsmith (1969) was the first to show the presence of a positive correlation between the size of the financial system and long-run economic growth. The size of financial development was captured by the ratio of the value of intermediary assets to GNP and economic growth based on data for 35 countries over the period of 1860-1963. He argued that the positive relationship was driven by financial intermediation improving the efficiency rather than the volume of investment. However, three main problems arise in this study. Firstly, although the period of study is long, the sample size is small. Secondly, no work is provided on the direction of causality. Lastly, no other factor that might influence growth is controlled for in his work. Although the problems of Goldsmith (1969) were evident, empirical studies only emerged in the early 1990s. King and Levine (1993a,b) solve the sample problem by working on 80 countries on a 30-year horizon (1960-1989). King and Levine (1993b) study controls for a number of potential determinants of economic growth such as initial income, educational attainment, inflation and government

[3]In principle the average influence of the determinants of economic growth is estimate. A number of studies that have dealt with this issue are,Gelb, 1989, WorldBank, 1989, Roubini and Sala-i Martin, 1992, Fry, 1997 and King and Levine, 1993a. Durlauf, Johnson, and Temple (2005) provide a review on the econometrics of the cross-country growth literature.

spending. Their study considers productivity growth and capital accumulation as the channels through which finance could affect growth and thus examine the association of financial development indicators within these channels. Their findings support a positive and significant relationship between several financial development indicators and economic growth. Their paper also examines whether the size of the financial system in 1960 can predict the rate of any of the dependent variables over the next 30 years. The results convey that indeed, the vector of the financial indicators is a good predictor of the subsequent rates of economic growth, capital accumulation and productivity growth. De Gregorio and Guidotti (1995) use a growth regression[4] to examine the relationship between long run economic growth and financial development using a dataset of 95 countries between 1960 and 1985. The bank credit to non-financial sector is used as the explanatory variable and the findings support a positive relationship between intermediation and real growth and more specifically that financial development is related to improved growth performance. These studies concentrate only on the banking system by using size indicators of financial development. They fail to take into account other measures which could directly measure the ability of the financial system To overcome this limitation, some studies attempt to examine the role of stock markets in promoting economic growth. Atje and Jovanovic (1993) show that stock markets have both positive level and growth effects on economic activity. According toDemirgüç-Kunt and Levine (2004), and confirmed by Demirgüç-Kunt and Maksimovic (1998) and Levine and Zervos (1998)) these studies are important for governments' to set reforming priorities in the different segments of the financial system. Levine and Zervos (1998) use data from 1976 to 1994 to examine whether banking or stock market contribute more in the growth accounting equation. They find a positive and significant relationship between stock market (measured by turnover or value traded to GDP) and bank development with GDP per capital growth. More specifically, they show that one standard deviation in stock market liquidity and banking sector explains a difference of 0.8 and 0.7 respectively in annual GDP per capita growth. These results suggest that whether the type of the financial system is market based

[4] The growth regression is presented in Section 4.4.

or bank based is of secondary importance in the growth process.[5] Other empirical work such as Beck and Levine (2002) compares the two and support the bank based idea. However, the evidence from Levine and Zervos (1998) content that the important feature for growth is the existence of liquid and efficient financial intermediaries, regardless of whether there are equity markets or banks. Moreover, their empirical work becomes important for policy as it conveys that equity markets and banks are complements rather than substitutes and thus in markers such as the European one, market based economies and bank based economies can coexist and both can promote growth. Their results coincide with those of Levine (1991) and Bencivenga, D., and M. (1995). The same conclusions are drawn from the studies of Levine, Loayza, and Beck (1999) and Beck, Levine, and Loayza (2000) which find a significant impact of financial intermediation indicators on the real GDP growth and productivity. They however find an ambiguous effect on physical capital growth and saving. In contrast to these results Harris (1997) shows little support on the view that stock markets help to explain growth rates especially in the developing countries.

More specific research comes from La-Porta, Lopez-De-Silanes, and Shleifer (2002) where the state ownership of the banking sector is the proxy for financial development. The cross country regression reveals that the ownership and control of the banks in the 1970s contributed negatively to the growth process. They control for institutional quality controls and also disentangle the effects of state ownership on investment and productivity and show that although investment is not significantly affected, productivity is largely affected. The conclusion of their research is that public intervention in the credit markets deters resource allocation. This is in contrast to other research such as Sapienza (2004) and Papaioannou (2005) which give evidence for supporting public choice theories.

Aghion, Howitt, and Mayer-Foulkes (2004) test the effect of financial development on convergence. Adding the financial sector in a Schumpeterian model of the 19th century imply that all countries above some threshold level of financial development should converge in

[5]Demirguc-Kunt and Levine (1999) analyse cross section growth regression and conclude that countries become more market based as their income increases. Chakraborty and Ray (2006) provide a theoretical model and find that neither system is unambiguously better for growth, but a bank-based system relatively outperforms a market-based one along other dimensions.

growth rate, and that financial development has a positive but gradually diminishing effect on steady-state GDP. The authors test these implications by estimating a cross-country growth regression by augmenting it by an interaction term between financial development and the country's initial relative output relative to the US GDP. The countries with higher financial development have a higher probability of converging to the U.S growth rates. They conclude however that the direct effect of financial development is not significantly different from zero.[6] La-Porta, de Silane, Shleifer, and Vishny (1997) consider the differences in countries' legal origins an exogenous factor for the development of the countries' financial development. It is exogenous because most of the countries obtain their legal systems through colonization or occupation. They thus develop the "legal origins" hypothesis where legal systems affect financial development and thus economic activity. Whether a country enforces laws from the British, French, German or Scandinavian background laws, its growth process depends on these through the impact of law on the financial systems. The empirical work that followed has emphasised that the legal system signifies an essential determinant of economic growth, especially in relation to financial development. The idea is that any financial instrument needs a legal system to support it. For example, the legal system makes it harder for a debtor to default on its debt obligation. It acts as a protection line between the rights of the borrowers and the lenders. The legal origins variable is captured through Instrumental Variables (IV) such as the legal rights of creditors, the soundness of contract enforcement and the level of corporate accounting standards. The authors try to distinguish how important is the legal systems for the firms in need of external finance. The results imply that countries with better legal protections have higher and broader capital markets and more external finance. The studies that followed such as Levine (1998), Demirgüç-Kunt and Maksimovic (1998) and Levine (1999) also show that the finance-growth nexus is statistically significant.[7]

Some other cross country studies such as Levine and Renelt (1992) and Sala-i Martin

[6] Aghion and Howitt, 2006give a review on the Schumpeterian growth models of technological innovation and attempt to identify specific channels through which finance affects economic growth in cross country regressions (see also Howitt, 2000)

[7] The main problem of using the IV approach is that legal origin may affect economic growth through a third channel, for example through regulation. Acemoglu and Johnson, 2003 find that in such cases, their IV estimates are biased upwards and interpreted as upper bounds of the true effect of financial development.

(1997) perform a regression where a range of non-financial variables explain real growth to some extend while financial variables are found to be ineffective. Odedokun (1996) examines 81 countries and concludes that money aggregates have a negative effect on marginal productivity. Harris (1997) argues that the effect of stock market activity in less developed countries relative to developed countries is rather weak. Results from studies such as those of Shleifer and Vishny (1986) and Shleifer and Summers (1988) support the negative implications of stock market liquidity. Also Ram (1999) makes a use of annual data for 95 countries over 1960-89 and shows that the correlation between financial development and economic growth is negligible or negative even if the regression is applied to each individual country or on groups of countries according to their income levels.

Table 3.1 displays a number of cross country studies stated by their results. Most of the studies conclude on a positive relationship between different indicators of financial development and growth.

4.2.2 Time-Series Studies

Following Arestis and Demetriades (1997), time-series explore the finance-growth relationship mainly through the application of Granger causality tests in a vector autoregression system of equations (VAR). Most of the cross country studies take for granted that the link between financial and real sector runs from finance to real economy. On the contrary, time series studies give priority to the issue of causality. Time series results rarely give a clear directional causality pattern between finance and the real sector. The first time series study is that of Gupta (1984) working on 14 developing countries. Using monetary indicators as well as private credit to measure financial development and industrial production as an index of economic development, his study supports that causality runs from financial development to growth. However, his results are unreliable considering that the industrial production is only a small portion of the total output in particular for most of the developing countries.

Patrick (1966) supports the hypothesis that the direction of causality alters over the development process. At initial levels of economic development a supply-leading pattern is observed where the creation of financial institutions is responsible for higher growth through a reallocation of resources from traditional to modern sectors. At later stages, the demand-following hypothesis develops where the need for financial services coming from higher growth leads to an expansion of the financial system. Jung (1986) applies Granger causality tests for 56 countries for the period 1950 to 1981 and provides support for the supply leading hypothesis. Hansson and Jonung (1997) examine the case of Sweden over 1834 and 1991 and argue that a bi-directional causality is observed between bank credit and real output for 1834 to 1991 whilst a supply-leading relationship occurs for 1890-1934. Neusser and Kugler (1998) use the financial sector GDP as a proxy for financial development and manufacturing GDP as an indicator of economic growth and apply causality tests to find results consistent with the supply leading view and conclude that finance is important for growth. They also apply cointegration and causality tests on 13 OECD countries between 1960 and 1994 and find that the causal link between finance and the real sector is weak especially for the smaller countries. They however establish a feedback from manufacturing GDP to financial services without making inferences on the direction of causality. Similar studies and conclusions are obtained by Demetriades and Luintel (1996); Greenwood and Smith (1997); Luintel and Khan (1999); Rousseau and Vuthipadadorn (2005); Xu (2000) The latter applies an examination on 41 countries between 1960 and 1993 and rejects the hypothesis that financial development merely follows economic growth and has a negligible effect on it.

Cross country studies usually treat developed and developing countries as belonging to the same category. Demetriades and Hussein (1996), as well as Arestis and Demetriades (1997), separate these two groups of countries and examine them separately to prove the variability across countries even if the same estimation techniques are used. They content that different countries have different institutional systems and some of these systems are relatively more significant for growth. They conclude that even if countries have the same level of financial development, different financial sector policies and institutions alters the impact of finance on growth. Demetriades and Hussein (1996) reveal evidence of bi-directionality and reverse causation when applying causality tests on 16 developing countries. Claiming that finance leads growth it is thus dangerous for policies and institutions in the developing countries. Rousseau and Wachtel (1998) examine the period of 1871-1929 USA, Canada, Sweden, Norway and UK over a period of 1871-1929. The large time span allows for testing long term causal patterns like those described by Patrick (1966) and Gerschenkron (1962). Their study claims that the finance-growth nexus is driven by financial intermediation variables which affect the growth process.

In a more recent empirical work examining the case of Malaysia, Ang and McKibbin (2007) use a multivariate cointegration approach analysis to index financial development in order to overcome issues of over-parameterization. A number of causality tests used in their study concludes that growth is causing financial development in the long run. However, Caporale, Howells, and Soliman (2005) examining the same country while using stock market data concludes that the stock market development enhances economic growth through a rise in the efficiency of investment which feeds back to productivity. These results highlight the debate of bank based versus market based economies in promoting growth. Arestis, Demetriades, and Luintel (2001) argue in favour of banks, that the role of stock markets has been over-emphasized by cross-country studies. They even find a negative effect of stock markets in five of the developed countries examined. Against this view, Thangavelu and Ang (2004) using Australia as the case study show that economic development increases the demand for banking services and causes an enhancement of the financial sector. There are also cases of neither demand-following nor supply-leading hypothesis. Chang (2002) uses multivariate VAR models for Mainland China to test both of these hypotheses. Based on multivariate error correction models (ECM), Granger causality implies no dependence of finance on growth or vice versa.

Time series studies give mixed conclusions on the issue of causality. Table 3.2 outlines some of the most influential time series studies. What is noticed however is that supply leading patterns tend to occur somewhat more frequently than demand-following.

4.2.3 Panel Studies

Dynamic panel estimation techniques have been used in order to eliminate the problems of cross country studies. Panel techniques allow for financial development and growth determinants that are time-invariant unobserved country characteristics to be controlled.[8] Fixed-effect panel techniques are subject to less endogeneity problems. Heterogeneous country effects are allowed and thus financial development has differential effects across countries. Among many others, the empirical studies of Levine, Loayza, and Beck (1999), Beck, Levine, and Loayza (2000), Benhabib and Spiegel, 2000, Rousseau and Wachtel (2000), Beck and Levine (2004) and Rioja and Valev (2004) convey a positive relationship between indicators of financial development and growth. Gertler and Rose (1991) develop one of the first panel studies on the finance-growth nexus and find that a one percentage point rise in per capita income is associated with a one and a half percentage point increase in private domestic credit and the relation is very robust. Berthélemy and Varoudakis (1997) apply a fixed effect model for 82 countries. Although they establish a negative relationship between finance and growth, they claim that under poverty traps, financial systems cannot efficiently fulfil their functions and that the impact of a poor financial system is that it holds the economy stable at a low equilibrium.

Loayza and Ranciere (2004), use a dynamic panel pooled mean group estimator employed by Pesaran and Smith (1995) to internalize parameter heterogeneity and conclude that there is a positive significant relationship between finance and growth in the long run but not in the short run. This finding is supported by the idea that too much finance in the sense of fast expanding credit can lead to financial crisis and thus impede economic growth. Arcand, Berkes, and Panizza (2011) using cross country and panel techniques convey the same conclusion. Levine, Loayza, and Beck (1999) use a GMM estimator developed by Arellano and Bond (1991) for panel data. They find a positive relationship between the exogenous financial development factor and economic growth, capital accumulation and productivity growth. Calderón and Liu (2002) use the Geweke decomposition test on 109 developed and

[8]See Bond, Hoeffler, and Temple, 2001 for a discussion of the GMM dynamic panel techniques used in most of the empirical growth models with a panel set of data.

developing countries conveying a bi-directional causality. Christopoulos and Tsionas (2004) use panel unit roots and panel cointegration techniques and conclude that causality runs from financial development to economic growth but they find no feedback relationship.

Micro level studies also employ panel techniques. Such studies attempt to lessen limitations such as omitted variable, reverse causality and multicollinearity. The micro approach helps to increase understanding of the theoretical mechanisms behind finance and growth. Rajan and Zingales (1998) work on a cross-country cross-industry approach and content that a better developed financial system help reduce market frictions which otherwise create a wedge between the cost of external and internal finance. This helps the industries which are highly dependent on external finance to expand proportionately more than the firms which are not as dependent on external finance. In general, the firms using external finance based in highly developed countries tend to prosper more compare with other firms. They use industry level data (36 manufacturing industries) and 41 countries and propose a two-step approach. They first construct a measure for external finance and then test whether sectors highly dependent on external finance tend to grow faster. The important innovation of this paper is the introduction of both country and industry fixed-effects. Studies that followed confirm the strong positive effect of financial development with industry growth and hence economic growth (Demirguc-Kunt and Maksimovic, 2002; Claessens and Laeven, 2004; Braun, 2003; Bertrand, Schoar, and Thesmar, 2007; Guiso, Jappelli, Padula, and Pagano, 2004; Allen, Qian, and Qian, 2002).[9]

4.3 A note on Causality and Country Specific Studies

The ambiguity arising from the conclusions of these studies is explained according to Al-Yousif (2002) by the fact that most of the studies focus on the correlation between finance and growth and this does not demonstrate or imply any causality direction. The issue of causality direction between financial development and the real sector is a central aspect

[9]Ciccone and Papaioannou, 2005 apply a micro approach to assess the impact of human capital on growth. Others use this method to explore the impact of product market regulation on firm entry (Perotti and Volpin, 2004; Fisman and Sarria-Allende, 2004)

among researchers. Evidence on causality can influence policy reforms and their degree of importance in enhancing financial intermediary development. Imperative statements such as “banks were the happiest engines that ever were invented” by Hamilton (1781) and banks harm the “morality, tranquillity, and even wealth” by President John Adams (1819) ought to be made only when causality has been established. It is possible that financial development is merely the leading indicator of economic growth instead of a causal indicator.

Studies concentrating on causality however, also lead to ambiguous results most probably because of simultaneity, omitted variables, nonstationarity of variables, insufficient sample size and unobserved country specific effect. To solve the problem of small sample size, Holtz-Eakin, Newey, and Rosen (1988) use a panel vector autoregression model (VAR) with a large cross country sample under a small period of time. In 1984, Gupta used quarterly data of industrial output of 14 developing countries to measure economic development and reported a direction of causality from financial development to economic growth. Rousseau and Wachtel (2000) use Arrelano and Bond procedure of testing causality in a VAR model providing evidence of causality from finance to growth. Levine, Loayza, and Beck (1999) use a GMM dynamic panel estimator and instrumental variables capturing cross country characteristics to address the issues of simultaneity and unobserved country specific effect. Calderón and Liu (2002) apply tests of linear dependence and Geweke test to establish the direction of causality in a panel data set of 109 countries. They find a feedback effect which implies that financial development promotes economic growth and at the same time economic growth is a catalyst for financial development. They also find that the degree of causality from finance to growth is bigger in the developing than in the developed countries. Moreover, causality tests show that financial development causes total factor productivity growth which is relatively greater in developing countries.

Integration and cointegration properties of the data are introduced in Christopoulos and Tsionas (2004) work which also concludes in a unidirectional causality from finance to growth. They test the long run relationship between the financial sector and the real sector by applying unit root test, panel cointegration analysis, cointegration test and dynamic panel data estimation for a panel vector error correction model (VECM). Their findings suggest a unitary equilibrium relation between financial deepening and economic growth as well as a support for the finance-led hypothesis in the developing countries of their sample. Pesaran, Pick, and Timmermann (2011) propose a different than the traditional Engel and Granger approach to causality which is superior in that it is applied even if the regressors are not purely stationary or integrated. It is also statistically more efficient in the case of small samples. In 1995, Toda and Yamamoto (1995) estimated a VAR which guarantees the asymptotic distribution of the Wald statistic through the robustness of the integration and cointegration properties of the process. Esso (2010) use both of these techniques and conclude that for some developing countries GDP per capita significantly causes financial development in Cape ('demand-following' view) as confirmed by Demetriades and Hussein (1996). In some other countries however financial development 'leads' economic growth and agrees with the 'finance - led' growth hypothesis. Hurlin and Venet. (2001) however, find that causal relationship from growth to finance, occurs in developed than in developing countries. Apergis, Filippidis, and Economidou (2007) examine whether a long-run relationship between finance and growth exists using panel integration and cointegration tests. Their results support a bi-directional causality between financial deepening and growth, which remains robust to various specification of the sample.

A major constraint in establishing causality empirically is that time series for developing countries is not widely available. Cross country studies built aim to break this constraint but as Ahmed (1998) argues, the issue of causality cannot be addressed in such a framework since each country has its policies and its own financial institutions (Demetriades and Andrianova, 2004; Kirkpatrick, 2005). Since each country has its own characteristics such as social capital, law and regulation, researchers move towards examining the long run relationship between finance and growth in country-cases. Country-specific studies establish a relationship between the local policy frameworks, financial development and growth within a special case and attempt to overcome the difficulties arising from efforts to disentangle country-specific characteristics. For example the U.S removed regulatory restrictions on branching and bank ownership. Jayaratne and Strahan (1996) relate the impact of such changes to growth and conclude that state banking deregulation is associated with an increase in GDP per capita. Individual country studies become essential for policy in the EU since it gives evidence on how the banking and financial integration affects productivity and hence the growth rate. Such evidence are given by Guiso, Sapienza, and Zingales (2004) who investigate the effects of firm access to finance and how it affects the growth of different Italian regions. Financial development turns out to be a fundamental characteristic in the growth process. Ang and McKibbin (2007) use data available from Malaysia use multivariate cointegration and tests of causality and argue that output growth enhances financial development in the long-run. They control for multicollinearity and upward bias in the estimators by using financial indicators constructing financial development index. Thangavelu and Ang (2004), find that economic growth Granger causes financial development in Australia through an effect on the banking sector. Rao and Tamazian (2008) use Indian data to reject the view that finance follows where enterprise leads. Using panel data in China, Aziz and Duenwald (2001) cannot support the hypothesis that financial development boosts economic development. Kilimani (2007) provides evidence on the link and causality between the financial and the real sector in Uganda and contend that causality runs from financial development to growth when M2/GDP is used as a proxy indicator. Although country case studies are important for examining the relationship between finance and growth at a national level, they cannot be used for general inferences on this relationship. The results obtained from one country cannot constitute as a reference for policy formulation in other countries.

4.4 Limitations of the Empirical Research

Most of the empirical work that follows after the work of Goldsmith (1969) uses a Barro-type regression summarised in equation 4.4.1:

$$g_{i,t} = \Delta ln\left(y_{i,t}\right) = \alpha + \beta_i f_{i,t} + \gamma_i C_{i,t} + \mu_i + \epsilon_{i,t} \tag{4.4.1}$$

where $ln\,(y)$ is the log of real GDP per capita or any other form of welfare available, g is the growth rate of y, f is an indicator of financial development, C is a conditioning information set,μ is a country specific element of the error term without necessarily being distributed with a mean of zero, ϵ is an error term with a mean of zero, i is the country, industry, firm or household according to the type of study and t is the time period. The focus falls on parameter β_i as its significance and sign are under debate. This parameter can be biased and results can be inconsistent because of measurement error, lack of appropriate data, reverse causation and omitted variable bias. For many years, the f vector included variables capturing the size, efficiency and activity of banks and thus included monetary aggregates or private credit to GDP. In later years especially after 2000, this vector is expanded to include the size, liquidity and efficiency of the stock markets especially for the developed countries since the data for the developing ones is scarce. Micro-based data and non-bank financial institutions data is also used in recent research.

4.4.1 Cross country growth equation

The common cross country equation is of the form

$$g_i = \Delta ln\,(y_i) = \alpha + \beta f_i + \gamma C_i + \delta ln\,(y_{i,t-1}) + \epsilon_i \tag{4.4.2}$$

This regression equation only has cross country but not time series dimension. The initial level of income, $ln\,(y_{i,t-1})$ enters to control for convergence predicted by the neoclassical Solow-Swan models (i.e. the further away a country is from its steady state, its growth rate will be higher). Benhabib and Spiegel (2000) replace this term by the physical capital accumulation $\Delta ln(K_i)$. The growth rates and the explanatory variables are measured as an average over the sample period or as an initial value. Cross country studies examine the sign and significance of parameter β as evidence for a partial correlation between finance and growth. The conditional set of variables includes initial levels of human or physical capital, institutional quality, geography, government policy variables to allow for cross country differences in productivity and testing for an independent partial correlation of finance with growth. If β takes a positive and significant value is a sign of a positive partial correlation between financial variables and growth. The pioneers of empirical work on finance and growth King and Levine (1993a) as well as Levine and Zervos (1998) used regression 4.4.2 using bank variables and stock market variables respectively. Both of these papers find a positive link between measures of financial development and growth. Although the results are statistically and economically significant OLS estimates can be affected by an unobserved country specific effect, μ_i as in equation 4.4.1. For example Aghion, Howitt, and Mayer-Foulkes (2004) content that countries who have room from improvement and are thus away from the technological frontier are relatively more affected by the efficiency in the financial intermediaries. Moreover, countries with higher human capital or greater openness to trade tend to find financial development more useful. Thus, the effect of financial development may not be homogeneous across countries. Such an effect breaks down the orthogonality conditions

$$E(C_i^{'}\epsilon_i) = 0 \tag{4.4.3}$$

$$E(\gamma_i^{'}\epsilon_i) = 0 \tag{4.4.4}$$

$$E(f_i^{'}\epsilon_i) = 0 \tag{4.4.5}$$

and leads to a positive correlation of the lagged dependent variable with the error term hence

$$E[\gamma_{i,t-1}^{'}(\mu_i + \epsilon_i)] \neq 0 \tag{4.4.6}$$

Omitted variable bias is very likely in such regressions if other explanatory variables are also correlated with μ or if some explanatory variables are ignored from the equation and thus

$$E[C_i^{'}(\mu_i + \epsilon_i)] \neq 0 \tag{4.4.7}$$

It is impossible to control all the likable factors that may prosper economic growth. There is data for more than a hundred countries and a large set of C that can foster growth. The effect of omitting variables can be tested by adding more variables in an existing equation. Garretsen et al. (2004) argue that as legal and social capital factors are added in the regression, the positive β observed by Levine and Zervos (1998) no longer holds. Moreover, as Rioja and Valev (2004) find, grouping countries according to their financial development levels gives a different impact of finance on growth. The static assumption in these broad pure cross country regressions means that the model is made into a one-period framework. Inferences about the long run are thus unverifiable since economic growth is a long term phenomenon and a long time series data is a sufficient and necessary condition for inferences and analysis of the finance-growth link. These are factors that make cross country studies susceptible to the sample of countries, the control variables used, the time span used and the econometric application.

Multicollinearity arises among the regressors and is thus hard to disentangle the effect of the different independent variables on economic growth. One can conclude that well-developed countries have well-developed financial systems. However, they also have well-developed education systems, political stability, high institutional quality etc. The inter-correlation between the regressors has led to only a few variables being considered as significant determinants of economic growth (Levine and Renelt, 1992; Sala-i Martin, 1997; Sala-I-Martin, Doppelhofer, and Miller, 2004). Measurement error is another issue with pure cross country studies. There is a possibility that financial development indicators are inaccurate such that

$$(\widetilde{f_i}) = f_i + u_i \tag{4.4.8}$$

where $\widetilde{f_i}$ is the true level and f is the measured level of financial development. If,

$$E(\epsilon_i^{'} u_i) \neq 0 \tag{4.4.9}$$

then the equation 4.4.2 suffers from attenuation bias which implies that the estimates are conservative. Measurement errors can occur due to data problems. There is no grounded theory for establishing proxies of financial development. Usually financial indicators are constructed taking into consideration the channels through which finance affects growth. However, measurement error may lead to upward bias of the estimated financial development parameter especially if other variables from the conditioning set are measured with error. This is because is likely for the coefficient on financial development to capture part of the effect of these miss-specified variables.[10] There is also a lack of high quality data. This may prevent researchers from gathering information on historical financial environment of individual countries. Thus a cross country regression can say little about any policy implications ought to be pursued.

Reverse causation is another limitation of pure cross country studies. Most of the cross country studies take for granted the finance led view and expand models based on this assumption. However, financial development can cause economic growth but also be caused by economic growth. The relationship between the financial sector and the real sector may be due to economic growth leading to an expansion of financial services. Demetriades and Luintel (1996, 2001) specify an equation where the financial development vector becomes the dependent vector and find a positive impact of economic growth on f. Since this potential endogeneity is not controlled for in such simple equations, the estimators are likely to be biased and inconsistent. It is possible that financial development indicators such as market capitalization increase when future growth is expected and thus,

$$f_i = \theta y_{i,t-1} + v_i \tag{4.4.10}$$

and also,

$$E(\epsilon_i' v_i) \neq 0 \tag{4.4.11}$$

[10] As an example consider a regression equation with human capital and financial development. If one assumes that human capital is is measured with some error but financial development is not, then the coefficient of financial development will capture part of the human capital proxy which has not been specified. More details are given by Mankiw (1995) and Krueger and Lindahl (2000).

which violates the orthogonality condition. Reverse causality should not be ignored because as it may may suggest some underlying structural problems such as political interference in the financial system, corruption, political uncertainty, economic uncertainty such as inflation etc. An approach that gives relatively less biased results is the use of a set of simultaneous equations so that a specification for the financial development equation is clear.

Researchers search for instrumental variables to extract the exogenous component of financial development. Instrumental variables need to be correlated with financial intermediaries' indicators as to explain cross country differences in financial development but also be uncorrelated with economic growth besides their link with financial development.

Remedies to endogeneity and other biases include instrumental variables in the regression equation. These are instruments used to disentangle the effect of the endogenous variable that is not related to any of the biases. It is a way to control for the possibility that financial development and growth are both caused by other factors. The most common instrumental variable is the legal origins of the country as explained above. The research of law and finance identifies variables which explain financial structure but not economic growth. Other instruments include proxies for geographic conditions, (Sokoloff and Engerman (2000)) religion and culture (Stulz and Williamson, 2003). Including instrumental variables changes the simple regression equation into the following set of equations

$$g_i = \alpha_1 + \beta_1 f_i + \gamma_1 C_i + \delta_1 ln\left(y_{i,t-1}\right) + \epsilon_i \tag{4.4.12}$$

$$f_i = \alpha_2 + \beta_2 Z_i + \gamma_2 C_i + \delta_2 ln\left(y_{i,t-1}\right) + \chi_i \tag{4.4.13}$$

$$(\widetilde{f_i}) = f_i + u_i \tag{4.4.14}$$

where C and Z are the included and the instrumental variables respectively. Vector Z allows the identification of that part of f_i which is uncorrelated with ϵ_i and thus

$$E(Z_i^{'}\epsilon_i) = 0 \tag{4.4.15}$$

$$E(Z_i^{'}u_i) = 0 \tag{4.4.16}$$

Equation 4.4.12 is estimated by two stage least squares (TSLS) and it is considered to solve for omitted variable bias, measurement error and reverse causality. TSLS estimator can also be obtained by GMM. However, Ahmed (1998) and Ericsson, Irons, and Tryon (2000) claim that the use of instrumental variables as a solution to endogeneity is inefficient because when the data is averaged over a long period of time the growth dynamics are diluted and the regressions can lead to spurious relationships. The original data may not be contemporaneously correlated unlike the time-averaged data. Testing the conditions 4.4.15 and 4.4.16 requires the Sargan test (Sargan, 1958). Nevertheless, testing for overidentifying restrictions is relatively weak as it **i)** needs a greater number of instrumental variables compared to exogenous variables and **ii)** tends to reject the validity of instruments if the sample is small (Murray, 2006). The problem of causality also remains as instrumental variables in cross-country regressions focus on the endogeneity of financial development and thus all of the other control variables are treated as exogenous. Setting a priori a belief on causality based on theory does not help in determining the causal relationship of the variables. Moreover, instrumental variables approach ignores the independent and simultaneous effect of equity markets. Lastly, if the excluded exogenous variables are weak, the IV results are biased towards OLS and become inconsistent. Care is needed when choosing instrumental variables as they can be positively correlated with omitted variables and leads to an upward bias of the IV estimator for β_1.

4.4.2 Time series caveats

The aim of the time series approach is its ability to tackle the issue of causality. Time series requires the use of higher-frequency data collected from one or few countries. Higher frequency often implies yearly data which has more econometric power than the multi-year average data used in cross-sectional studies. However, due to data availability the data in time series is usually short especially for developing countries. To avoid the loss of degrees of freedom the usual approach is to include only one lag in the econometric model which is insufficient to capture short run effects and serial correlation issues. Time series approach also relaxes the constraint imposed by cross country studies that $\beta_i = \beta$ in equation 4.4.1. However, the time series approach is subject to omitted variable bias. Because of data availability, the time series single equation includes up to four variables in order to preserve the degrees of freedom. So, claiming that

$$f_t = g(y_{i,t}, Z_{i,t}) \tag{4.4.17}$$

and

$$y_t = h(f_{i,t}, Z_{i,t}) \tag{4.4.18}$$

is a sufficient specification of the finance-growth relationship is ungrounded. The problem becomes bigger if a VAR is considered because no restrictions are imposed according to the theory. The time series analysis relies on Granger causality tests (Granger, 1969) which may lead to a misinterpretation of the results. If one internalises the expectations about the impact of future economic development on financial development, financial development becomes a leading indicator losing any causal powers. The economic time series $f_{i,t}$ is said to be Granger caused by $y_{i,t}$ if controlling for the past values of $f_{i,t}$ and the lagged values of $y_{i,t}$ helps in predicting the current value of $f_{i,t}$. The test involves a j^{th} order VAR as follows

$$y_{i,t} = \alpha_0 + \sum_{i=1}^{j} \alpha_{1i} y_{i,t-1} + \sum_{i=1}^{j} \alpha_{2,i} f_{i,t-1} + \epsilon_{1t} \tag{4.4.19}$$

$$f_{i,t} = \beta_0 + \sum_{i=1}^{j} \beta_{1i} y_{i,t-1} + \sum_{i=1}^{j} \beta_{2i} f_{i,t-1} + \epsilon_{2t} \tag{4.4.20}$$

Where α_0 and β_0 are constant drifts and ϵ_{1t},ϵ_{2t} are serially uncorrelated zero mean errors.

The null hypothesis is that no Granger causality exists from financial development to growth and thus $\alpha_{21} = \alpha_{22} = ... = \alpha_{2j} = 0$ or from economic growth to financial development and thus, $\beta_{11} = \beta_{12} = ... = \beta_{1j} = 0$. The Granger causality test helps to show how past values of a variable predict the current values of another. Nevertheless, prediction does not imply causality (Demetriades and Andrianova, 2004). The problem with this specification is that variables have unit roots and are thus nonstationary in most countries. First differenced bivariate VAR model is usually introduced to avoid the issues occurred when variables are nonstationary or not in levels. However, this approach removes long-run information from the data set. Therefore the need arises to test whether a long run relationship exists. Methods of testing cointegration are the Engle and Granger (1987) and the Johansen and Juselius (1990) approaches. The basic requirement is that two or more nonstationary series are integrated in the same order. A major problem arising from these approaches are that they are not reliable in small sample sizes as illustrated by Kremers, Ericsson, and Dolado (1992). Even if one increases the number of observations, Hakkio and Rush (1991) contend that the robustness of the cointegration analysis does not improve. Care is needed though since cointegration again does not control for omitted variable or measurement biases.

4.4.3 Caveats of dynamic panel regressions

Country studies and micro-level studies The dynamic panel is formed as follows

$$g_{it} = \alpha + \beta f_{it} + \gamma C_{it} + \delta J_{it} + \mu_i + \zeta_t + \epsilon_{it} \tag{4.4.21}$$

where C_{it} is a set of exogenous variables, J is a set of endogenous variables and ζ_t is a vector of time dummies. The interesting component of such an equation is that the current values of f and J are affected by current and past values of the growth rate but are not related with future values of ϵ_{it}. Dynamic panel techniques are judged to be sensitive to small model permutations as proved by Favarra (2003).[11] As Wachtel (2003) argues, any

[11] Hauk and Wacziarg (2009) provides a general description and criticism of the panel techniques in the context of growth econometrics.

relationship reported between financial development and growth is due to between country differences instead of within country differences over time and it is thus a mistake to consider μ_i as constant. The GMM method developed by Arellano and Bover (1995) and Blundell and Bond (1998) takes the first differences of equation 4.4.21 in order to eliminate the country-specific effect. This solves the omitted variable bias. If however the unobserved country specific effects are included in the error term, the results become biased and inconsistent according to Pesaran, Smith, and Im (1995). What is more, the differenced residuals are correlated with the dependent variable which implies that the pooled OLS estimated are inconsistent and instrumental variables are essential. Anderson and Hsiao (1980, 1982) argue that the lag values of the endogenous explanatory variables are valid instruments for the current differences in endogenous variables. Arellano and Bond (1991) thus propose the use of these instruments and a two-step GMM difference estimator. One of the disadvantages of this estimator is the loss of pure cross-country data dimension. Also, according to Griliches and Hausman (1986) the estimator may reduce the signal-to-noise ratio and increase the measurement error bias. The robustness and validity of the instruments is also questioned (Blundell and Bond, 1998) if the lagged dependent and the explanatory variable have high autocorrelation.

Country studies mentioned above such as that of Jayaratne and Strahan (1996) use the differences-in-differences approach between the treatment and the control groups before and after a policy change. This estimator reduces but does not completely eliminate the reverse causation and omitted variables bias. Underestimation of the standard errors is another potential problem of this estimator as pointed out by Bertrand, Duflo, and Mullainathan (2004). Industry studies by Rajan and Zingales (1998)) use a similar approachby including industry and country specific effects. Their regression however also suffers from omitted variables and reverse causation biases. Although these problems are addressed by including interaction terms between industry and country characteristics, the differences-in-differences estimator depends on the assumption that the industry characteristics do not change across countries. On a firm-level, the approach used by Demirgüç-Kunt and Maksimovic (1998) provides additional information but suffers from identification issues. It ignores the externalities (positive or negative) to other firms arising from the effect of finance on firm growth.[12]

4.5 Conclusions

This chapter gave an extensive literature and empirical review of the financial development and growth nexus. It separated the studies into cross country, time series and panel data, described the methods, the results and the conclusions. It then described the caveats of each and every empirical way which attempted to capture this relationship by concentrating on the econometrics of finance and growth. The reader is introduced to the limitations of the up-to-date literature and empirical work so that the aim of the thesis becomes clearer. These limitations act as an aim for building more efficient models to provide a role of financial development in growth theories. The unresolved issue of causality is raised to familiarise the reader with the problems of identification which the subsequent chapters will try to avoid.

[12] Beck (2008) provides a full description of the problems in econometric growth regressions in the context of finance and economic growth.

Chapter 5

Model Evaluation

5.1 Introduction

Lucas' critique (Lucas, 1976) began a new strand of research for building macroeconometric models. Previews model formulations were judged on the basis of not being structural as well as for incorporating ungrounded identifying restrictions (Sims, 1980). Dynamic stochastic general equilibrium (DSGE) models emerged in the hope to overcome these shortcomings. The empirical performance of DSGE models is under scrutiny by researchers. There is no settlement on the best way to evaluate a DSGE model especially after the Bayesian methods of estimation were introduced. Moreover, macroeconomic data are generally non-stationary and in order to test models researchers used techniques such as the HP-Filter or the Band Pass to remove the trend. However, the stationarised data has been judged for drifting away from the theories used in these models. This chapter is introducing the reader to a fairly new and unfamiliar testing procedure; indirect inference. It aims to explain its application on DSGE RBC models and its suitability when working with non-stationary data. Section 5.2 gives a general description of the indirect inference procedure and briefly explains the reasons this method is used instead of any other.[1] Section 5.3 expands the general idea of indirect inference in the context of testing a DSGE model and explains its usefulness when

[1] Other methods include the Likelihood Ratio (Corradi and Swanson, 2007) and the Del Negro-Schorfheide measure (Del-Negro and Schorfheide, 2006)

working with non-stationary series. Section 5.4 concludes.

5.2 Indirect Inference

5.2.1 Definition

Indirect inference was first introduced by Gourieroux, Monfort, and Renault (1993) and Smith (1993). Indirect inference is a simulation-based method for evaluating or making inferences about the parameters of economic structural models with intractable likelihood functions. Evaluation in this case means applying the classical statistical inference on a calibrated or an already (partially) estimated (DSGE) model in order to judge its performance. This is related, but it is not however the same as estimating a macroeconomic model using indirect inference. One of the advantages of this method is its ability to maintain the basic idea of evaluating RBC models through a comparison of the moments generated by data simulated from the model with those of actual data.

Similar to other simulation-based methods, indirect inference requires the possibility to simulate data from the economic model for any set of parameter values. It differs however in that it uses an auxiliary (or approximate) model to form a criterion function. The auxiliary model could be an inaccurate description of the time series properties in the data. This model is a reflection of both, the actual and the simulated data generated by the model and it selects features of the data and analyses them. Indirect inference becomes useful when estimating models for which any criterion function (e.g. likelihood function) is difficult to evaluate. The set of such models includes nonlinear dynamic models, models with unobserved or latent variables and models where data is incomplete or missing.

The main aim of indirect inference is to optimally choose the parameters for the auxiliary model by minimizing the distance between a given function of the two sets of estimated coefficients of the auxiliary model. In simple words, the choice of the parameters is such that the observed data and the simulated data look the same through the auxiliary model. The auxiliary model is characterised by a set of parameters which are estimated by the observed and also the simulated data. The aim is for these two sets of parameters to be as close as possible. Gouriéroux and Monfort (1997) apply indirect inference on continuous time models, Monfardini (1998) to stochastic volatility models, Dridi and Renault (2000) to semi-parametric models and Keane and Smith (2003) to discrete choice models. Gouriéroux, Renault, and Touzi (2000) use indirect inference as a bias correction in various time series models.

5.2.2 Indirect Inference: The Method

In order to make the procedure of indirect inference clear suppose that the economic model is of the form:

$$y_t = J\left(y_{t-1}, x_t, u_t; \theta\right) \quad t = 1, 2, \ldots, T \tag{5.2.1}$$

where $\{y_t\}_{t=1}^{T}$ is a vector of observed endogenous variables, $\{x_t\}_{t=1}^{T}$ is a vector of observed exogenous variables, $\{u_t\}_{t=1}^{T}$ is a vector of unobserved random errors. These errors are assumed to be independent and identically distributed (i.i.d) with a known probability distribution F. θ is a $k \times 1$ vector of the parameters of the economic model that are subject to estimation. Equation 5.2.1 gives a probability density function for y_t conditional on y_{t-1} and x. Analytical tractability of this density is not a requirement for indirect inference since it relies on the numerical simulation of the economic model. The auxiliary model is in the form of a conditional probability density function

$$f\left(y \middle| y_{t-1}, x_t, \alpha\right) \tag{5.2.2}$$

where α is a p-dimensional vector of parameters. The auxiliary model must be exactly or over identified. In other words, the number of parameters p should be at least as large as the number of parameters in the model, k (i.e $p \geq k$). The conditional distribution of y_t in equation 5.2.1 cannot accurately be described by the density f. Using the observed data, the parameters of the auxiliary model can be estimated by maximizing the log of the likelihood function f defined by:

$$\hat{\alpha} = \arg\max_{\alpha} \sum_{t=1}^{T} logf\left(y_t | y_{t-1}, x_t, \alpha\right) \tag{5.2.3}$$

This estimated parameter vector $\hat{\alpha}$ acts as a 'statistics' vector that summarizes certain characteristics of the data. The aim of indirect inference is to choose the parameters for the economic model in such a way as to reproduce this set of statistics as close as possible. The parameters of the auxiliary model can also be estimated in three steps via simulated data generated from the economic model.

Step 1: The errors

From the distribution F, $n = 1, 2.\ldots.N$ sequences of random errors $\{\widetilde{u}_t^n\}_{t=1}^{T}$ are drawn. Siince N is the number of sequences that the indirect inference uses$n$ is the number of the simulation.

Step 2: Parameter vector

An initial parameter vector θ is chosen. Using the sequences of random errors generated as well as the observed exogenous variables, equation 5.2.1 is iterated. This helps to generate N simulated sequences of the endogenous variables, $\left\{\widetilde{y}_t^n\left(\theta\right)_{t=1}^{T}\right\}$.

Step 3: Maximisation of log likelihood

The average of the log of the likelihood of all N simulations is maximised in order to obtain an estimated vector of parameters $\tilde{\alpha}\left(\theta\right)$:

$$\tilde{\alpha}\left(\theta\right) = \arg\max_{\theta} \sum_{n=1}^{N} \sum_{t=1}^{T} logf\left(\widetilde{y}_t^n\left(\theta\right) | \widetilde{y}_{t-1}^n\left(\theta\right), x_t, \alpha\right) \tag{5.2.4}$$

The task of indirect inference is to choose θ so that $\tilde{\alpha}\left(\theta\right)$ and $\hat{\alpha}$ are as close as possible. θ is estimated with indirect inference under the assumption that the data observed is generated by the true model. Normally, if $p = k$, the chosen θ is such that, the economic model reproduces exactly the estimated parameters of the auxiliary model. If $p > k$ indirect inference picks θ as to minimize the distance between $\hat{\alpha}$ and $\tilde{\alpha}\left(\theta\right)$ based on a chosen metric. Also, as T grows to infinity while the number of simulations, N, does not change, $\tilde{\alpha}\left(\theta\right)$ and $\hat{\alpha}$ converge to a 'pseudo-true value' that depends on θ. Again, the value of θ chosen by indirect inference is the one that describes the observed data in terms of the auxiliary model in a perfect way.

5.3 Indirect Inference: The Evaluation of DSGE modeling

Specifying this method to be applied on a DSGE, let the representative model be:

$$y_t = f\left[y, L(y_t), x_t, L(x_t), (y_t^E), L(y_t^E); \theta; u_t\right] \tag{5.3.1}$$

The difference between 5.2.1 and 5.3.1 is the inclusion of the lag series of the endogenous variable vector as well as the vector of the expected y_t. The lag series L has a maximum lag length of k such that: $L, L^2, L^3, \ldots.., L^k$. The errors u_t are the ones collected from the structural equations and thus called structural errors. In other words, this is the vector of errors when the endogenous variables on the right hand side are set at their true values.

Before illustrating the steps towards the evaluation of the model, it is necessary to distinguish between indirect inference and indirect estimation of structural models. Indirect estimation as used by Smith (1993), Gregory and Smith (1991a,b) and Gourieroux, Monfort, and Renault (1993) refers to the method of choosing the parameters so that when the model is simulated the generated estimates of the auxiliary model are similar to those obtained from the observed data. Indirect inference refers to the evaluation of the model where the parameters of the structural model are taken as given.

The evaluation procedure is divided in three steps.

Step 1: Calculation of the errors This step involves calculating the errors of the economic model based on the actual data. A sufficient but not necessary assumption is for the errors to be normal. In the case of no expectational terms in the equations, calculation of errors is simply provided by the equation and the data. The inclusion of expectations requires estimation of an auxiliary model as demonstrated by McCallum (1976) and Wickens (1982). The number of the structural errors is assumed to be less than or equal to the number of endogenous variables. In many cases where the only structural error is the productivity shock one can assume that other errors exist but are constant during the stochastic simulation. Minford, Meenagh, and Wang (2006) give as an example the case of a war which is a shock not expected to appear in more than one sample.

Step 2: Bootstrapping, simulated data, empirical distributions conditional on the null hypothesis The null hypothesis is that the true economic model is the structural model with the given estimates. The null hypothesis implies that $\{u_t\}_{t=1}^{T}$ are omitted variables. In this case, they are modelled by AR(1) processes of identically and independently distributed shocks ϵ_t. In other words, $\{u_t\}_{t=1}^{T}$ are the residuals from an AR(1) estimation. The simulated disturbances are bootstrapped from these errors. The draws of the disturbances occurs by time vector because of the need to preserve the simultaneity between them. The number of independent draws (i.e. the number of simulations), N, is set to be 1000. The model is solved by projection method as described in Minford, Marwaha, Matthews, and Sprague (1984); Minford, Agenor, and Nowell (1986). The simulated data is then created.

Step 3: The Wald Statistic Deciding whether to reject or not reject the null hypothesis requires the estimation of the auxiliary model with simulated data. An auxiliary model needs to be chosen and be estimated using the simulated data already generated from the structural model with the given estimates. In this case, a PVAR(1) is chosen to be the auxiliary model.[2] In simple words, since there are 1000 simulations, the PVAR is estimated on each one and thus there exist 1000 vectors of coefficients, $\hat{\alpha}_T^s$ where $s = 1, 2 \ldots 1000$. These vectors reflect on the sampling variation implied by the structural model. A matrix can be created by bringing these vectors together. For example, if the PVAR consists of l equations and $l \times l = M$ coefficients, then a matrix of $N \times M$ is created from which the mean, the covariance and the 95% confidence bounds are easily calculated.

Next, the auxiliary model is estimated using the actual, observed data and the vector of coefficients $\hat{\alpha}_T$ is collected. Once both forms of the auxiliary model are estimated the

[2] Chapter 6 provides all the details.

performance of each auxiliary model is compared. If the structural model is not to be rejected it must be that its predictions about the impulse response functions, moments and time series properties of the data should match those based on the data. In order to perform a formal statistical test of the model performance the Wald statistic is calculated as follows:

$$\left[\hat{\alpha} - \frac{1}{S}\sum_{s=1}^{S}\tilde{\alpha}_T^s(\theta)\right]' \hat{\Omega}(\theta) \left[\hat{\alpha} - \frac{1}{S}\sum_{s=1}^{S}\tilde{\alpha}_T^s(\theta)\right] \tag{5.3.2}$$

where $\hat{\Omega}(\theta)$ is the estimate of the optimal positive definite weighting matrix. This allows for the calculation of the 5% of the bootstraps that generate the highest distance and thus fall outside the 95% confidence limits generated by the bootstrap process.

Generally, the Wald test, tests whether the estimates of the auxiliary model based on the actual data could have been generated from the defined structural model. It should be noted here, that the PVAR is of limited key macro variables because tests of raising this number increases the probability of rejection. The lag is chosen to be of order 1. However, if the model is not rejected at this stage, an order of 2 is attempted. If the model is rejected at lag order 1, no higher orders are attempted. If there is a failure to reject the null, the conclusion is that the economic model does not significantly differ from that of the true, observed data. In this specific case the Mahalanobis Distance is used to be normalised into a t-statistic as a measure of the overall closeness between the model and the data. This t-statistic reveals the same information as the Wald test but the results are in the form of a t-value and thus the model can be rejected if this t-value takes a number greater than the t-statistic at 5% (1.64).

5.3.1 Auxiliary Models

Given choices for the parameters describing the economic environment, the DSGE models determine the evolution of aggregate macroeconomic time series such as output, consumption, and the capital stock. The economic model implies a law of motion for these variables which is generally nonlinear. Key variables such as the capital stock are poorly measured due to the lack of a proper data and definitions. It is thus difficult to obtain a closed-form solution for the likelihood function. Indirect inference can be used to obtain estimates of the parameters of the economic model. A common choice for the auxiliary model is a vector autoregression (VAR) for the variables of interest. The choice of the auxiliary model exploits the fact that the solution to a log-linearised DSGE model can be represented as a restricted vector autoregressive moving average (VARMA) model and this can closely be represented by a vector autoregressive model (VAR). VAR models are known as a useful tool for exploring the dynamic interaction of multiple time series.

These models comprise equations explaining a small number of key macroeconomic variables where each equation includes the same set of explanatory variables, lagged values of all the variables in the system. The VAR approach is useful in analyzing an observed economic phenomenon without having a prior explanation for it. A simple two variable VAR(1) is represented by

$$y_t = \beta_{11} x_{t-1} + \beta_{12} y_{t-1} + \epsilon_{yt} \tag{5.3.3}$$

$$x_t = \beta_{21} x_{t-1} + \beta_{22} y_{t-1} + \epsilon_{xt} \tag{5.3.4}$$

so that the path of $\{y_t\}$ is affected by current and past values of the sequence $\{x_t\}$ in 5.3.3 while $\{x_t\}$ is affected by current and past values of the sequence $\{y_t\}$ in 5.3.4. The errors $\epsilon_{yt}, \epsilon_{xt}$ are uncorrelated white noise disturbances of zero mean and constant variance. The above system of equations can be re-written in a more general and compact form as:

$$A_0 Y_t = A(L)^h Y_t + \epsilon_t \tag{5.3.5}$$

$$\begin{cases} Y_t = A_0^{-1} A(L)^h Y_t + A_0^{-1} \epsilon_t \\ Y_t = \Xi_1(L)^h Y_t + \eta_t \end{cases} \tag{5.3.6}$$

where Y_t is a $n \times 1$vector of endogenous variables, A_0 is a $n \times n$ matrix of coefficients, L is the lag operator and $A(L)^h = A_1 L + \cdots\cdots + A_h L^h$ is the h^{th}order lag polynomial and $E(\epsilon_t \epsilon^{'}) = I$ provides the variance-covariance matrix of the structural innovations. Equation

5.3.5 is the structural model under the assumption that there exists restrictions on the matrix A so as to identify the coefficients. Equation 5.3.6 is the reduced form VAR. Notice that η_t are composites of the white-noise processes ϵ_t and thus also have zero mean and constant variance. This basic reduced-form VAR is unable to give a detailed structure of the relationship or shocks, which is what the policymaker really wants to know. To identify the shocks hitting the system and their impact on the economy, the model needs extra assumptions. The outcomes of the VAR analysis largely depend on these assumptions and the identification restrictions cannot be readily tested against the data and so shock identification remains a highly controversial issue. A type of model that is not susceptible to this problem is the DSGE model. In this case, economic theory is used to define all the linkages between variables. The tight economic structure solves the identification problem. However, since theory is never able to fully explain the data, a VAR is considered to 'fit' the data better.

Sims (1980) pioneered VAR models as models summarizing the information given by the data and as a tool for conducting various policy experiments. According to the Wold theorem Wold (1954) any time series vector can be represented by a VAR under mild regularity conditions. The main restriction imposed by the Wold theorem is that the VAR model should go to infinity if it is to be considered 'good'. 'Good' models are those which replicate the conditional and unconditional moments and a VAR is used to summarize these. There are numerous methods for selecting a lag length the simplest being the likelihood ratio. Using a VAR(1)[3] is considered a restricted version of some larger-dimensional model. To 'judge' and compare a model's statistics, 68 or 95 percent bands for the statistics of the data are used as in Christiano et al. (2005). Inferences on the quality of the model depend on whether the model's statistics are inside or outside these bands for any number of variables chosen.

This is one simple approach to test a DSGE model. There is a tight relationship between dynamic equilibrium models and VARs. The example given by Del-Negro and Schorfheide (2006) connects to the procedure of indirect inference and helps to identify this relationship. Suppose that the vector of the DSGE model parameters is fixed. One can generate 1 million observations from the DSGE model. This occurs from drawing a sequence of shocks and

[3] A model with n lags is represented by VAR(h).

put them into the model to obtain artificial data. Next, a VAR is estimated with h lags using the artificial data. The estimated VAR is considered as an approximation to the DSGE model having the property that its first h autocovariances are equivalent to the first h autocovariances of the DSGE model. The greater the number of lags the higher is the accuracy of the VAR approximation of the DSGE model. If this experiment is repeated but with different vector of parameter values the estimation of a DSGE model is almost like estimating a VAR with cross-equation restrictions. In even simpler words, to obtain a simulated approximation to the binding function, choose a set of parameters for the economic model and derive the law of motion implied by this set of parameters. Simulate data using this law of motion, and then using OLS fit a VAR to the simulated data. Indirect inference chooses the parameters of the economic model so that the VAR parameters implied by the model are as close as possible to the VAR parameters estimated using the observed time series.

As in Canova, Finn, and Pagan (1994), there are other ways of testing DSGE theories. Cointegration restrictions implied by an RBC model are driven by permanent technology shocks and are imposed on a VAR and then tested by the standard tools. DSGE models are considered to be too simple to capture the complex random and probabilistic nature of the data. If one compares their outcomes with the observed data, the probability of making meaningful inferences is low. The main characteristic of DSGE models is that they can tell a story about how the economy responds and evolves after an exogenous shock. The direction of the main macroeconomic variables might be easy to see but the magnitude of the impact and the timing of the output responses is relatively uncertain. GMM estimations as well as likelihood methods are weak in dealing with such issues. [4]Examples of DSGE models tested by a VAR include Dedola and Neri (2007). In a standard RBC model with habit formation, they use a VAR with several macro variables and examine the fitness of the model when robust sign restrictions are imposed to identify technology shocks in the data. Pappa (2005) present a sticky and a flexible-price model with monopolistic competition and use a VAR

[4]GMM and simulation estimators can be tailored to focus only on those aspects where misspecification is smaller as for example the Euler equation or the great ratios. Maximum likelihood estimation and testing require that at least under the null, the whole model is correct.

with a number of macro variables to verify whether an RBC style model fits the data better than a sticky price model.

This thesis constitutes a contribution to the application of the indirect inference methodology described above. Although DSGE models have been under test for many years, the theory of financial development and/or human capital has not been tested in such a way before. This work has two main original pieces. The first one is the introduction of human capital and financial development in a DSGE model to be tested via indirect inference. The second is the use of a panel vector error correction model (PVECM) as an auxiliary model -which is represented by PVAR in levels-. The need for a PVECM arises because the data used for the purpose of analysis in this thesis is nonstationary. When examining one country, a VECM is used to deal with nonstationarity. Handling non-stationarity is described in more detail in subsection 5.3.2. As described in Chapter 4, voluminous research on the relationship and/or causality between financial development and growth has failed to deal with the identification problem. The simple growth regressions suffer from biases which lead to spurious results. However, this thesis on the one hand uses indirect inference within the concept of financial development theory as an original way to 'solve' the identification problem by setting a well-defined structural DSGE model. On the other hand, the auxiliary model also becomes original since it uses a number of countries. Thus this work deviates from the simple VAR representation of the DSGE towards a relatively more complicated panel procedure.

5.3.2 Non-stationarity

Non-stationarity implies that some part of the data moves in a random unpredictable manner each quarter. This behavior of the macroeconomic data creates ambiguity when making predictions about the long term. Unit root models imply extremely different dynamic properties and the classical statistical tools are not able to help in testing the null. The consensus amongst economists is that macroeconomic time series are near-unit-root processes and this makes tests have low power. The usual way to abstract from this feature of macroeconomic data is to remove the trend using a number of mathematical transformations including deterministic or stochatic detrending and differencing. Most commonly, tests of macroeconomic models are done on stationarised data since any stationary series is easier to be predicted (its statistical properties do not change over time). The Hodrick-Prescott (HP) filter is the best known technique applied in non-stationary data in the real business cycle literature. Although this filter seems to have withstood the test of time the criticisms remain. HP as well as Band Pass (BP) filters are not based on the theories used in these models. They concentrate on the statistical properties of the data and deviate from information drawn from the data which could potentially be essential for the model's fit. The drawbacks of the HP filter are described by Cogley and Nason (1993). Instead, using original data for determining or testing economic long run relationships is superior in that it can explain deviations from the steady time trends usually observed when in times of crises. The testing procedure of indirect inference utilises the original data.

A VAR is still suitable in cases of nonstationarity since covariance stationarity although convenient, is unnecessary. One solution could be to take first differences if all variables are $I(1)$. Thus, a VAR in growth rate appropriate. In the case of cointegrated series however, one can transform a VAR into a vector error correction model (VECM) and to jointly estimate short-run and long-run coefficients from the data. The VECM is a safer option than the differenced VAR because the latter reduces the degrees of freedom and thus the information about the long-run properties of the data. If the shocks are nonstationary[5] then a VAR in differences may be needed. This is because a permanent productivity shock leads to a production function which is not cointegrated. This may lead to a non-stationary path of the disturbances in the VAR in levels. A plot of the disturbances is usually informative on their stationarity. Breaks or outliers may be observed but most of the times a unit root behavior is not indicated. Hence, a VAR in levels could be appropriate even if a time series y_t looks non-stationary. As Sims, Stock, and Watson (1990) claim, the estimates of VAR coefficients can be consistent even when unit roots are present.

In this case, a multi-country model is evaluated and thus a panel-data vector autoregression methodology is used (PVAR). This technique is a combination of a VAR where all

[5]This is usually the case with the productivity shock or nominal shocks (i.e. money supply shock).

variables are treated as endogenous with panel-data technique. The panel-data approach allows for unobserved individual heterogeneity.

To reduce any non-stationary data into stationarity a first-differenced VAR can be used as the auxiliary model or and a VECM that includes cointegration relations implied by the DSGE model. In the class of structural models where the true model also belongs, the endogenous variable vector y_t can be written in the linearized form as a function of the lagged vector y, a vector of exogenous variables x,z and of errors u.

$$y_t = f\left(y_{t-1}, x_t, z_t, u_t\right) \tag{5.3.7}$$

The assumption made is that x are non-stationary, $I\left(1\right)$variables with drift trends which may be zero. The vector z contains $I\left(0\right)$variables with a (possibly non-zero) deterministic trends. The error vector, u, contains $I\left(0\right)$error processes with zero means and deterministic trends such that:

$$u_t = \gamma t + \mu\left(L\right) v_t \tag{5.3.8}$$

This implies that there are cointegrating relationships in the model that define the trend values of y as linear functions of the trends in these exogenous variables:

$$A\bar{y}_t = B\bar{x}_t + C\bar{z}_t + \gamma t \tag{5.3.9}$$

where

$$\Delta x_t = \alpha \Delta x_{t-1} + d + \epsilon_t \tag{5.3.10}$$

and thus

$$\bar{x}_t = x_t + \frac{\alpha}{1-\alpha}\Delta x_t + dt \tag{5.3.11}$$

and

$$z_t = c + \phi t + a(L)\varepsilon_t \tag{5.3.12}$$

$$\bar{y}_t = A^{-1}\left(B\bar{x}_t + C\bar{z}_t + \gamma t\right) \tag{5.3.13}$$

The above sequence of equations help to define a VECM as:

$$\Delta y_t = D\epsilon_t + E\varepsilon_t + F_{v_t} - \Gamma\left(y_{t-1} - \bar{y}_{t-1}\right) \tag{5.3.14}$$

5.3.3 Model Selection

This thesis builds a DSGE model (as illustrated in Chapter 6). Since the model is already calibrated, indirect inference is used in the framework of evaluating the model instead of estimating the model. To be more specific, the use of indirect inference is to test the calibration rather than the model as the latter would imply using different shares for each country or estimating to get to the 'best' possible parameters. It is worth noting however, that in the rest of this thesis the expression 'testing the model' will be equivalent to 'testing the calibration'. Sequentially, the auxiliary model is a window through which the calibrated model is examined. There is a common structural structure for all countries and the question imposed is whether, on average, these countries respond to one cause (financial development) or another (human capital). The aim is to examine whether there is an average structural model with common coefficients which are chosen by calibration that can be captured by a PVAR with also common coefficients.

The PVAR, is chosen to include all the endogenous variables. In that case, the amount of coefficients necessary to be matched is large and the analysis becomes more complicated. It is thus better to focus on the variables of interest. In this case the main interest is growth. Therefore, if the behavior of say, export and consumption cannot be explained by the model and thus the null hypothesis is rejected, then one goes on with an auxiliary model including less variables. Some relationships, like the one of consumption and exports is a complex one so unless someone is interested in testing the role of consumption there is no harm in exluding these variables from the PVAR setting. In this thesis, the test is based on 3 variables and increases to 5. If the model is rejected when 5 variables are included, no further variables are included since the probability of the model being rejected increases by the complexity arising as the number of matching coefficients increases and the test becomes more stringent.

The order of the PVAR is also of importance here. For the combination of the variables that lead to a rejection of the model at PVAR(1), the lag order does not increase any further. However, for the versions of the PVAR(1) that the model is not rejected, the lag order increases to PVAR(2) and the analysis is repeated.

5.4 Conclusion

This chapter introduced the reader to the concept of indirect inference. It provided a definition of the method as first described by Smith and described the aim of the method. A detailed description of the method guides the reader into a step by step procedure and leads to the evaluation of DSGE modelling. This chapter distinguishes between evaluation and calibration methods and describes the difficulties with the former as to justify the use of the latter in the subsequent chapters. An introduction to the idea of auxiliary models is given concentrating on VAR and VECM regressions. The reader is also introduced to the use of non-stationary data and gets familiarised with the drawbacks of filtering techniques. The idea of auxiliary model and its use in indirect inference is important if one is to understand the subsequent chapters which use a panel VAR to conduct them aim of indirect inference.

Chapter 6

A Multiple-Country Real Business Cycle Model

6.1 Introduction

This chapter follows the idea of non-stationary macroeconomics in a manner similar to Davidson, Meenagh, Minford, and Wickens (2010). Non-stationarity implies that some part of the data moves in a random unpredictable manner each quarter. This behavior of the macroeconomic data creates ambiguity when making predictions about the long term. The usual way to abstract from this feature of macroeconomic data is to remove the trend using a number of mathematical transformations including deterministic or stochatic detrending and differencing. Most commonly, tests of macroeconomic models are done on stationarised data since any stationary series is easier to be predicted (its statistical properties do not change over time). The Hodrick-Prescott (HP) filter is the best known technique applied in non-stationary data in the real business cycle literature. Although this filter seems to have withstood the test of time the criticisms remain. HP as well as Band Pass (BP) filters are not based on the theories used in these models. They concentrate on the statistical properties of the data and deviate from information drawn from the data which could potentially be essential for the model's fit. The drawbacks of the HP filter are described by Cogley and Nason (1993). Instead, using original data for determining or testing economic long run relationships is superior in that it can explain deviations from the steady time trends usually observed when in times of crises. The aim of this chapter is to introduce the reader in a model which can be tested using the original data. Section 6.2 sets up an RBC model. Section 6.3 describes the method of calibration and the solution method of the model. Section 6.4 describes the computer algorithm while Section 6.5 explains the simulation procedure and graphically describes the motion of variables after a productivity shock (Impulse Response Functions, IRFs). Section 6.6 concludes.

6.2 Model

Consider an open economy economic model, $\mathcal{M}$. The home economy is small and populated by identical infinitely lived agents who produce a single good which they use to consume and invest. The rest of the world (or the foreign country) is large faced with the same choices but is unaffected by changes in the home country. At the beginning of period t, the representative agent chooses to consume a commodity bundle, the amount of time she wants to spend at work (and thus leisure) and the total amounts of factor inputs necessary for the production of output to be realised. The household has the choice of withdrawing from its normal work activities to be involved in an innovative procedure which raises productivity. This can be done via either of the two channels; spending time on finding credit (financial development) or human capital. This setup is similar to Klette and Kortum (2004) or Lucas (1988) where the agents abstract from work to be educated or as in Aghion and Howitt (1998) where the role of R&D is emphasized. The agent is constrained by time availability and the resource constraint. In period t the economy is hit by a number of random shocks. Important assumptions include: a) perfect information (no market imperfection) b) ability to access to capital (private credit) from the bank if desired for the purpose of investing and innovating c) there is free goods trade but these do not enter the production function and thus are exchanged as final goods. The model in Section 6.2.1 is a general form of the model where initially productivity is exogenous. It is later extended to include either financial development or human capital as driving forces of the productivity that make it endogenous.

6.2.1 The Representative Agent

The aggregate consumption is a function comprised of domestic and foreign (imported) goods,

$$C_t = f\left(C_t^d, C_t^f\right) \tag{6.2.1}$$

All the prices are relative to the general price level P_t. Following Armington (1969) the composite consumption utility index in the aggregator form

$$C_t = \left[\gamma\left(C_t^d\right)^{-\rho} + (1-\gamma)\left(C_t^f\right)^{-\rho}\right]^{-\frac{1}{\rho}} \tag{6.2.2}$$

where γ is the Armington weight attached to the home goods in the consumption function, $\sigma = \frac{1}{1+\rho}$ is the elasticity of substitution between the two intermediaries. While the Armington aggregator is judged for forcing the specialization pattern in trade to be determined in advance is useful in empirical applications (Kose, 2011). The Armington elasticity is an important parameter in the international business cycle literature that attempts to find the source of the high frequency fluctuations in macroeconomic aggregates. The consumer maximises the expected lifetime utility in a stochastic environment subject to the budget constraint. Since agents are assumed to be homogeneous, they are all faced with the same preferences,

$$U_0 = \max_{c_t, L_t} E_0\left[\sum_{t=0}^{\infty} \beta^t u\left(C_t, L_t\right)\right] \tag{6.2.3}$$

where β is the discount factor, C_t is the consumption in period t, L_t is the amount of consumption spent on leisure time, E_0 is the mathematical expectations operator. The preference ordering does not depend on $'t'$. We assume that $u\left(C, L\right)$ is increasing in $\left(C, L\right)$ and is concave. The utility function is assumed to follow a time-separable utility functional form similar to McCallum and Nelson (2000).

$$U_0\left(C_t, L_t\right) = \theta_0\left(1-\rho_o\right)^{-1}\phi_t C_t^{1-\rho_0} + \left(1-\theta_0\right)\left(1-\rho_2\right)^{-1}\xi_t\left(L_t\right)^{1-\rho_2} \tag{6.2.4}$$

where $0 < \theta_0 < 1$, and $\rho_0, \rho_2 > 0$ are the substitution parameters. In other words, they show the marginal utility of consumption and leisure respectively. In a Cobb-Douglas setting ρ_0 and ρ_2 would be zero. The seriesϕ_t, ξ_t are the preference errors. Barro and King (1984) note that time-separable preference ordering of this form would not restrict the sizes of intertemporal substitution effects. In other words, it doesn't restrict the elasticity of substitution between consumption and leisure to be one where it implies the choice between the two being independent of relative prices. Past work and consumption don't influence the current and future tastes. However, such a utility function constrains the relative size of various responses such as those of leisure and consumption to changes in relative price and permanent income. The authors argue though that the presumption that departures from separability matters for the purpose of RBC analysis matters only for days and weeks and not for months or years. Therefore, since macroeconomic analysis is concerned primarily with time periods as quarters or years, time-separability of preferences is considered justified and a reasonable approximation in this context.

The total endowment of time is normalised to unity such that

$$N_t + L_t + z_t = 1 \tag{6.2.5}$$

or

$$N_t = 1 - L_t - z_t$$

where N_t can be the amount of time spend in work and z_t the amount of time spent in the innovation process created by the access to credit or by expanding human capital skills. It can be considered as the entrepreneurial activity that a household can undertake which involves spending the time denoted as z. The representative agent's budget constraint is

$$C_t + \frac{b_{t+1}}{(1+r_t)} + \frac{b_{t+1}^f}{\left(1+r_t^f\right)} = \Pi_t + w_t\left(1 - L_t - z_t\right) + b_t + b_t^f - \pi_t z_t \tag{6.2.6}$$

where

$$\Pi_t = y_t - (r_t + \delta) K_t - w_t (1 - L_t - z_t) \tag{6.2.7}$$

and

$$y_t = A_t K_t^{1-\alpha} (1 - L_t - z_t)^{\alpha} \tag{6.2.8}$$

where b_t^f and b_t are the foreign and the domestic bonds respectively, y_t is output,π_t is a tax/subsidy (negative tax) on entrepreneurial activity. It can be thought of as a tax imposed by the lack of either financial dvelopment or human capital or as a negative tax by the presence of either of the two. Π is the profits of firms passed on to the households. It is exogenous to the household however and thus no first order condition is taken with its respect.

The consumers maximises the utility subject to the constraint

$$\begin{aligned} \max_{c_t,,k_t,b_t,b_t^f,L_t,z_t} \quad & E_0 \left\{ \sum_{t=0}^{\infty} \beta^t \left[\theta_0 (1-\rho_o)^{-1} \phi_t C_t^{1-\rho_0} + (1-\theta_0)(1-\rho_2)^{-1} \xi_t (L_t)^{1-\rho_2} \right] \right\} \\ & + \lambda_t \left[\Pi_t + w_t (1 - L_t - z_t) + b_t + b_t^f - \pi_t z_t - C_t - \frac{b_{t+1}}{(1+r_t)} - \frac{b_{t+1}^f}{\left(1 + r_t^f\right)} \right] \end{aligned} \tag{6.2.9}$$

to reach to the first order conditions

$$\frac{\partial \mathcal{L}}{\partial C_t} = 0 = \beta^t \theta_0 \phi_t C_t^{-\rho_0} - \beta^t \lambda_t \tag{6.2.10}$$

$$\theta_0 \phi_t C_t^{-\rho_0} = \lambda_t$$

$$\frac{\partial \mathcal{L}}{\partial C_{t+1}} = 0 = \beta^{t+1} \theta_0 \phi_{t+1} C_{t+1}^{-\rho_0} - \beta^{t+1} \lambda_{t+1} \tag{6.2.11}$$

$$\theta_0 \phi_{t+1} C_{t+1}^{-\rho_0} = \lambda_{t+1}$$

$$\frac{\partial \mathcal{L}}{\partial b_{t+1}} = 0 = -\beta^t \frac{\lambda_t}{1+r_t} + \beta^{t+1} E_t \lambda_{t+1} \tag{6.2.12}$$

$$\frac{\lambda_t}{(1+r_t)} = \beta E_t \lambda_{t+1}$$

$$\frac{\partial \mathcal{L}}{\partial b^f_{t+1}} = 0 = -\beta^t \frac{\lambda_t}{1+r^f_t} + \beta^{t+1} E_t \lambda_{t+1} \tag{6.2.13}$$

$$\frac{\lambda_t}{\left(1+r^f_t\right)} = \beta E_t \lambda_{t+1}$$

$$\frac{\partial \mathcal{L}}{\partial L_t} = 0 = \beta^t \left(1-\theta_0\right) \xi_t L_t^{-\rho_2} - \beta^t \lambda_t w_t \tag{6.2.14}$$

$$\left(1-\theta_0\right) \xi_t L_t^{-\rho_2} = \lambda_t w_t$$

The first equation shows that the marginal utility of domestic consumption is equal to the shadow price of output. The last equation shows that the marginal disutility of labor (or the marginal utility of leisure) is equal to the real wage; to the labour's marginal product.

Combining the first order conditions yields the following:

$$(1+r_t) = \frac{1}{\beta} E_t \left(\frac{\phi_t}{\phi_{t+1}}\right) \left(\frac{C_t}{C_{t+1}}\right)^{-\rho_0} \tag{6.2.15}$$

$$L_t = \left\{ \left(\frac{\theta_0}{1-\theta_0}\right) \frac{\phi_t}{\xi_t} \frac{1}{C_t^{\rho_0}} w_t \right\}^{-1/\rho_2} \tag{6.2.16}$$

or

$$w_t = \frac{\left(\frac{1\text{-}\theta_0}{\theta_0}\right) \frac{\xi_t}{\phi_t} C_t^{\rho_0}}{L_t^{\rho_2}} \tag{6.2.17}$$

and

$$\frac{1+r_t^f}{1+r_t} = 1$$

This last equation shows that the real exchange rate is fixed otherwise the purchasing power condition would be proven so that the interest rate differential is equal to the expected change in the real exchange rate.

6.2.2 Endogenising Productivity

Productivity growth is assumed to be triggered by either the level of financial development in the country or by the government percentage share of education spending. The idea is that growth is triggered by people choosing to be entrepreneurial in response to their incentives. These activities can take the form of acquiring skills via education or by borrowing credit for investing in their business plans. If the private credit to GDP is low in the economy, people will lose the latter incentive and they might go for higher education instead. Therefore, greater productivity is enhanced through the incentives people have to take a business opportunity realised by either financial development or human capital. Thus, subsidising or imposing a negative tax on these should generate higher productivity. Each country has a different level of total factor productivity and the choices of its citizens determine the rate at which they raise this by diverting their time from normal work to productivity-enhancing activity.

The growth of productivity is expressed as:

$$\frac{A_{t+1}}{A_t} = a_0 + a_1 z_t + u_t \tag{6.2.18}$$

where z_t is the entrepreneurial activity,u_t is the error process and a_1 is the effect of the entrepreneurial activity on productivity growth.

It is assumed that there is some innovative or entrepreneurial activity the household undertakes which involves spending time z. The labour is withdrawn from 'normal' work activities and uses this time for an activity that raises productivity. This activity is enhanced either by financial development or human capital. The household must divert a specific amount of time away from standard work into this growth enhancing activity. Thus, the agent decides how much time to devote to z by maximising its expected welfare as above.

The first order condition with respect to z is:

$$\frac{\partial \mathcal{L}}{\partial z_0} = 0 = \left\{ \sum_{t=1}^{\infty} \left[\lambda_t \partial y_t / \partial z_0 \right] \right\} - \lambda_0 \left(w_0 + \pi_0 \right) \tag{6.2.19}$$

The idea here is that z_0 affects all future y_t as it raises productivity at all future points of time.

Equation 6.2.19 leads to [1]

$$0 = E_0 \sum_{t=1}^{\infty} \alpha_1 \frac{A_0}{A_1} \beta^t \theta_0 \phi_t \frac{y_t}{C_t^{\rho_0}} - \lambda_0 \left(w_0 + \pi_0 \right) \tag{6.2.20}$$

from which z_0 is obtained. This is the optimal value invested in activities enhanced by *either* financial development *or* human capital. So one can think of two such z for each case where the causal factor changes such that z_0^{fd}, z_0^h. Since however the result will be the same, $z_0^{fd}, z_0^h = z_0$.

$$z_0 = \frac{\left\{ E_0 \sum_{t=1}^{\infty} \beta^t \theta_0 \phi_t \frac{y_t}{C_t^{\rho_0}} \right\}}{\lambda_0 \left(\pi_0 + w_0 \right)} - \frac{\alpha_0 + u_0}{\alpha_1} \tag{6.2.21}$$

This can be used with equation 6.2.18 to find that:

$$\frac{A_1}{A_0} = \frac{\alpha_1 \left\{ E_0 \sum_{t=1}^{\infty} \beta^t \theta_0 \phi_t \frac{y_t}{C_t^{\rho_0}} \right\}}{\lambda_0 \left(\pi_0 + w_0 \right)} \tag{6.2.22}$$

Equation 6.2.22 is a description of entrepreneurs ability to make allowance for the productivity growth already coming from other sources when they decide optimal effort. These sources exactly offset in their decision and thus it is the entrepreneurs that determine productivity growth. Note that now it is assumed that y_t and C_t both being non-stationary

[1] This is obtained by differentiating the Lagrangean above with respect to z_0. Note that A_t is determined by 6.2.18. Then, $\frac{\partial y_t}{\partial z_0} = \frac{\partial A_t}{\partial z_0} k_t^{1-\alpha} \left(1 - L_t - z_t\right)^{\alpha} = \frac{y_t}{A_t} \frac{\partial A_t}{\partial z_0}$ for $t \geq 1$. Since $A_t = \frac{A_t}{A_1} \frac{A_1}{A_0} A_0$ and $\frac{A_t}{A_1}$ is not dependent on z_0 then, $\partial A_t / \partial z_0 = A_t / A_1 \left(\frac{\partial A_1 / A_0}{\partial z_0} \right) = \frac{A_t}{A_1} A_0 \alpha_1$. This implies that $\frac{\partial y_t}{\partial z_0} = y_t \frac{A_0}{A_1} \alpha_1$. This then leads to equation 6.2.20.

can be approximated by random walks so that $E_0 y_{t+i} = E_0 y_0$ and $E_0 C_{t+i} = C_0$. Using the information on λ_0 and w_0 from the first order conditions and ommitting the second order terms of the numerator in equation 6.2.22, it becomes:

$$\frac{A_1}{A_0} = \frac{\left\{ \frac{\alpha_1 \beta}{1-\beta} \theta_0 \phi_0 \frac{y_0}{C_0^{\rho_0}} \right\}}{\theta_0 \phi_0 C_0^{-\rho_0} \left\{ \pi_0 + \frac{\left(\frac{1\text{-}\theta_0}{\theta_0}\right) \frac{\xi_t}{\phi_t} C_t^{\rho_0}}{L_t^{\rho_2}} \right\}}$$

$$\frac{A_1}{A_0} = \frac{\left\{ \frac{\alpha_1 \beta}{1-\beta} \theta_0 \phi_0 \frac{y_0}{C_0^{\rho_0}} \right\} L_0^{\rho_2}}{L_0^{\rho_2} \theta_0 \phi_0 C_0^{-\rho_0} \pi_0 + (1\text{-}\theta_0)\, \xi_0 C_0} \tag{6.2.23}$$

Linearising this leads to equation 6.2.24.

$$\frac{A_1}{A_0} = \psi_0 - \psi_1 \left(\pi_0' + c_o \right) + error_0 \tag{6.2.24}$$

where $\pi_0' = L_0^{\rho_2} \theta_0 \phi_0 C_0^{-\rho_0} \pi_0$.

The idea is that the tax on entrepreneurs consists of the particular imposts levied on business activity as such. As mentioned earlier, this is a negative tax or a subsidy for the presence of a well established financial sector or a strong human capital sector. In an economy where financial development or human capital is a causal factor for growth, implies that peoples' choice of z is made so that they generate growth instead of income. It is worth noting that an increase in z is leading to a reduction in labour supply offering to the production process. This effect is however assumed to be negligible as z is a very small proportion of total labour supply.

6.2.3 The government

It is assumed that the government's expenditure of current output follows a non-negative stochastic process such that $G_t \leq y_t$ for all t. The variable G_t denotes government expenditure at t. A second assumption made is that government expenditure does not enter the agent's objective function. In models of business cycles which incorporate expectations, the output is always at the desired level. Agents internalize the information available up to current time

t and maximise their welfare subject to their constraints. In this framework, the government does not distort the decisions of the agent directly and thus any stabilization policies have no effect on the consumer's welfare. This is a no-tax economy and thus the government expenditure is financed by issuing debt, bonds b_t each period which pays a return next period.

The government issues bonds each period and collects a return next period thus

$$G_t + b_t = \frac{b_{t+1}}{(1+r_t)} \tag{6.2.25}$$

where b_t is real bonds.

6.2.4 The representative firm

The representative firm buys labour and capital which are used as input factors in the production function so that the present discounted stream of cash flows,V, is maximised in a stochastic environment. The firm is constraint by the constant returns to scale production technology.

$$y_t = A_t N_t^{\alpha} K_t^{1-\alpha} \tag{6.2.26}$$

where $0 \leq \alpha \leq 1, Y_t$ is the aggregate output, K_t is capital carried forward from period $t-1$ and A_t is the state of technology. The production function is concave satisfying the Inada-type conditions so that the marginal product of capital or labour reaches infinity as the factors go to zero while it reaches zero as the factors go to infinity.

$$\lim_{K\to 0}(F_K) = \lim_{N\to 0}(F_N) = \infty$$

$$\lim_{K\to \infty}(F_K) = \lim_{N\to \infty}(F_N) = 0$$

The capital stock follows the perpetual inventory equation:

$$K_t = I_t + (1-\delta)K_{t-1} \tag{6.2.27}$$

where δ is the depreciation rate and I_t is gross investment. The representative firm maximizes the present discounted stream, V, of cashflows. It is constrained by the constant-returns-to scale production function and the quadratic adjustment costs of capital. The firm's problem is thus to maximize,

$$V = \max E_t \sum_{i=0}^{T} d_{it}^{i} \left[y_t - K_t \left(r_t + \delta \right) - w_t N_t^d - 0.5\nu \left(\Delta K_{t+i} \right)^2 \right] \tag{6.2.28}$$

which is the same as:

$$= E_t \sum_{i=0}^{T} d_{it}^{i} \left[y_t - K_t \left(r_t + \delta \right) - w_t N_t^d - 0.5\nu \left(K_t - K_{t-1} \right)^2 \right]$$

subject to the evolution of the capital stock in the economy (6.2.27). Here r_t is the interest paid for the capital and w_t is the rental rate of labour inputs used by the firm. The firm takes these as given in its decision process. Illustrated by equation 6.2.26, the output of the firm is not only determined by labour and capital but also by the technology parameter A_t. The firm optimally chooses capital and labour so that marginal products are equal to the price per unit of input. The first order conditions with respect to $K_t$and N_t are as follows:

$$\frac{\partial V}{K_t} = 0 = \frac{\partial y_t}{\partial K_t} - \left(r_t + \delta \right) + d_{1t} \xi E_t \left(K_{t+1} - K_t \right) - \xi \left(K_t - K_{t-1} \right) \tag{6.2.29}$$

$$0 = \frac{1-\alpha}{K_t} y_t - \left(r_t + \delta \right) - \xi \left(1 + d_{1t} \right) K_t + d_{1t} \xi E_t K_{t+1} + \xi K_{t-1}$$

$$\frac{\partial V}{\partial N_t} = 0 = \frac{\alpha y_t}{N_t} - w_t \tag{6.2.30}$$

or

$$w_t = \frac{\alpha y_t}{1 - L_t - z_t} = MPL \tag{6.2.31}$$

so that firms set w_t equal to the marginal product of labor.

and thus

$$\nu \left(1 + d_{1t}\right) K_t = \nu K_{t-1} + d_{1t} \nu E_t K_{t+1} + \frac{1-\alpha}{K_t} y_t - \left(r_t + \delta\right) \tag{6.2.32}$$

$$N_t = \frac{\alpha y_t}{w_t} = \left[\frac{w_t}{\alpha A_t}\right]^{\left(\frac{1}{\alpha - 1}\right)} K_t \tag{6.2.33}$$

6.2.5 The foreign sector

As Obstfeld and Rogoff (1996) state, in open economies, a country's investment and consumption plans are no longer constrained by its own production frontier but also by the rest of the world production function. As in Armington (1969), demand for products in this framework are distinguished not only by their kind but also by their place of production. The Armington assumption that home and foreign goods are differentiated purely because of their origin of production has been a workhorse of empirical trade theory.

The foreign sector contains the import and export equations for the home country as well as the current account position which is reflected in the foreign bonds evolution equation. The model contains 'trade equations'. The import and export equations of the home country are as follows:

$$logC_t^f = logIM = \sigma log \left(1 - \gamma\right) + logC_t \tag{6.2.34}$$

$$logEX_t = \sigma^f log \left(1 - \gamma^f\right) + logC_t^f \tag{6.2.35}$$

The export equation shows that exports are a positive function of the total consumption in the foreign country.

In an open economy model, the home country and the foreign country agents need a means of transaction to carry out the trading procedure. The foreign agents require home money to buy home goods (i.e for their imports) and get foreign money from selling their products (i.e. from their exports). The foreign country also sells foreign bonds to the home country. So their net supply of foreign money is equal to net exports plus sales of foreign bonds i.e. the balance of payments surplus. A similar story occurs in the home country such that the net supply of the foreign country equals the net demand of the home country. The home country gets foreign money from exporting their products to the foreign agents and require foreign money for imports and purchases of foreign bonds. So if home agents adjust their sales of foreign bonds then all balances. In equilibrium it is assumed that exports and imports are equal and hence the agents have no incentive to change their asset position. In disequilibrium any change between the domestic and the foreign bonds will depend upon net exports,

$$NX_t = EX_t - IM_t \tag{6.2.36}$$

Foreign bonds thus evolve over time as follows:

$$b_t^f = \left(1 - r_{t-1}^f\right) b_{t-1} + NX_t \tag{6.2.37}$$

Finally, the goods market clearing position is

$$Y_t = C_t + I_t + G_t + EX_t - IM_t \tag{6.2.38}$$

6.3 Model Calibration and Solution

6.3.1 Model Calibration

The model is calibrated according to the work of Kydland and Prescott (1982), Obstfeld and Rogoff (1996), Orphanides (2003) and McCallum and Nelson (2000). It is a method constantly under scrutiny but it is a widely used method as an alternative to traditional methods of analysing data in economics.[2] The main characteristic of this method is that instead of estimating them, the parameters of the model are determined by the long-run, steady state behavior of the economy. These parameters are used for defining the model's unconditional equilibrium distribution for the endogenous variables which is then compared to that of the data. This method is an attempt to build theoretical models using parameters that are chosen to ensure that the model is a good imitation of some particular characteristics of the historical data observed (Hoover, 1995). Data are thus used to calibrate the model economy so that it mimics the world as closely as possible. The main principle in the calibration method is to use economic theory to be able to extract as much information as possible from the data. In the calibration approach, theory helps in identifying the value of the coefficients and the measurements are used to give intuition to the theory (Cooley, 1997).

Calibration differs from estimation. As Kydland and Prescott (1996) state estimation attempts to measure the size of something or to provide an approximate quantity of something. To estimate a parameter, a researcher looks for a situation in which the signal-to-noise ratio is high as to create statistical significance. The data is combined with the theory and the researcher constructs a probability model and developed an estimator that is robust enough, relative to the parameter that is to be estimated and to features of the hypothesis made.

Calibration on the other hand, requires the search for constants that can be used to satisfactory explain the economic behavior of macro variables under various circumstances. It implies the use of parameter values from a variety of sources and other relevant econometric studies and 'great ratios' which usually represent the shares in accounting identities such as the share of labour in total revenue and of exports in GDP. The difficulty arises when information on the time-series data needs to combined with the information on the shares. [3]

The DSGE models have become a means through which macroeconomic models are evaluated. There is now a reconcilliation between the short-run behavior (business cycles) and

[2]Many are against this method and choose to estimate rather than calibrate RBC models with methods such as Maximum Likelihood or Generalised Method of Moments. Examples include Altug (1989) and Christiano and Eichenbaum (1992).

[3]The differences between estimation and calibration are explained in Cooley (1997).

the long run behavior (growth). Using calibration implies specifying a model in terms of the parameters chosen to capture the preferences, technology and institutional development. [4] The main justification for using calibration is that the estimates arising from econometric models fail to give information on the deep structural parameters which is actually the main focus of interest in RBC models.[5] In order to generate simulations numerical values need to be assigned to the structural parameters of the model as follows:

Table 6.1: Calibrated Values of the Coefficients in RBC model

Coefficient	Value
α	0.70
β	0.97
γ, γ^f	0.70
δ	0.025
θ_0	0.5
ρ	-0.5
ρ_0	1.20
ρ_2	1.00
σ, σ^f	1.00

The coefficient of relative risk aversion (the fraction of elasticity of goods substitution) (ρ_0) is set at 1.2 and the substitution elasticity between consumption and leisure (ρ_2) at unity. The Armington weights $\left(\gamma, \gamma^f\right)$ are both set high at 0.7 and the elasticity of substitution between the home and foreign consumption $\left(\sigma, \sigma^f\right)$ is set at unity to reflect that the countries competitiveness exists but it is not sensitive to the foreign alternatives. The calibrated values are taken from micro-data estimates or from empirical characteristics of the economy under examination. The parameters in the model have been calibrated to match the historical data.

Kydland and Prescott (1982) use the steady-state of the model as levels which ought to match the sample averages of the main economic variables. The exogenous stochastic processes should also be calibrated but it is a harder task concerning the lack of information flowing from the real economy. For example, it is hard to find the stochastic structure of the technology shocks or the shocks to the preferences. Therefore, $AR(1)$ processes are assumed

[4] Wickens (1995) states that the main implication of RBC analysis is that the parameters associated with the functions to be optimised i.e. preferences, technology, policy reaction functions and any other constraints are structural.

[5] This is because, econometric models are expressed in terms of parameters that are functions of the deep structiral parameters.

for productivity shocks so that the persistence properties in actual time series can be used to calibrate some aspects of the model. The coefficient in the $AR(1)$is chosen such that the simulated output series displays similar persistence to the GDP series from the observed data.

6.3.2 Model Solution

The model presented in this thesis is considered to be a dynamic, nonlinear, rational expectations model. It is dynamic in that the lags and the expected lags of the endogenous variables enter the equations. It is nonlinear in the variables, the parameters and expectations. Finally, it is a rational expectations model in that expectations of future endogenous variables are forecasts conditional on the model itself. The model is log-linearized and solved by the projection method described in Minford, Marwaha, Matthews, and Sprague (1984); Minford, Agenor, and Nowell (1986). This method is set out in Fair and Taylor (1983) and it is used for forecasting or policy implications and one of its advantages is that it can handle models with serial correlation of the errors and also that when applied to linear models it provides similar conclusions as other relevant methods. Using this method, the model can be solved taking into account the restrictions set by the rational expectations.

Models like the one presented in this chapter are typically characterised by an intertemporal optimization problem that produces a set of Euler equations:

$$E_t\left(f\left\{y_t, y_{t-1}, \cdots\cdots, y_{t-p}, y_{t+1,} \cdots\cdots, y_{t+q}, \alpha_j, x_t\right\}\right) = 0 \tag{6.3.1}$$

which is equivalent to

$$f_j\left\{y_t, y_{t-1}, \cdots\cdots, y_{t-p}, E_{t-1 y_t}, E_{t-1}y_{t+1,} \cdots\cdots, E_{t-1}y_{t+q}, a_j, x_t\right\} = u_{jt} \tag{6.3.2}$$

where y_t is an n-dimensional vector of endogenous variables, x_t is a vector of exogenous variables, u_{jt} is a vector of stochastic shocks, all at time t. E_t is the mathematical expectations operator and α_j is a parameter vector where $j = 1....n$. After the model's calibration, comes the model's solution.[6] The solution aims to give the predicted current values of the endogenous variables or the *ex-post* forecasts. In equation 6.3.1, solution implies a stochastic process for y_t. The incorporation of expectations leads to difficulties in obtaining a practical solution. A forward-looking solution sequence is calculated while initial and terminal conditions are set that specify forecast values and expectations at the forecast horizon. The non-linear difference equations present, do not allow for a closed-form solution for each of the endogenous variables. Iterative or indirect methods have been used to calculate the stochastic process of the variables which corresponds to the solution. This means that one starts with an initial approximation to a solution and then generate a number of better approximations that converge to an exact solution.[7]

The programme development used for the solution of model guarantees that the model solution is re-initialised instead of aborted when faced with problems such as taking logs of negative numbers. If the expectations of future variables are somehow known then 6.3.1 is a standard system of simultaneous equations. Common non-linear techniques such as the Gauss-Seidel iterative process[8] are used to solve the model repeatedly each time using a different set of expectations. Solution is achieved every time values for variables in vector y are provided. The number of iterations is increased until full convergence is ensured. This also implies that the model's equations are to be equal with the model's forecasts as the computer algorithm by Matthews and Marwaha (1979) ensures. As an example consider information given for the year 1980q1 available to all agents. The algorithm initially guesses a set of expectations and solves the model for 1980q2 onwards. It then checks whether the expectations and the forecasts are equal. If not, then it changes the set of expectations until convergence is reached.

[6] Some macroeconomists have attempted to algorithms to solve equation 6.3.1 in the non-linear case. A review of these is given in Taylor and Uhlig (1990).

[7] The convergence as well as the speed of convergence is of interest here.

[8] The Gauss-Seidel method is most widely used algorithm since it is simple and it always achieves convergence for non-explosive models.

6.4 Model Algorithm

The complexity and the non-linear form of the model require the use of a computer algorithm. The nature of rational expectations models is such that the forward expectations terms tend to create unstable roots. For a solution to be achieved however, stable roots or a saddlepath is necessary. Terminal conditions are imposed to first ensure that the transversality conditions are met and secondly to ensure a stable path towards the convergence of rational expectations. There are an infinite number of consistent paths. To ensure that the stable path will be chosen, the forecast values and the expectations at the end of the forecast horizon are set as terminal conditions at equilibrium. In other words, for the unique stable path to be chosen, beyond some terminal date, N, all expectational variables are set to their equilibrium values. To avoid sensitivity of the model to variations in the terminal date, it i usually safer for the terminal date to be 'large'. Although there are many other methods[9], the long run equilibrium condition of the model can be used to choose the terminal conditions as in Matthews and Marwaha (1979).

The interative method of Gauss-Seidel is built in a programme called RATEXP developed by Matthews (1979) and Minford, Marwaha, Matthews, and Sprague (1984). The programme uses a dynamic programming technique (i.e. a backward-solving technique). However, the solution vector is approached simultaneously for all $t = 1, 2, ...T$ but convergence follows a backward process. First, a dynamic solution of the model is reached for a given time span and a given set of 'guesses' for the initial values of the expectational variables. These initial values are used and adjusted in an iterative manner until convergence is obtained. When the expectations become equal to the solved forecasts, the initial expectations set is slowly altered until convergence is obtained. This is how expectational variables are endogenised in that particular period. In a nutshell, the simple steps of the algorithm are

- 'Guess' a set of expectations
- Solve the model given this set

[9] In other cases, the steady-state properties of the model are used to choose the terminal conditions of the model (Whitley, 1994).

- Check for equality between expectations and solved forecasts
- Alter expectations until convergence is achieved
- Re-solve the model using the new values for the expectational variables

6.5 Model Simulations

In order to produce the sample of simulations desired (in this case 1000) a base run is first created which is simply set equal to the data. This becomes convenient to use after the simulations are generated. To get the simulated data one needs to calculate the structural errors. When the equations have no expectation terms, the structural error are simply calculated as the difference of the model from the data and are thus considered as the values necessary to replicate the data. If the equations include expectations, the residuals are estimated using McCallum (1976) and McCallum (1976) method of instrumental variables. Here we use the lagged variables in a univariate time series processes for each expectational variable. The structural residuals produce the shocks or the innovations which perturb the model. In this case we have seven errors. Excluding the error coming from the production function (the Solow residual), for each of the remaining six, a low-order ARIMA process is estimated in order to determine their autoregressive behavior. For the productivity shock the estimation is done on the differences and it also includes the financial development (FD) indicator or the educational development (ED) indicator according to the theory tested.

The resulting innovations are then bootstrapped by time vector in order to preserve any correlations between them. The shocks are thus drawn in an overlapping manner and added into the model base run. For example, in period 1 a vector of shocks is drawn and is input to the base run given its initial lagged values. The model is solved for period one and beyond for all the future periods. In period 2, this becomes the lagged variable vector. For period 2, another vector of shocks is drawn with replacement and added to the solution. The model is then solved for period 2 and beyond and this becomes the lagged variable for period 3. This process is repeated for period 3 onwards until 1000 simulations are completed and generated.

This creates the bootstrap sample by the model's shocks.

The model was initially applied to each country separately. Then, it is necessary to add these bootstraps on to the Balanced Growth Path (BGP) implied by the model and to the trend terms in the exogenous variables and error processes. The BGP is found when solving for the effect of a permanent change in each error/exogenous variable at the terminal horizon T. The deterministic rate of change of this variable is then multiplied by this change. This gives 1000 different scenarios of the economy's state over the sample period. These bootstraps are then used for the estimation of a VECM; an auxiliary equation. When the model is applied on all countries and the PVAR is the auxiliary model, the BGP is excluded through estimation.

6.5.1 Impulse Response Functions: Productivity Shock

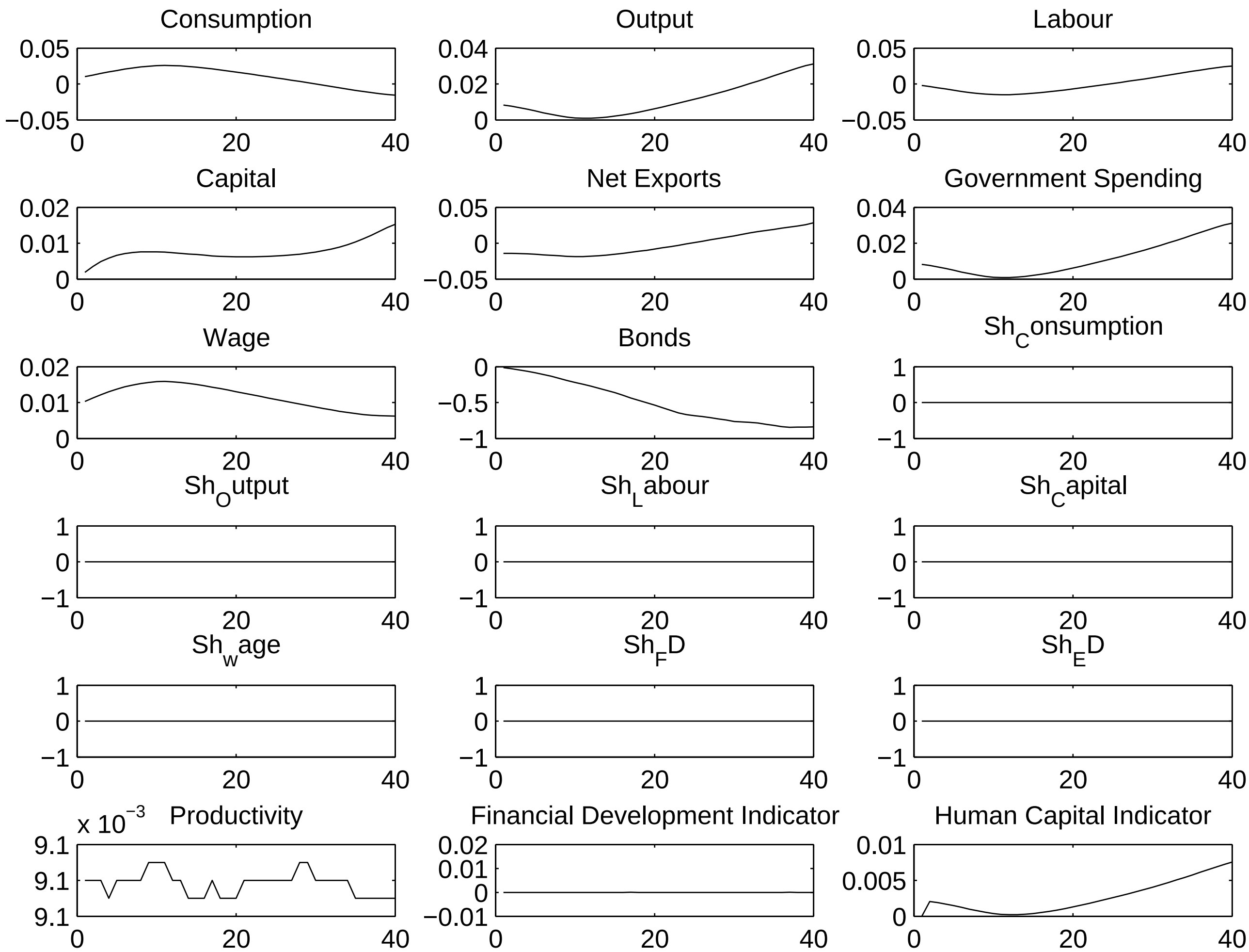
Once the model is solved, the model's implications are examined under the effect of one-off rise of a number of variables. This is an opportunity to analyse the transition phase of the model to its steady-state. One may consider the existence of such transition phase occurring due to an initial position of the economy outside the steady state or a structural change which changes the steady-state. This type of analysis is important when interested in evaluating possible effects of change in policy interventions or in tastes and preferences. The usual way to capture deviations from steady state is to have one or more of the exogenous variables being perturbed and then compare this to the original, base, solution of the model. Therefore, an impulse response function illustrates the deviations from the base after a demand or supply shock is imposed which can be of a temporary or a permanent nature. The general idea of impulse response functions (IRFs) is their ability to show how one variable responds over time to a single innovation in itself or in another variable. Innovations in the variables are represented by shocs to the error terms of the equations.

The length of the simulation period is an issue under debate. The chosen period needs to be long enough so as to capture the effects of changes through the model. One needs to be careful when setting the terminal date. The model's simulation should be unaffected by the choice of the terminal date. For this reason, the terminal date should be sufficiently far in the future. Moreover, a simulation over a long period of time is a necessary condition for observing the model's long-run solution (Darby, Ireland, Leith, and Wren-Lewis, 1998). The simulations for this model start in 1981, quarter 3 and end in 2007, quarter 4 for all the countries. For the baseline simulation, the endogenous variables are set so that they capture the historical values in an exact way. This is done by adding errors to each equation[10]. The residuals are simply calculated as if the expected endogenous variables are equal to the actual values and hence include not only the shocks to the equations but also the forecast errors.

What is of importance here is the effect of a permanent increase in the productivity by 1 standard deviation shock. A positive unanticipated increase in productivity encourages higher output and increases permanent income through a reduction of the marginal costs. The increase in output cannot occur without an increase in both, capital and labour. The economy settles at a new permanently higher level of capital stock consistent with the higher output. Capital however is slow to arrive and an increase in the real interest rate is necessary to avoid any excess demand for the short-period limited supply. This explains the behavior of the consumption and the capital stock in periods 5-38. Although real wages are increasing in order to encourage labour to work more and increase production, the increase in the real interest rate distorts consumption as well as the uncovered interest parity condition which is restored with an increase in the real exchange rate. A high real exchange rate makes foreign goods cheap relative to domestic goods, so net exports decline as the terms of trade deteriorate. However, as the new capital stock arrives and becomes sufficient, the real exchange rate moves back to equilibrium causing an increase in the exports relative to the imports. Moreover, as the real exchange rate is back to its equilibrium level, the higher output is now sold at the foreign markets for a lower price. In this model, the income effect does not seem to be strong enough to push the labour supply down and create an increase in the real wage. As output increased, the prices in the economy fall. It can be explained by the simple pricing method of firms. If the workers lose their wage bargaining power then the prices set up by a mark up on the wage become lower together with the wage.

[10]See Appendix B.

Figure 6.5.1: Impulse Response Functions for Increase in Productivity



Note: Sh_output stands for shock to output etc.

6.6 Conclusions

This chapter provides theoretically coherent micro-foundations for macroeconomic models and constructs an econometrically testable DGE open economy model which is proposed to calibrate using quarterly data on ten countries. The model is based on optimisation decisions made by rational agents excluding money, taxes and unemployment benefits. The reader is guided through the first order conditions of the consumer's and the firm's optimisation problem which are used to derive the behavioural equations of the model. The world economy is taken as given and all of the countries are considered as small open economies. Therefore, in a safe way, only the domestic economy has a fully constructed model. It provided the calibrated values which drive the model's behavior and explained the reason of their use. It then described the model solution by explaining the model algorithm and the model simulations in detail. The chapter ends by a description of impulse response functions which describe a shock of productivity and its impact on the rest of the variables. This confirms that the model is working and thus one needs to set up an empirical model for testing. It is the empirical issue that forms the basis for the next and last chapter.

Chapter 7

Testing a Multi-Country RBC model

"I prefer to use the term 'theory' in a very narrow sense, to refer to an explicit dynamic system, something that can be put on a computer and *run*"

Robert Lucas (1989)

7.1 Introduction

The testing procedure described in Chapter 5 is used to test the model described in Chapter 6. The aim is to test whether there exists a relationship between financial development and growth or/and educational development and growth. Two theories of growth are set up and each of them is tested via indirect inference. The chapter introduces the reader to the data used, describes the auxiliary model and analyses the results. Section 7.2 describes the data as well as the sources used to formulate the model. Section 7.3 explains in detail the two theories representing the models under test while section 7.4 empirically evaluates the auxiliary model and gives the reasons for the choice of the specific auxiliary model. Section 7.5 describes the testing procedure before providing the results in Section 7.6. Section 7.6 also explains Wald Statistic, the transformed Wald and the M-metric. Section 7.7 discusses the results while Section 7.8 gives the IRFs from a shock to productivity. Section 7.9 provides the results from four robustness tests and Section 7.10 concludes.

7.2 Data

There are 10 countries in this study out of which 2 are developing. More developing countries would be a further development. However, the limited availability of the data on the wages and/or explosive AR(1) processes of the errors do not allow the use of them. Most of the data on the macroeconomic variables is collected from the International Monetary Fund's (IMF) International Finance Statistics database (IFS). The data collected consists of quarterly data ranging from 1980q1 to 2007q4. Data availability ranges from 1960q1 to 2010q4. However, for most of the countries the first 20 years of data are not readily available and are thus excluded from the sample. Moreover, to avoid internalizing the shocks caused by the 2007 financial crisis, the sample also excludes the years after 2007q4. In the cases where quarterly data is not provided by the IFS, the World Bank (WB) dataset is used to interpolate annual data into quarterly data. Variables for the wage data is collected from UNESCO Institute for Statistics. Only yearly data is available thus interpolation is used to create the sample coverage data.

The financial development indicator, private credit from financial and non-financial institutions to GDP is not widely available on the IMF database. The data source is Beck, Demirguc-Kunt and Levine (Beck, Demirgüç-Kunt, and Levine, 2000) database available from the WB. The indicator for human capital is the government spending to GDP ratio and is collected from the IMF database. The unobservable variable, capital stock, is created following Caselli (2004). The perpetual inventory equation is used:

$$K_t = I_t + (1 - \delta)K_{t-1} \tag{7.2.1}$$

where I_t is investment and δ is the depreciation rate. The initial level of capital is given by:

$$K_0 = \frac{I_0}{(g + \delta)} \tag{7.2.2}$$

whereI_0 is the value of investment in 1980q1 and g is the average geometric growth rate of investment series between the 1980q1 and 2007q4.

7.3 The Theories Under Testing

Chapter 6 has described the model $\mathcal{M}$. Two theories are constructed to represent the model. The theory of financial development (T_{fd}) supports that the null hypothesis is that a model where financial development is a causal factor of growth is the true model. If this is true, policy implications arise in favor of developing deeper financial systems to boost economic growth since the expectation is that a financially developed country has a greater feasibility to produce relative to a country who is less financially developed. Countries from the sample used in this thesis which follow this strategy are among others Australia, Canada, Japan, Netherlands and Sweden. This idea is established from other econometric studies allowing for a relationship between financial development (which is thought to have a direct effect on the production of technological innovation) and TFP.[1] The growth of TFP is therefore a positive function of the country's level of financial development. Moreover, if the null is not rejected then the model can be considered as one that explains the observed data behavior of a mixture of variables including growth.[2]

The same idea is applied to test a theory of human capital (T_h) which follows the idea of Romer (1991), where human capital causes productivity and growth. In this case, the model is represented by a theory where human capital is a causal variable. Therefore, the null hypothesis is that, a model where higher human capital leads and causes output is able to explain the behavior of the data of macroeconomic variables. The policy implications in this case is to boost the education system via more proportion of the GDP spent on public education. France and Finland are found in the group of countries with the highest public spending on education.

The model represented by T_{fd} considers human capital to be endogenous and financial development to be trend deterministic. They are thus characterised by the following equa-

[1] Studies include King and Levine (1993b) and Arizala and Galindo (2009)

[2] The financial development indicator enters in the productivity equation. This is based on the theories of financial development and growth as described in Chapters 2-4.

tions:

$$\begin{cases} fd_t = c + \gamma_{fd} T + e_t^{fd} \\ h_t = \mu_h y_{t-1} + e_t^h \end{cases} \tag{7.3.1}$$

where fd_t is the financial development indicator and h_t is the human capital proxy. The coefficients c, γ are estimated while the parameter μ_h is calibrated after regressions of this form have been examined on a number of countries and found the general behavior of the relationship between past levels of output and current public school expenditure. It thus claims that past levels of output affect the government's decision to spend on education. In other words, the level of income in a country is causing the level of public spending. Another way of thinking about it is that public spending on education is a share past output with some measurement error. The parameter μ_h is given a value of 0.25.

An environment like the one described by T_{fd} supports the idea that as the cost of finance becomes less the economy's growth level is increased. The proxy used for fd is the private credit from financial and non-financial institutions to the GDP. The economy is comprised by homogeneous agents that have the opportunity to work and earn wages or they can visit the bank for a loan which they can use for innovative purposes. The latter case leads to an increase in productivity through the force of private credit flowing within the economy. The critical assumption here is that there are no explicit constrains in reaching credit within economies. However, between countries, the level of financial development is a proxy for the access to credit. For instance, countries with higher ratio of private credit to GDP are considered to be less financially constrained. This model does not endogenize the banking sector. It does not show the production function of the banking system. One could easily add intermediaries with a credit production but the main point remains that any fluctuation in the economy is caused by productivity. The impact of banking or other factors is not to be neglected but this thesis concentrates on a single key growth causal mechanism. This theory is mainly exctracted from studies where one of the most widely used mechanisms through which credit can have an impact on growth is the productivity channel (Schumpeter, 1912;

Bagehot, 1873).

The second model represented by the human capital theory, T_h follows Romer (1991). In this environment, as the cost of education becomes less for the agent, there is a greater incentive to get some time off work and spend time on gaining education. This enhances higher long term economic growth levels through an effect on productivity growth. The agent embodies knowledge which he/she trasfers onto innovative or productive efficient ideas. In period t the economy is hit by a number of random shocks. Important assumptions include: a) perfect information (no market imperfection) b) ability to use the education services provided by the government if desired for the purpose of investing in education. When the human capital becomes the main variable explaining growth, the financial development equation becomes endogenous. Thus the equations supporting the human capital theory are:

$$\begin{cases} fd_t = \mu_{fd} y_{t-1} + e_t^{fd} \\ h_t = c + \gamma_h T + e_t^h \end{cases} \tag{7.3.2}$$

The parameter μ_{fd} is calibrated to be 0.006 after regressions are examined to establish a relationship between past income and private credit. Theory, T_h claims that private credit is a function of past income. It is expected that a higher level of income in the economy positively affects the level of credit flowing in the economy (i.e. that financial development is demand driven). Like in T_{fd} parametes c, γ are estimated by OLS regressions. A model of human capital claims that human capital development can explain growth and other macroeconomic variables. The aim becomes to see which model does a relatively or absolutely a better job in fitting the data behavior and then confirm the effect of financial development or human capital development on economic growth via impulse response functions.

7.4 The Auxiliary Model

7.4.1 Non-Stationary Data

The method of indirect inference has already been used for testing calibrated or already estimated DSGE macroeconomic model where the data are stationary (Le, Meenagh, Minford, and Wickens, 2011). In this test procedure the residuals of the calibrated model are treated as observable, are calculated from the given estimates and are allowed to be stationary or non-stationary. A necessary condition for applying this test is that the auxiliary model is chosen in such a way that the distribution of the test statistic has a good size and power properties. A testing method is required to have a 'reasonable' amount of power. That means that it would not be useful if it rejects everything that is slightly not true or if it rejects nothing at all. For the model under test, it is taken for granted that this testing method is of both good size and power as indicated from other authors applying it to either stationary (Le, Meenagh, Minford, and Wickens, 2011) or non-stationary data (Meenagh, Minford, and Wickens, 2012).

A usual way in which DSGE models are estimated includes the filtering of macroeconomic data as to make it stationary. As already explained, methods of filtering the data may distort the dynamic properties of the model. Examples include the production of cycles where possibly none exist. The disadvantages of the filtering methods lead to the use of the original data when testing this model. The data generated by DSGE models are often non-stationary. In this case, the model incorporates non-stationary exogenous technology shock in the production function which generates non-stationarity. Other reasons for observing non-stationary generated data include state variables (i.e. functions of predetermined variables) depending on accumulated shocks or world income incorporated in the export function.

After linearising the model in Chapter 6, the assumption is that the solution of the model can be represented by a vector error correction model for each country (VECM). Since the technology shock is an unobservable non-stationary variable one or more of the long-run structural equations will have a non-stationary residual. If the residuals calculated from the data and the calibration are treated as observables one can observe as many cointegrating relations as endogenous variables. This allows the solution of the model to be represented as a VECM in which the non-stationary residuals appear as observable variables. The VECM can then be represented as a VAR. Levels VAR is more robust than VECM because it can be used even when the system does not have stochastic trends and cointegration. The VECM is constructed under the null hypothesis to make sure that it achieves cointegration. As Meenagh, Minford, and Wickens (2012), state it would have been useful to test for the existence of cointegration for each equation of the DSGE model. However, this is not possible because a) any non-stationary residual is treated as a possible cointegrating variable and b) a lack of cointegration would make the DSGE model impossible to be solved and thus no simulations and no application of the Wald would be attainable.

7.4.2 Empirical Methodology of Panel Vector Autoregression (PVAR)

To accomplish the aim of ranking, accepting or rejecting a model an auxiliary model is built to capture the dynamics offered by the model and represented by the two theories. Choices of auxiliary models are usually a VAR, a VECM or a PVAR in the case of many countries. The connection between VARs and DSGE models is made clear in Chapter 6. Working with nonstationary series also implies the use of VECM which is re-written as a VAR in levels. The idea of a PVAR in financial development is established and empirically set in Love and Zicchino (2002). A PVAR is the same as a VAR but is applied in a country level panel data to study the dynamic relationship between countries' financial development and economic growth as well as countries' human capital development and growth. A VAR on panel data aims at identifying the financial development-growth and human capital-growth relationship while allowing for fixed effects (i.e. country specific unobserved heterogeneity in the levels of the variables). A VAR also gives the opportunity for allowing country-specific time dummies to capture aggregate country-specific shocks to macro variables that may affect all countries at the same time.

In order to evaluate the model's ability in replicating certain characteristics of the data, a PVAR is built for a group of variables alone. It is not clear from other empirical studies which variables are to be included in a PVAR and what order of lag oughts to be used. In this case a PVAR of order 1 (PVAR(1)) is used with a group of three to five variables. In the case of a VAR, a limited number of macro variables and a lag order of one is preferable because increasing either of the two increases the stringency of the overall test of the model. In this case, if a model is rejected by a PVAR(1) no attempt is made to proceed to a stringent test of based on a higher order PVAR. In general a VARMA is usually the representation of a stationary loglinearised DSGE model. If the DSGE model is to be true, this means that the true PVAR should be of infinite order. However as Meenagh, Minford, and Theodoridis (2008) note, raising the lag order of the PVAR worsens the fit to the data probably due to the complaxity in the bahaviour being captured.

The PVAR(1) takes the form:

$$\vartheta_{i,t} = f_i + \Gamma_1 \vartheta_{i,t-1} + \delta_i T + e_{i,t} \tag{7.4.1}$$

where Γ_1 is a vector of the country-common coefficients on each macro variable which are represented by the vector $\vartheta_{i,t}$, f_i is a vector of constants for each country to capture the effects across units and δ_i captures country specific effects over time and T is time-trend. The time trend is the Balanced Growth Path (BGP) for each country.

For any model under test, $\vartheta_{i,t}$ is either five, four or three macro variable vector. The choice of macro variables is described in table 7.1.

Table 7.1: Summary of PVARs

	T_{fd}	T_h
PVAR 1	c, y, nx, A, fd	c, y, nx, A, h
PVAR 2	c, y, A, fd	c, y, A, h
PVAR 3	$, y, A, fd$	y, A, h
PVAR 4	c, y, nx, A, fd, h	c, y, nx, A, fd, h
PVAR 5	c, y, A, fd, h	c, y, A, fd, h
PVAR 6	y, A, fd, h	y, A, fd, h

The abbreviations are for c:Consumption, y:Output, nx:Net Exports A: Productivity fd: Financial Development and h: human capital.

Six different versions of a PVAR are set up for each of the theories under examination. For example, for the purposes of testing the model represented by, T_{fd}, the vector $\vartheta_{i,t}$ in version 1 includes five variables;$\{y_{i,t}, c_{i,t}, nx_{i,t}, A_{i,t}, fd_{i,t}\}$, while for T_h, $\vartheta_{i,t}$ will be a five variable vector $\{y_{i,t}, c_{i,t}, nx_{i,t}, A_{i,t}, h_{i,t}\}$. By applying the VAR procedure to the panel data the assumption is made that the underlying structure is the same for each country. However, this is not the case in practice and to overcome this restriction fixed effects are introduced, f_i. Equation 7.4.1 implies that the error term satisfies the orthogonality condition so that the following is true:

$$E\left[\vartheta_{i,t}e_{i,t}\right] = E\left[f_i e_{i,t}\right] = 0 \tag{7.4.2}$$

The procedure followed includes opening up the vector to treat each equation separately on all the sample countries. As an example, lets consider the case where $\vartheta_{i,t} = \{y_{i,t}, A_{i,t}, fd_{i,t}\}$. The idea is to first take the actual data and apply the following equations using OLS on the balanced panel data:

$$y_{i,t} = f_{1,i} + \gamma_{11}y_{i,t-1} + \gamma_{12}A_{i,t-1} + \gamma_{13}fd_{i,t-1} + \delta_{1,i}T + e_{1i,t} \tag{7.4.3}$$

$$A_{i,t} = f_{2,i} + \gamma_{21}y_{i,t-1} + \gamma_{22}A_{i,t-1} + \gamma_{23}fd_{i,t-1} + \delta_{2,i}T + e_{2i,t} \tag{7.4.4}$$

$$fd_{i,t} = f_{3,i} + \gamma_{31}y_{i,t-1} + \gamma_{32}A_{i,t-1} + \gamma_{33}fd_{i,t-1} + \delta_{3,i}T + e_{3i,t} \tag{7.4.5}$$

The 10 sample countries thus share the same parameters except the constant the the time trend where each country has its own. This trend variable can serve as a proxy for a variable that affects the dependent variable but is nevertheless not directly observable although it is highly correlated with time. In this case it captures the change in output with respect to time. This effect is different for each country and thus dummies are used to capture the uniqueness of the trend variable across countries.

Running equations 7.4.3 to 7.4.5 on the data will give a set of 9 parameters.[3]

In this case, the data vector will be

$$\Gamma_1 = [\gamma_{11}, \gamma_{12}, \gamma_{13}; \gamma_{21}, \gamma_{22}, \gamma_{23}; \gamma_{31}, \gamma_{32}, \gamma_{33}]'$$

The next step is to apply these equations, separately on every single simulation. The simulation matrix will be similar of size $n \times k$ where n is the number of simulations and k is the number of parameters. In this case such a procedure will provide a vector of 9000 coefficients. The same procedure is done for all the different combinations of macroeconomic variables included in the PVAR. Each version is then tested by comparing the data coefficient vector to the simulation coefficient vector via the M-metric.[4]

For versions 1 to 3, the model represented by T_{fd} is supporting that h is irrelevant and thus left out while T_h supports the same idea for the variable fd. There is a further attempt to include both variables fd and h in the same PVAR which becomes even more demanding. The power of the model increases as it has to match more details. For example, under version 1 vector ϑ becomes $\{y_{i,t}, c_{i,t}, nx_{i,t}, A, fd_{i,t}, h_{i,t}\}$. The idea is to collect the relevant coefficients from each version and establish explanatory relationships between the three main variables of interest; y, fd, h. The expectation is that the simulation coefficients from versions 3 and 6 will be closer to the data.

7.5 The Testing Procedure

The explanatory power of the model described in Chapter 6,$\mathcal{M}$, is empirically tested via the method of indirect inference implemented on the full original, non-stationary data. By applying the method of indirect inference on this model of non-stationary economic behavior, the hope is to provide a place for financial development and/or education development as a determinant of growth through an impact on productivity. The model, $\mathcal{M}$ is applied to ten

[3]The constnat and the parameters on the trend are not of interest when calculating the Wald and are thus ignored.

[4]More details on the M-metric will be given below.

countries which are all given the same calibrated values for the parameters in the structural model. It is set up as a null hypothesis under which it is considered the true model in the sense that it provides a true description of the data behavior so that its structural residuals are also the true errors.

There are two sets of data for each country. The first set describes the original data while the second set is the simulated data. The auxialiary models are chosen for the original sample data so that they describe the data efficiently and closely. As already mentioned, the auxiliary model used here is initially a PVAR with consumption, output, technology, financial development or educational development (or both) as the endogenous variables. The PVAR is augmented to include net exports and also reduced to only output, productivity and financial development or educational development (or both) as alternative tests of the model. In order to understand the implications of the model $\mathcal{M}$ about the data on any of the theories T, the auxiliary models are estimated on each of the pseudo-samples generated from the model. This provides a distribution of the PVAR's parameters according to the structural model. The aim is to compare the performance of the auxiliary model based on the observed data with its performance when applied on the simulated data derived from the given distributions of the parameters. Therefore the test is whether the PVAR estimated on the actual data samplies lies within this distribution created from the PVAR on the simulated data at some level of confidence (95% in this case). This is done for both theories so that conclusions can be drawn on which theory matches the data behavior best.

The PVAR acts as a vehicle with which the structural model is estimated and the null hypothesis is either rejected or accepted. The question is: is it possible for T to have been generated my $\mathcal{M}$? To answer this question a test statistic based on the distributions of the parameters of the auxiliary model is used. The criterion used is represented by a Wald statistic which captures the difference between the vector of relevant PVAR coefficients from the simulated and actual data. Under the null, the PVAR estimates based on the simulation data will not be significantly different from the PVAR estimates based on the actual data.

Each log-linear equation[5] is augmented by an error whose unit root properties are tested.

[5]Each equation is shown in Appendix B.

The residuals extracted from the AR(1) processes represent shocks or innovations entering the model which are considered to be the ones generating the data. In a simple framework consider the following equations:

$$Data = Model + e_t \tag{7.5.1}$$

$$e_t = \rho e_{t-1} + \eta_t \tag{7.5.2}$$

So the model, $\mathcal{M}$ is made up of a number of equations 7.5.1. The number of such equations equals the number of endogenous variables. Not all equations are given an error term as there is no need to do say in te case of equalities. [6] The error term e_t are ommited variables and are modelled by AR(1) process as in 7.5.2. The residuals η_t are iid shocks and they are used as time vectors from which errors are drawed with replacement and put into the error processes (7.5.2) which are in turn put into the model (7.5.1). The DSGE model is bootstraped with these shocks and 1000 bootstrap simulations of the data are generated which represent what the implied model and its shocks have generated for the sample period of the data.

7.5.1 The Wald Test

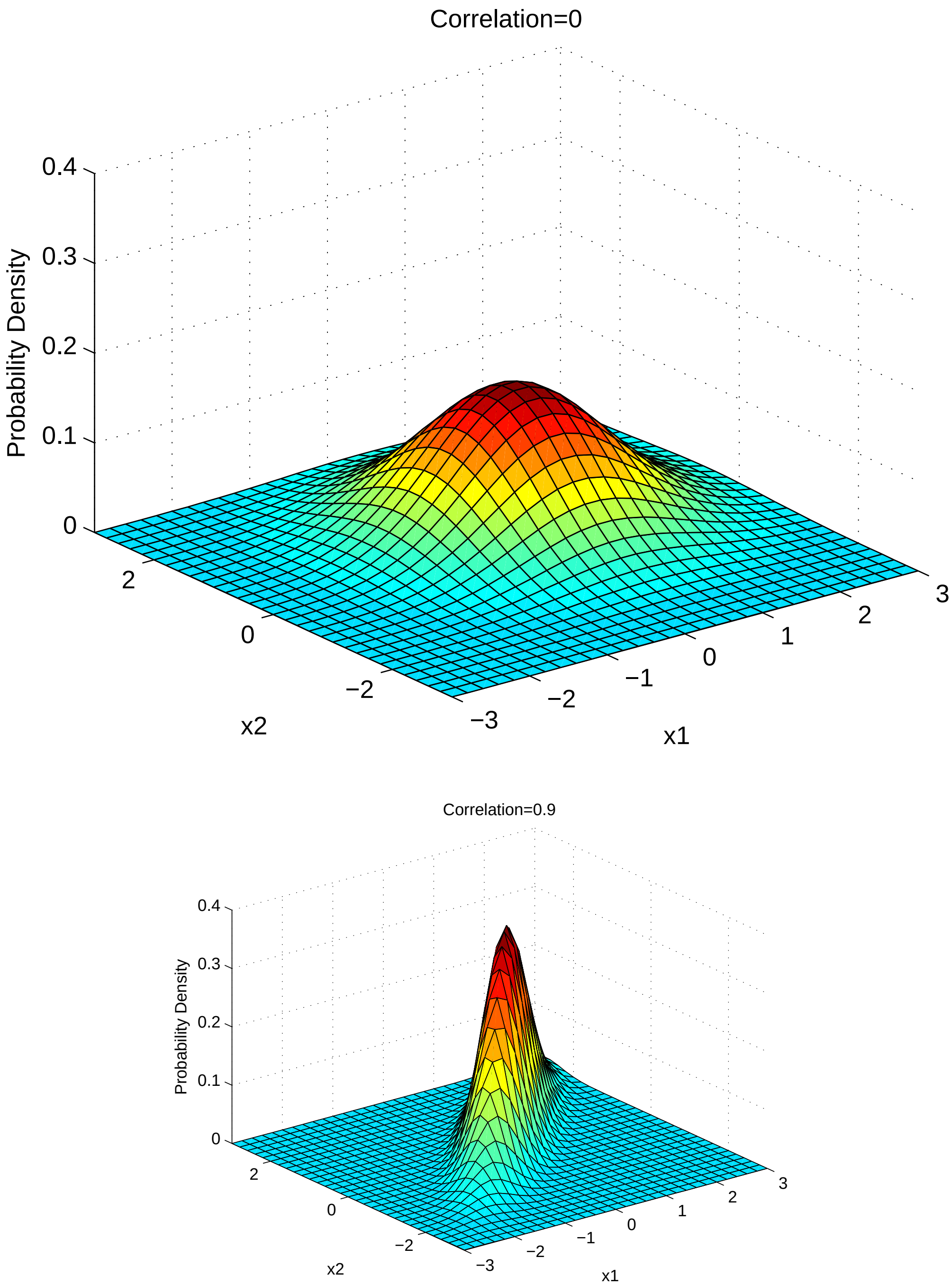
In order to create the joint and individual distributions of the parameters of the PVAR implied by the model, the PVAR estimation is carried out on each bootstrap sample. This gives 1000 estimates which provide the sampling distribution under the null hypothesis and the 95% confidence intervals. The sampling distribution for the Wald test statistic is used as a critical judge of the model. The Wald computes the joint distance of the data coefficients from the mean of the simulation distribution. As described in Chapter 5 this distance is represented by:

$$Wald = \left[\hat{\alpha} - \overline{\tilde{\alpha}_T^s(\theta)}\right]' \hat{\Omega}(\theta) \left[\hat{\alpha} - \overline{\tilde{\alpha}_T^s(\theta)}\right] \tag{7.5.3}$$

[6] Also the an the productivity error term is captured in growth instead of levels and the fd or h variable is included as shown in Appendix B.

In this case, $\hat{\alpha}$ is the set of coefficients supplied by the PVAR using the observed data while $\overline{\widetilde{\alpha_T^s}(\theta)}$ is the mean of the VAR coefficients found in the 1000 simulated samples. The idea of the test is usually represented by 7.5.1.

Figure 7.5.1: Bivariate Normal Distributions



The figure concerns the case of only two parameters of the auxiliary model being considered. It is an example of how the data is compared to the model predictions using the

Wald test. Two cases are examined; one where the correlation between the variables is zero and one where it is 0.9. The height of the diagram represents the density of the parameter combinations across samples. The mountain represents the joint distribution generated from the model simulations. Two points are shown on each graph. Lets consider point A to be the real-data-based estimates of the two parameters. In the case of no correlation the model succeeds in providing a sensible explanation of the real world. Here, the mean of each parameter's distribution is constant no matter what the value of the other parameter is. However, when there is a high and positive covariance between the parameter estimates across samples the mountain seems to rotate in such a way that now the model seems to fail in explaining the reality. Now the data falls far from what the model predicts. However, if the real-data-based estimates are represented by point B then the hypothesis that the model is generating the data is not rejected. More PVAR parameters may follow various kinds of distributions but in general the idea remains that each pair of parameters will create ridges -as described- in multiple dimensions.

The aim is to see which of the models represented by each theory is better at explaining the data oberved (i.e. which model is point B). To reach a conclusion a 'directed' Wald test is used. It is a restricted Wald statistic and evaluation is based on a more restricted sets of features and provides answers concerning which features the model can capture and which it cannot. The 'full' Wald test derives from the fact that the Wald statistic is based on the full set of variables instead of a more limited set of variables. The Wald statistic is represented by the percentile of the distribution where the actual generated parameters lie.[7] This is reset as to have the 95% value of the variate at the same point as the 95th percentile of the bootstrap distribution. For example, a number of 96 for the Wald implies that the data generated features fall beyond the 95% contour of the joint distribution and thus the model is rejected by the data at a 95% confidence level.

The Wald statistic is transformed in a normalised t-value following the logic that the square root of this statistic, $\sqrt{Wald}$, is the Mahalanobis distance. By adjusting its mean and

[7] More specifically, it is calculated as the percentile band around the joint mean within which the data generated features fall in that joint distribution.

standard deviation, this becomes a normalised t-value where the 95% point is 1.645, and is used as a measure of the distance between the original and the simulated data.[8] Wilson and Hilferty (1931) transform a chi-square variable to the Z-scale so that their p-values closely approximated. The reason for standardizing the values of a χ^2 distribution is to allow the statistical significance of the statistics, or p-values, to be more approachable and conveniently represented. Following Wilson and Hilferty (1931) the normalised Mahanalobis distance is basically a t-statistic and is given as:

$$t = \left\{ \frac{\left[(2MD)^{1/2} - (2n)^{1/2}\right]}{\left[(2MD_{95\%})^{1/2} - (2n)^{1/2}\right]} \right\} \times 1.645 \tag{7.5.4}$$

where MD is the value of the Mahalanobis distance derived using the actual data; $MD_{95\%}$ is the value of the Mahalanobis distance corresponding to the 95% tail of simulated distribution and n is the degree of freedom of the variant. This ensures that the Mahalanobis distance is 1.645 whenever the MD coincides with the 95% critical value of the simulated distribution.

7.6 Results

7.6.1 The Transformed Mahalanobis Distance

After each and every regression has been performed using STATA, the coefficients are callected and the transformed Mahalanobis distance is calculated in Matlab. [9]The results are best described by looking at the transformed Mahalanobis distance (t-stat) for the different PVARs estimated as described in Table 7.2.

[8]The $\sqrt{\chi^2}$ is a normal variable and thus the Mahalanobis distance is the square root of the Wald value. The square root of a chi-squared distribution can be converted into a t-statistic by adjusting the mean and the size. The way is normalised here follows Le, Meenagh, Minford, and Wickens (2012) so that the resulting t-statistic is 1.645 at the 95% point the distribution and thus anything falling beyond would lead to the rejection of the model.

[9]The codes are available on request.

Table 7.2: Results-PVAR(1)

	T_{fd}	t-stat	T_h	t-stat
PVAR 1	c, y, nx, A, fd	4.76	c, y, nx, A, h	2.93
PVAR 2	c, y, A, fd	4.65	c, y, A, h	2.61
PVAR 3	y, A, fd	**0.39**	y, A, h	**0.63**
PVAR 4	c, y, nx, A, fd, h	3.73	c, y, nx, A, fd, h	3.03
PVAR 5	c, y, A, fd, h	3.29	c, y, A, fd, h	2.37
PVAR 6	y, A, fd, h	**0.686**	y, A, fd, h	**1.241**

Applying the above procedure to the DSGE model with financial development and human capital the conclusion is that the long run relationship between the macroeconomic variables is slightly better explained by T_{fd}. The conclusion is formed after massively rejecting both theories for all versions except for versions 3 and 6. Under the latter cases, a financial development model explains the data bahaviour for the specific subset of variables better than a human capital model. The results are providing an answer to the following question: How well does the calibrated model replicate the actual data? After the simulations are obtained one wonders whether the model is good enough to give simulated data close to the actual data. The hypothesis set is that if the structural model is correctly specified, the set of parameters obtained from the PVAR should not differ significantly from those obtained from the auxiliary model using observed data. The null hypothesis is thus that the model under test is the true model. Although only two out of six versions attempted are accepted, when the two theories representing the model are ranked against each other T_{fd} seems to to do a better job in replicating the data behavior relative to T_h according to the testing procedure.

The starting point is a PVAR with five variables. Up until version 3, the data coefficients differ between the two theories. Versions 1 to 3 are loose in terms of the number of variables that the model oughts to explain. In versions 4 to 6, the model is under more pressure and its power is higher. The expectations rise to a model which can explain not only the behavior of growth but also the behavior of the opponent theory. In these versions, the coefficient vector occurring from the data is the same for both theories. The expectation is that the Wald statistic gets lower as we reduce the number of variables that the model is trying to explain. The less the number of coeffients, the better the fitness of the model since it has less job to do in terms of matching. The anticipations are realised. Version 3 does a better job in explaining the behavior of the endogenous variables compared to all the other versions. Similarily, the results from version 6, as expected, are not rejected in comparison with 4 and 5.

The analysis is concentrated on PVAR 3 and PVAR 6 as under both theories the null is not rejected. The results thus indicate that both models in this specific DSGE setting do not fail to capture the reality and are both able to explain observed relationships between educational development and growth as well as financial development and growth. The theory of financial development shows that the simulations are exremely close to the data which confirms that growth could successfully be explained in a model of financial development as a driver of productivity. This by no means implies that educational development is not important determinant of growth. This simply implies that for the selected countries, human capital also seems to be justified as the main driver of productivity but the simulations are further from the data when compared to a financial development theory. Nevertheless, the non-rejection here implies that the models are both true and thus not rejected as a causal account of the facts against which they are being tested.

7.6.2 Confidence Intervals

The challenge now is to ensure that a model of financial development fits the data better. The transformed mahalanobis distance (t-stat) is one indicator. One needs to look closer at the lower and upper 95% bounds on the coefficients from the simulations and observe whether these include the real data estimate. These are demonstrated in tables 7.3 to 7.6. The fifth column identifies whether the real data estimate falls in or out the bounds formed by the simulation estimates. Table 7.7 gives the Wald percentiles as well as the p-values. As already discussed, the former is an indicator which if it takes a value of 100 the model fails to capture the actual dynamics. The Wald statistic is a measure of the distance between the simulations and the data. The lower the Wald, the better job done by the model. A Wald of 100 indicates that the observed parameter estimates lie on the 100% .contour., i.e. in the

95% rejection region. The p-value is the probability that the model is not rejected by the data. It is clear that a Wald of 100 will give a p-value of zero indicating that there are no chances for the model not to be rejected [10].

Table 7.3: Version 3-Confidence Intervals and Wald Statistic: Theory fd

Variable	95% lower bound	95% higher bound	Real data estimate	IN/OUT
y_y	-0.0063384	0.79377	0.61841	IN
y_A	-0.337405	1.44155	0.43677	IN
y_{fd}	-0.030895	0.92252	0.055945	IN
A_y	-0.0079599	0.77389	0.19008	IN
A_A	-0.39302	1.1714	0.76918	IN
A_{fd}	-0.0569525	0.92242	0.022818	IN
fd_y	-0.00771885	0.79001	0.0001793	IN
fd_A	-0.44377	1.22005	-0.0062034	IN
fd_{fd}	-0.045215	0.92221	0.9281	OUT

Table 7.4: Version3-Confidence Intervals and Wald Statistic: Theory h

Variable	95% lower bound	95% higher bound	Real data estimate	IN/OUT
y_y	-0.0208635	0.98498	0.61305	IN
y_A	-0.16129	0.95831	0.44361	IN
y_h	-0.205955	0.94136	0.021448	IN
A_y	-0.019182	0.989675	0.19372	IN
A_A	-0.172455	0.956065	0.76446	IN
A_h	-0.219185	0.93893	-0.0061089	IN
h_y	-0.022013	0.987885	-0.041996	OUT
h_A	-0.154185	0.952415	0.038943	IN
h_h	-0.23032	0.944015	0.98848	OUT

[10] The p-value is calculated as $(100 - Wald)/100$

Table 7.5: Version 6-Confidence Intervals and Wald Statistic: Theory fd

	95% lower bound	95% higher bound	Real data estimate	IN/OUT
y_y	-0.457245	0.986140	0.100290	IN
y_A	-0.924275	0.97322	0.010447	IN
y_{fd}	-0.012781	1.03825	0.060568	IN
y_h	-0.00086405	0.00355625	0.0006641	IN
A_y	-0.83072	4.9217	0.5618	IN
A_A	-0.426480	0.985465	0.91569	IN
A_{fd}	-0.90197	0.975965	-0.0007653	IN
A_h	-0.0129230	1.07165	0.014016	IN
fd_y	-0.00088255	0.003478	-0.0002577	IN
fd_A	-0.83694	5.06195	-0.3328	IN
fd_{fd}	-0.417895	0.986425	0.014922	IN
fd_h	-1.0271	0.972705	0.98963	OUT
h_y	-0.0153625	1.0859	0.03769	IN
h_A	-0.0008252	0.0034244	0.0000483	IN
h_{fd}	-0.89115	4.9547	0.028096	IN
h_h	-0.408815	0.986975	0.0048705	IN

Table 7.6: Version 6-Confidence Intervals and Wald Statistic: Theory h

	95% lower bound	95% higher bound	Real data estimate	IN/OUT
y_y	-0.370045	0.988445	0.10029	IN
y_A	-0.79725	0.950955	0.010447	IN
y_{fd}	-0.0312305	0.935225	0.060568	IN
y_h	-0.0013686	0.00390335	0.0006641	IN
A_y	-0.24624	4.0501	0.5618	IN
A_A	-0.30586	0.991125	0.91569	IN
A_{fd}	-0.78677	0.965025	-0.0007653	IN
A_h	-0.0319025	0.93455	0.014016	IN
fd_y	-0.0011514	0.00404345	-0.0002577	IN
fd_A	-0.28285	3.74755	-0.3328	OUT
fd_{fd}	-0.2675	0.986775	0.014922	IN
fd_h	-0.87695	0.952745	0.98963	OUT
h_y	-0.024635	0.93534	0.03769	IN
h_A	-0.0007048	0.00365625	4.83E-05	IN
h_{fd}	-0.325955	3.9283	0.028096	IN
h_h	-0.0358615	0.934615	0.0048705	IN

Table 7.7: Wald and p-values

	Version 3	Version 6
T_{fd}	**Wald:** 68.9 **p-value:** 0.31	**Wald:** 70.8 **p-value:** 0.29
T_h	**Wald:** 85.2 **p-value:** 0.14	**Wald:** 87.2 **p-value:** 0.13

For both theories, the Wald statistic rejects at 100 all of the versions besides 3 and 6. Concentrating on these versions of the PVAR, the Wald statistic for the financial development model is 68.9 for version 3 of the auxiliary model while for version 6 it is 70.8. This indicates that there is substantial closeness to the data. A model of educational development has a Wald of 85.2 and 87.2 respectively. This implies that there is hope for both theoretical model in which fd or h drive the economy to generate a joint distribution of the PVAR coefficients that simultaneously explains the ones observed in reality. Since this is the case one needs to rank the theories by observing the p-value which is lower for fd compared to h. These results indicate that the dynamic properties of the data are very close to those implied by the model T_{fd} and less closely for T_h as the probability of not rejecting the model represented by T_{fd} is higher (0.31 and 0.29) compared to the p-values for T_h (0.14 and 0.13). One can state that a model of financial development is more 'successful' than a model of human capital.

7.7 Discussion

The discussion of the results is separated into three parts. First, one needs to look at the testing results in terms of the Wald percentiles and the p-values and how these change as the test becomes more strict. Secondly a description of the lead-lag relationships for the versions of the PVAR that are not rejected should provide information about the explanatory power of both theories representing the two models. Lastly, possible reasons are provided for the success and/or the failure of the models.

7.7.1 The Wald Percentiles and p-values

For clarification purposes one needs to understand what the regressions imply. The first three versions test each model in terms of whether it can generate the behavior of the economy and also of the driver exogenous variables whether this is financial development or human capital indicators. However, version 4-6 become more demanding an asks the model to generate the behavior of the non-driver variable. The question under versions 4-6 is whether the driver model accounts for the economy's behavior and also the the behavior of the non-driver variable. These versions are thus considered more demanding since the models do not have a theory for the non-driver variable and the only information given is that this variable is driven by the lag economic activity of the country.

For all versions except 3 and 6, both models are rejected as the true models and give a Wald of 100. Thus the probability that the model is not rejected as the true model is zero. This can be explained via the increase in the power of the model as more variables are included. Notice how the t-stat falls as the number of variables in the PVAR are reduced from version 1 to 6. Therefore, the more the number of variables (and the higher the PVAR orders), the results worsen. The first of each set consists of a wide range of variables which includes consumption and exports. Both models perform badly. When the second of each set eliminates net exports the power of both models decreases as the t-stat falls but none of the models can be considered as the true one. Version 3 includes only the output, productivity and the driver (while for version 6 it also includes the non-driver). Only then the Wald is relatively lower and the p-value is relatively higher for both models. This is consistent with other work on DSGE models confirming their weakness in accouting for a full range of variables relative to a smaller subset of key variables. Typically, a macroeconomic model is of interest for economists if it can replicate the behavior of the key macro variables which in this case are output, productivity and the driver variable. Using this information together with the Wald and p-values, none of the models is rejected although T_{fd} seems to perform better.

7.7.2 Lead-Lag Relationships

To get closer to the 'truth' the lead-lag relationships are reviewed to examine which are the macroeconomic relationships that can be captured by each model. As the number of relationships explained by the theory increases, the model is considered better. The model of financial development represented by T_{fd} as well as the model of human capital represented by T_h match the behavior of a subset of key variables from among the full test. So there are a subset of variables that these models, can explain and others they cannot. Theory T_{fd} is not far away from the dynamic properties it implies. In other words, the model's simulation and the actual data do not fall far away and it does not fail to pick up lagged responses at the individially coefficients level. This implies that model predicted correlations among three and four key macroeconomic variables are closer to actural data in a model where the economy is driven by the levels of financial development.

To simplify the discussion the PVAR is written to include only the 9 coefficients of interest.[11] The results in Table 7.3 are an indicator of the model's performance with the following set of equations:

$$y_{i,t} = \beta_{11} y_{t-1} + \beta_{12} A_{t-1} + \beta_{13} fd_{t-1}$$

$$A_{i,t} = \beta_{21} y_{t-1} + \beta_{22} A_{t-1} + \beta_{23} fd_{t-1}$$

$$fd_{i,t} = \beta_{31} y_{t-1} + \beta_{32} A_{t-1} + \beta_{33} fd_{t-1}$$

where the coefficient β_{11} is read as y_y on the tables and β_{32} is fd_A and so on. The results in Table 7.4 come from the same pattern of equations but with h in the place of fd. Looking at 7.3, while most of the real-data-based estimates of the PVAR coefficients are individually captured by the 95% bounds implied by the model simulations the financial development's response to its own lagged value is found to exceed its corresponding upper bound. Table 7.4

[11] The equations are for a PVAR version 3 of T_{fd} but one could do the same for T_h.

shows that the model with human capital as the driver fails to capture two relationships. The response of human capital to lag output and its own lagged value exceed their corresponding lower and upper bound respectively.

Tables 7.5 and 7.6 show how the models perform under the more strict condition implied by version 6 as discussed above. The financial development theory again performs better since only one relationship is not captured by the model. The response of financial development to the lag human capital is above the 95% upper bound. That is to say that past human capital does not explain the behavior of the financial development or in other words, a model where financial development is the causal indicator, lagged human capital is not related to financial development. A model where the leading indicator is human capital fails to capture the response of financial development to lag productivity and lag human capital.

The main conclusion is that if financial development is the driver of growth, it is possible for its behavior not to be related to past output, productivity but rather output and productivity will be related to past financial development. Also, human capital will be related to past financial development, output and productivity while these might not be related to past human capital. The same idea follows if human capital is the causal variable where financial development is replaced with human capital. The dynamics of the important macroeconomic variables are evident from both models. In other words, none of the models is poor in predicting any long run relationships occuring between past financial development and human capital and current growth or productivity and vice versa. However, a model where the causal variable is financial development can explain the behavior of the opponent theory while a human capital model cannot.

7.7.3 The Success and the Failure of the Models

One can think of many reasons on the grounds of which the financial development model fails in the other versions. These results depend on the set of countries used. In this case, the set of developed countries prevails. The failure of the fd theory could possibly be justified by a non-linear, non-monotonic relatioship between financial development and growth. Greenwood and Jovanovic (1990); Acemoglu and Zilibotti (1996); Khan (1999) describe the idea of endogenousely emerging financial institutions that have a positive but an unambigious effect on growth. The magnitude of the effect depends on the level of economic or financial development of the country. Some research claims that the growth effect of financial development is unclear at low levels of development while it becomes positive as development expands. The ambiguity may arise from adverse effects of financial development on the propensity to save(Obstfeld, 1994; Devereux and Smith, 1994) or from the negative effects that the adoption of economic resources by the financial sector has on growth (Deidda and Fattouh, 2001). Another stream of research (Rioja and Valev, 2004) proposes that at low levels of financial development, additional development of the financial market has an uncertain effect on growth. At high levels of financial development additional financial development may have a positive but a smaller effect on growth. Theoretically, the latter explanation could be used to partly justify the rejection of the fd theory.

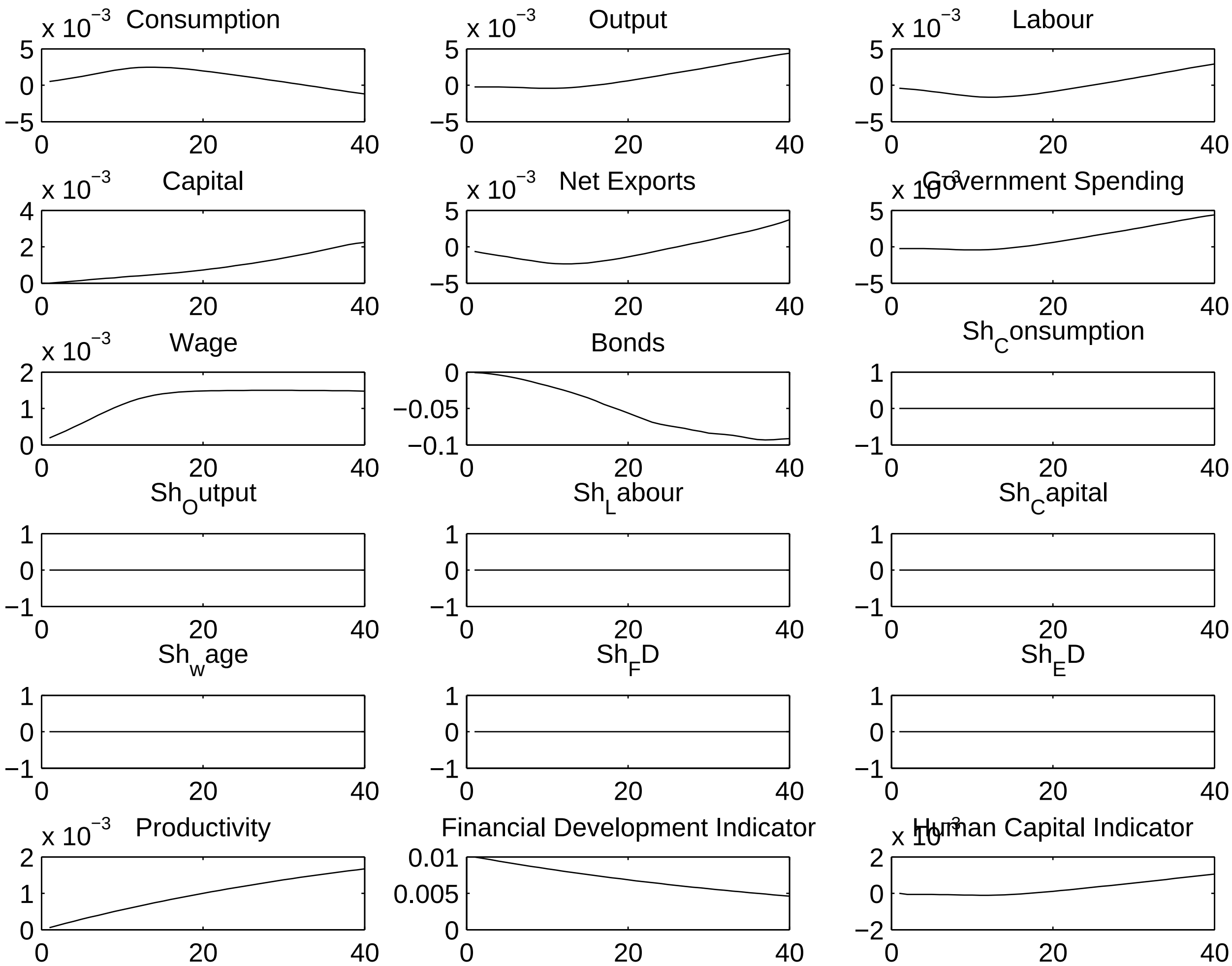
The distinction between the two theories can be explained by the nature and measure of human capital. Firstly, human capital, unlike other types of capital, is not perfectly tradable. This implies that its marginal product across individuals is not equalized and this gives rise to aggregation problems and thus, aggregate output no longer depends merely on the average level of the human capital, but also on its distribution. This leads to a second point. The distribution of human capital is determined not only by individual ability but also by the investment financing opportunities. Thus with no or limited access to finance spending on education by the government is not enough to drive the growth of the economy as this distribution is an approximate determinant of the distribution of earnings. Thus, if a population's abilities are normally distributed, a skewed distribution of education services would potentially cause great welfare losses (Mincer 1974). Finally, to the extent that education is mostly public funded, inequalities in education and human capital are largely "structural inequalities" (as compared to "market inequalities"), which could have an unambiguous negative impact on development(Easterly, 2007). Rajan and Zingales (2006) explain the persistence of underdevelopment in the light that the elite and the already educated middle class will try to protect their rents by denying the poor of their education opportunities. Therefore, this structural model needs to control for human capital inequalities if the effect of educational development is to be captured completely (LIM and TANG, 2008).

7.8 Impulse Response Function: A Financial Development Shock

The dynamic relationship among the proxy for financial development and growth is examined using IRF to demonstrate the effect of a positive one off shock to the private credit on economic growth over time. Since the previous sections show that financial development is accepted as a causal factor of growth, the goal is to assess this role. The expectations is that the variables considered to be more dependent on external finance would face sharper increases from their steady states. As also expected, the results also show that TFP increases as well.

The size of a financial development shock whose is determined by the standard deviation of the financial development innovation series. Figure 7.8.1 demonstrates the results. As expected the output, although innovations to financial development do not initially affect growth too much it eventually reaches a new permanent level. This is reflecting the direction of causality running from finance to growth. Moreover, there is also a positive effect on the education proxy. This is again expected as education is considered to be a sector of the economy which dependents on finance. The effect of consumption is captured solely through the terminal conidtions of the model. It shows a small increase initially while it falls back to zero at the the end. This is also a sign of consumption being driven by the financial indicator. Trade is a highly dependant sector on finance. The effect is the same as that on growth indicating that finance leads to higher trade shares. Moreover, the capital sector is financially driven as implied by the permanent positive effect of a financial shock. As a final conclusion from the IRFs, there is evidence of financial development promoting economic growth and productivity.

Figure 7.8.1: Impulse Response Functions for Increase in Private Credit to GDP



7.9 Sensitivity Analysis

In order to check the robustness of the results above three extensions are made. The first one involves repeating the analysis for the non-rejected models including two lags instead of one lag in the PVAR. The second one is based on changing the calibrated values with which the financial development indicator and the human capital indicator affect the productivity process. The third one imposes the same balance growth path on each country and the fourth separates the countries into developed and developing and re-examines.

7.9.1 Two-lag PVAR

As already stated in Section 7.6, the versions PVAR 3 and PVAR 6 are not rejected. The same technique is repeated for running a PVAR(2) for each of these versions of the auxiliary model. Table 7.8 indicates the results. Under this scenario, the number of coefficients to be matched increases. The causal model is reflected through the coefficients. For the 18 coefficients case (PVAR 3), the results thus indicate the strength of financial development theory in explaining these coefficients. A model where human capital is considered to be the causal factor, is not capable of explaining these coefficients beyond a lag order of 1.

When the auxiliary model becomes one with 32 coefficients, (PVAR 6) both models fail to capture the relationships of the variables included in the PVAR. The results indicate that both of the models have nothing to say for the causal processes. The auxiliary models presented in PVAR 6 are unable to explain the behavior of the variables involved. It is however important to notice that the ranking is still in favour of the financial development theory. Although both models are rejected, the theory of human capital is rejected at a bigger degree. The ranking remains the same whether one looks at PVAR 3 or PVAR 6 which is another indication of the financial development theory being clearly distinguished from the human capital theory. The individual coefficients for both versions of the PVAR the results indicate to the same conclusions as above. More than one relationship fails to be captured in the case of human capital theory. A model with a causal force coming from financial development is able to explain more relationships relative to those that the human capital theory can explain.

Table 7.8: Results-PVAR(2)

	T_{fd}	t-stat	T_h	t-stat
PVAR 3	y, A, fd	**1.58**	y, A, h	2.71
PVAR 6	y, A, fd, h	2.26	y, A, fd, h	2.73

Table 7.9: Wald and the p-value

	Version 3	Version 6
T_{fd}	**Wald:** 95.0 **p-value:** 0.05	**Wald:** 95.1 **p-value:** 0.049
T_h	**Wald:** 95.4 **p-value:** 0.046	**Wald:** 95.7 **p-value:** 0.043

The Wald statistic for both theories is now higher compared to the analysis under one lag. This indicates that the probability of each model not being rejected is reduced. However, for version 3, the financial development theory still indicates closeness to the data. A model of educational development has a Wald of greater than 95. This implies that there is no hope a theoretical model in which h drives the economy to generate a joint distribution of the PVAR coefficients that simultaneously explains the ones observed in reality. Since for version 6, both theories are rejected, one needs to rank the theories by observing the p-value which is higher for fd compared to h. These results indicate that the dynamic properties of the data are very close to those implied by the model T_{fd} and less closely for T_h as the probability of not rejecting the model represented by T_{fd} is higher (0.05 and 0.049) compared to the p-values for T_h (0.046 and 0.043). One can state that a model of financial development is more 'successful' than a model of human capital.

Increasing the lag of the PVAR has not altered the ranking of the theories. However, both models perform worse than before. Even for the version in which the financial development theory is not rejected the probability of this event is very low. Under this lag order the test is more demanding and the results are expectable.

7.9.2 Calibration: The Productivity Process

In Appendix B, the equation for the Solow residual is represented as

$$A_t = A_{t-1} + \alpha_1 z + u_t^{fd} \tag{7.9.1}$$

where z is either fd or h. For the analysis in sections prior to Section 7.9,$\alpha_1$was set to

0.006 under the financial development theory where as for the human capital theory it was set to 0.05. In this section, the calibrated values for the two theories is reversed. Thus the magnitude with which the two theories were set to affect the productivity process are now reversed. The results are shown in Table7.9.2. Since for the rest of the versions of the PVAR, both models are rejected only versions 3 and 6 are reported below.

Table 7.10: Results-Calibration Reversal

	T_{fd}	t-stat/Wald/p-value	T_h	t-stat
PVAR 3	y, A, fd	**1.34/94.7/0.053**	y, A, h	2.30
PVAR 6	y, A, fd, h	**1.54/94.9/0.051**	y, A, fd, h	2.13

Financial development theory seems to explain the relationships under both versions. A model driven by human capital is rejected under both versions. This indicates that T_{fd} is not as sensitive to the calibration changes as T_h is. The conclusion remains the same. Under both contexts (before and after the calibration reversal) a model driven by financial development fails to be rejected in either versions of the PVAR. However, a model with human capital as the causal factor is rejected after the calibration reversal which is an indication of its failure to explain the relationships demanded beyond the already calibrated values. The Wald statistic and the p-value indicate that the probability of the human capital model not being rejected is zero.

7.9.3 Common BGP

The above description depends on testing the model assuming that the Balanced Growth Path (BGP) of each country is different. Another analysis is done where the restriction of all countries sharing the same BGP is imposed. In this case the PVAR is described by equation 7.9.2.

$$\vartheta_{i,t} = f_i + \Gamma_1 \vartheta_{i,t-1} + \delta T + e_{i,t} \qquad (7.9.2)$$

The same procedure is followed and the results are provided in Table 7.11. In this case a model where human capital is the causal variable, is totally rejected. Versions 3 and 6 are

Table 7.12: Wald Percentile/p-values

Version	Wald T_{fd}	p-value	Wald T_h
3	81.4	0.18	100
6	87	0.13	100
1,2,4,5	100	0	100

again better in the sense that they provide the lowest trasnformed t-statistic but it turns out that on these subsets of variables T_{fd} model is not rejected while T_h is rejected in both cases.

Table 7.11: Results

Version	Theory	$t - stat$	Reject/Do not reject
1	T_{fd} T_h	4.0100 7.8453	Reject Reject
2	T_{fd} T_h	3.0067 6.7055	Reject Reject
3	T_{fd} T_h	**0.8492** **5.4236**	**Do not reject** **Reject**
4	T_{fd} T_h	3.4544 6.4985	Reject Reject
5	T_{fd} T_h	3.4672 5.6841	Reject Reject
6	T_{fd} T_h	**1.1434** **5.2415**	**Do not reject** **Reject**

In this case, the Wald percentile is 100 for all other versions except 3 and 6 for theory T_{fd}. In contrast, the Wald percentile is 100 for all versions of the auxiliary model represented by T_h.

On an individual examination of the coefficients showned by Table 7.13 and 7.14 the results are not extremely different from the ones where the BGP for each country is different. In this case, T_{fd} is not able to explain a relationship running from past productivity to financial development but the important thing is that is captures relationships that run from financial development to the rest of the variables. A model with human capital as a causal factor cannot explain the effect of lagged human capital to output not to productivity as seen in table 7.14. It thus fails to capture the main relationships that is expected to and hence the reason is rejected.

Table 7.13: Version 3-Confidence Intervals:T_{fd}

	95% lower bound	95% higher bound	Real data estimate	IN/OUT
y_y	-0.445635	0.9969750	0.093257	IN
y_A	-1.26275	0.980025	0.0076162	IN
y_{fd}	-0.000622	0.0041157	0.0006117	IN
A_y	-0.063862	5.9019	0.6376	IN
A_A	-0.458355	1.03925	0.91406	IN
A_{fd}	-1.25715	0.97502	-0.0014204	IN
fd_y	-0.00055125	0.0042498	-0.0002698	IN
fd_A	-0.061482	5.963000	-0.31526	OUT
fd_{fd}	-0.497765	0.993975	0.010545	IN

Table 7.14: Version 3-Confidence Intervals:T_h

	95% lower bound	95% higher bound	Real data estimate	IN/OUT
y_y	-0.39782	0.98855	0.098771	IN
y_A	-0.060626	0.93635	0.056634	IN
y_h	-0.00118775	0.0040455	0.006549	OUT
A_y	-0.125815	4.3319	0.56206	IN
A_A	-0.405625	1.0764	0.9158	IN
A_h	-0.055867	0.935855	0.93884	OUT
h_y	-0.00132515	0.0041591	-0.00257	OUT
h_A	-0.647435	4.16265	-0.33282	IN
h_h	-0.46114	1.02095	0.0056763	IN

What differs from the regressions with separate BGPs is that the long run relationships cannot be explained by the educational development proxy.

T_{fd} passes the more stringent test and can explain the behavior of all macro variables in the PVAR including that of the educational development. With a Wald percentile of 81.4, the observed dynamics are not only individually, but also jointly explained by the theoretical model T_{fd}. By using the 'directed' Wald, examination of the theoretical model focuses on the partial capacities in explaining the dynamics. The comparison of the structural model with financial development shows that if the model is restricted to human capital as a driving mechanism of productivity and growth, then the model is rejected by the dynamic data. The implication under these conditions that there is no hope at all for the theoretical model T_h

Table 7.15: t-statistic: Developed Vs Developing Countries

Developed	Version 3	Version 6
fd	0.38	0.39
h	0.43	0.96
Developing	Version 3	Version 6
fd	1.19	0.88
h	**1.75**	**1.88**

to generate a joint distribution of the PVAR coefficients that simultaneously explains the ones observed in reality. In conclusion, under both cases, with or without a common BGP, a model where financial development is a causal factor of growth is superior to one where human capital is a causal factor.

7.9.4 Country Group Results

As a robustness test, the sample is divided into developed and developing countries. The sample is dominated by developed countries. Nevertheless, the results for developing countries are very close to those for developed and to those on average. In terms of ranking the two theories the results are the same. A theory of fd is better at explaining the observed behaviours. The model represented by h in version 3 and version 6 of the auxiliary model is rejected. One can conclude that the average type of analysis used in the main thesis is correct since even when the sample is separated the results are not very different.

7.9.5 Financial Development or Human Capital: Why bother?

As indicated from the sensitivity analysis, a financial development proves to be more stable and reliable. The results indicate that the model of financial development fails to be rejected for all the cases under version 3 of the PVAR. The main conclusion is that, for the cases where both models are rejected, the ranking is important but what is of even more importance is the fact that both models have nothing to say about the causal processes. The human capital model is rejected at more stages compared to the financial development model. This tells us that this model cannot explain the behavior of the variables in the PVAR. The main question of this thesis is whether on average these 10 countries respond to financial depth or to human capital investments. If there is an average structural model with common coefficients that can be represented by a PVAR then this is the financial development model. None of these models captures the exact causal process. However, the financial development theory gives a clearer picture.

From these tests, there is no policy implication in the sense of a rule that the policy maker ought to follow. However, the non-rejection of the human capital model in comparison with the human capital one is sending a message to the policy makers whose priority is growth, that it is perhaps time to give more weight on the financial depth of the country. Countries like India, used have policies focused on the education and on increasing human capital. After the 1990s with financial liberalisation, India's growth rates expanded. This is only one example which indicates the importance of financial development. This thesis does not falsify the human capital theory. Human capital remains an important cause of economic growth. It is only when compared with financial development on average that one ought to rethink the place of financial depth in economic models.

It also depends on the interests of the policy makers. As seen from the results, if a policy maker is interested in consumption or net exports then none of these models are good enough to be considered as the 'true' models for him/her. As indicated, both models fail to capture complex relationships in fine detail. However, if the policy interest is growth then the success of both models (i.e. the fact that they are not rejected) leads the policymaker to pursue policies that focus on financial development and growth. Since the fd model is more successful relative to the h model, the policy maker could enhance financial development which will in turn feed back to growth.

7.10 Conclusion

This chapter introduced the reader to the data and gave an extensive description of the auxiliary models representing the DSGE model under test. There are two models where productivity growth is either caused by financial development or human capital. The results indicated that a model where productivity is driven by financial development is a better at explaining the data behavior than a model where human capital is a causal factor. For every structural causal process there is a reduced form which is picked up by the VAR. The question is whether the PVAR of the data is closer to either model fd or model h. These reduced forms are the growth regressions as explained in Section 7.4 and the test is asking which model can explain the growth regressions implied by that we observe. In order to explore whether a model can explain the growth regressions, a bootstrap of the random elements in the error process is done to create the sampling variation of the data as implied by the model(s). This sampling variation permits the derivation of statistical confidence limits for the parameters of the growth regressions under the null hypothesis of the model as shown in Section 7.6. This together with the Wald estimates and the p-values allow for the rejection or the acceptance of the model(s). The results indicated that the model of fd is superior to that of h although, a model of human capital is not rejected. It is however ranked second when considering the p-values. To check the magnitude of a positive shock to fd, Section 7.8 shows the evolution of the variables across time through IRFs. The conclusion is that fd is leading the rest of the macroeconomic variables. Robustness analysis as shown in Section 7.9 shows that the results do not change much and the conclusion remains the same. A model where fd is a causal factor of growth is superior compared to one where h is the driver.

Chapter 8

Conclusions

This thesis sets up an open DSGE model whose performance is reviewed using a relatively new method called indirect inference. This calibrated based method of testing the model exploits the properties of the model's error processes through bootstrap simulations. Two theories are built within the model so as to make the productivity growth rate endogenous. The first is the theory of financial development. Macro-economists have not up to date agreed the degree of importance for financial development in growth theories. What is more, the issue of causality has not been settled and due to identification problems in all econometric work, this issue will probably never be settled. The approach of this thesis is to incorporate in the decisions of the rational agents the ability to have the credit to build on their innovative ideas. This credit enters into the productivity growth equation as a causal and driving factor. The more financially developed a country is, the more innovations occur and the higher is the level of productivity and hence growth in the economy. The null hypothesis under this scenario is that a model represented by the dynamic behavior of a well-fitting auxiliary model such as a PVAR where financial development leads, can explain the actual data behavior.

The financial development theory is tested against the human capital theory. Almost every country that is capable is also willing to invest huge amounts of capital into producing human capital. This thesis claims that there might be episodes of growth where this policy might not be the best to follow. A model where human capital in terms of the percentage of GDP spent on public education, is the driver of productivity and thus economic growth is also tested in the same way. The agents in this model have the ability to choose some time off work to invest in developing their human capital. Human capital has been tested a lot more compared to financial development in economic growth models. However, testing one theory against the other for the same group of countries could simply lead to the conclusion that both models can be true but one is closer to the data than the other. The role of both of these theories in growth models is provided in Chapter 2.

The models described in Chapter 6 are tested by the method of indirect inference as described in Chapter 5 and applied in Chapter 7. The initial aim is to evaluate an already calibrated structural model. Hence, the parameters of the structural model are given and the aim is to compare the performance of the auxiliary model estimated on the simulated data from the given structural model with the performance of the auxiliary model when estimated from actual data. A linear DSGE model can be nested in a VAR. The use of PVAR as an auxiliary model is justified in Chapter 5. The comparison between the two models is based on the distributions of the two sets of parameter estimates of the auxiliary model. The proposed test statistic is a multi-parameter portmanteau Wald test that focuses on the structural model's overall capacity to replicate the data's dynamic performance. Through this statistic the probability value of any model not being rejected is calculated and the decision for ranking the two theories is made.

Chapter 7 provides the reader with the results which indicate that a model where financial development and the rest of the macroeconomic variables follow is not rejected and is superior to one where human capital is the leading factor of growth. The innovation in this thesis is the abandonment of the widely-used methods of regressing (usually using cross-country data) growth on a number of exogenous growth drivers and checking for their statistical significance. The critique of these methods is given in Chapter 4 and includes their failure for identification, likely bias and data-mining. The linear reduced forms derived from models of endogenous growth are a mere guess at the variables that might be included in the determinants of growth. There is a problem of omitted variables which usually leads to the inclusion of powers to the existing variables which will make the error term correlated with the regressors causing a bias in a direction not easily estimated.

The problem of identification arises because no one knows what model is generating these reduced forms. Many different models could give rise to the same relationships between the chosen regressors and growth. An example is when the regressors are correlated with the true causal mechanisms whatever they are and this leads to significant regression coefficients on the chosen regressors even if in fact these come from different set of causes. What is different in the method of testing used in this thesis is that firstly, all possible implications of a model set up are used and the data is to decide to reject it. Secondly, the model has to be identified and thus leave no space for confusion with any other model. The model is estimated on the data and must not be rejected at this stage. Lastly, if the model implies any other relationships i.e. any other growth regressions, these regressions must be consistent with the model being true.

The thesis provides an additional contribution to the application of indirect inference as a pioneer work using a PVAR as an auxiliary model. The relationship between a VAR and DSGE models have been established since 1980. Models using indirect inference have focused in the use of a VAR while as this thesis extends the analysis in a panel framework. This thesis deals with non-stationary data by using a PVECM represented as PVAR in levels. Financial development and human capital have not entered a DSGE in such a way as the one presented in this thesis. Hence the thesis constitutes a contribution in the financial development and growth nexus as well as the human capital and growth relationships.

Chapter 2 of this thesis provides a review of the relevant literature of growth theories and an overview of RBC models. The review of RBC models leads to the conclusion that monetary factors are not the sole source of economic fluctuations but on real productivity shocks which can occur endogenously or endogenously. This chapter also showed how human capital and financial development indicators have entered into growth theory concluding that not a lot of theoretical compared to empirical work has been done on the role of financial development.

In Chapter 3, the reader is introduced into the mulch-faceted concept of financial development through definitions of the functions and explanations of the indicators used. The high correlation between the variables as proved in the appendix led to the use of private credit to GDP as the main indicator of financial development for the model in this thesis.

In Chapter 4, the reader is introduced to the empirics of finance and growth. The aim of this Chapter is mainly to show that the econometric models used up to now suffer from a lack of identification as well as omitted variable bias and other problems that cannot constitute them as 'true' models for testing the relationship between financial development or human capital and economic growth. Chapter 4 has thus provided the problems with econometric techniques that should be avoided and hence led to the idea of indirect inference as an alternative way of finding a model more capable of describing the data behavior.

In Chapter 5, the method of indirect inference is described. Indirect inference is a simulation based method for evaluating or making inferences about the parameters of economic structural models. This method can be applied on an already calibrated DSGE model and can be completed in three simple steps. The first step is the one where the errors are calculated and after tested for unit root processes, the second step becomes bootstrapping the disturbances of these errors and adding them in the model as to create pseudo-samples. The third step is to calculate the Wald statistic which is basically a calculation of the Mahalanobis distance being transformed into a comparable t-statistic.

Chapter 6 builds a model that is an enriched variant of a prototype RBC model embodying a representative agent framework as in McCallum (1989). The model leads to the first order conditions in terms of all the variables including financial development and human capital. An equation for the productivity growth is set up to include the positive effects of either of these two factors and constitute them as leading indicators. When one of them is the leading indicator the other follows together with the rest of the macroeconomic variables. In conclusion, an econometrically testable business cycle model is built that can serve as a benchmark for quantitative analysis of policy. The solution algorithm used to solve the model is explained. Given the highly non-linear and complex nature of the model, it is solved using an algorithm developed by the Liverpool Research Group for solving complex non-linear rational expectations models. The model helps to construct the structural equations as in Appendix B and thus provides the simulations mimicking the 10 economies quarterly data behavior.

Chapter 7 provides the procedure of building the auxiliary model, the PVAR. It explains the way its estimation is carried out and provides the results. In sum, the testing procedure leads to the conclusion that a model in which financial development is a leading indicator, is a closer to the data compared to one where human capital leads. However, the model of human capital is not rejected. It simply comes second. This Chapter also provides two alterations of the PVAR; one where each country shares the same BGP and one where the group of countries is separated into developed and developing. The ranking of the models does not change although the human capital model is rejected in the case of developing countries.

If one is to draw policy implications from this setup, as countries consider ways to promote more rapid and long term economic growth, policies aiming at enhancing the financial sector performance should be high on the agenda. The developing countries should be persuaded to sharpen their policy focus on the financial sector. The above model is confirming those believing in the importance of financial development in causing and promoting growth. If this is the case the question is 'why do some countries have growth-promoting financial systems while others do not?' Governments have a very important role to play in promoting well-functioning financial systems by providing a stable political and macroeconomic environment, fiscal discipline and strong governance. There is also need for well-functioning legal and information infrastructure as well as strong regulation and supervision that promote market monitoring without distorting the incentives of the market participants. Liberalization of the financial system allowing foreign entry as well as avoidance of ownership of financial institutions also help to encourage financial development in the country. Government can also be responsible for increasing access to financial services.

The non-rejection of the financial development model in comparison with the human capital one is sending a message to the policy makers whose priority is growth, that it is perhaps time to give more weight on the financial depth of the country. Countries like India, used have policies focused on the education and on increasing human capital. After the 1990s with financial liberalisation, India's growth rates expanded. This is only one example which indicates the importance of financial development. By no means does this thesis insinuates that human capital is not an important cause of economic growth. It is only when compared with financial development on average that one ought to rethink the place of financial depth in economic models.

The central idea of my thesis has been to create a connection between the theory and the empirics in macroeconomics. The ways I followed was to first criticise some of the current empirical work and built a theoretical micro-founded model. The next step was to establish the facts in terms of the time series properties of various macroeconomic variables and finally test the model against the stylised facts of the world using rigorous bootstrapping methodology for 10 countries. This involved replicating the stochastic environment to see whether the regression coefficients in the data lie within the 95% confidence limits for those coefficients implied by the model. A step further is to estimate the model perhaps on country to country basis and then to panel data. Applying the procedure to alternative macroeconomic models will be my main research interest.

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Appendix A

Country Facts

A.1 Financial Development Index

Table A.1 shows the sample countries used for the purposes of this thesis. The second column is an index of the level of financial development in these countries as demonstrated by The Financial Development Report 2012. This is a ranking out of 62 countries covered in the Index. The overall ranking is constructed looking at, what the report defines as, pillars. The institutions are important for allowing the development of financial intermediaries. The institutional rank is measured by examining the laws and regulations that allow the development of deep and efficient financial intermediaries markets and services. Financial stability pillar is an indication of shock absorption. The negative impact of financial instability on economic growth was more evident during the recent and past financial crises as significant losses appeared to investors resulting in systemic banking crises, currency crises and sovereign debt crises.

The interesting feature of Table A.1 is that a country highly ranked overall can have an extremely high financial instability and vice versa. **Chile**, while moderately ranked oveall has a greater financial stability index than all the countries in the sample. This is possibly due to the evolution of the country towards liberalizing its financial sector and benefits from low risk of sovereign debt crisis. However, having an inefficient banking system downgrades the positive effects of financial stability. **Mexico** has a very low financial access pillar which places the country very low in the rankings. If, as the model implies, financial development described by access to credit, leads to economic growth, it mught be necessary for Mexico to create financial liberalization policies. **France** and **Italy** face the highest financial instability among the sample. Both of these countries, among other factors have a volatile banking system while Italy also has a high risk of sovereign debt crisis. Italy has also a weaker financial access which, according to the results of this thesis, should become a focus of policy.

Australia and Canada are known as mommodity-driven economies. They are both countries experiencing high financial and especially banking stability. Canada scores relatively high in policies and institutions which promote financial access and stability. The policies promoting financial development are a sign of the latter being a determinant factor for growth. The two Scandinavian countries in the sample, **Sweden** and **Finland** have been ranked very low in their non-banking financial services although there are signs of improved financial access. However, they both have strong institutional position encouraging financial development. Sweden is ranked first in financial liberalisation and Finland benefits from corporate governance. **The Netherlands** also benefits from strong corporate governance and also a large banking system. However, its financial stability is weak and its access pillar is not strong. Nevertheless, Finland and Netherlands have a well-developed human capital sector unlike **Japan** which suffers from weak human capital pool. Japan also suffers from a decline in the ease with with the private sector can access credit. However, the banking system is both large and efficient. The sample of countries is a mixture of countries with different levels of human capital and financial development. The one thing they have in common is their efforts to increase financial access and stability. A model thus that proves the importance of both of these is vital for policy implications.

Table A.1: Sample Countries-Financial Development Index 2012

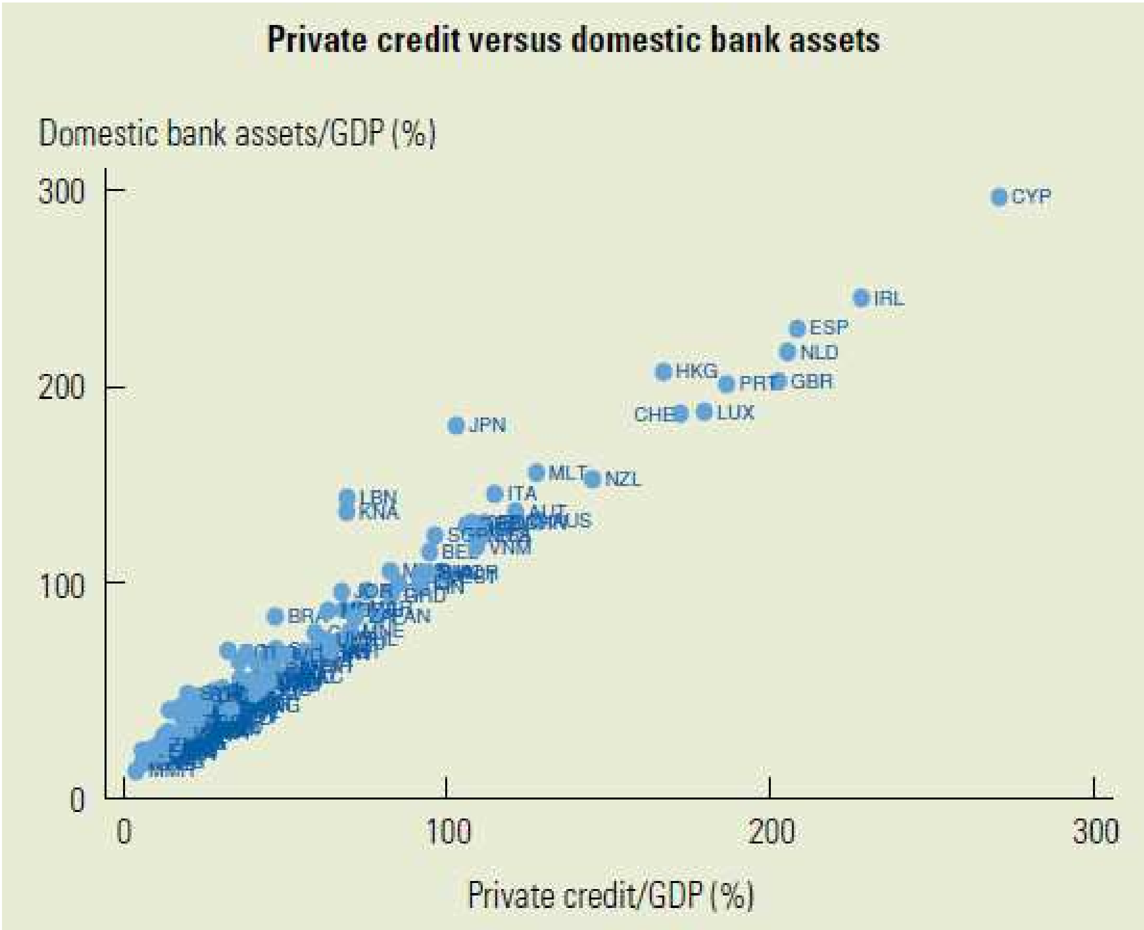
Country	Overall	Institutional	Financial Stability
Australia	5	18	9
Canada	6	6	13
Chile	29	26	7
France	14	17	42
Finland	17	5	22
Italy	30	32	51
Japan	7	15	19
Mexico	43	44	14
Netherlands	9	7	16
Sweden	10	4	25

A.2 Financial Development Indicators

Table A.2 describes the most common indicators used in the research for financial development and growth and the source from which one can collect them. This thesis has used the private credit as the main indicator for describing financial development. The indicators can be categorised in terms of depth, acess, efficiency and stability characteristics as shown in Table A.3. The usual way to characterise the financial system is by measuring its size and financial depth is one of the most common used measure of size. The private credit is used in the majority of the research trying to demonstrate the link between financial depth and economic growth. As an alternative to private credit, total banking assets are used which includes credit flowing to the government. Although it is a more comprehensive measure, it is not widely available. Finding the correlations between indicators of similar characteristics can help deciding the indicator(s) to be used. An example of this is demonstrated in Figure A.4. The correlation coefficient is about 0.98 and thus private credit is considered as a close approximation of total banking assets. More on the correlation between the financial indicator variables is demonstrated on Table A.4.

Figures A.2.2 and A.2.3 demonstrate the evolution of financial indicators over three different decades for the sample countries. Private credit is expanding for all countries but Japan and Sweden. Japan faces a reduction in the depth variables over the period 2001-2010 while

Figure A.2.1: Correlation between Private Credit and Domestic Bank Assets



Source: Global Financial Development Report 2013

significant improvements are noticed in the stock and bond market variables. All countries seem to be improving on their stock market development, even Mexico although the ratio is very low. The last decade was, for most countries a decade of financial developments.

A.3 Economic Performance Indicators

The countries' economic performance is usually indicated via economic growth rates. Table A.5 shows the variables used to construct the data of the thesis while Figures A.3.1 and A.3.2 diagrammatically show the performance of each variable across three decades. All of the sample countries have high percentage of their GDP spent on education while all of them seem to increase their degree of openness.

Table A.2: Frequent Financial Development Indicators

Financial Development	**Source**	**Indicator**
Private Credit	Beck et al. 2010	Private Credit by deposit money banks and other financial institutions/GDP
Liquid Liabilities	Beck et al. 2010	Liquid liabilities/GDP
Banking Intermediation	Beck et al. 2010	1. Deposit money bank assets/(deposit money + central)bank assets 2. Deposit money bank assets/GDP 3. Bank deposits/GDP 4. Financial system deposits/GDP 5. Bank credit/bank deposits
Stock Market	Beck et al. 2010	1. Stock market capitalization/GDP 2. Stock market total value traded/GDP
Bond Market	Beck et al. 2010	1. Private bond market capitalization/GDP 2. Public bond market capitalization/GDP
Financial Indices	World Economic Forum	1. Financial Access 2. Financial Stability 3. Financial Markets 4. Banking Financial Services 5. Non-banking Financial Services

Table A.3: Characteristics of the Financial System

	Financial Institutions	Financial Markets
DEPTH	**Private sector credit to GDP** Financial institutions' assets to GDP Money (M2 aggregate) to GDP Deposits to GDP Value-added of the financial sector to GDP	**Stock market capitalization plus outstanding domestic private debt securities to GDP** Private debt securities to GDP Public debt securities to GDP International debt securities to GDP Stock market capitalization to GDP Stocks traded to GDP
ACCESS	**Accounts per thousand adults** (commercial banks) Branches per 100,000 adults (commercial banks) Percent of people with a bank account (from user survey) Percent of firms with line of credit (all firms) Percent of firms with line of credit (small firms)	**Percent of market capitalization outside of top 10 largest companies** Percent of value traded outside of top 10 traded companies Government bond yields (3 month and 10 year) Ratio of domestic to total debt securities Ratio of private to total debt securities (domestic) Ratio of new corporate bond issues to GDP
EFFICIENCY	**Net interest margin** Lending-deposits spread Noninterest income to total income Overhead costs (percent of total assets) Profitability (return on assets, return on equity) Boone indicator (Herfindahl, or H-statistic)	**Turnover ratio** (turnover/capitalization) for stock market Price synchronicity (co-movement) Price impact Liquidity/transaction costs Quoted bid-ask spread for government bonds Turnover of bonds (private, public) on securities exchange Settlement efficiency
STABILITY	**z-score** (or distance to default) Capital adequacy ratios Asset quality ratios Liquidity ratios Other (net foreign exchange position to capital, etc.)	**Volatility** (standard deviation/average) of stock price index, sovereign bond index Skewness of the index (stock price, sovereign bond) Price/earnings (P/E) ratio Duration Ratio of short-term to total bonds (domestic, international) Correlation with major bond returns (German, United States)

Source: Global Financial Development Report

Table A.4: Correlations of Financial Development Indicators

High Income									
	dbacba	llgdp	cbagdp	dbagdp	pcrdbgdp	pcrdbofgdp	bdgdp	fdgdp	bcbd
dbacba	1	0.194867	-0.91093	0.31397	0.293239	0.288326729	0.263556	0.273614	0.191166
llgdp	0.194867	1	-0.05078	0.805089	0.705775	0.616094172	0.989782	0.977026	-0.09612
cbagdp	-0.91093	-0.05078	1	-0.22724	-0.25772	-0.2747819	-0.10672	-0.12473	-0.25318
dbagdp	0.31397	0.805089	-0.22724	1	0.944517	0.793975076	0.808635	0.793501	0.411311
pcrdbgdp	0.293239	0.705775	-0.25772	0.944517	1	0.869383619	0.711177	0.705617	0.563898
pcrdbofgdp	0.288327	0.616094	-0.27478	0.793975	0.869384	1	0.639198	0.652022	0.465224
bdgdp	0.263556	0.989782	-0.10672	0.808635	0.711177	0.639198118	1	0.983534	-0.08537
fdgdp	0.273614	0.977026	-0.12473	0.793501	0.705617	0.652022267	0.983534	1	-0.08757
bcbd	0.191166	-0.09612	-0.25318	0.411311	0.563898	0.465223731	-0.08537	-0.08757	1
Middle Income									
	dbacba	llgdp	cbagdp	dbagdp	pcrdbgdp	pcrdbofgdp	bdgdp	fdgdp	bcbd
dbacba	1	0.245866	-0.67685	0.451093	0.458474	0.444201219	0.40965	0.352137	0.208167
llgdp	0.245866	1	-0.05017	0.764609	0.660985	0.598837204	0.872865	0.832898	-0.22849
cbagdp	-0.67685	-0.05017	1	-0.13921	-0.188	-0.175690073	-0.09141	-0.08354	-0.18491
dbagdp	0.451093	0.764609	-0.13921	1	0.917665	0.865439545	0.868342	0.833547	0.136798
pcrdbgdp	0.458474	0.660985	-0.188	0.917665	1	0.951274161	0.777672	0.748556	0.315069
pcrdbofgdp	0.444201	0.598837	-0.17569	0.86544	0.951274	1	0.731935	0.702334	0.298936
bdgdp	0.40965	0.872865	-0.09141	0.868342	0.777672	0.731935212	1	0.948967	-0.17677
fdgdp	0.352137	0.832898	-0.08354	0.833547	0.748556	0.702333986	0.948967	1	-0.21211
bcbd	0.208167	-0.22849	-0.18491	0.136798	0.315069	0.298936031	-0.17677	-0.21211	1
Low Income									
	dbacba	llgdp	cbagdp	dbagdp	pcrdbgdp	pcrdbofgdp	bdgdp	fdgdp	bcbd
dbacba	1	0.375786	-0.64951	0.573856	0.560418	0.531763106	0.411581	0.201567	0.348719
llgdp	0.375786	1	0.025341	0.739933	0.697014	0.718373501	0.932424	0.735891	-0.14615
cbagdp	-0.64951	0.025341	1	-0.07141	-0.15381	-0.134568891	-0.00043	-0.02759	-0.21297
dbagdp	0.573856	0.739933	-0.07141	1	0.734098	0.711840313	0.715465	0.537744	0.098698
pcrdbgdp	0.560418	0.697014	-0.15381	0.734098	1	0.923655986	0.765279	0.607307	0.348232
pcrdbofgdp	0.531763	0.718374	-0.13457	0.71184	0.923656	1	0.760314	0.672013	0.237539
bdgdp	0.411581	0.932424	-0.00043	0.715465	0.765279	0.760313987	1	0.801474	-0.19512
fdgdp	0.201567	0.735891	-0.02759	0.537744	0.607307	0.672012852	0.801474	1	-0.32367
bcbd	0.348719	-0.14615	-0.21297	0.098698	0.348232	0.237539313	-0.19512	-0.32367	1

Figure A.2.2: Financial Development Indicators

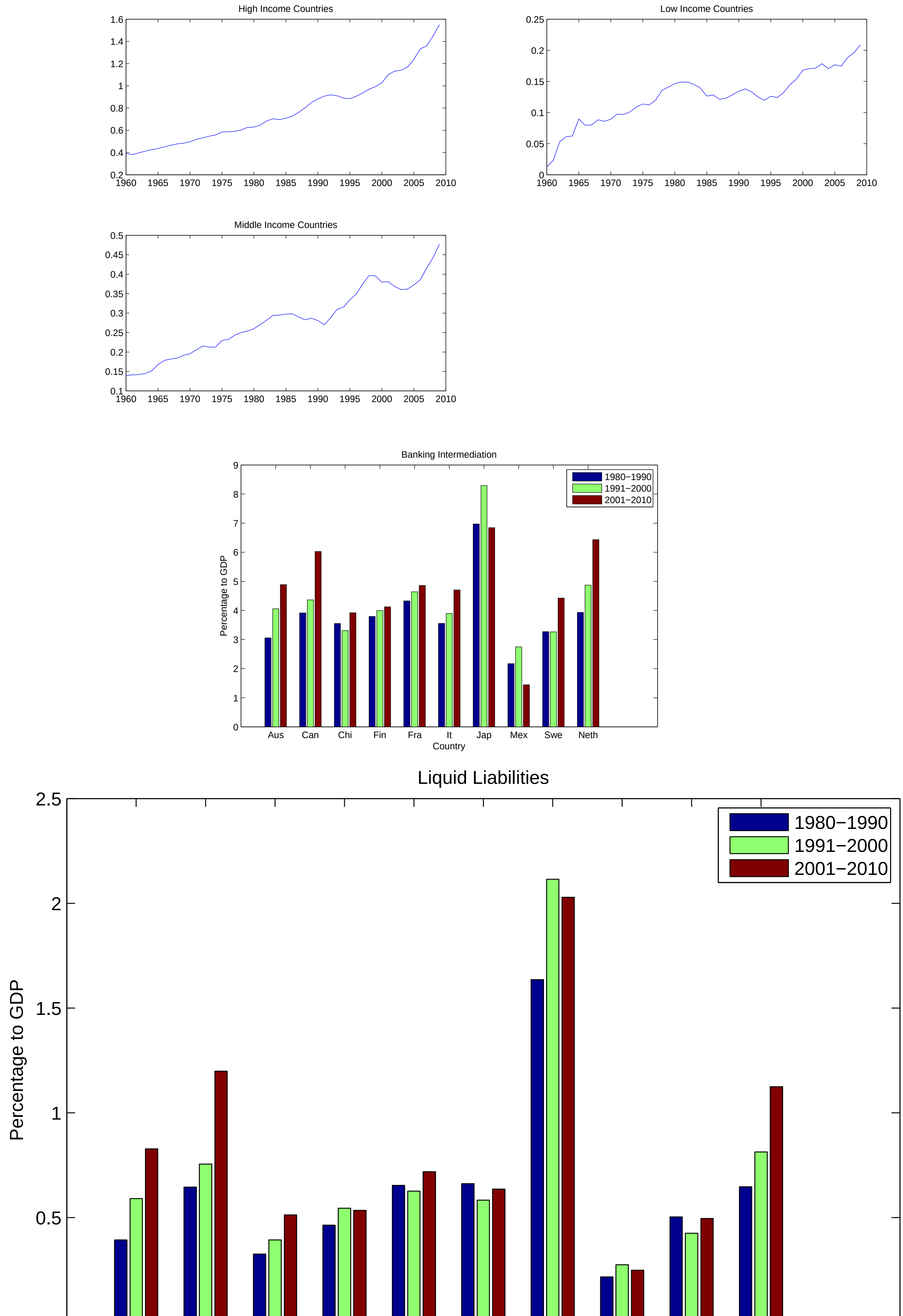


Figure A.2.3: Financial Development Indicators(cont.)

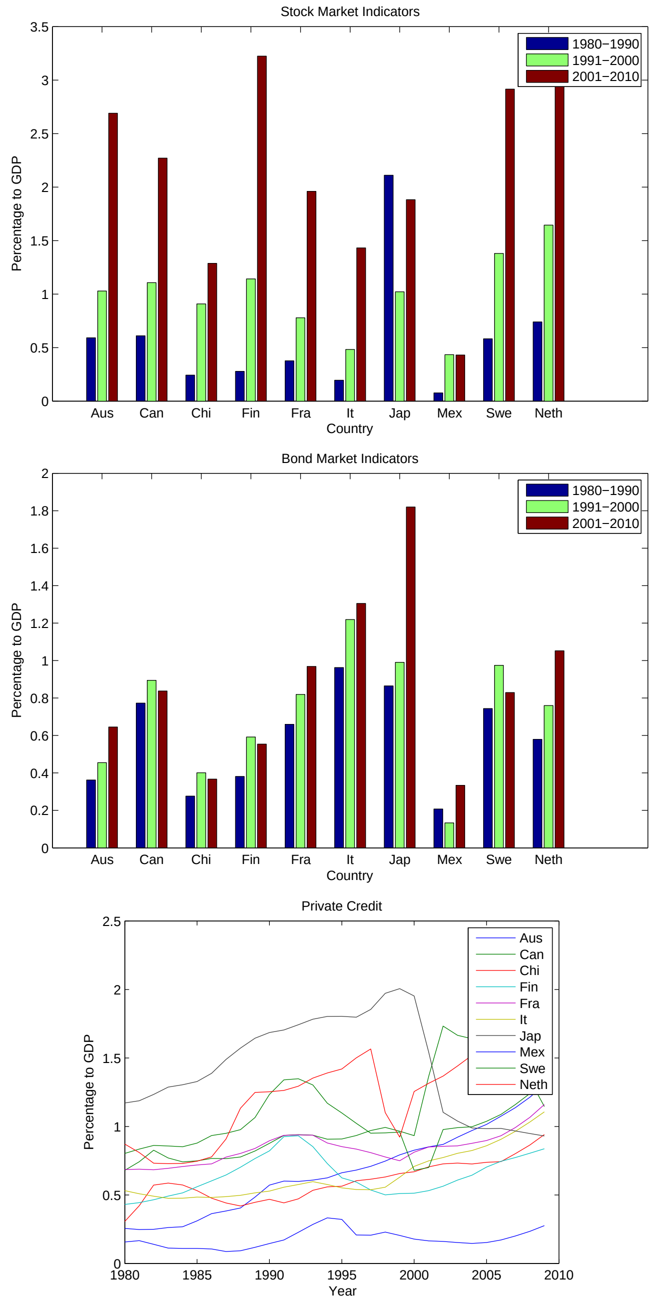
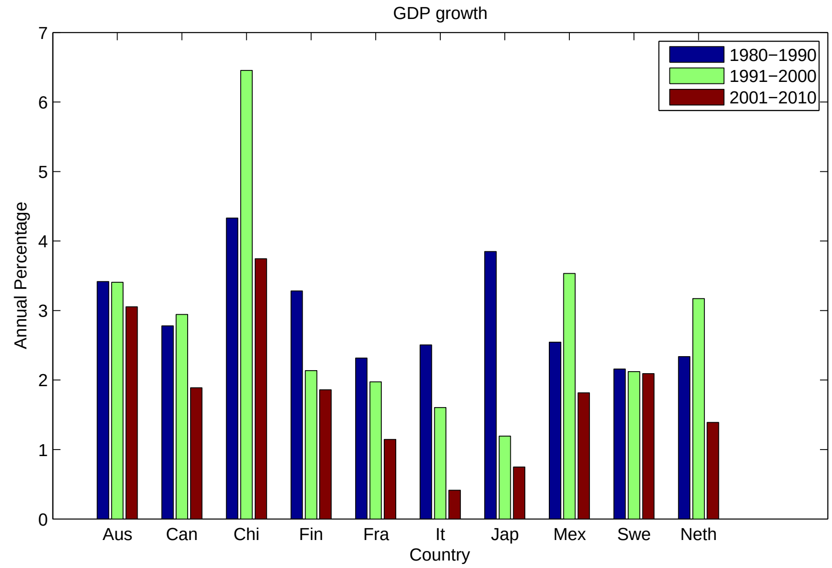
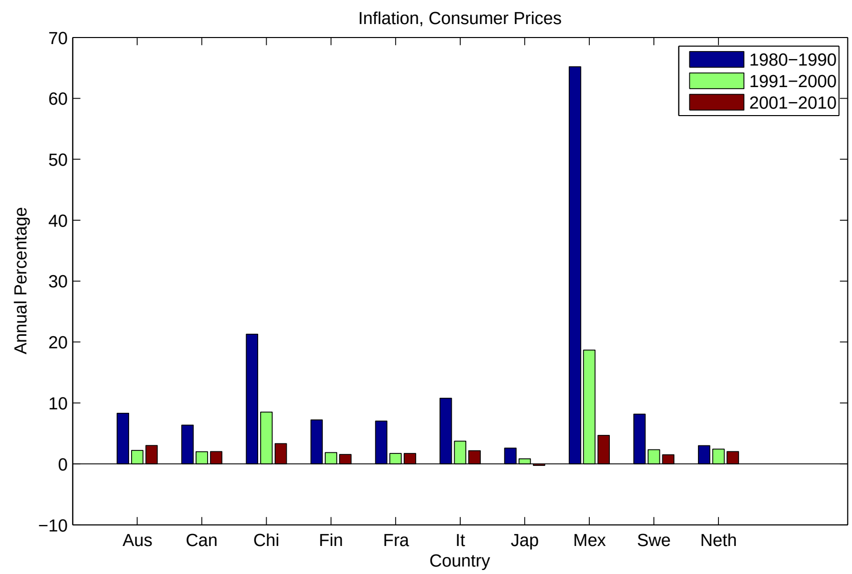


Table A.5: Economic Performance Indicators

Economic Performance	Source	Indicator
Economic Growth	World Bank	Annual GDP growth (%)
Inflation	World Bank/IMF/WID	CPI Inflation (%)
Trade/Openness	World Bank	(Exports + Imports of goods and services)/GDP
Government Expenditure	World Bank	General government final consumption expenditure as a % of GDP
Real Interest Rate	World Bank/IMF	Lending interest rate adjusted for inflation as measured by the GDP deflator
Government spending on education	World Bank/IMF/UNESCO	Public spending on education as a % of GDP

Figure A.3.1: Economic Indicators





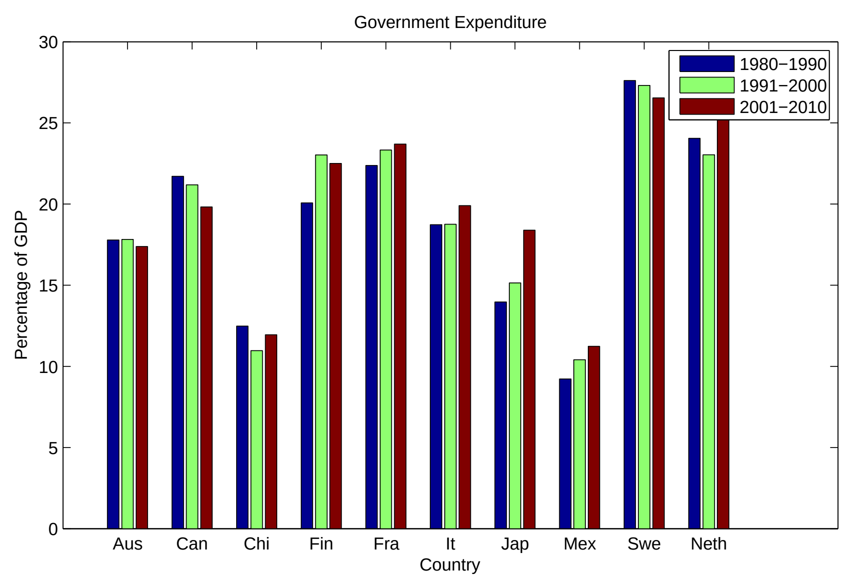
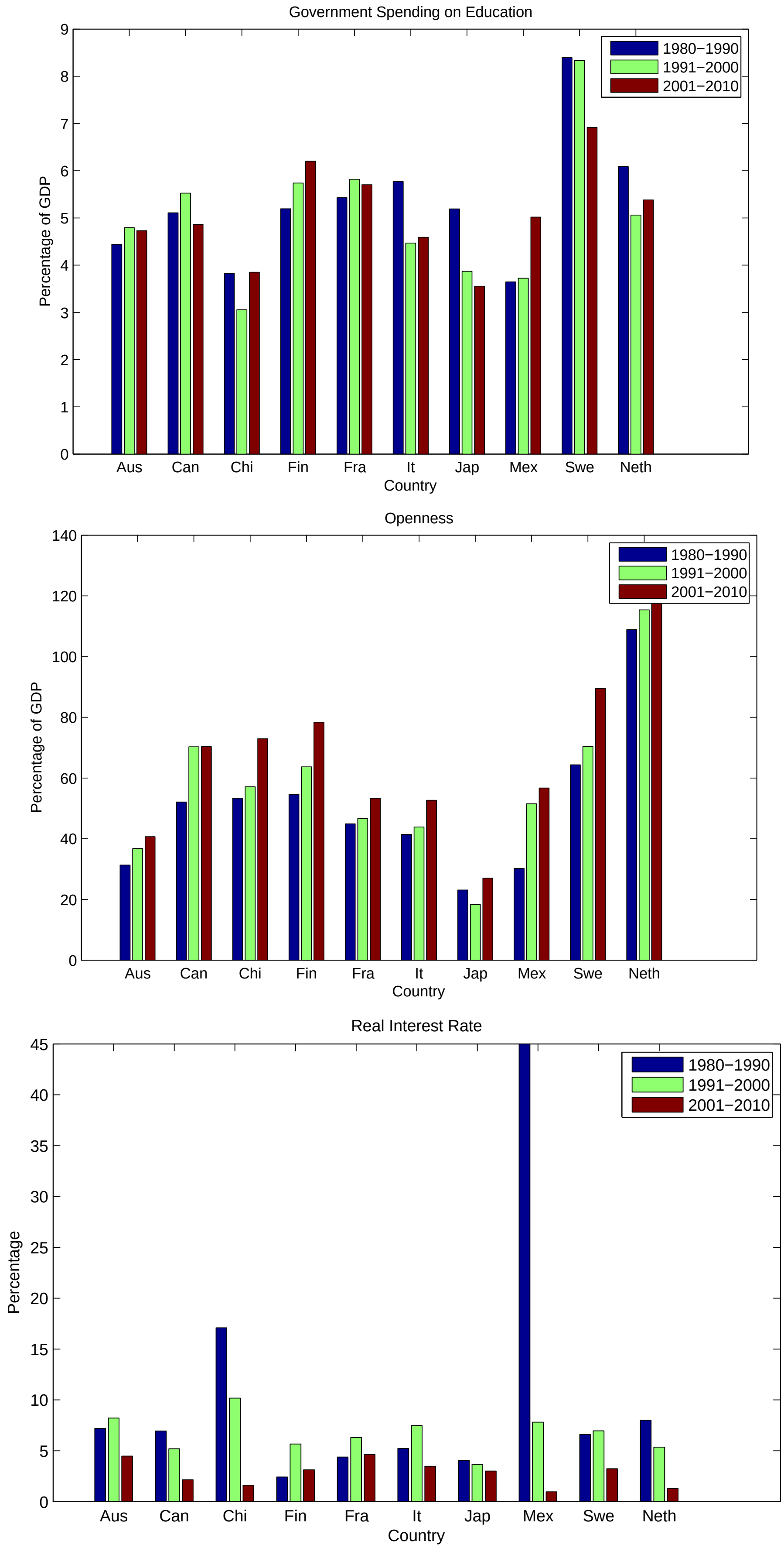


Figure A.3.2: Economic Indicatos(cont.)



Appendix B

Behavioral Equations

Endogenous Equations

Consumption

$$logC_t = E_t logC_{t+1} + \frac{1}{1.2}\left(log(\frac{1}{0.97}) - r_t\right) + e_t^c \tag{B.0.1}$$

Output

$$log\left(y_t\right) = 0.7logN_t + \left(1 - 0.7\right)logK_t + e_t^y \tag{B.0.2}$$

where $e_t^y = A_t$

Labour Demand

$$logN_t = log0.7 + logY_t - logw_t + e_t^n \tag{B.0.3}$$

Capital

$$logK_t = c + \zeta_1 logK_{t-1} + \zeta_2 E_t K_{t+1} + \left(1 - \zeta_1 - \zeta_2\right) logY_t - 10r_t + e_t^k$$

$$logK_t = c + 0.5logK_{t-1} + 0.475E_t K_{t+1} + 0.025logY_t - 10r_t + e_t^k \tag{B.0.4}$$

Net Exports

$$logNX_t = logY_t - \frac{8}{1.3}\left(logK_t - logK_{t-1}\right) - \frac{0.381}{1.3}logG_t - \frac{1}{1.3}logC_t \tag{B.0.5}$$

Government

$$logG_t = ln0.3 + logY_t \tag{B.0.6}$$

Wage

$$logw_t = 1.2logC_t + log\left(1-0.5\right) + logN_t + e_t^w \tag{B.0.7}$$

Evolution of foreign bonds

$$b_t = \left(1 + r_t^f\right)b_{t-1} + NX_t \tag{B.0.8}$$

Financial Development Theory

Productivity

$$A_t = A_{t-1} + \alpha_1 fd_t + u_t^{fd}$$

$$A_t = A_{t-1} + 0.006fd_t + u_t^{fd}$$

Financial Development

$$fd_t = c_{fd} + \gamma_{fd}T + e_t^{fd} \tag{B.0.9}$$

Human Capital

$$h_t = \mu_h Y_{t-1} + e_t^h \tag{B.0.10}$$

Human Capital Theory

Productivity

$$A_t = A_{t-1} + \alpha_1 h_t + u_t^h$$

$$A_t = A_{t-1} + 0.05 h_t + u_t^h$$

Financial Development

$$fd_t = \mu_{fd} Y_{t-1} + e_t^{fd} \tag{B.0.11}$$

Human Capital

$$h_t = c_h + \gamma_h T + e_t^h \tag{B.0.12}$$

Market Clearing Conditions Goods section

$$Y_t = C_t + I_t + G_t + EX_t - IM_t \tag{B.0.13}$$

$$I_t = K_t - (1 - \delta) K_{t-1} \tag{B.0.14}$$

Appendix C

Literature Review on Tables

Table C.1: Cross-Country Sudies

Author	Sample-Region	Sample-Time Period	Method	FD Indicators		Findings
Goldsmith(1969)	35 countries	1949-1963	OLS	total assets of all financial intermediaries/GDP		• Unambiguous relationship between financial development and growth • Low correlation coefficients imply statistically weak relationship
Atje and Jovanovic (1993)	94 countries	1980-85	OLS	Credit extended by private and government banks/GDP	Annual value of all stock market trades/GDP	• Stock markets have positive effect on the level and growth rate of GDP • No such conclusion is drawn from the use of banking indicator
King and Levine (1993a)	80 countries	1960-1989	OLS	Liquid liabilities/GDP Commercial bank assets/GDP	Private credit/GDP Credit to private and government sector/GDP	• Positive relationship between many of the FI and the a)real GDP per capita, b) the rate of physical capital accumulation and c)the TPF growth • Support for Schumpeter's theory
Japelli and Pagano (1994)	30 countries	1960-1985	Growth regression analysis	Maximum amount if credit accessible for private agents/secured assets		• Development of financial markets leads to lower savings and economic growth • Welfare of current and future generations can be deteriorated
Harris (1997)	39 countries	1980-1988	TSLS	Investment ratio*stock market turnover/GDP		• Weak support of the hypothesis that stock market enhances marginal productivity of capital and

Table C.2: Cross-Country Studies (cont.)

							thus growth for less developed countries • Weak statistical significance of the stock market effect on developed countries
Demirguc-Kunt and Maksimovic	30 countries	1980-1991	OLS	Bank deposits/GDP Stock Market Capitalization Stock Market Turnover			• Active stock markets and well developed legal systems enhance firm growth • A larger banking sector eases external access of firms and increase their growth • Developed markets increase the external finance dependence
Levine and Zervos (1998)	47 countries	1976-1993	OLS	Bank credit/GDP Capitalisation of domestic listed companies/GDP	Value traded/FDP Volatility if share returns		• Stock market liquidity and banking development are positively and robustly correlated with current and future rates of economic growth, capital accumulation, and productivity growth.
Ram (1999)	95 countries	1960-1989	OLS				• Weak and negative correlation between financial development and economic growth • Analysis on individual countries leads to the same result
Levine, Loyaza[i] and Beck (2000)	71 countries	1960-1995	OLS	Liquid Liabilities/GDP	Assets of commercial and central		• Better financial systems facilitate economic growth • Efficiency of legal and

Table C.3: Cross-Country Studies (cont.)

				banks/GDP Private credit/GDP		accounting standards help in explaining differences in financial intermediaries
Rousseau and Watchel (2000)	84 countries	1960-1995	Growth regression analysis	M3/GDP (M3-M1)/GDP Total credit/GDP		• Inflation affects financial development and thought it, it hinders economic growth • There is a strong and robust effect of financial development on growth independent of the presence of inflation • However, the effect becomes weaker at times of high inflation
Deidda and Fattouh (2001)	80 countries	1960-1989	Threshold OLS model	Liquid Liabilities/GDP		• Using initial per capita income as threshold, a positive relationship between financial depth and economic growth is observed • Without threshold effects, the positive relationship is observed in developed countries but no significant relationship is observed in low income countries
McCaig and Stengos (2005)	71 countries	1960-1995	GMM	Liquid Liabilities/GDP Private Credit/GDP Commercial Assets/Central Bank Assets		• Strong positive effect of financial development on growth when LL and PC are used as indicators. • Weaker relationship is observed when CA/CBA is used and thus conclude that it

Table C.4: Cross-Country Studies (cont.)

						is not a good proxy
Aghion, Howitt and Foulkes (2004)	71 countries	1960-1995	Split-Sample growth regressions	Private credit/GDP		• Financial development is a powerful force of growth • Significant and sizeable effect between initial GDP per capita and financial intermediation so the likelihood of converging to U.S growth rate increases with the level of financial intermediation
Djankova, McLiesha and Shleifer (2007)	129 countries	1978-2003	OLS	Private credit/GDP		• Strong legal origin effect in credit market institutions • Private credit is relatively more important in richer countries
Arcand, Berkes and Panizza (2011)	40 countries	1970-2000	OLS	Private credit/GDP $\left(\frac{Private\ credit}{GDP}\right)^2$		• Positive and robust correlation between financial depth and economic growth when the country has relatively small financial institutions • There is a threshold above which finance starts having a negative effect on growth (above 80-100% of GDP)
						•

[i] They also use a GMM dynamic panel approach with the same amount of countries. The results remain the same.

Table C.5: Time-Series Studies

Author	Sample-Region	Sample-Time Period	Method	FD Indicators		Findings
Gupta (1984)	14 countries	1961q1-1980q4	VAR, Granger Causality	M1, M2,M3 Private credit		• Causality from financial systems to economic growth for 8 countries • Bi-directional relationship for 6 countries
Jung (1986)	56 countries	Different periods between 1959-1980	VAR, Granger Causality	Cash/M2 M2/GDP		• Support of Patrick's supply leading hypothesis for less developed countries • Demand-following observed mostly in developed countries
Demetriades and Hussein (1996)	16 countries	1960-1995	VAR,VECM,EG cointegration, Johansen cointegration, Granger causality	Bank deposit liabilities/GDP	Bank claims on private sector/GDP	• Little support for the supply-leading hypothesis • Bi-directional causality implying financial development and growth are jointly determined
Arestis and Demetriades (1997)	Germany and U.S	1979q1-1991q4	Johansen cointegration, VECM, weak exogeneity tests	SMC ratio Stock market volatility M2 /GDP domestic	Bank credit/GDP (for U.S)	• In Germany causality runs from financial development to growth • The reverse is true for the U.S • SMC affects real GDP through the banking system • Stock market volatility has a negative effect on output
Rousseau and Wachtel (1998)	5 countries	1870-1929	VAR, Granger causality	Money base Various bank deposit and credit indicators[i]		• Support of Granger causality from financial development to the real sector • Output is highly responsive to the intensity of financial intermediation
Luintel and Khan (1999)	10 countries (developing)	36 to 41 years	VAR,Johansen cointegration, Granger causality	Ratio of total deposit liabilities of deposit banks		• In the long-run, financial depth is positively and significantly affected by the levels of per capita real GDP

Table C.6: Time-Series Studies (cont.)

					• bi-directional causality between financial development and economic growth in all the sample countries
Xu (2000)	41 countries	1960-1993	VAR, Impulse response function	M2	• Rejection of the hypothesis that financial development simply follows growth • Financial development stimulates investment and thus growth for 27 sample countries
Al-Yousif (2002)	30 countries (developing)	1970-1999	ECM, Granger causality	M1, M2/nominal GDP	• Bidirectional relationship • Country specific results which vary according to country and financial development proxies.
Caporale, Howells and Soliman (2005)	4 countries	1979q1-1998q4	VAR, Modified Wald, Toda and Yamamoto (1995)	SMC/GDP Value trated/GDP	• Stock markets have a positive and strong effect on economic growth • Causality runs from stock markets to growth through investment
Baliamune-Lutz (2010)	18 countries (Africa)	1960-2001	VAR, Johansen cointegration, Granger causality,IRFs	Liquid Liabilities/GDP Private credit/GDP	• Overall a negative effect of financial development on growth • Evidence of bi-directional causality and reverse causation
Fukuda (2012)	5 countries	1982q1-2007q4	VECM,ADRL	M2/GDP Various banking and stock market indicators	• Different causal directions for each country • Deeper financial development can lead to financial crisis • Financial crisis has negative effect on economic growth

[i]Such indicators include the assets of commercial banks, the combined assets of commercial banks and savings institutions, the assets of commercial banks, savings institutions, insurance companies, credit cooperatives, and pension funds and investment company assets.

Table C.7: Panel Studies

Author	Sample-Region	Sample-Time Period	Method	FI Indicators	Findings
Gelter and Rose (1994)	69 countries (developing)	1950-1988	Panel regression analysis	Bank credit to non-financial sector/GDP (M2-M1)/GDP	• Positive relationship between financial development and growth • Financial and real development are a joint product
De Gregorio and Guidotti (1995)	12 countries (Latin America)	1960-1985	OLS, Panel data random effects	Private credit/GDP	• Financial development leads economic growth but this conclusion varies across countries • Unregulated financial liberalization and expectation of government bailout can have a negative effect of finance on growth
Odedokun (1996)	71 countries	1960s-1980s	GLS	nominal value of the stock of liquid liabilities/nominal GDP or M2/GDP	• In 85% of the sample countries financial development promotes economic growth • The growth-enhancing effects of finance are more pronounced in the low income countries • Panel results show that growth promoting results do not change across regions and levels of growth
Berthelemy and Varoudakis (1997)	85 countries	1960-1990	Panel regression analysis	M2/GDP	• In the steady state, the growth rate depends positively on the number and competition rate of banks • Educational development is a pre-condition of growth

Table C.8: Panel Studies (cont.)

					• If educational development is low, financial development has negative effects on growth
Rajan and Zingales (1998)	41 countries (industry level)	1980-1990	OLS, Panel data fixed effects	$\frac{Private\ credit + SMC}{GDP}$ Accounting standards	• The industries depending on external finance tend to grow proportionately more in financially developed countries • Financial development is beneficial for the rise of new firms
Graff (2000)	93 countries	1960-1990	Panel regression analysis	Composed a new proxy to capture the share of resources a society needs to devote to run the financial system	• Not a stable relationship found between finance and growth • Financial development brought harmful effects for growth during 1975-80 • No evidence of reverse causation • Causality runs mainly from financial development to growth
Beck, Levin, Loayza (2000)	77 countries	1960-1995	GMM panel estimator, IV	Private credit/GDP Liquid liabilities/GDP Commercial Bank Assets/Total Bank Assets	• Financial intermediation exerts positive impact on TFP and growth • Weak long run links between financial development, physical capital and private savings
Benhabib and Spiegel (2000)	5 countries	1965-1985	GMM panel estimation	Private credit/GDP M2/GDP Commercial Bank Assets/Total Bank Assets	• The importance of financial development to TPF and growth alter according to the indicators used and country fixed effects • Generally, a positive relationship is observed between FIs and TPF growth
Rousseau and Wachtel (2000)	47 countries	1980-1995	Panel VARs, GMM estimator	M3/GDP	• Stock markets promote economic growth

Table C.9: Panel Studies (cont.)

				SMC/GDP SVT/GDP	• Liquidity is vital for market development and growth per capita
Cetorelli and Gambera (2001)	41 countries 36 industries	1980-1990	Panel regression analysis	Private Credit/GDP Banking concentration	• Banking concentration has negative effects on growth • Countries with firms having high dependence on external finance benefit from banking concentration • Financial development and GVA of manufacturing industries are positively correlated
Calderon and Liu (2003)	109 countries	1960-1994	Panel VAR, Geweke decomposition, Granger causality	M2/GDP Private credit/GDP Real financial balance sheet items/GDP	• Financial development promotes economic growth • Bi-directional relationship between financial development and economic growth • Financial development has larger relative effects to developing countries • Causal relationship observed from financial development to TPF
Beck and Levine (2004)	40 countries	1976-1998	OLS and GMM	Turnover Ratio SVT/GDP SCM/GDP Private credit/GDP	• Stock market and banking development contributes positively in growth • Stock market and bank indicators enter all regressions significantly claiming that stock markets and banks offer different services
Christopoulos and Tsionas (2004)	10 countries	1970-2000	Panel VECM, Cointegration techniques, modified OLS	Total bank deposit liabilities/nominal GDP	• Long run causality runs from financial development to growth • No bi-directional nor short-run

Table C.10: Panel Studies

					causality observed
Rioja and Valev (2004)	74 countries	1961-1995	GMM panel techniques	Bank based and market based financial development indicators	• Examination is done when separating the countries into high, middle and low regions. In low regions the effect of financial development is negligible or unambiguous • Countries with already high financial development are positively affected by an expansion of the financial sector
Nuno Carlos Leitão (2010)	31 countries	1980-2006	GMM estimator	Private credit Deposit Money banks	• Stable relationship between financial development and growth • Financial development stimulated trade and TPF growth
Kar, Nazliogly, Agir (2011)	15 countries (MENA)	1980-2007	Panel regression analysis, Granger causality	Money aggregates Bank and Credit indicators	• No strong evidence to give financial development a role in economic growth • Results support both demand following and supply leading hypothesis thus causality is country specific
Qayyum, Siddiqui and Hanif (2012)	9 countries	Mixed from 1974-2001	Heterogeneous Panel regression analysis, Causality	Liquid liabilities SMC, SVT Private credit	• No evidence of a positive relationship between indirect finance and growth • Significant relationship between the size but not the activity of the financial system • Expansions of the financial system at times of high inflation can be harmful for economic growth

Table C.11: Country-Case Studies

Author	Sample-Region	Sample-Time Period	Method	FI Indicator	Findings
Fritz (1984)	Philipines	1969-1981	Granger Causality	Various monetary variables	• Support for supply leading hypothesis for 1969-75 and 1975-81
Wood (1993)	Barbados	1946-1989	Granger Causality	M2/GDP	• Rejection of Patrick's hypothesis • Demand-following evidence observed in 1946-1986 • Supply leading evidence observed in 1969-1990
Demetriades and Luintel (1996)	India	1961-1991	ECM,PCA		• Banking sector controls negatively affect the process of financial development • Financial development and economic growth are jointly determined
Jayaratne and Strahan (1996)	U.S	21 years	OLS,WLS	Banking Deregulation Indicator	• Bank monitoring and screening improvements are a key to growth • Support of the theory that better financial systems are a channel of savings to efficient investments
Hanson and Jonung (1997)	Sweden	1834-1991	Cointegration analysis, Granger causality	Total credit to non-financial sector per capita	• Financial system greatly affected Sweden between 1890-1939 • No stable relationship between finance and growth
Choe and Moosa (1999)	Korea	1970-1992	VAR, Granger causality	Currency, Deposits Securities, Stocks, Insurance and	• Financial development leads economic growth • Biased towards bank-based

Table C.12: Country Case Studies (cont.)

				Pension	markets hypothesis supporting market failure
Bell and Rousseau (2001)	India	1951-1995	VAR,VECM, Johansen cointegration, VECM, Granger causality, IRFs	Domestic assets of deposit money banks Total domestic credit to non-banks Private credit	• Expansion of the financial system enhances capital accumulation • Key financial aggregates shift output towards industry • These aggregates enhance investment and growth • No evidence of FI effect on TFP in manufacturing thus support for 'debt accumulation hypothesis'
Thangavelu and Ang (2004)	Australia	1960q1-1999q4	VAR, Granger causality	Domestic bank deposits/nominal GDP Private claims/nominal GDP Equity turnover/GDP	• Economic growth Granger causes banking development when using banking indicators • Stock markets are essential in promoting growth when using market indicators • Financial deregulation positively affected the Australian growth
Guiso, Sapienza and Zingales (2004)	Italy	1989-1998	OLS	Access to local credit	• Effect of financial development differs across firms depending on their size • Small firms are more dependent on local credit and thus increased access to it promotes their growth • Integration of the financial system drives large firms to external finance

Table C.13: Country Case Studies (cont.)

Ang and McKibbin (2007)	Malaysia	1960-2001	VECM, Johansen cointegration, Granger causality and PCA	M3/nominal GDP Commercial bank assets/total bank assets Private credit/nominal GDP	• Support of the demand-following hypothesis • Positive relationship between financial development and growth • No support of the theory that bank-based markets promote economic growth
Kilimani (2009)	Uganda	1970q1-2006q4	ECM, Granger causality, Johansen cointegration	M2/GDP Total credit/GDP	• Causality runs from financial development to growth when M2/GDP is used as an indicator
Johannes, Njong and Cletus (2011)	Cameroon	1970-2005	ECM, Johansen cointegration	M2/GDP Bank credit/GDP	• Positive long run relationship between financial development and growth • No causal relationship observed in the short run • In the long run causality runs from financial development to growth •